ENVIRONMENTAL MANAGEMENT FOR DEVELOPING COUNTRIES

ENVITEK A.Ş.

PREPRINTS

I

A Contribution of ENVİTEK A.S. to the "International Drinking Water Supply and Sanitation Decade"

Milliyet Yayın A.Ş.
Ayazağa Ofset Tesisleri'nde hazırlanmış ve basılmıştır.

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ENVIRONMENTAL TECHNOLOGY
RESEARCH AND DEVELOPMENT CENTER
ISTANBUL, TURKEY

FOREWORD

One of the most serious problems which developing countries are facing along with their struggle for development is the protection of the Environment. ENVİTEK A.S. *being aware of this need has decided to organize the "International Symposium on* Environmental Management *for Developing* Countries". This *will be the second Symposium which is organized in* İstanbul, Turkey *within the framework of the* "Sanitation Decade" *following the "International Symposium on* Enviromental Technology" *which took place two years ago.*

In this publication, preprints of the papers to be presented in the Symposium are printed exactly as received from the lecturers without any modification . Although *detailed "typing instructions" have been mailed to each participant, a few papers have not been prepared according to these instructions. Our intention, however, is to prepare the formal* Proceedings *in which the discussions will be included along with the edited and retyped papers.*

In these volumes, the papers are presented in an alphabetical order according to the family name of the first author. Names *of the first authors also appear at the lower right corner of the odd numbered pages, thus facilitating the identification of the papers.*

ENVİTEK A.S., ***by organizing this Symposium, has tried to contribute to the*** *assimilation of knowledge as well as to the improvement of the cooperation between scientists and engineers in developing countries.*

Realization of these two goals, for which ENVİTEK A.S. *will continue to work, will contribute to the development of "the most appropriate technology for developing countries", a goal which is seriously required in today's world.*

İstanbul, July 25, 1984

ENVİTEK A.S.

ENVİTEK-Environmental Technology Research and Development Center A.S. is a privately owned organization established in 1983. With its wide range of activities, ENVİTEK A.S. aims to contribute to the protection of the environment and betterment of the standards of living. These activities may be classified in the following groups :

a) Activities Related to the Dissemination of Knowledge

In order to contribute to the dissemination of knowledge, ENVİTEK A.S. organizes symposia, seminars and courses related to environmental problems. A scientific journal related to environmental science and technology will soon be published. The library of ENVİTEK A.S., the biggest library in environmental engineering that a private organization in Turkey posseses, is the most important source of information for these activities.

b) Research

ENVİTEK A.S. is the only privately owned organization in Turkey which has a fully equipped laboratory where all experiments related to water and wastewater analysis and some relevant experiments on air pollution and solid wastes can be performed. Facilities for bench-scale model tests for treatability studies are also available. Through these facilities, ENVİTEK A.S. performs studies which will contribute to the development of "appropriate technology" applicable in the Middle East. The laboratory facilities are also used to perform studies for the direct needs of the public and private sectors.

c) Consulting

The staff of ENVİTEK A.S. consists of distinguished engineers and scientists who have a vast experience on municipal and industrial wastewater treatment plant design, environmental pollution control, environmental management, etc.

d) Contracting

ENVİTEK A.S. undertakes the construction facilities related to its fields of activities among which water and wastewater treatment plants have the major share.

e) Representation

ENVİTEK A.S. acts as an agent for a number of well known foreign companies in Turkey and the Middle East.

f) Other Activities

In order to contribute to the general environmental conditions, ENVİTEK A.S. has the potential of undertaking a number of diversified projects. Among these, forset development schemes, recycling of wastes, reuse of water, recreational facilities, sporting facilities, etc. can be counted.

ENVİTEK A.S. fully aware that the most advanced technology is not necessarily the most appropriate for a developing country, in all its activities has the objective of finding the solution which is best applicable to the local conditions, ENVİTEK A.S. is open to suggestions and ready for cooperation with all concerned organizations or individuals along these lines.

The International Symposium on Environmental Management for Developing Countries, July 25-31,1984, İstanbul, is a contribution of ENVİTEK A.S. to the Sanitation Decade.

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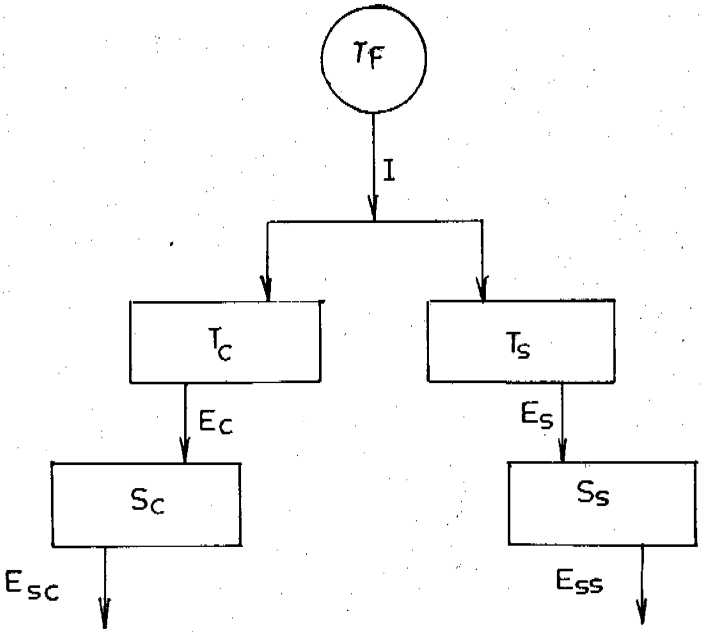
Introduction

The role of attached biological film in the self-purification of waste-water is significant, along with factors like, velocity of waste-water, turbulence, natural gradient, dissolved oxygen, sunlight. The film gets attached to the fixed objects such as stone, twigs, silt. The micro-organisms in the film get their food from the waste-water flowing past them. Similar technique is adopted in the many fixed biological processes such as, trickling filters, biodiscs, biodrums, biobaskets[1-7]. The principles involved in these treatment are well explored[8-12]. Contact aeration[13-15] and the submerged bed filters, extended biological filteration is also dependent on the same basis[16-17]. The Hay's process[18] had an early death due to the World War II.

Materials and Method

Fig. (1) is the experimental set up. Acrylic plastic sheet tanks Fig. (2) were used. One was a control and other had fixed surfaces, in the form of 9 cm x 9 cm asbestos sheets. The two tanks had equal aeration. The feed used was synthetic sewage.



I - Influent
T_F - Feed tank
T_C - Control tank
T_S - Surfaces tank
S_C - Settling tank for E_C

S_S - Settling tank for E_S
E_C - Effluent from T_C
E_S - Effluent from T_S
E_{SC} - Effluent from S_C
E_{SS} - Effluent from S_S

FIG 1 - SCHEMATIC DIAGRAM OF EXPERIMENTAL SET-UP

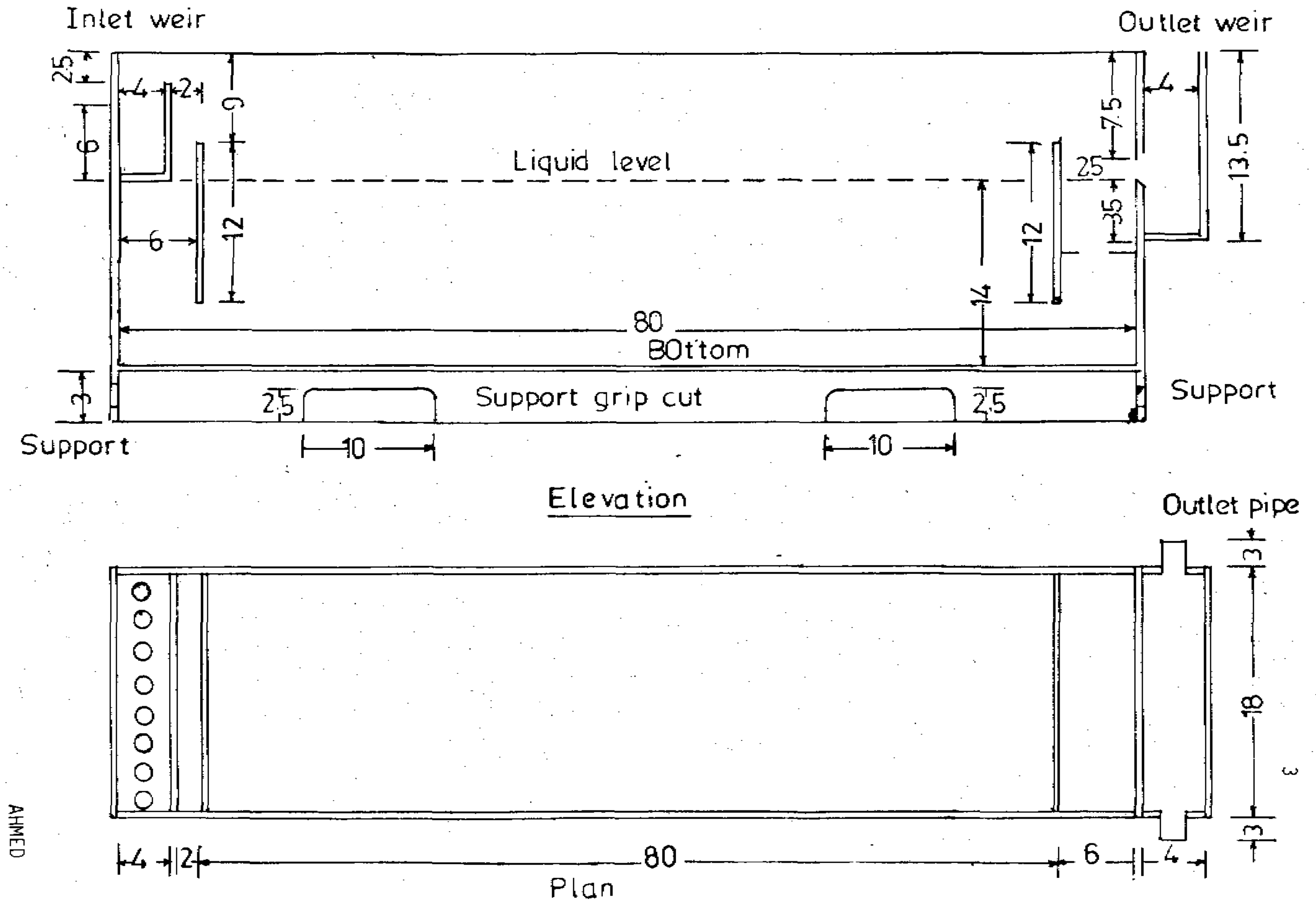


FIG. 2 - DETAILS OF · REACTOR

Parameters used are: BOD, turbidity, dissolved oxygen, surface area, biomass and kinetic coefficients like yield coefficient Y, Decay coefficient, kd, Maximum specific growth max and Monod's half velocity constant K_s. Statistical analysis has also been done.

The fixed surfaces are used, and the influent organic loading has been varied. The analysis was performed as per the Standard Methods[19].

B.O.D. and Biomass

The organic influent loading is increased gradually which is reflected in influent B.O.D. variation. Due to entranced substrate greater biomass has been found Fig.(3). This is seen in both the control tank, T_c and in the tank with additional surfaces. T_s Fig. (4). The increased biomass has resulted in extra B.O.D. removal Fig. (5). As in earlier work, the T_s, performed better with 95.2% removal composed to T_c with 90.10% removal Fig. (6).

Variable Surface Area

When surface area is gradually increased, the biomass also gradually increases, but at a later stage it flattens out, Fig. (7), as there is no sufficient space for further growth of biomass, and the B.O.D. removal also becomes constant.

As the B.O.D. applied per unit area is increased, the B.O.D. removal falls down Fig. (8).

Turbidity Removal

The turbidity removal has slightly improved as the influent B.O.D. has been increased Fig. (9). Consistently the turbidity in surfaces tank effluent is almost negligible, which is due to "Phagocystosis".

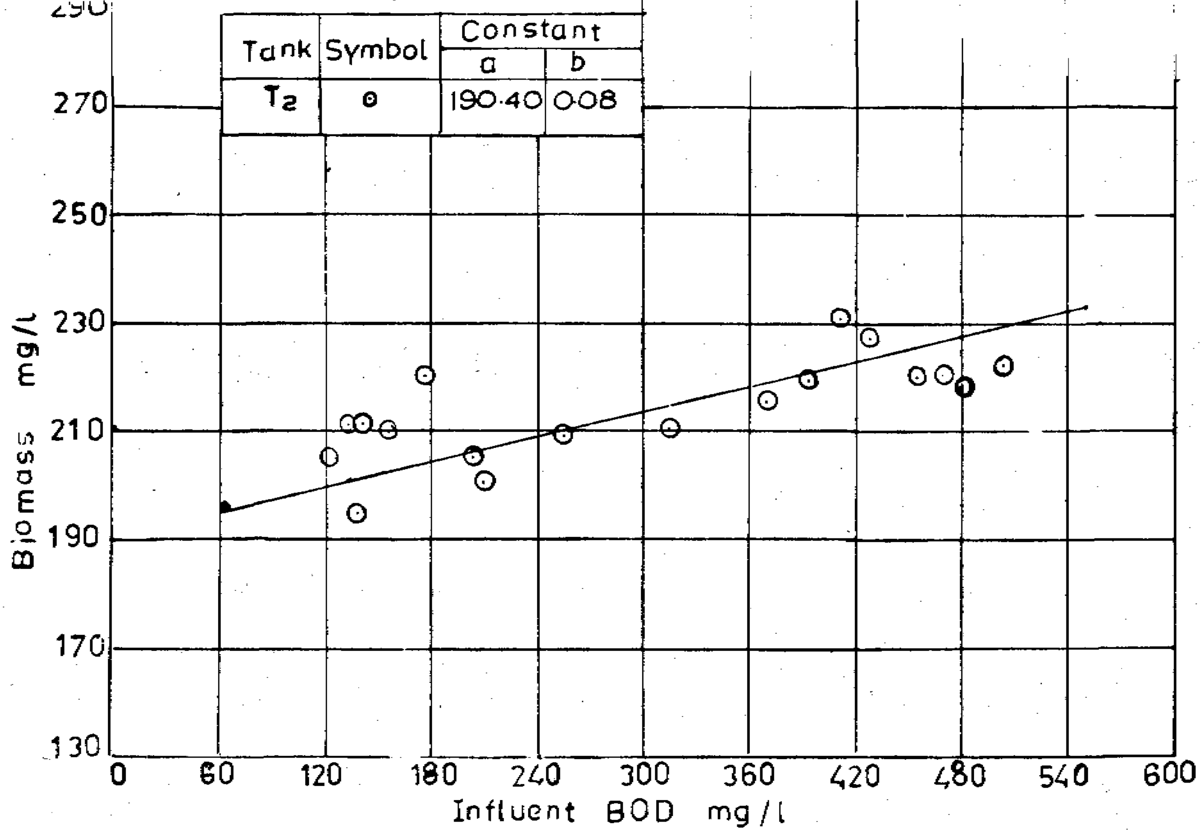


FIG. 3. RELATION BETWEEN INFLUENT BOD AND BIOMASS IN T_s

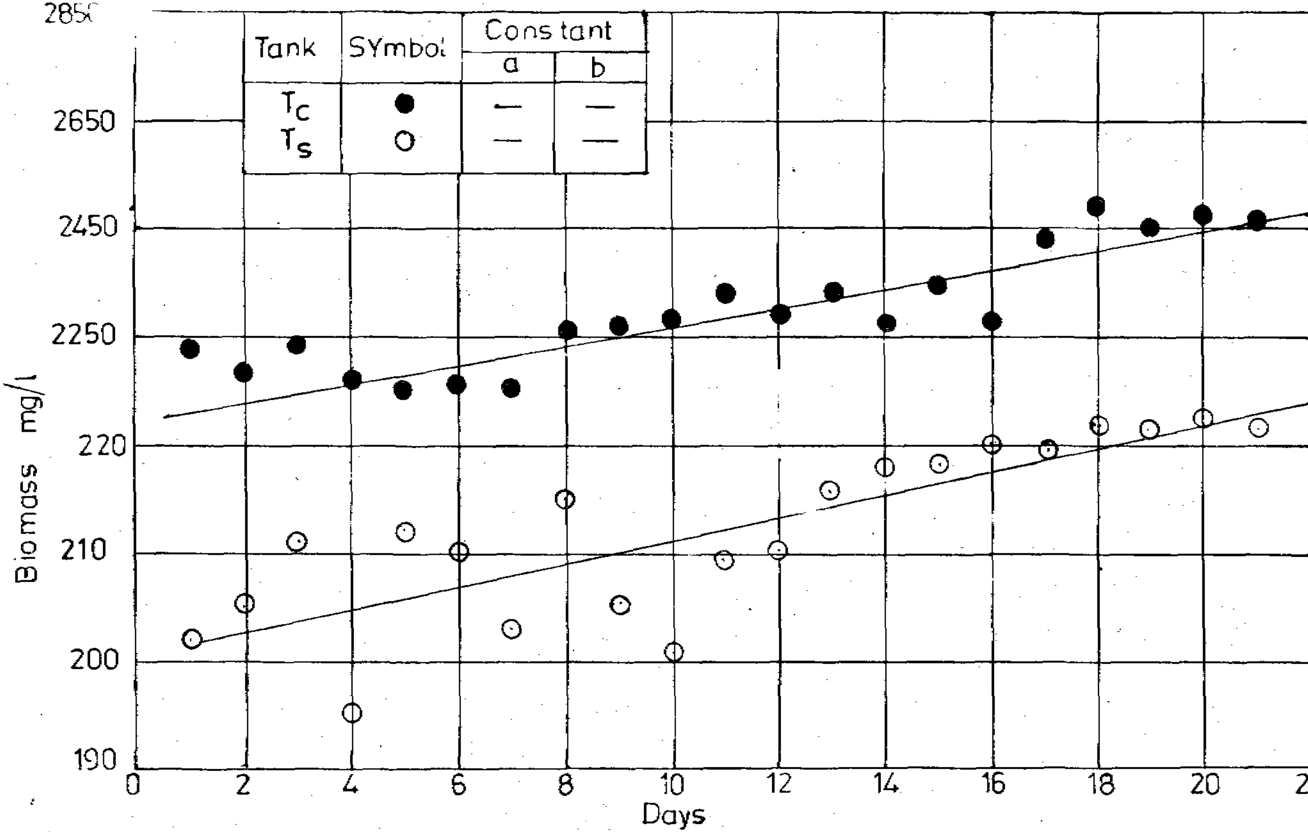


FIG. 4 GROWTH OF BIOMASS

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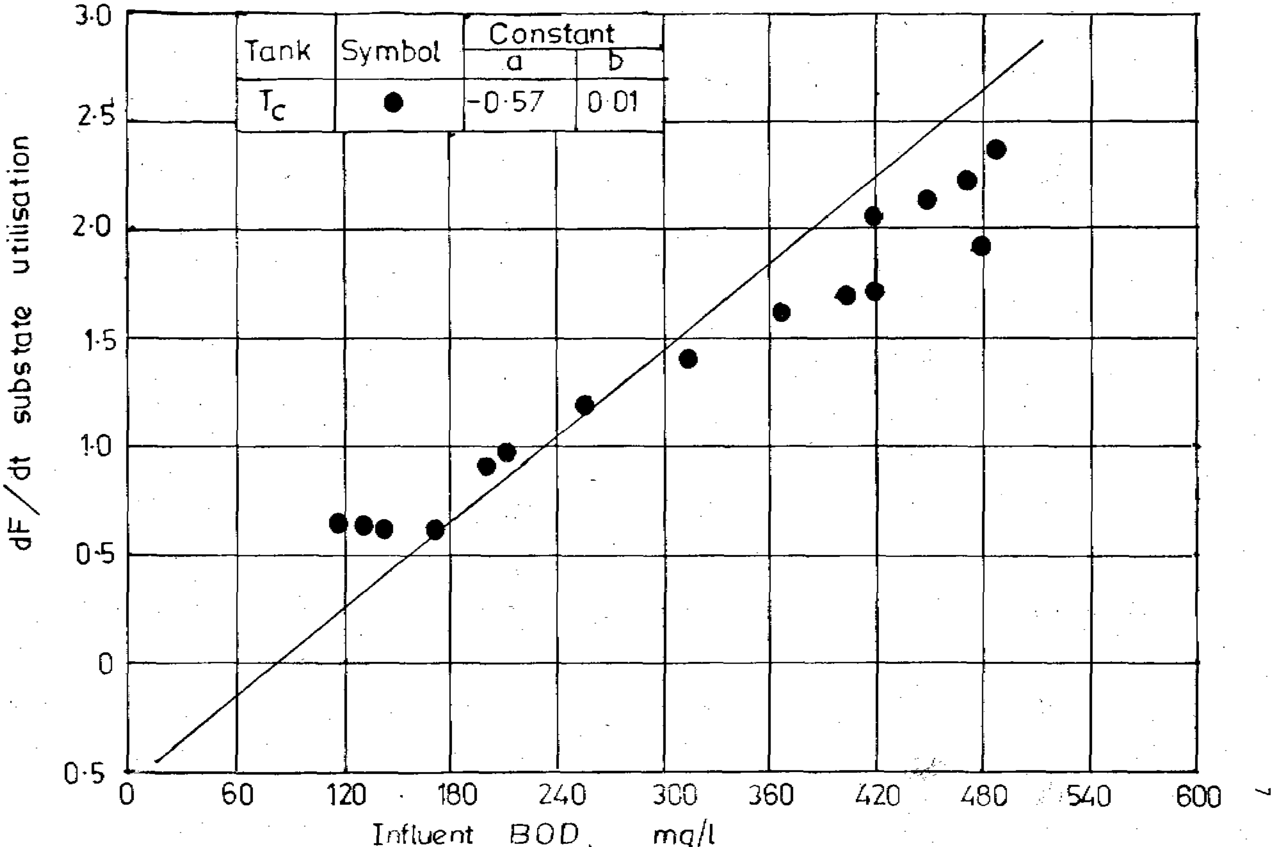

FIG.5 - INFLUENT BOD AND SUBSTRATE UTILISATION IN T_s

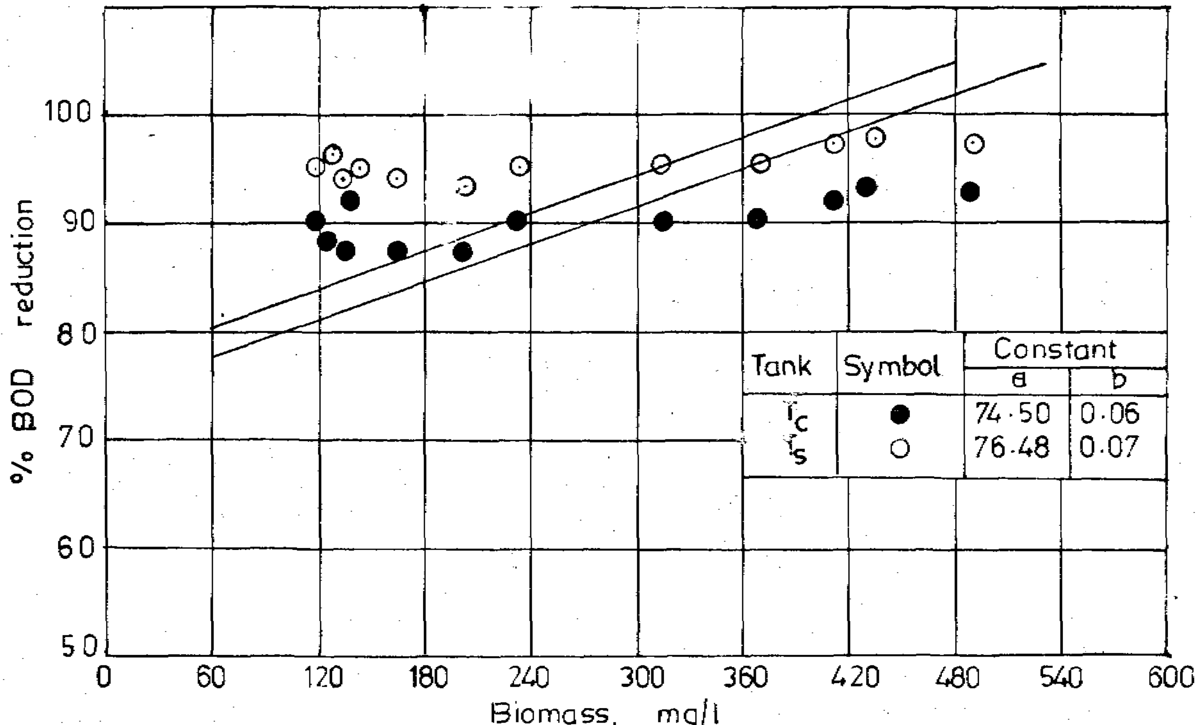

FIG 6 BOD REDUCTION AND BIOMASS

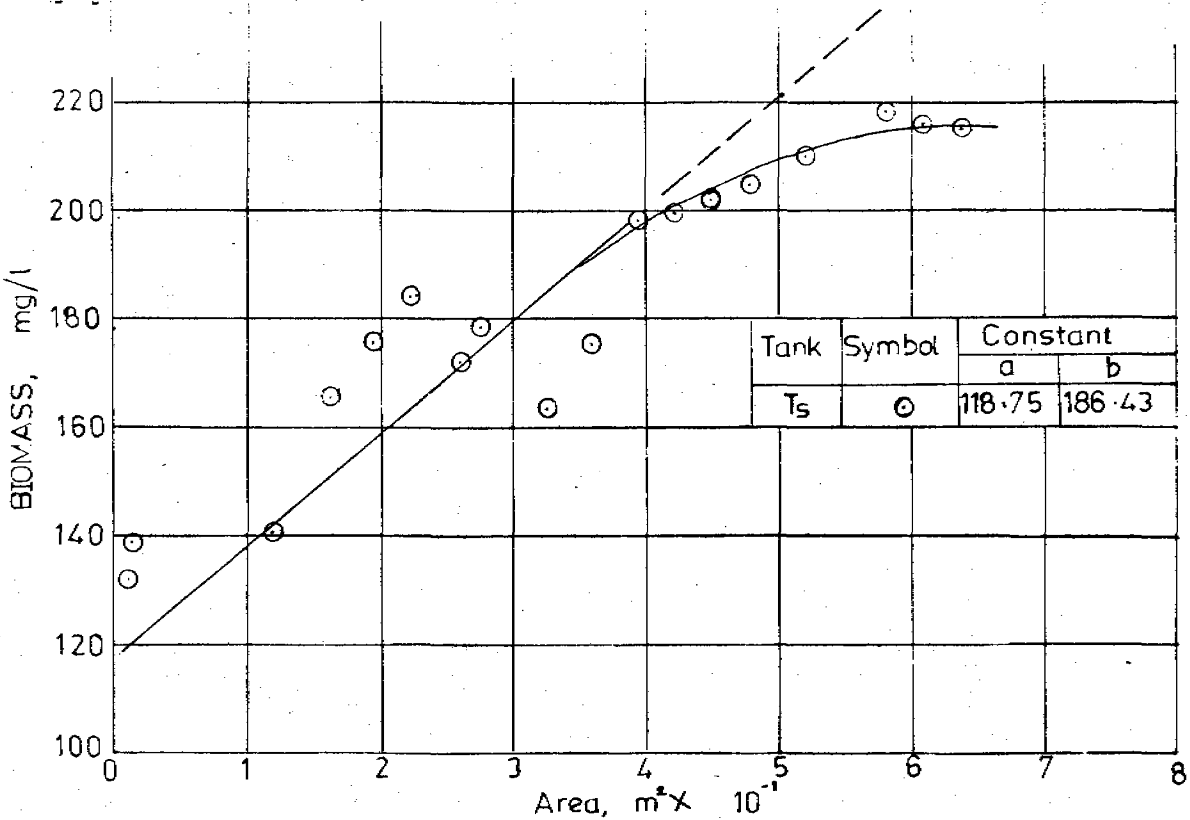

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FIG 7 - BIOMASS AND SURFACE AREA IN Ts

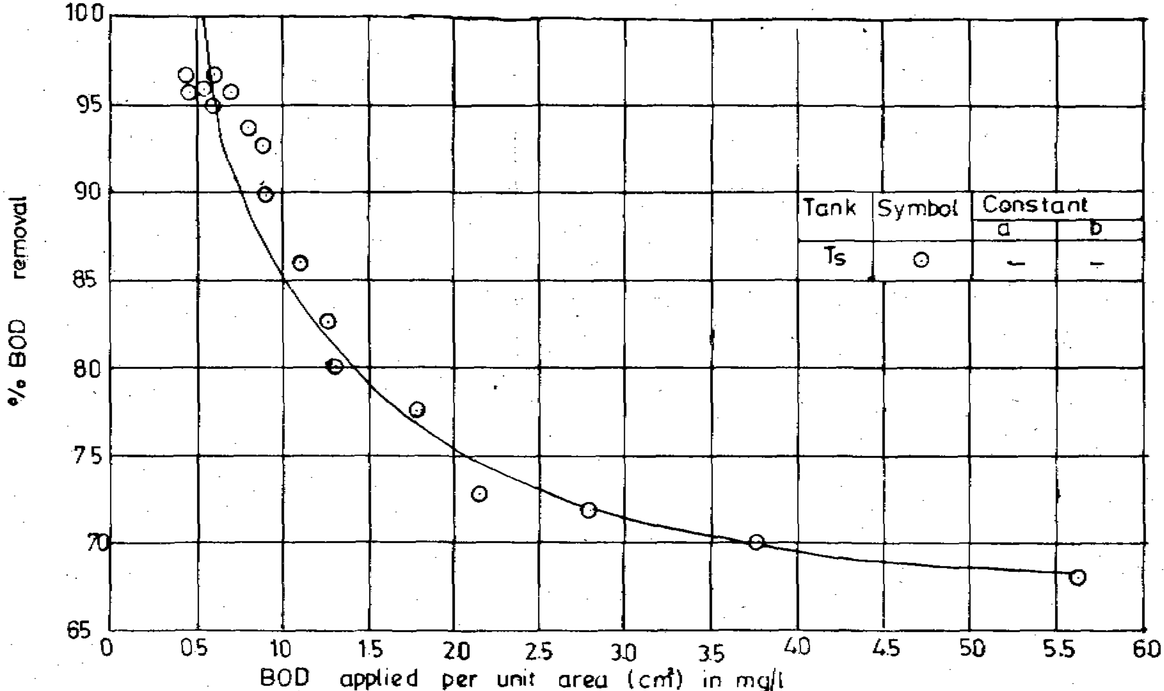

FIG 8 RELATION BETWEEN APPLIED BOD AND % BOD REMOVAL WITH VARIABLE AREA

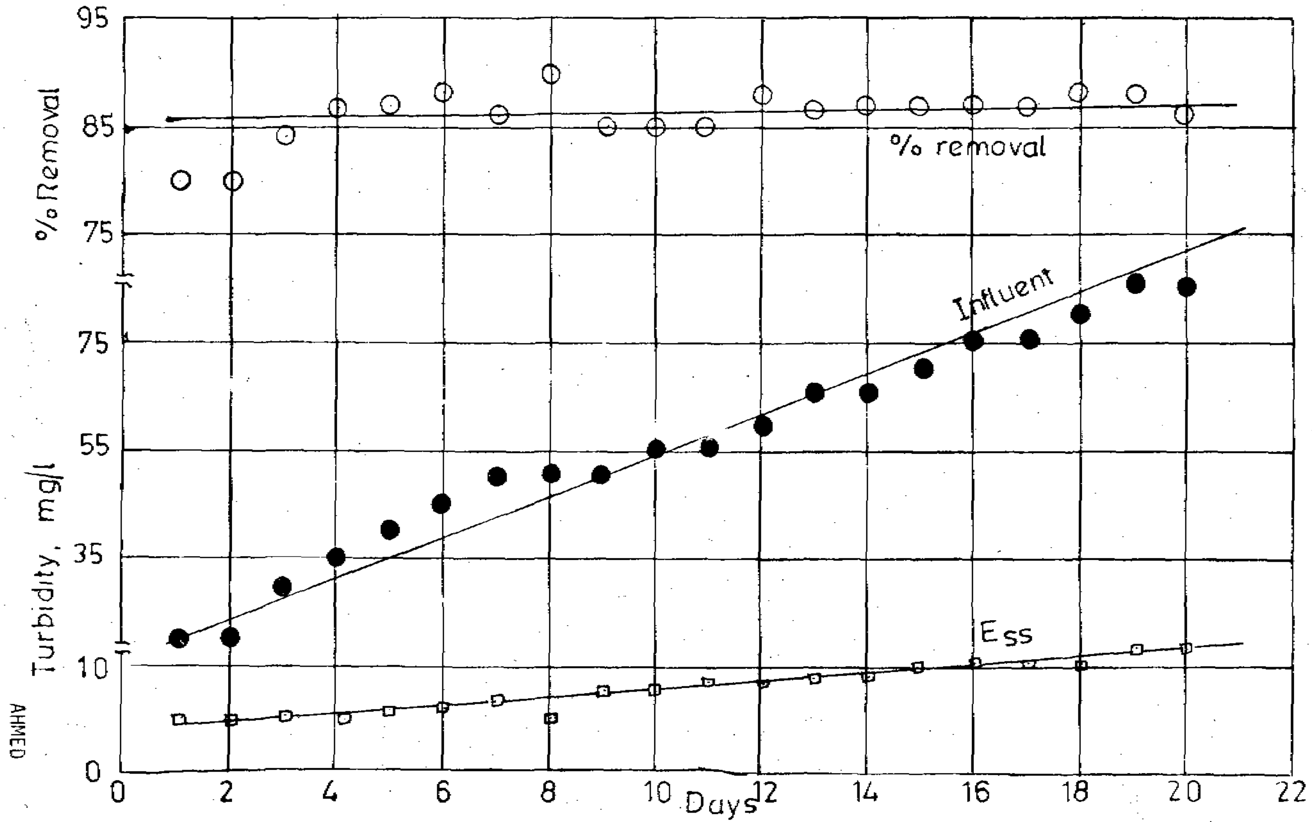

FIG . 9 – TURBIDITY Vs DAYS

Dissolved Oxygen (D.O.)

Fig. (10) indicates the % excess in D.O. in T_s compared to T_c which is nearly 135%.

Kinetic Coefficients

Fig. (11-13) show the various kinetic coefficients. The values for Y, Kd, max, K_s and P are 0.1, 0.00019, 0.002, 61.82 and 10.00 respectively. They do not much confirm to the values found in the literature for steady flow, as the flow in this study is variable.

Summary

The investigation shows that the fixed biological film technique in the form of fixed surfaces in waste-water treatment gives a better performance, compared to the control tank, without any additional surfaces which corresponds to the extended process of activated sludge. The B.O.D. and turbidity removal is better. The most significant finding is almost the complete absence of suspended solids in the effluent, which results in the great reduction of volume of the settling tank, sledge digester and the drying beds. The excess residual D.O., reduces the cost of aeration. Also, there is no need for recirculation and hence savings in electric energy and machinery. By knowing the kinetic coefficients design can be more specific and the required surface area can be calculated.

The study brings out clearly that additional surfaces provide a better and economical treatment, which should help immediately and in the long run the waste-water treatment for all the countries in general and the developing countries in particular.

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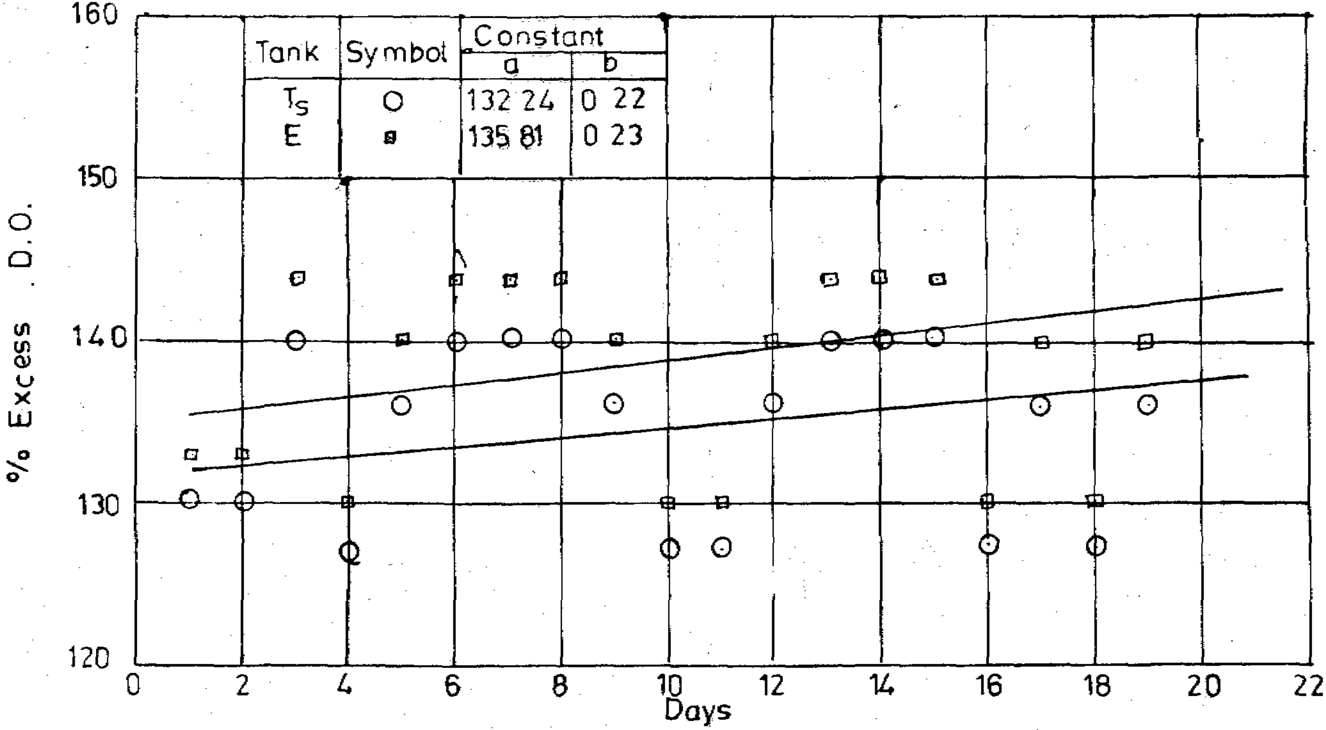

FIG 10 — % EXCESS D·O· IN T_s AND E_{ss}

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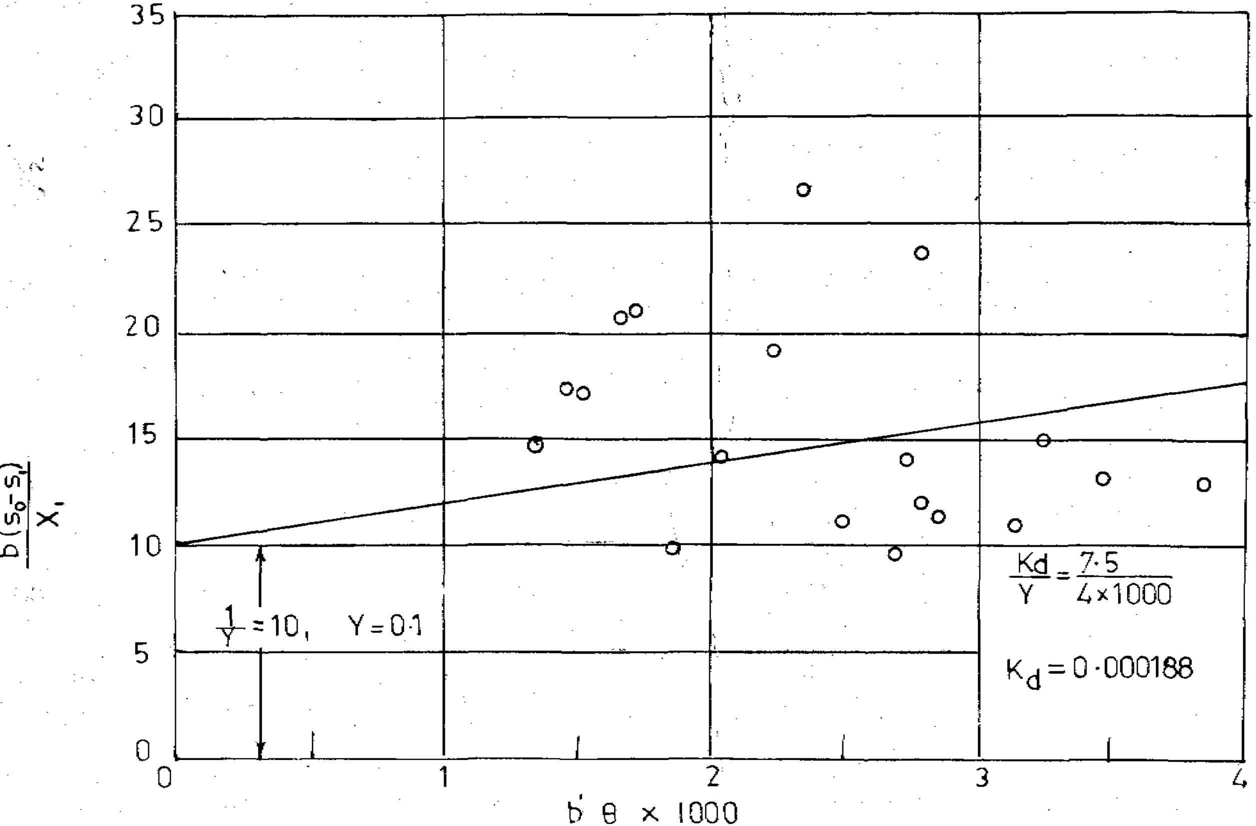

FIG 11 – KINETIC COEFFICIENTS FOR CONTROL – WITH ARTIFICIAL SEWAGE

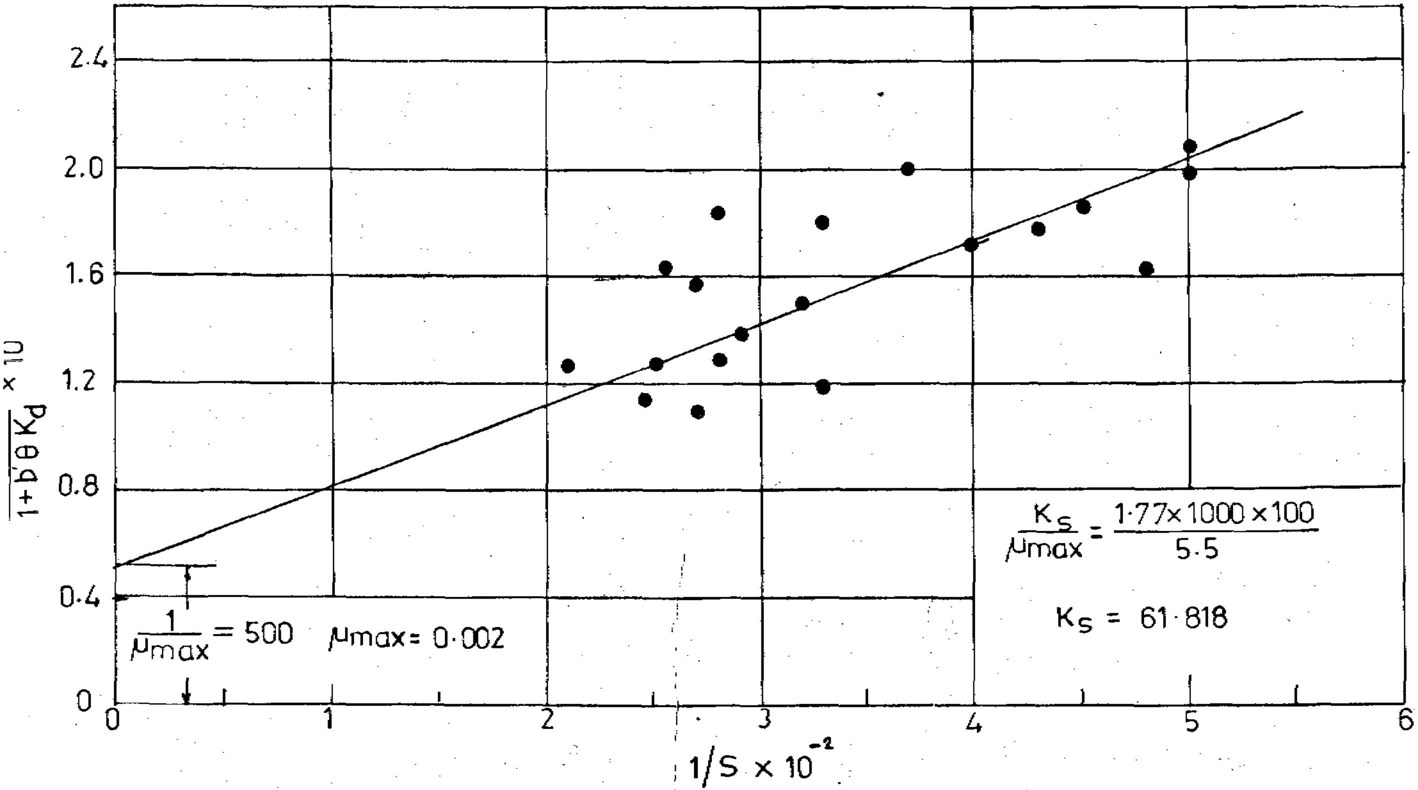

FIG 12 KINETIC COEFFICIENTS FOR T_c WITH ARTIFICIAL SEWAGE

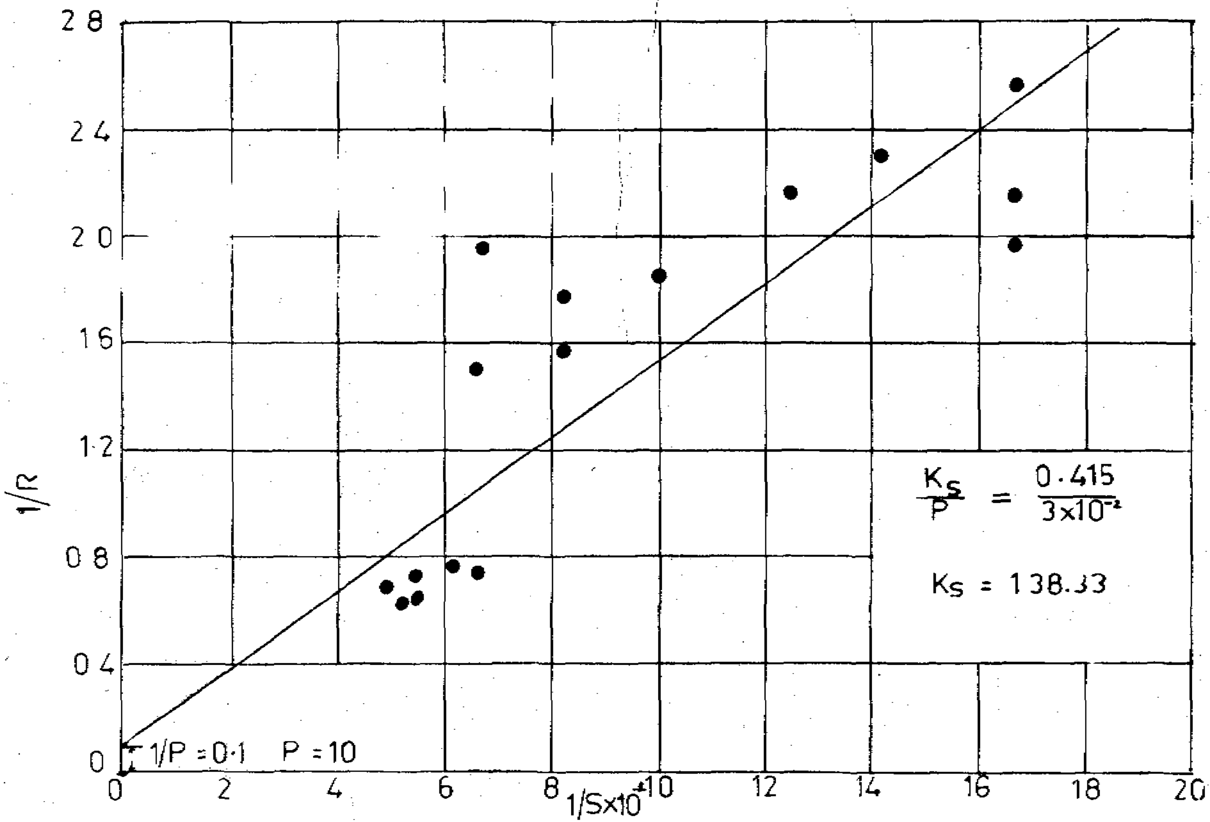

FIG. 13 – KINETIC COEFFICIENTS FOR T_S – WITH ARTIFICIAL SEWAGF

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THE VARIATIONAL [illegible] OF WA[illegible] OF WADI AL-FUDHA (ERBIL IRAQ) ON [illegible]MENT

Dr. [illegible]iadh H. Al-[illegible] *

Maha A.M. Al-[illegible] **

INTRODUCTION

The makhmur pla[illegible] [illegible] sub-basi[illegible] desingated as the Easter[illegible], [illegible] Western [illegible] Northern sub-basins. It[illegible] [illegible] 0 km^2 and [illegible] of the central sub-basin, [illegible] cont[illegible] main drain the wadi Al-Fudha in the [illegible] pl[illegible], [illegible]70 km^2. The drainage density of the ent[illegible] [illegible], [illegible] the length of streams per [illegible] drain[illegible] is 0.71 km/km^2. The area is charecterized [illegible] [illegible]meabl[illegible] [illegible] low rainfall intensities and high infiltr[illegible]on rates [illegible] is [illegible] by Qara Changh Mountain in the North, [illegible] the West and the little Zab [illegible] or [illegible]

To assess the var[illegible]on in [illegible] water in the above area, data of groun[illegible] water samples from 136 well-sites has been available for analysis.

The water of Northern sub-[illegible] was found [illegible] of the Ca-SO4 type and that of the central sub-basin, containing the alluvial deposits of cl[illegible], silt [illegible] sand, was found to be of the Na-SO4 type. P H values, electrical conductivity, total soluble salts, Cl, SO4, HCO , NO3. Sodium adsorption Ration and hardness were determined for all samples and water classes, according to the yardsticks given by [illegible]tovisk (1962) and Todd (1970) in the fresh, brackish, saline [illegible] brine categories fixed.

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** Maha A.M. Al-Dabbagh, University of Baghdad, [illegible]ghda[illegible], Ira[illegible]

An attempt is made herein to assess the variation in water quality of the Erbil Plain, with special reference to the waters of Wadi Al-Fudha. Primary references for testing the suitability or otherwise of water samples for drinking and irrigation purposes are (4), (5), (6), (7), (11) and (12).

Previous analysis (1) showed that the waters in the Makhmur Plain were not suitable for drinking, irrigation and livestock. Present analysis indicates that limited use of these waters both for irrigation and drinking purposes is possible.

Also, methods of water treatment are suggested so that the alluvial plain of Wadi Al-Fuda, particularly its southern part, could be utilised more profitably.

CHEMICAL ANALYSIS OF WATERS

Water samples were taken from both wells and springs and after chemical analysis, following results were obtained:(1)

Chemical Parameters	Minimum-Maximum Values	
	Well Water	Spring Water
PH	7.00 - 8.15	6.88 - 7.81
EC (m mhos/Cm)	0.72 - 18.86	0.34 - 6.98
TSS (ppm)	487 - 18524	280 - 5135
CL - (ppm)	28 - 2723	24 - 1310
SO_4^{--} (ppm)	180 — 9600	24 - 1944
HCO_3^- (ppm)	31 - 1147	73 - 268
NO_3^- (ppm)	11 - 223	No data
SAR	0.3 - 15.81	0.07 - 8.01
Hardness (ppm)	49 - 1850	118 - 433

The standards and criteria adopted by the various agencies like the Public Health Service, U.S.A., (1962), the World Health Organisation (1963), and the National Academy of Sciences and National Academy of Engineering (1972), U.S.A., are given in Table 1. (8):

Table 1

Standards and Criteria for drinking water in mg/l.

Substance or property	Public Health Service, 1962		EPA interim 1975	WHO, 1963		Nat.Acad.Sci., Nat.Acad.Eng., 1972
	Desirable Maximum limit	Abs. maximum limit		Max. acceptable	Max. allowable	
Alkyl benzyl Sulfonate	0.5			0.5	1	0.5
Ammonium nitrogn.						0.5
Arsenic	0.01	0.05	0.05		0.05	0.1
Barium		1	1		1	1
Cadmium		0.01	0.01		0.01	0.01
Calcium				75	200	
Chloride				200	600	250
Chromium(hexavalent)		0.05	0.05		0.05	0.05
Color(Pt-Counits)				5	50	75
Copper	1			1	1.5	1
Cynide	0.01	0.02			0.2	0.2
Fluoride[x]	0.6-0.9	0.8-1.7	1.4-2.4			1.4-2.4
Iron (Fe^{2+})	0.3			0.3	1	0.3
Lead		0.05	0.05		0.05	0.05
Magnesium						
Magnesium and Sodium sulfates				500	1000	
Manganese(M_n^{2+})	0.05			0.1	0.5	0.05
Mercury			0.002			0.002
Nitrate Nitrogen	10		10			1
Nitrite Nitrogen						
Organics:						
Carbon Chloroform extract	0.2			0.2	0.5	0.3
Carbon alcohol extract						1.5
PH (units)				7-8.5		5-9
Phenolic Compounds(as phenol)	0.001			0.001	0.002	0.000 001
Selenium		0.01	0.01		0.01	0.01
Silver		0.05	0.05			
Sulfate	250			200	400	250
Total dissolved solids	500			500	1500	
Zinc.	5			5	15	5

Ayers (9) (1975) gave guidelines for interpretation of water quality for irrigation purposes. These, together with the method of calculating the Adjusted Sodium Adsorption Ratio (SAR) are given in Tables 2 and 3 below:

Table 2

Guidelines for interpretation of water quality for irrigation

Problems and quality parameters	No Problems	Increasing problems	Severe problems
Salinity effects on crop yield:			
TDS concentration (mg/l)	480	480-1920	1920
Deflocculation of clay and reduction in K and infiltration rate:			
TDS concentration (mg/l)	320	320	128
Adjusted SAR	6	6-9	9
Specific iontexicity:			
Boron (mg/l)	0.5	0.5-2	2-10
Sodium (as adjusted SAR) if water is absorbed by roots only	3	3-9	9
Sodium (mg/l) if water is also absorbed by leaves	69	69	
Chloride (mg/l) if water is absorbed by roots only	142	142-355	355
Chloride (mg/l) if water is also absorbed by leaves	106	106	
Quality effects:			
Nitrogen in mg/l	5	5-30	30
Bicarbonate as HCO_3 in mg/l	90	90-520	520

Adjusted SAR value is calculated by the following equation:

$$\text{Adjusted SAR} = \frac{Na}{\frac{Ca+Mg}{2}} \quad 9.4 - p(k_2^1 - k_c^1) - p\,(Ca+Mg) - PALK \qquad -(1)$$

Na, Ca and Mg in the above equation are the concentrations of these ions in irrigation water in m eq/l. Table 3 shows the other terms in this equation in relation to the concentration [illegible] Ca and Mg (9). If the term within brackets in [illegible] equation is greater than 1, irrigation water moving through the soil has a tendency to precipitate lime and to dissolve lime through soil if this value is less than 1.

<u>Table 3</u>

Valves of p $(k_2^1-k_c^1)$, p (Ca+Mg), and p Alk in equation (1).

Concentration Ca+Mg+Na, m eg/l	$p(k_2^1-k_c^1)$	Concentration Ca+Mg m eq/l	p(Ca+Mg)	Concentration CO_3+ HCO_3, m eq/l	pAlK
0.5	2.11	0.05	4.60	0.05	4.30
0.7	2.12	0.10	4.30	0.10	4.00
0.9	2.13	0.15	4.12	0.15	3.82
1.2	2.14	0.20	4.00	0.20	3.70
1.6	2.15	0.25	3.90	0.25	3.60
1.9	2.16	0.32	3.80	0.31	3.51
2.4	2.17	0.39	3.70	0.40	3.40
2.8	2.18	0.50	3.60	0.50	3.30
3.3	2.19	0.63	3.50	0.63	3.20
3.9	2.20	0.79	3.40	0.79	3.10
4.5	2.21	1.00	3.30	0.99	3.00
5.1	2.22	1.25	3.20	1.25	2.90
5.8	2.23	1.58	3.10	1.57	2.[illegible]
6.6	2.24	1.98	3.00	1.98	2.70
7.4	2.25	2.49	2.90	2.49	2.[illegible]
8.3	2.26	3.14	2.80	3.13	2.[illegible]
9.2	2.27	3.90	2.70	4.[illegible]	2.4[illegible]
11	2.28	4.97	2.60	[illegible]	2.[illegible]
13	2.30	6.30	2.50	[illegible]	2.2[illegible]
15	2.32	7.90	2.40	[illegible]	2.1[illegible]
18	2.34	10.00	2.[illegible]	[illegible]	2.[illegible]
22	2.36	12.50	2.2[illegible]	[illegible]	1.90
25	2.38	15.80	2.1[illegible]	[illegible]	1.[illegible]
29	2.40	19.80	2.0[illegible]	[illegible]	1.70
34	2.42				
39	2.44				
45	2.46				
51	2.48				
59	2.50				
67	2.52				
76	2.54				

The National Academy of Sciences and National Academy of Engineering of the U.S.A. (1972) also fixed the recommended maximum limits in mg/l for trace elements in irrigation water. These are given in Table 4.

Table 4

Recommended maximum limits in mg/l for trace elements in irrigation water

	Parmanent irrigation of all wells	Upto 20 years irrigation of fine textured neutral to alkaline soils (ptt 6 to 8.5)
Aluminium	5	20
Arsenic	0.1	2
Beryllium	0.1	0.5
Boron-sensitive crops	0.75	2
semitolerant crops	1	
tolerant crops	2	
Cadmium	0.01	0.05
Chromium	0.1	1
Cobalt	0.05	5
Copper	0.2	5
Fluoride	1	15
Iron	5	20
Lead	5	10
Lithium-Citrus	0.075	0.075
Other crops	2.5	2.5
Manganese	0.2	10
Molybdenum	0.01	0.05
Nickel	0.2	2
Selenium	0.02	0.02
Venadium	0.1	1
Zinc	2	10

The same agency also fixed the quality criteria for drinking water for farm animals. These are given in Table 5.

Table 5

Quality criteria for drinking water for farm animals

	Maximum concentration, mg/l
Total dissolved solids	3000
Aluminium	5
Arsenic	0.2
Boron	5
Cadmium	0.05
Chromium	1
Cobalt	1
Copper	0.5
Fluorine	2
Lead	0.1
Mercury	0.01
NO_3-N plus NO_2-N	100
NO_2-N	10
Selenium	0.05
Vanadium	0.1
Zinc	25

Identical information is also available for processing and petroleum industries.

Following standard hydrogeological techniques of analysing large number of chemical analyses of groundwater samples (10), maps showing spatial variations of water quality, bar graphs, circular diagrams and radial coordinates, stiff diagrams and piper's trilinear diagrams have to be plotted to arrive at worthwhile conclusions regarding the variation in water quality of the Wadi under study.

Before applying the actual techniques, however, it is necessary to check the accuracy of the chemical analysis by the principle of equivalence of the cations and anions in the groundwater or surfacewater sample. Thereafter the alkalinity and hardness can be expressed as $Ca\ Co_3$ and total dissolved soilids estimated and verified from actual results (11). This is done below for a few typical water samples of the Wadi Al-Fudha. Figure 1. shows the hydro-geological classification of this Wadi and Figure 2 the geometrical model of the wells characterising the Wadi. Figure 3 shows the Location Map of Makhmur Plain under study.

Well No.100 (1)

Ion	Concentration, mg/l
Ca^{++}	680
Mg^{++}	173.1
Na^{+}	621
K^{+}	4.3
Cl^{-}	639.9
SO_4^{-}	2664
HCO_3	109.8
PH	7.22

The cation-anion balance sheet, to check the accuracy of theanalysis, is prepared as below:

Cations				Anions			
Ion	Con centra tion mg/l	mg/meq	meq/l	Ion	Con centra tion mg/l	mg/meq	meq/l
Ca^{++}	680	20	34	Cl^{-}	639.9	35.5	18.02
Mg^{++}	173.1	12.2	14.18	SO_4^{--}	2664	48	55.5
Na^{+}	621	23.0	27	HCO_3^{-}	109.8	61	1.8
K^{+}	4.3	39.1	0.11				
Total	1478.4		75.29		3413.7		75.32

The results seem to be reasonable as the sum of the cations and anions is the same.

Only the bicarbonate ion, HCO_3^{-}, will cause alkalinity.

Alkalinity expressed as $CaCO_3$

$= 1.8$ meq/l X 50 mg $CaCO_3$/meq

$= 90$ mg/l as $CaCO_3$

Hardness will be caused by calcium (Ca^{++}) and magnesium (Mg^{++})

Hardness expressed as $Ca\ Co_3$

$$= (34\ meq/l + 14.18\ meq/l)\ (50\ mg\ CaCo_3/meq)$$

$$= 2409\ mg/l\ as\ CaCo_3$$

Total dissolved solids:

$$TDS = Cations + anions\ (expressed\ in\ mg/l)$$

$$= 1478.4 + 3413.7\ mg/l$$

$$= 4892.1\ mg/l$$

Electrical conductivity for most waters in micromhos/cm is related with the TDS in mg/l by the following relationship:

TDS in mg/l = 0.55 to 0.7 X Conductivity
Value of sample in (M.mhos/Cm)

Thus the experimental conductivity value of 5.7 millimhos/Cm = 5700 Mmhos/Cm does not seem to be tenable with the above relationship. Since the concentration of total dissolved solids, together with a detailed chemical analysis, is used to assess the suitability of water for agricultural, industrial and other uses the measurement of electrical conductivity vis-a-vis the total dissolved solids needs reassessment. Observed value of TDS, however, is 5076 mg/l against the above calculated value of 4892.1 mg/l.

Identical analysis for the other wells of Wadi Al-Fudha, namely, well Nos.129, 87, 92, 93, 102 and 130 yield the following results:

Well No.129

Ion	Conc. mg/l
Ca^{++}	460
Mg^{++}	194.4
Na^{+}	586.5
K^{+}	5.85
Cl^{-}	502.68
SO_4^{--}	2688
HCO_3^{-}	201.3
PH	7.5

Analysis

Cations				Anions			
Ion	Conc. mg/l	mg/meq	meq/l	Ion	Conc. mg/l	mg/meq	meq/l
Ca^{++}	460	20	23	Cl^{-}	502.68	35.5	14.16
Mg^{++}	194.4	12.2	15.93	So_4^{--}	2688	48	56
Na^{+}	586.5	23.0	25.5	HCO_3^{--}	201.3	61	3.3
K^{+}	5.85	39.1	0.15		-	-	-
	1246.75		64.58		3391.98		73.46

Results seem unreasonable as the sums of cations and anions are not the same.

Alkalinity expressed as Ca CO_3 = 3.3 meq/l X 50 mg $CaCo_3$/meq

= 165 mg/l as $CaCO_3$

Hardness expressed as $CaCo_3$ = (23 meq/l+15.93 meq/l)(50mg $CzCO_3$/meq)

= 1946.5 mg/l as $CaCO_3$

TDS = 1246.75 mg/l + 3391.98 Mg/l

= 4638.73 mg/l.

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Electrical conductivity is observed to be 7.53 milli mhos/Cm = 7530 Mmhos/Cm and in this well the observed TDS of 4[illegible]44 mg/l is seen to fall within the range of 0.55 to 0.7 X conductivity value of sample in Mmhos/Cm, which are 0.55 X 7530 = 4141.5 mg/l and 0.7 X 7530 = 527/mg/l. Thus, even though the total TDS value of this water is above the acceptable limit there is an element of reasonability about the test results.

<u>Well No.87</u>

Ion	Conc. mg/l
Ca^{++}	565
Mg^{++}	194
Na^{+}	448.5
K^{+}	37.8
Cl^{-}	260.5
SO_4^{--}	2184
HCO_3^{-}	164.7
PH	7.22

<u>Analysis</u>

Cations				Anions			
Ion	Conc. mg/l	mg/meq	meq/l	Ion	Conc. mg/l	mg/meq	meq/l
Ca^{+}	565	20	28.25	Cl^{-}	260.5	35.5	7.34
Mg^{++}	194	12.2	15.90	SO_4^{--}	2184	48	45.50
Na^{+}	448.5	23.0	19.50	HCO_3^{-}	164.7	61	2.70
K^{+}	37.8	39.1	0.96				
	1245.3		64.61		2609.2		55.54

In this well also the sums of cations and anions are different and results seem to be unreasonable.

Alkalinity expressed as $CaCO_3$ = 2.7 m eg/l X 50 mg $CaCO_3$/meq

= 135 mg/l as Ca CO_3

Hardness expressed as $CaCO_3$ = (28.25 meq/l+15.90 meq/l)
50 mg$CaCO_3$/meq)

= 2207.5 mg/l as $CaCO_3$

TDS = 1245.3 mg/l + 2609.2 mg/l

= 3854.5 mg/l

Electrical conductivity is found to be 4.76 milli mhos/Cm = 4760 Mmhos/Cm and the observed TDS of 4533 mg/l is outside the range of 0.55 to 0.7 X conductivity value of sample in Mmhos/Cm.

Well No.92

Ion	Conc. mg/l
Ca^{++}	660
Mg^{++}	230.8
Na^{+}	782
K^{+}	9.4
Cl^{-}	1049.3
SO_4^{--}	2016
HCO_3^{-}	137.3
PH	7.0

Analysis

Cations				Anions			
Ion	Conc. mg/l	mg/meq	meq/l	Ion	Conc. mg/l	mg/meq	meq/l
Ca^{++}	660	20	33	Cl^{-}	1049.3	35.5	29.55
Mg^{++}	230.8	12.2	18.91	SO_4^{--}	2016.0	48	42
Na^{+}	782	23.0	34	HCO_3^{-}	137.3	61	2.25
K^{+}	9.4	39.1	0.24				
	1682.2		86.15		3202.6		73.8

The inequality of cations and anions in this case also indicates the unreasonability of results.

Alkalinity expressed as $CaCO_3$ = 2.25 meq/l X 50 mg $CaCO_3$/meq

= 112.5 mg/l as $CaCO_3$

Hardness expressed as $CaCO_3$ = (33 meq/l + 18.9/meq/l) (50 mg$CaCO_3$/meq)

= 2595.5 mg/l as $CaCO_3$

TDS = 1682.2 mg/l + 3202.6 mg/l

= 4884.8 mg/l against the observed value of 5553 mg/l.

Observed Electrical Conductivity is 6.8 milli mhos/Cm = 6800 Mmhos/Cm and the observed TDS is again outside the range of 0.55 to 0.7 X conductivity in Mmhos/Cm.

<u>Well No.93</u>

Ion	Conc. mg/l
Ca^{++}	560
Mg^{++}	233.8
Na^{+}	563.5
K^{+}	4.8
Cl^{-}	524.6
SO_4^{--}	2160
HCO_3^{-}	140.3
PH	7.45

<u>Analysis</u>

Ion	Conc. mg/l	mg/meq	meq/l	Ion	Conc. mg/l	mg/meq	meq/l
Ca^{++}	560	20	28	Cl^{-}	524.6	35.5	14.77
Mg^{++}	233.8	12.2	19.16	SO_4^{--}	2160	48	45
Na^{+}	563.5	23.0	24.50	HCO_3^{-}	140.3	61	2.3
K^{+}	4.8	39.1	0.12				
	1362.1		71.78		2824.9		62.07

In this case also the inequality of cations and anions indicates the unreasonability of results.

Alkalinity expressed as $CaCo_3$=2.3 meq/1X50 mg $CaCo_3$/meq

=115 mg/l as $CaCo_3$

Hardness expressed as $CaCo_3$ = (28 meq/l+19.16 meq/l) (50 mg$CaCo_3$/meq.)

= 2358 mg/l as $CaCo_3$

TDS = 1362.1 mg/l + 2824.9 mg/l

= 4187 mg/l against the observed value of 5171 mg/l.

Observed Electrical Conductivity is 5.77 millimhos/cm; the range in which TDS should be is 0.55 X 5770 = 3173.5 mg/l and 0.7 X 5770 = 4039 mg/l. Both the calculated and observed TDS values are found to lie outside this range.

Well No.102

Ion	Conc. mg/l
Ca^{++}	250
Mg^{++}	46.17
Na^{+}	41.4
K^{+}	8.9
Cl^{-}	28.32
SO_4^{--}	624
HCO_3^{-}	213.5
PH	7.8

Analysis

Cations				Anions			
Ion	Conc. mg/l	mg/meq	meq/l	Ion	Conc. mg/l	mg/meq	meg/l
Ca^{++}	250	20	12.5	Cl^{-}	28.32	35.5	0.79
Mg^{++}	46.17	12.2	3.78	SO_4^{--}	624	48	13
Na^{+}	41.4	23.0	1.80	HCO_3^{-}	213.5	61	3.50
K^{+}	8.9	39.1	0.23				
	346.47		18.31		865.82		17.29

The sum of cations and anions in this case is not much different and the results do not seem to be as unreasonable as in wells Nos.129, 87, 92 and 93.

Alkalinity expressed as $CaCo_3$ = 3.5 meq/l X 50 mg $CaCo_3$/meq
= 175 mg/l as $CaCO_3$

Hardness expressed as $CaCO_3$ = (12.5 meq/l + 3.78 meq/l)
(50 mg $CaCO_3$/m eq)
= 814 mg/l as $CaCO_3$

TDS = 346.47 mg/l + 865.82 mg/l
= 1212.29 mg/l against the observed value of 1184 mg/l.

Observed Electrical Conductivity is 1.44 millimhos/cm = 1440 Mmhos/Cm.

The specified range for TDS is 0.55 X 1440 = 792 mg/l to 0.7 X 1440 = 1008 mg/l.

The observed TDS is thus outside this range.

Well No.130

Ion	Conc. mg/1
Ca^{++}	71[illegible]
mg^{++}	7[illegible].[illegible]4
Na^{+}	12[illegible]
K^{+}	3[illegible].15
Cl^{-}	20[illegible].[illegible]0
SO_4^{--}	1584
HCO_3^{-}	1[illegible]4.[illegible]
PH	[illegible].7

Analysis

Cations				Anions			
Ion	Conc. mg/1	mg/meq	meq/1	Ion	Conc. mg/1	mg/meq	meq/1
Ca^{++}	710	20	35.5	Cl^{-}	203.20	35.5	5.72
Mg^{++}	75.94	12.2	6.22	SO_4^{--}	1584	48	33
Na^{+}	126.5	23.0	5.5	HCO_3^{-}	134.2	61	2.2
K^{+}	33.15	39.1	0.85				
	945.59		48.07		1921.4		40.92

The inequality of the sum of cations and anions indicates the unreasonability of the results.

Alkalinity expressed as $CaCO_3$=2.2 meq/1X50 mg $CaCO_3$/meq

= 110 mg/1 as $CaCO_3$

Hardness expressed as CaC[illegible] = (35.5 meq/1+6.22 meq/1)

= (50 mg CaCO$_3$/meq)

= 2086 mg/1 as $CaCO_3$

TDS=945.59 mg/1+1[illegible].4 m[illegible]

=2866.99 mg/1

Observed Electrical [illegible]onductivity is 3.7 millimhos/Cm = 3700 Mmhos/cm. Observed TDS of 3592 mg/1 is seen to fall outside the range of 0.55 to 0.7 X conductivity value of sample in Mmhos/Cm.

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The variation characteristics of water in wells of Wadi Al-Fudha can thus be summarised as below:

Table 2

Well No.	Whether the sum of cations and anions balance	Alkalinity as $CaCO_3$ mg/l	Hardness as $CaCO_3$ mg/l	Calculated TDS mg/l	Observed TDS mg/l
130	No	110	2086	2866.99	3592
129	No	165	1946.5	4638.73	4644
87	No	135	2207.5	3854.5	4533
92	No	112.5	2595.5	4884.8	5553
93	No	115	2358	4187	5171
100	Yes	90	2409	4892.1	5076
102	Yes	175	814	1212.29	1184

DISCUSSION OF RESULTS OF ANALYSIS

The distribution of the specific species of cations and anions in the water depend on the source of water. To satisfy the electroneutrality principle, the sum of the cations and anions, expressed in m eq per litre must be the same if the chemical analysis of the water samples is correct. This condition is not satisfied, as is clear from Table 2, in case of well Nos.130, 129, 87, 92, and 93; Well Nos.100 and 102 in the south of the Wadi satisfy the electroneutrality principle. There is reason to believe, therefore, that there are other constituents in the northern wells which have not been identified and the samples of these wells merit re-examination.

The hardness of water, as also the total dissolved solids, in well No.102 are substantially less than those in well No.100. In well No.102 the calculated TDS value is 1212.29 mg/l and its observed value is 1184 mg/l which is less than the W.H.O.'s maximum allowable limit of 1500 mg/l (Table 1). Similarly hardness in this well, in the form of Bicarbonate as HCO_3, is 213.5 mg/l against the permissible limit of 520 mg/l for irrigation water (Table 2).

For irrigation purposes the adjusted SAR value of well No.102 is found is as below (8):

$$\text{Adjusted SAR} = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}} \quad 9.4 - p(K_2' - K_c') - b\ (Ca+Mg) - p.Alk$$

Referring to Table 3,

$P\ (K_2' - K_c') = 2.34$

$P\ (Ca + Mg) = 2.10$

$P\ Alk = 2.45$

Expressing Na, Ca and Mg in epm
Adjusted SAR = 1.58

This value is low enough (12) and the water of this well is found to be good enough for irrigation purposes.

CONCLUSIONS AND RECOMMENDATIONS

Analysis of the water samples in the south of the Wadi Al-Fudha, particularly well No.102, indicates that the total dissolved solids and hardness in the water are within permissible limits. The value of Adjusted Sodium Adsorption Ratio is also low enough for irrigation purposes.

Chemical Analysis, based on electroneutrality principle, indicates that the waters of the Northern Wells in the Wadi have some unidentified constituents and more detailed examination of these water samples is warranted.

It may probably be presumptuous at this stage to suggest water treatment methods for the water in the northern part of the Wadi but screening, flocculation, sedimentation and filtration will be necessary.

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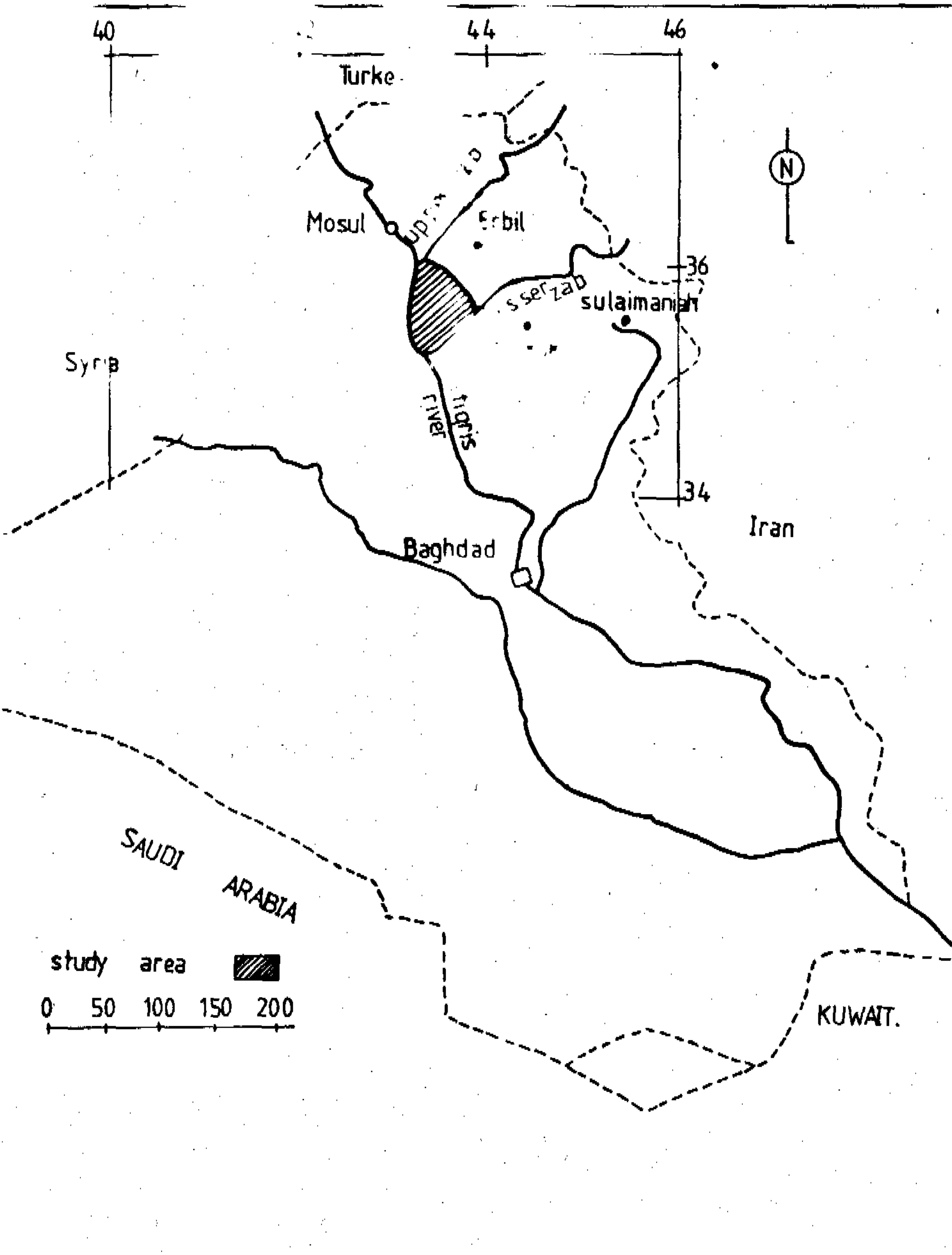

FIG.1. Location map of studied area

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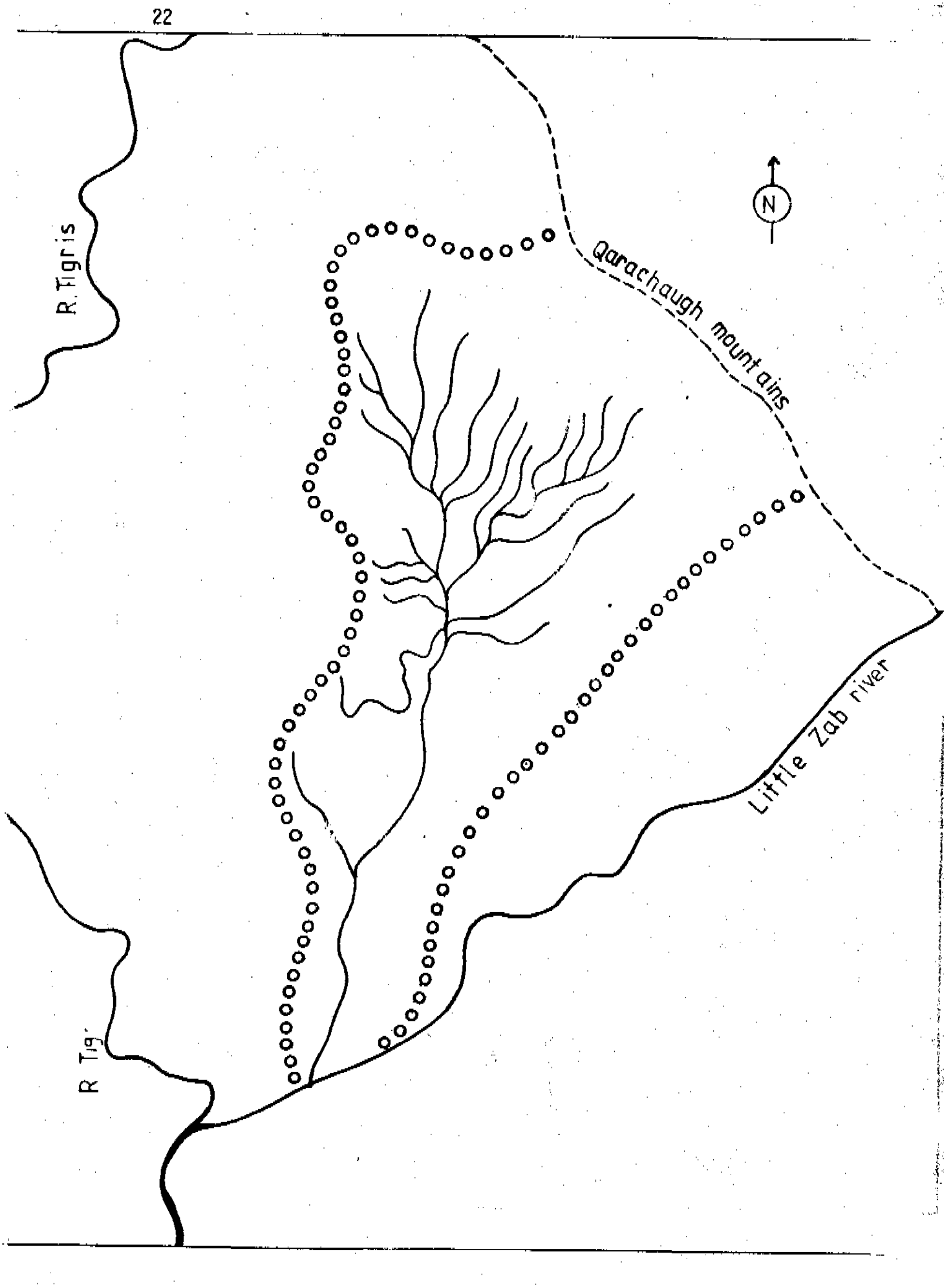

FIG.2. Central sub-basin of makhmur Basin

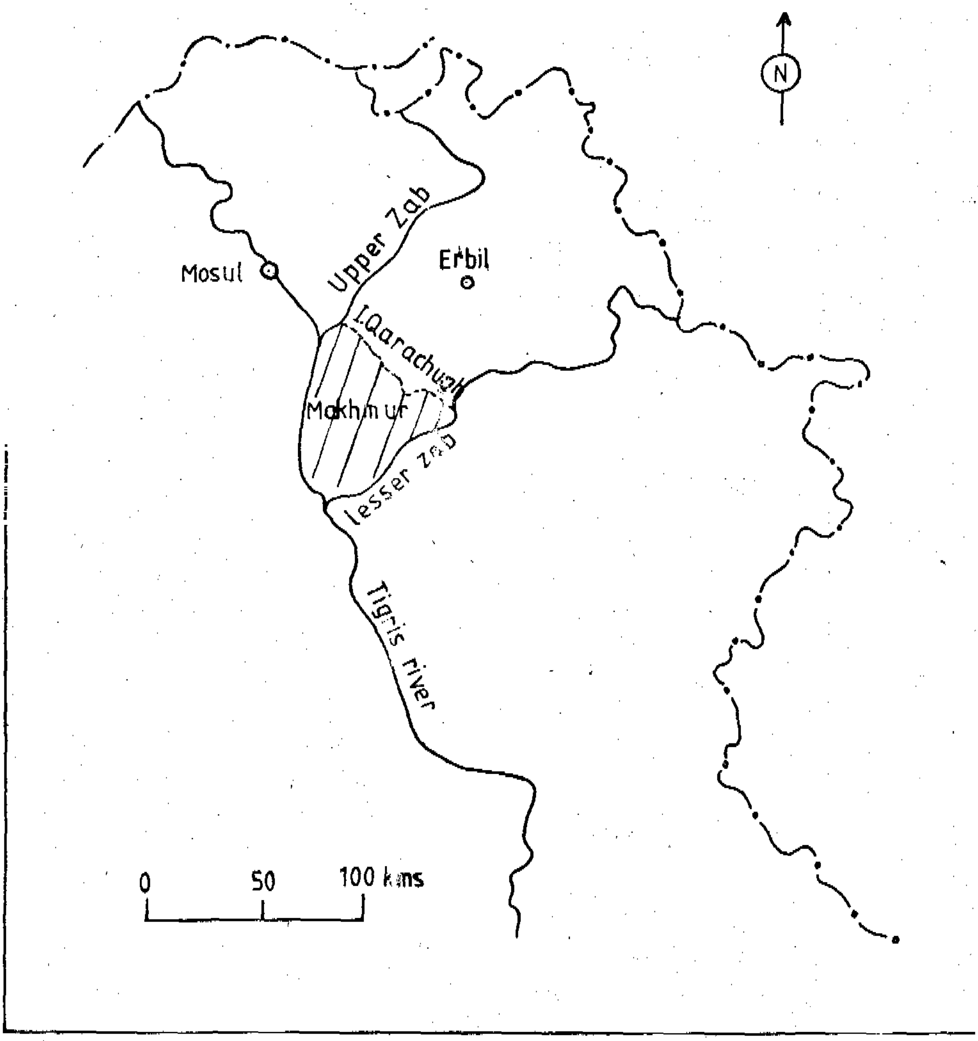

Fig. 3. location map of studied area

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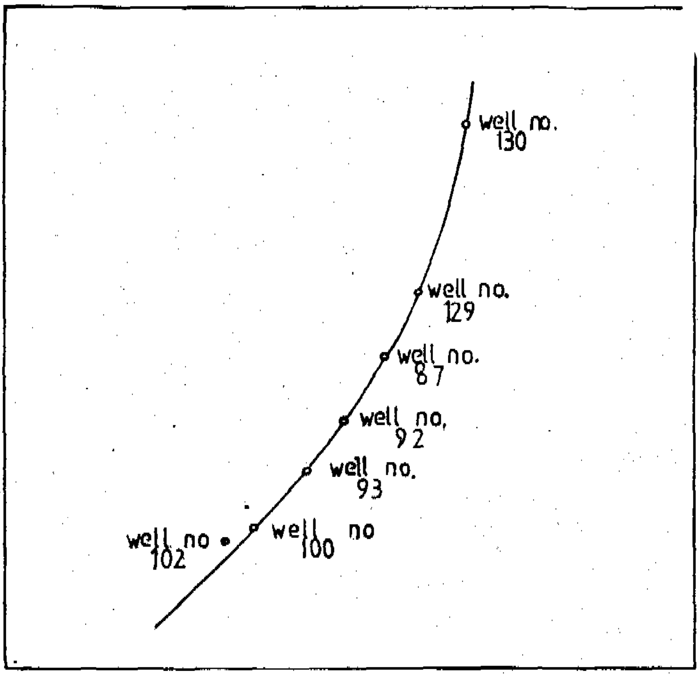

FIG 4 wells characterising Wadi all - Fudha

IMPROVEMENT IN REFINERY WASTEWATER QUALITY BY TREATMENT WITH ALGAL-BACTERIAL CULTURE

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INTRODUCTION

Toxic wastes are a problem currently affecting many regions of our nation and potentially threaten many others in the future. Toxic wastes have been discharged by municipalities and industrial complexes for many decades. Research is urgently needed to arrive at the right method of solving this problem. One of the methods for wastewater treatment, especially in the warm regions of the world, is the algal-bacterial system (Oswald, 1977; Mara, 1976). This method has been used successfully for treating municipal, agricultural and food industry wastewaters at a reasonably low cost (Oswald, 1973a, b, 1976; Gloyna, 1976; Metcalf and Eddy Inc., 1979), but it has not been used for treating refractory undiluted industrial wastewaters such as refinery effluents because of the toxic effects of the pollutants present in such effluents (Al-Shayji et al., 1983).

Refinery effluents can be treated with algal-bacterial cultures if the effluents are pre-treated by some other method to reduce the level of such pollutants as oil, chromium, ammonia and hydrogen sulphide to below the threshold level of toxicity for algal growth (Al-Shayji et al., 1983). Algal-bacterial cultures can also be used to remove residual pollutants after biological treatment of the effluents with activated sludge. This paper elaborates on this aspect of refinery wastewater treatment.

METHODOLOGY

A culture containing two species of algae, Scenedesmus and a thermo-tolerant Chlorella species was used for this study. The algal-bacterial culture was prepared by adding 5% activated sludge to the algal culture (v/v). The volume of the culture was increased gradually and was transferred outdoors to be acclimated to NO_3 and NH_4-N.

Two reactors were designed (Fig. 1), with a capacity of 20 l each, a flow rate of 4.6 cm^3/min and a detention time of three days, and placed them outdoors. Aeration and mixing were conducted by passing air through the media from the bottom along with each chamber in both reactors. Reactor (a) was fed with refinery wastewater subjected to nitrification and denitrification with activated sludge. Reactor (b) was fed with refinery wastewater that was steam-stripped to reduce ammonia concentration and physico-chemically pretreated to remove suspended solids, oil and chromium. Each reactor was fed continuously for two to three days and thereafter the feed was replaced with a fresh batch of pretreated wastewater. This technique was used during the entire study period. One litre of the effluent from each reactor was collected every two or three days for analysis. A haemocytometer was used for growth determination by counting the number of cells.

RESULTS AND CONCLUSIONS

The results (Fig. 2) indicate that algae growth in the denitrified refinery wastewater was better than that in the steam-stripped one. The latter medium was not toxic to algae because the pollutant concentration was much lower than the threshold levels of toxicity (Fig. [illegible]) Al-Shayji et al., 1983), but the growth in the former was higher, probably because there were sufficient nutrients left after the nitrification-denitrification processes.

Algal-bacterial cultures in both reactors efficiently removed 90-100% of the NO_2^- and NO_3^- and 75-80% of the ammonia (Fig. 3 and 4). These results indicate that algal-bacterial cultures can bring the residual nitrogen compounds in the denitrified effluents to harmless levels. They also indicate that algal-bacterial cultures can supplement or replace nitrification-denitrification processes for the purification of pretreated refinery wastewater, provided the concentration of the pollutants in the refinery effluents are below the threshold levels of toxicity for algal growth (Fig. 5) (Al-Shayji et al., 1983).

ACKNOWLEDGEMENT

The authors wish to acknowledge the Shuaiba Area Authority for funding the project AG-45B based on which results this paper has been prepared.

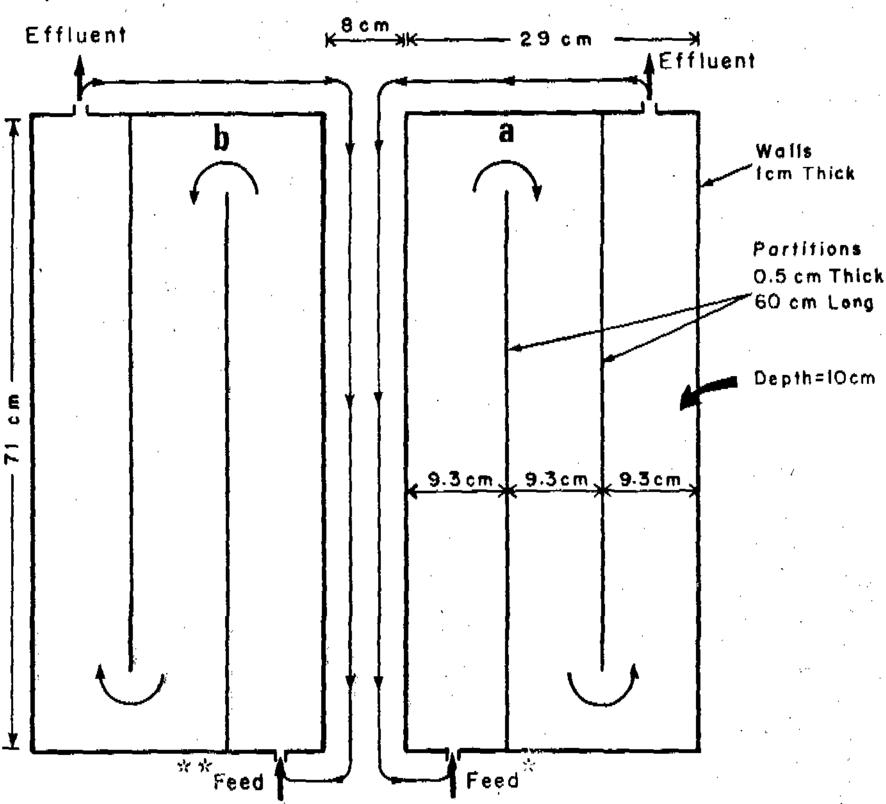

Fig. 1. Identical Reactors (a) and (b) for the Treatment of Refinery Wastewater by Algal-Bacterial Culture.

* Denitrified Effluent

** Effluent After Removal of S.S., Oil, Cr^{+}, NH_3 and H_2S

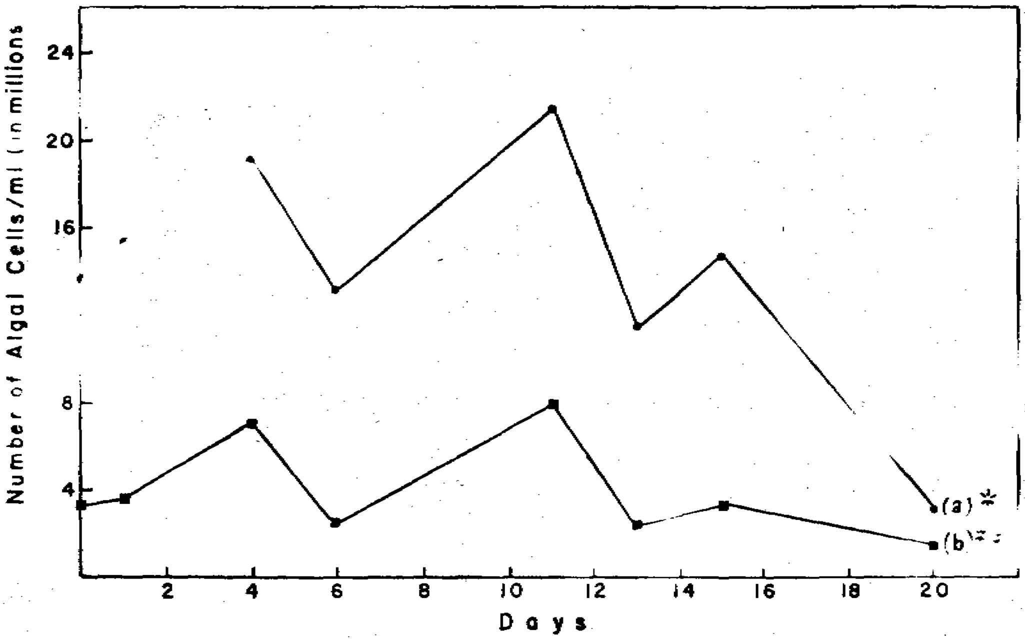

Fig 2 Growth of Algae in Pretreated Refinery Wastewaters

* Denitrified Effluent

** Effluent After Removal of S.S., Oil, Cr^{+}, NH_3 and H_2S

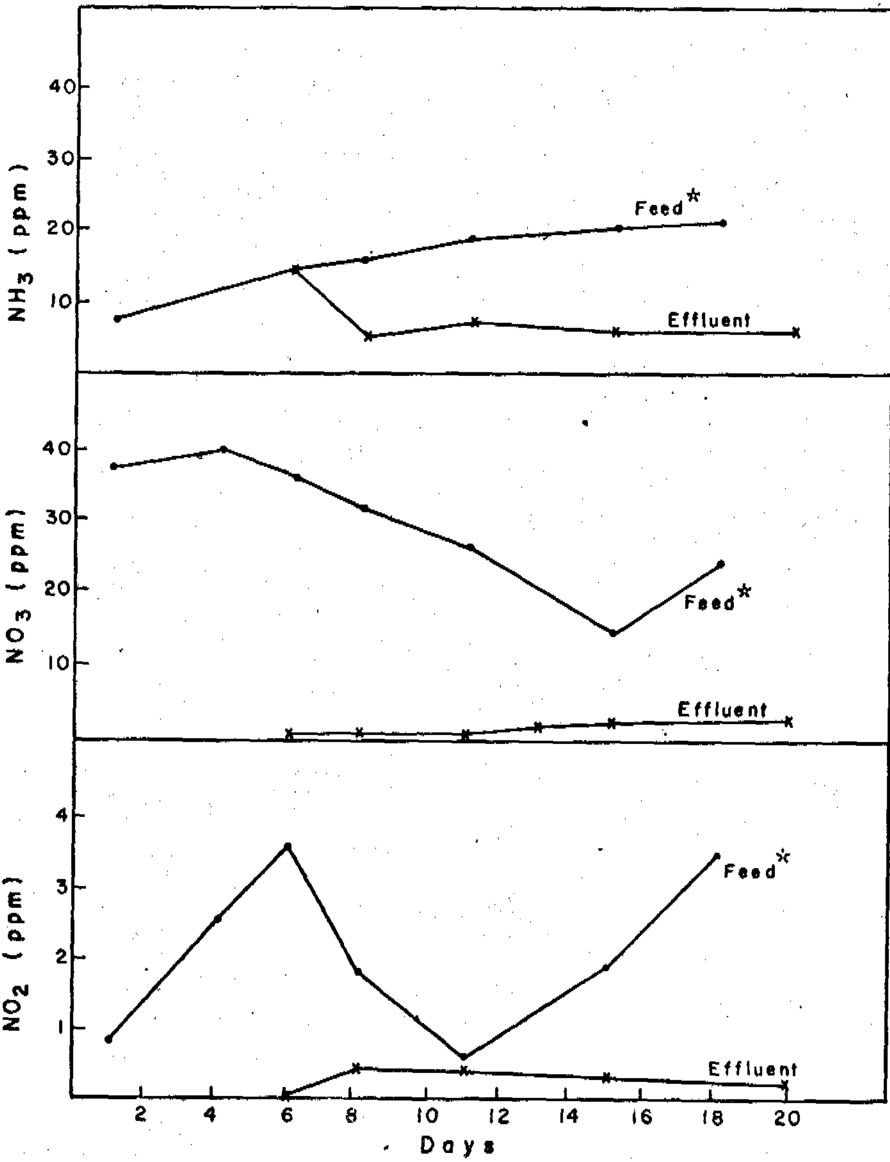

Fig. 3 Removal of Residual Ammonia Nitrate and Nitrite from Pre-Treated Refinery Wastewater by Algal-Bacterial Culture.

* Denitrified Effluent.

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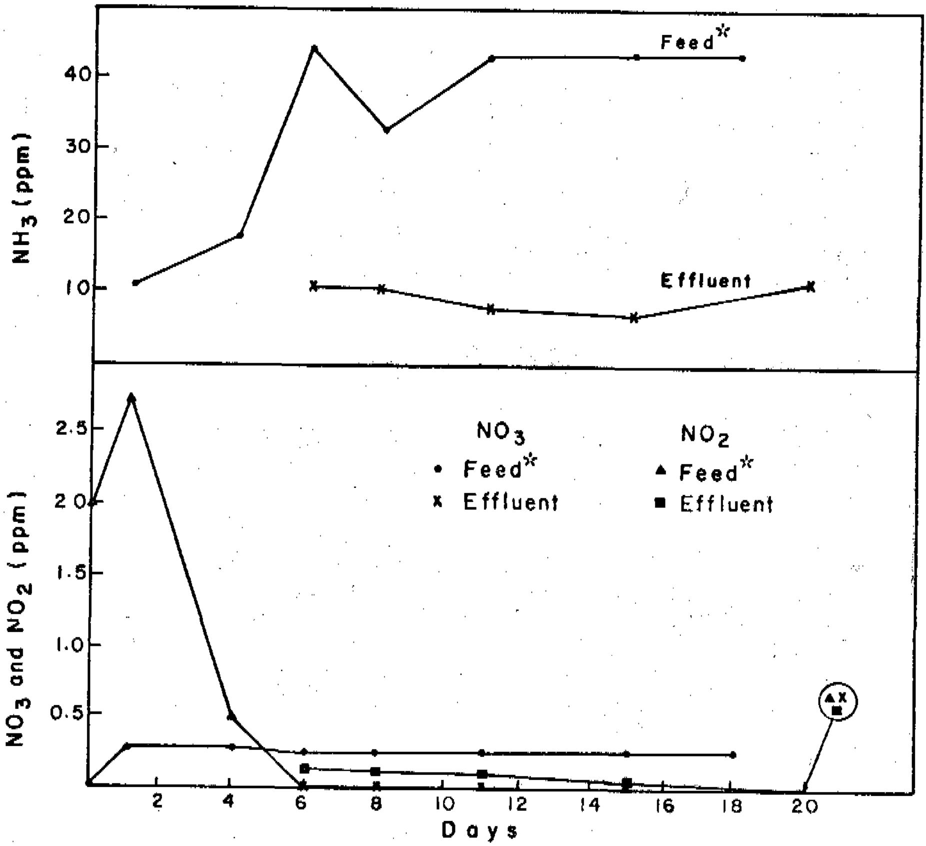

Fig. 4 Removal of Nitrate, Nitrite and Residual Ammonia from Pretreated Refinery Wastewater by Algal Bacterial Culture.

* Effluent after Removal of S.S., Oil, Cr^{+}, NH_3 and H_2S.

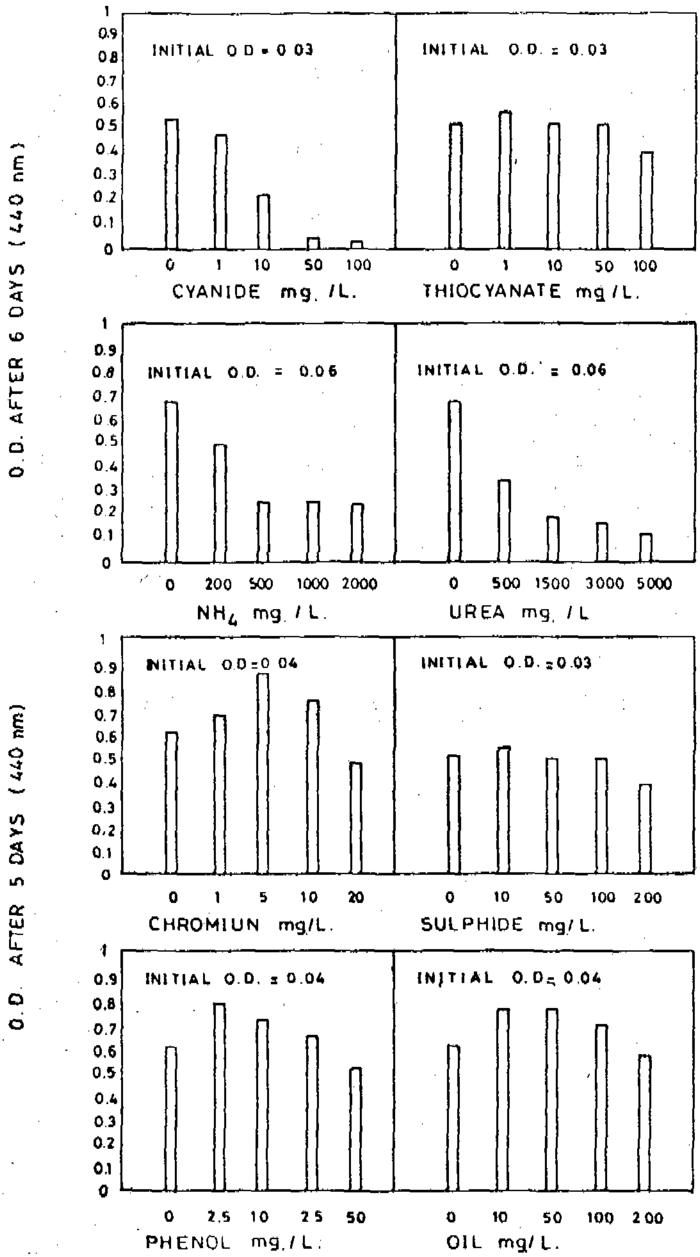

FIGURE 5. EFFECTS OF CHEMICAL POLLUTANTS ON THE GROWTH OF ALGAE

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[illegible] OF CHLORIDE CONCENTRATION IN [illegible] AT BAGHDAD

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ABSTRACT

The quality of surface waters may deter[illegible] due to the presence of various polluting [illegible] such as salts, organic and inorganic matters. Chloride is such a polluting parameter. The presence of chloride, in rivers and streams is due to waste-water and drainage water disposal. This study is concerned with evaluating chloride concentrations in river Tigris through Baghdad city. A regression models were derived for predicting chlorides in terms of distance, river flow and time of the year. Chloride variation with distance and time was studied and the effect of its concentration on various uses of the water was evaluated.

INTRODUCTION

Population increase in most of the Iraqi cities causes an increase in wastewater production which is mostly disposed into rivers and streams. Expansion in agricultural and irrigation schemes results in increased drainage water disposal into surface streams. Chloride concentrations like other water quality parameters are highly affected and in few cases exceeded the maximum allowable limits of 200 mg/l of raw surface water (U.S Env. Protection

Agency, 1972). The high concentration of chloride may limit the use of water for various purposes. Chloride level in rivers and streams changes from month to month due to discharge variation. More dilution is provided as flow increases. Chloride may enter surface waters through point and/or non point sources as water flows downstream. Evaluation of chloride concentration versus time distance, and flow rate is required inorder to maintain a proper surface water quality management system, and to protect the consumers from using deteriorated water. The purpose of this study is evaluate and model chloride concentration variation versus time, distance and flow rate in river Tigris at Baghdad.

SITE AND DATA COLLECTION

River Tigris monthly chloride concentration at Baghdad city were analysised for two year period (1979 and 1980). Water samples were taken from 15 stations distributed along a 66 km reach of the river. The distance between these stations are presented in Table 1. Station no 1 is considered as a reference point at which chloride concentration was at its minimum level prior to entering the city where several drainage and wastewater disposal canals discharge into the river. Figure 1 shows the location of sampling stations and wastewater and drainage canals discharging points into the river.

Chloride concentration in river Tigris is below the allowable limit for drinking water standard. The highest monthly chloride concentration recorded within the two years period was 80 mg per liter.

TIME AND DISTANCE AFFECT ON CHLORIDE

Chloride concentration in river Tigris seems to be affected by both time(months)and distance(station number). Hence analysis of variance was performed on the results based on monthly chloride concentration measured at each sampling station for the two-year period. Table 2 shows the results of this analysis. The interaction between the time and station effects on chloride concentration as indicated by the F-test is not significant at the 95 percent probability level. However the effects of both time and distance on chloride concentration

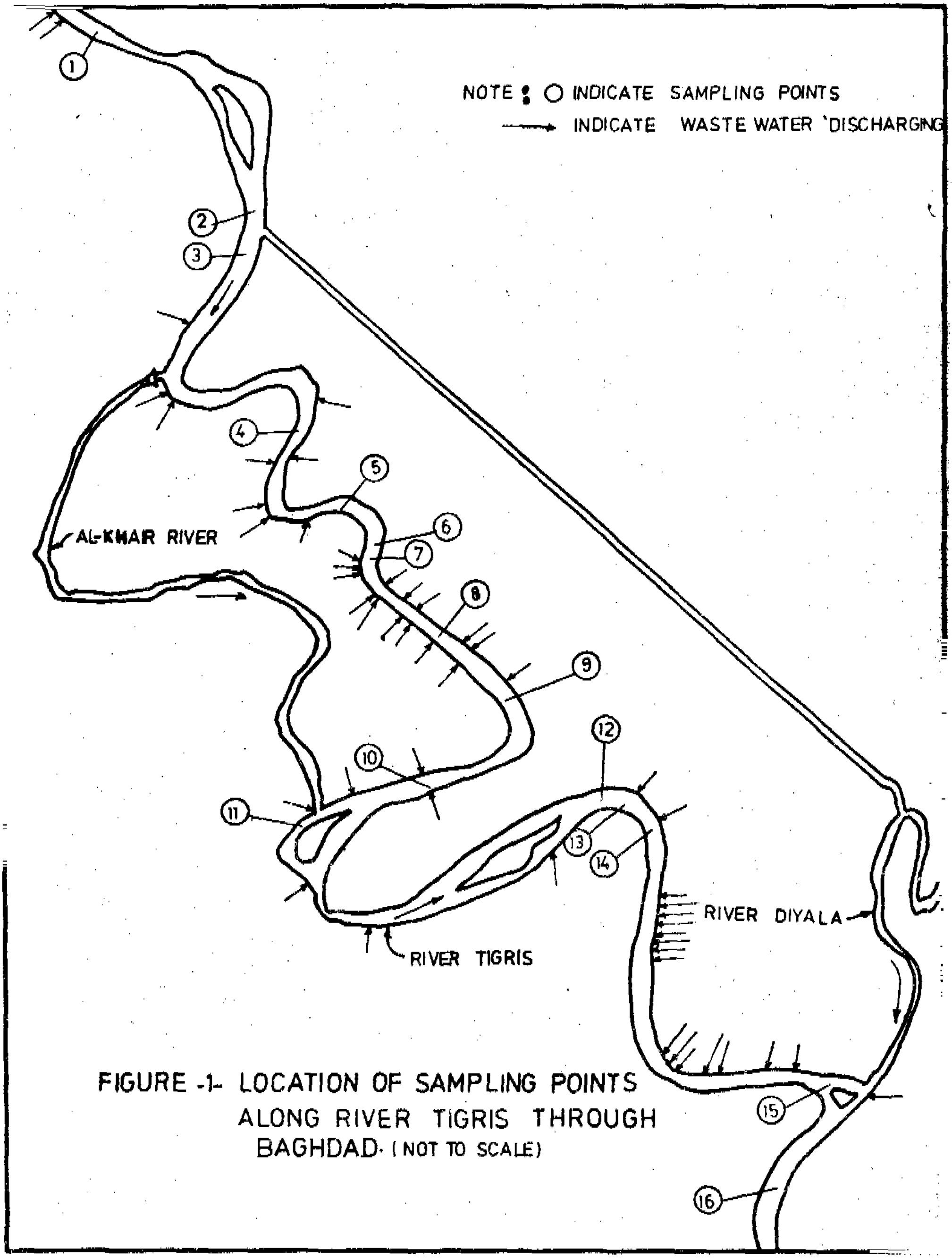


FIGURE -1- LOCATION OF SAMPLING POINTS ALONG RIVER TIGRIS THROUGH BAGHDAD (NOT TO SCALE) are significant at the 95 percent level of probability. These results indicated that time and distance are separately affecting the concentration of chloride concentration. Flow rate in the river is not included in this analysis since the flow in the river produces the same effect on chloride concentration as does the time.

In order to study chloride level behaviour versus time and distance, their effect on mean chloride concentration was separated.

Figure 2 shows mean chloride concentration at the 16 sampling stations for the two years period. Three jumps in mean chloride concentration(Figure 2) are

Table (1) Distance Between Stations and Distance from Reference Point in - KM -

Station No.	Distance from Ref. Point	Distance Between Stations
1	1.000	0.000
2	9.710	8.710
3	11.060	1.350
4	20.810	9.750
5	25.310	4.500
6	27.110	1.800
7	27.560	0.450
8	30.785	3.225
9	33.635	2.850
10	73.385	3.750
11	40.435	3.050
12	52.735	12.300
13	53.635	0.900
14	54.685	1.050
15	64.735	10.050
16	67.135	2.400

Table (2) Analysis of Variance Results Produced on Chloride Concentration in Two-Year Period

Source	D F	S S	M S	F-value
Time	11	78045.87	7095.08	46.77
Station	15	30819.03	2054.65	13.54
Interaction	160	16878.42	105.50	0.70
Error	121	18355.50	151.68	
Total	307	144560.00		

Table (3) Fourier Coefficients Harmonics to Mean of Chlorid with Harmonics Number

J	A(J)	B(J)	% of expl. Vari.
1	0.07	-10.84	86.20
2	-5.14	5.00	96.00
3	-0.45	0.69	97.00
4	0.28	0.53	97.00
5	3.74	0.32	99.90
6	1.11	0.00	100.00

[illegible] due to wastewater and drainage c[illegible] [illegible] into the river. The first jump in [illegible] [illegible] drainage c[illegible] river prior to sampling station 4. The second [illegible] is due to [illegible] river discharging in[illegible] [illegible] prior to sampling station 11. [illegible] [illegible] mean chloride concentration in [illegible] due to river [illegible] discharging into river [illegible] after sampling station 15. River [illegible] chloride concentration of above 200 mg/l [illegible] [illegible]. The drops in mean chloride concentration [illegible] due to dilution process provided [illegible] the river. [illegible] third degree polynomial equation was fitted to the data points with [illegible] value of [illegible] percent is shown on figure 2 and presented as follows:

$$[illegible] = [illegible]_1 * X + [illegible]_2 * X^2 [illegible]_3 * X^3 \qquad .....([illegible])$$

where

[illegible] = the predicted chloride concentration in mg/l.

X = distance in km from reference point [illegible].

[illegible], [illegible]$_1$, [illegible]$_2$ and [illegible]$_3$ are coefficients [illegible] the [illegible] values are determined to be [illegible], 1.77, -[illegible] [illegible] respectively.

This equation is used in describing the [illegible] chloride concentration for the two years [illegible].

Different harmonics were adapted describing mean chloride concentration versus time [illegible]. The mathematical description of mean chloride concentration by the periodic function μ_t versus time is achieved by selecting a given number of [illegible] such as follows:

$$\mu_t = \bar{x} + \sum_{j=1}^{m} \left\{ [illegible]_j \cos\left(\frac{2\pi jt}{[illegible]}\right) + [illegible]_j \sin\left(\frac{2\pi jt}{[illegible]}\right) \right\} \qquad ...$$

where

μ_t = predicted monthly mean chloride concentration in mg/l.

[illegible] = number of data point.

[illegible] = number of harmonic.

[illegible] = the Fourier coefficient for the [illegible] harmonic and t month number.

$\bar{x}$ = actual mean chloride concentration, mg/l.

Fourier coefficients can be calculated using the following equations :

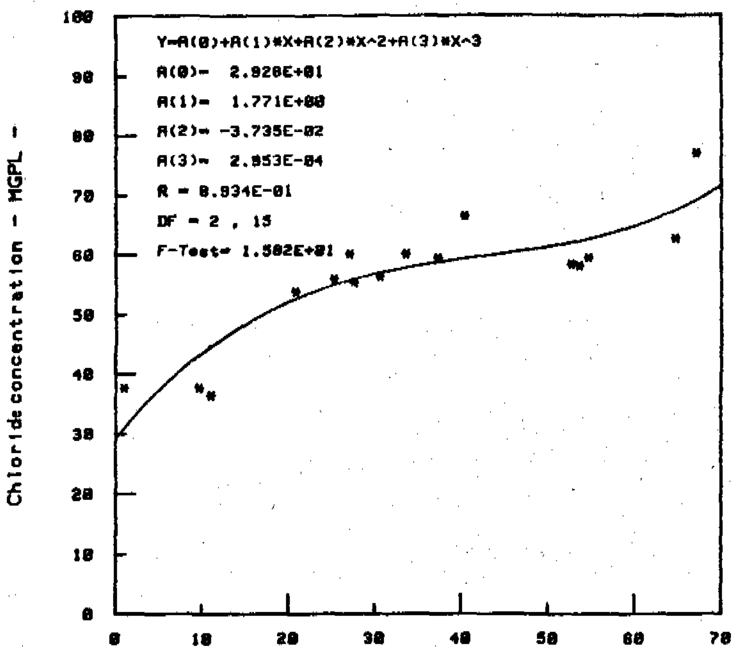
$$a_j = \frac{2}{w} \sum_{t=1}^{w} m_t \cos\left(\frac{2\pi jt}{w}\right) \qquad \ldots\ldots (3)$$

and

$$b_j = \frac{2}{w} \sum_{t=1}^{w} m_t \sin\left(\frac{2\pi jt}{w}\right) \qquad \ldots (4)$$

where

m_t = mean monthly chloride concentration in mg/l.



Fig(2) Mean Chloride Concentration Vs. Distances for Two Years Period.

The amplitudes c_j^2 of these hormonics are computed as follows:

$$c_j^2 = A_j^2 + B_j^2 \qquad \ldots\ldots [illegible]$$

The percent of the variance explaind by the periodic function may be computed as follows (Yevjevich 1975):

$$\text{Percent of explained Variance} = \sum_{j=1}^{m} \frac{c_j^2/2}{\sigma_v^2} \quad \ldots (5)$$

where

σ_v^2 = the variance of mean chloride concentration.

Table 3 presents the Fourier coefficients and percent of the explained variance for mean chloride concentration versus time for different number of harmonics.

It is seen that models with two harmonics explain 96.8 percent of the variance while those with 6 explain 100 percent of the variance. Thus the model with two harmonics may be used in predicting mean chloride concentration since it contains smaller number of coefficients, five in this case.

Figures 3 and 4 give a graphical representation of the periodic function with 2 and 6 harmonics. Excellent fits of μ_t to m_t are noted in both cases.

Both models show that chloride concentration is at its minimum level in April when the flow rate in river Tigris is at its highest level. Mean chloride concentration reaches its maximum level in October when flow rate in river Tigris is at its lowest level.

DEVELOPMENT OF THE GENERAL MODEL

Different technices are available in describing the variation of water quality parameters in streams and rivers. Among these tecunices are the solution of the flow equations and the statistical models. Statistical models are simpler to use and considered efficient in introducing different effects on the predicted parameter. Hence four regression models are developed to predict chloride concentration in terms of time(month)or discharge and station (distance).

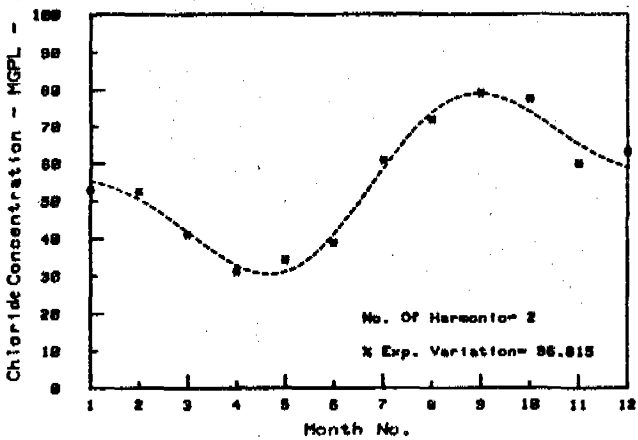


Fig.(3) The Chloride Concentration Vs. Month No.

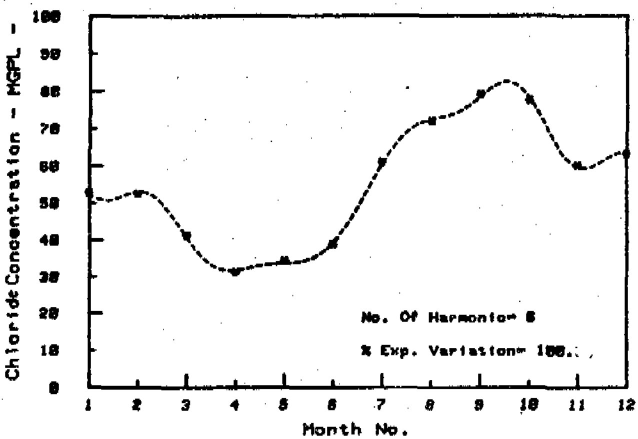


Fig.(4) The Chloride Concentration Vs. Month No.

These models are as follows:

Model no 1 : Cl = b_0(Time)^{b_1}(Station)^{b_2} ...(7)

Model no 2 : Cl = b_0 + b_1(Time) + b_2(station) ...(8)

Model no 3 : Cl = b_0(Discharge)^{b_1} (Station 12)^{b_2} ...(9)

Model no 4 : Cl = b_0 + b_1Ln(Discharge) + b_2(Station + 12) ...(10)

Where

Cl = predicted chloride concentration in mg/l.
b_0, b_1 and b_2 = are the coefficient of the regression function.
Time = month number(1,2,3,...12).
Station = distance in km from reference point station number 1.
Discharge = is the monthly stream flow in m^3/sec.

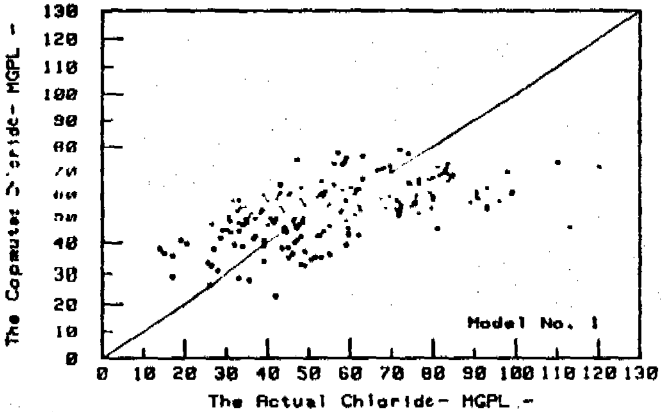
The values of the regression coefficients, the multiple correlation coefficient R and the F-value for each regression function are shown in Table 4. These F-values are greater than the F-table at the 95 percent probability level(Lebne and Taam 19[illegible]).

Figures 5,6,7 and 8 show predicted chloride concentration by models 1,2,3 and 4 versus actual chloride concentration. From these Figures and the results in Table 4, it can be concluded that models 3 and 4 give a better estimate of chloride concentration among other models.

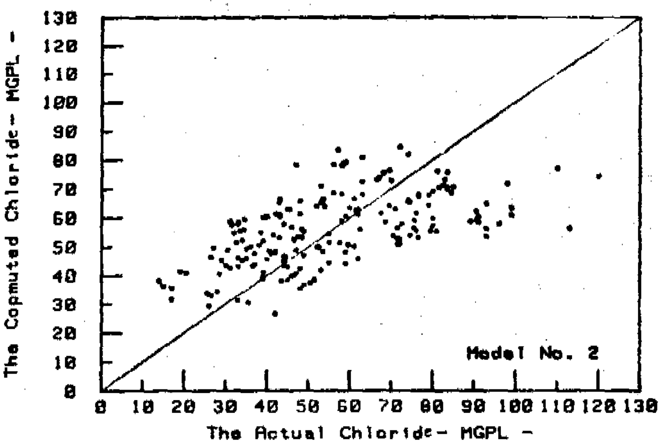
CONCLUSIONS

The results of the two-year chloride concentration analysis in river Tigris at Baghdad indicated the following conclusions:

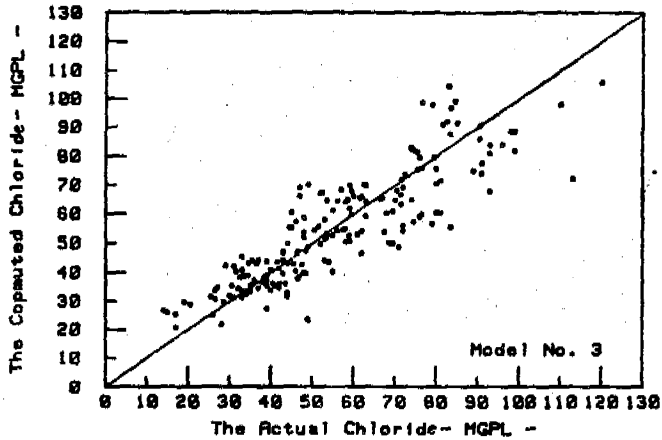
1. There is no interaction between the effect of time and distance on chloride concentration as river Tigris water flows downstream along the reach through Baghdad. Chloride concentrations are mainly affected by river discharge as indicated by tim(month number)and distance since many wastewater and drainage canals are discharging into the river through this reach.



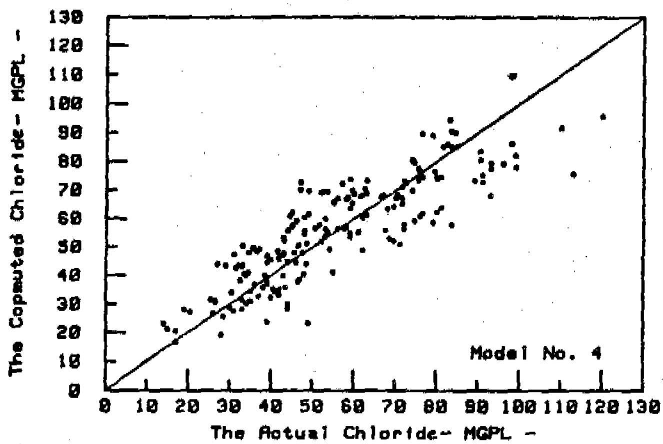
Fig(5) Computed ChlorideVs. Actual Chlorid



Fig(6) Computed ChlorideVs. Actual Chlorid



Fig(7) Computed ChlorideVs. Actual Chlorid



Fig(8) Computed ChlorideVs. Actual Chlorid

2. Harmonic Functuons were adapted for describing mean chloride concentration versus time, and the function with two harmonic is the best one.

3. Mean chloride concentration versus distance in the two-year period was present in term of three degree polynomial equation with R value of about 90 percent.

4. Different regression models for predicting chloride concentration were determined. These models which use discharge and distance in predicting chloride concentration are better than those use time and distance.

Table (4) The Coefficients of The Regression Function and Statistical Tests for Four Models

Model No.	A(0)	A(1)	A(2)	R	F-value
Model No.1	22.7	0.219	0.240	0.604	52.6
Model No.2	23.6	2.560	1.040	0.587	40.3
Model No.3	1296.0	-0.704	0.372	0.876	302.2
Model No.4	276.2	-36.900	0.452	0.857	255.2

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TREATMENT AND DISPOSAL ALTERNATIVES FOR THE SEWAGE OF ATHENS

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INTRODUCTION

The greater Athens area has a population of approximately 3,500,000, of which at present only 60-65% is served by the existing sewerage system, which through a main sewer (M.S.) reaches the Saronic Gulf at the Acrokeramos site. The M.S. is therefore the major point source of pollution of the Saronic Gulf, discharging between 500-600 x 10^3 m^3/day of sewage, of which a significant part constitutes industrial wastewaters. The remaining 35-40% of the population is served by cesspools and septic tanks.

The aim of this paper is to present a preliminary technical and economical evaluation of a number of treatment and disposal alternatives, taking into consideration projected loads and staged construction, the capacity and layout of the existing sewerage system, land availability and cost, necessary degree of treatment, disposal alternatives and social factors.

POLLUTIONAL LOADS

The loads adopted, shown in Table 1, are based on an extensive study conducted by Watson[1]. These estimates, despite the inevitable uncertainties involved during predictions of population growth rates, per capita water consumption and industrial contributions, are considered reliable for the purposes of this study. Moreover extensive quantitative and qualitative analyses made by the National Technical University during the period 1982-1984 confirm in general the predictions made by Watson, with the exception of the Phosphorus load which appears to be underestimated.

Table 1. Polluti[illegible] Load Pr[illegible]tions

	Unit	[illegible]82	19[illegible]	1991	2001	2026
Population served	[illegible]	2110		2913	3855	3713
Average daily flow	[illegible]	531	[illegible]08	789	1113	1245
Average summer daily flow	[illegible]		675	886	1267	1423
Peak hourly	m^3/se[illegible]		9.7	12.8	17.[illegible]	19.8
Storm fl[illegible]	"	[illegible]	4.6	4.6	4.6	4.6
BOD		[illegible]0	195000	226200	262900	254800
[illegible]		262000	280000	305000	326300	315400
Total "		[illegible]7800	30900	35800	42100	40600
To[illegible]	"	4200	4500	5330	6440	6230

Tod[illegible] [illegible]he measur[illegible] load is in the range 7000-8000 kg/day, therefore an [illegible]timate of around 12,000 kg/day for the year 2026 seems more reliable than the figure predicted by Watson (6230 kg/day).

EXISTING SEWERAGE SYSTEM

The biggest part of the sewerage system is designed on the seperate system and only the central area of the city of Athens is being sewered on the combined system.

The maximum design capacity of the M.S. is approximately 16.0 m^3/sec. Recent surveys by the Ministry of Public Works have shown that the deposits on the M.S. are limited, thus the above mentioned figure of 16.0 m^3/sec can be considered as attainable.

Taking into account the peak and storm flow, it follows that the theoretical maximum sewage flow, in terms of average summer daily flow, which can be safely transmitted through the M.S. is of the order of 800,000 m^3/day. A higher value, of approximately 1,000,000 m^3/day can be adopted, on the assumption that it is unlikely for the peak summer hourly flow and storm flow to occur simultaneously. However a number of safety measures (diversions, flow equalizations etc.) would be necessary in this case.

DISPOSAL ALTERNATIVES - DEGREE OF TREATMENT

Inner Saronic Gulf

During the last 10 years and especially from 1973 to 1976 a number of studies related to hydrodynamic factors and quality indices have been conducted[2]. Despite the fairly numerous data existing, concerning indices such as DO, nutrients, primary production, transparency and bottom deposits, it is not sufficient for a reliable mathematical ecological model of the Inner Gulf. The development of a reliable ecological model presents serious difficulties associated not only with the need for extensive data, but also with the uncertain ties involved during mathematical modeling of ecological phenomena.

The authors believe that for the purposes of this preliminary study the required effluent quality and the corresponding degree of treatment can be assessed on the basis of a critical evaluation of the existing data. However further studies, synchronised with the staged construction of the works, can lead to a better approach to the problem.

Current measurements indicate that the circulation within the Gulf is poor; tidal effects are also very weak. Dissolved oxygen levels are fairly low (between 5 and 5.5 mg/l) and further reduction should be avoided.

The trophic state of the Saronic Gulf can not be assessed with accuracy, given the ambiguity which characterises existing knowledge about such matters[3]. The concentrations of nutrients (N,P) and both phytoplangton and zooplangton in the Inner Gulf are significantly higher than those of the Outer Gulf. These concentrations, in the range 30-100 mg/l for N and 35-24 mg/l for P are not too high and indeed no serious eutrophic conditions have been observed in general. However, the authors believe that due to a) the unquestionable, in our opinion, importance of the Saronic Gulf with respect to recreational activities and tourism, b) local entrapment of nutrients (e.g. Keratsini area, Western and Inner Gulf, Elefsina Bay) and subsequent eutrophic conditions and c) the poor circulation within the Gulf, the possibility of a future need for nutrients removal can not be dismissed, and therefore should be taken into consideration.

On the basis of the above analysis the treatment scheme to be adopted, prior to discharge to the Inner Saronic Gulf, should consist of biological treatment followed by a short outfall. The The biological treatment scheme should include, primary treatment followed by activated sludge, sludge digestion and dewatering. Disinfection facilities should be included as a safety measure. A 150 m length diffuser, located at a depth of 40 m can provide a dilution of more than 40 times, which is sufficient to prevent contamination of the nearby shores by pathogenic bacteria. The need for nitrogen and phosphorus removal should be taken into consideration. However in view of the uncertainties related to such possible future requirement, a policy in which economical evaluations of the alternative options do not include nutrients removal for discharges to the Inner Saronic Gulf, seems prudent . However the extra land requirements of such a scheme should be taken into serious consideration during site selection.

Elefsina Bay

Elefsina Bay is a relatively shallow basin between the north coast of Salamis and the Attica coast. It has a maximum depth of about 33 metres, while the narrow straits between Salamis and the mainland are approximately 10 metres deep.

The unfavourable hydrodynamic characteristics of the Bay and the extensive discharges of wastewaters from the industrialised area of Elefsina have resulted in serious deterioration of water quality in the Bay. Dissolved oxygen levels are of the order of 4 mg/l and during the summer months the lower waters become depleted of oxygen and probably become anoxic close to the seabed. Increased nutrient concentrations have created eutrophic conditions. Furthermore there are indications of accumulation of toxic pollutants. It is questionable whether discharge of sewage from Athens irrespectively of prior treatment, into the Elefsina Bay should be considered as a viable alternative due to the present state, the poor assimilative capacity of the Bay, and social factors. In the case of adoption of this alternative the appropriate treatment scheme should include, from the beginning, high degree biological treatment and nutrients removal.

Kifisos River

Kifisos is a torrent in the Athens Basin with outlet into Phaleron Bay. Flow in it from natural sources occurs only during and immediately after rainfall. In Kifisos sewage flow in dry weather occurs as a result of a combination of incompletion of collectors and secondary sewerage in the industrial areas and a lack of enforcement of existing legislation that would ensure the connection to the sewer of every industry which could be intercepted. Because of their location in industrial, and generally lower income areas, these polluted flows have so far been tolerated, but with their unsightly appearance, odour nuisance and the attendant risk to public health, they are rapidly becoming a matter of increasing public concern.

Biological treatment is necessary in order to avoid adverse effects in the quality of both the Kifisos River and the Phaleron Bay. Nutrients accumulation in the Phaleron Bay will almost certainly lead to eutrophic conditions, thus adversely affecting the major tourist developments planned for this area. Therefore the treatment scheme should include biological treatment and nutrients removal from the beginning.

Reuse

Use of effluents for irrigation may be adopted for the areas north of Elefsina and Megara (approx. 1400 ha) as well as for Mesogia (4000 ha).

Factors that should be considered in assessing the need for preapplication treatment include the type of crop grown, the intended use of the crop, the degree of contact by the public with the effluent and the method of application. The irrigation of certain crops to be eaten raw by humans may require advanced wastewater treatment.

An appropriate treatment scheme could consist of high degree biological treatment, filtration and disinfection[4,5].

Industrial reuse can be practiced theoretically in the Elefsina area, although the quantities required are limited. The quality of the effluent should be similar to the quality of the effluent used for unrestricted irrigation.

ALTERNATIVE SOLUTIONS

All the alternative proposals include the operation of the Metamorphosis treatment plant which is under construction. The purpose of this plant is to treat the septage from the unsewered areas of Athens. In the future, when the sewerage network will be completed, it can, with minor modifications, receive by gravity and treat approximately 70,000 m^3/day domestic sewage from the northern suburbs of Athens. The effluent will be discharged to the Kifisos river and find its way to the Phaleron Bay.

The four alternative solutions for the treatment of the remaining 1,350,000 m^3/day are presented in figures 1-4 and can be outlined briefly as follows.

Solution I : A single treatment plant located on the island of Psyttalia, consisting of secondary biological treatment and standby disinfection followed by a short outfall, with provision for future nutrients removal. The land area required is about 34 ha. The construction of an additional main sewer of a length of approximately 7 km parallel to the existing M.S. is necessary as the maximum capacity of the latter does not exceed 800,000 m^3/d - 1,000,000 m^3/d. Necessary is also the construction of a 1.2 km undersea conduit connecting Acrokeramos and Psyttalia. For the proper operation of this conduit it is advisable to place the preliminary treatment units (screening, grid removal) at Acrokeramos. The excavations on the island amount to approximately 8 million cubic metres.

Solution II : A single treatment plant with a treatment scheme as above, located at Acrokeramos. The additional sewer is still required but there is no need for an undersea conduit. It is practically impossible to acquire an area of 34 ha at this location. The required area can be reduced, though not without adverse economical and operational consequences, to 22 ha by adoption of multi-storey tanks, Lamella plates or tube settlers, use of pure oxygen and removal of the sludge treatment units to a 3 ha area which can be obtained at very low cost and is located about 3.5 km away at an altitude of 60 m. The available area at Acrokeramos is only 8 ha, and the remaining 11 ha have to be acquired by earth fills in the sea (5 ha) and removal of existing industries (6 ha).

Solution III : a) Treatment plant at Acrokeramos treating 800,000 m^3/day. The required area, with adoption of the above-mentioned space saving modifications, amount to 16 ha. The available area is 8 ha, 6 ha to be obtained by earth fills and sludge treatment (2 ha) in another locations, as described before.

b) Treatment plant at Elefsina receiving 550,000 m^3/day. The treatment consists of biological stage, removal of nutrients. The construction of a 10 km tunnel transmitting the sewage to Elefsina through the mountain Aegaleo is required. Filtration and disinfection will be practiced for the portion of the effluent used for irrigating the 1400 ha area north of Elefsina and at Megara. The remaining effluent will be discharged to the Elefsina Bay through an outfall of approximately 1 km length.

Solution IV : a) treatment of 850,000 m^3/day at Acrokeramos, as in case III.

b) Expansion of the Metamorphosis treatment plant from a capacity of 73,000 m^3/d to a capacity of 300,000 m^3/d. The necessary treatment scheme consists of biological treatment and nutrients removal and the effluent will be discharged to the Kifisos river. Transportation of most of the sewage to the plant location requires pumping.

c) Treatment of 270,000 m^3/day at a plant located at Vari. The effluent after biological treatment, filtration and disinfection will be used for irrigation of the 4000 ha vegetation at

Mesogia. During the winter months the effluent will be discharged to the Evoikos Gulf. Extensive pumping is required for the transmission of the sewage to the plant location.

STAGED CONSTRUCTION

The construction of the works will be completed in three phases. The first phase is to be completed by 1985. The second and third phases will be required in 1990 and 2003 respectively.

The staged construction is in accordance with the anticipated future loads and sewerage construction program; the latter is to be implemented by the year 2001.

The capacity of each stage is presented in Table 2.

ECONOMICAL COMPARISONS

All alternative solutions are economically evaluated on the basis of present value of capital and operating costs, adopting an economic time horizon of 40 years. Included are all costs related to transportation of sewages and effluents as required for each solution (supplementary main sewer, undersea conduit, tunnel, outfalls, additional sewerage system, pumping etc), costs of obtaining the land and costs of replacing electrical and mechanical equipment.

For the assessment of present values a discount rate of 8% is adopted and the staged construction of the works is taken into consideration. The economic life for civil works is taken equal to 40 years while that for mechanical and electrical equipment equal to 20 years.

The cost of excavations for Psyttalia in alternative I is excluded as there was an expressed demand for the products of excavations to be used for marine works.

Table 3 presents the results of the economical comparisons.

DISCUSSION - CONCLUSIONS

Alternative I is the most economical, but both alternatives I and II should be considered economically equivalent given the small difference in total cost (0.6 million Drachmas) on the one hand, and the uncertainties involved in the assessment of the cost of the undersea conduit on the other. However there are the following significant advantages of solution I over solution II.

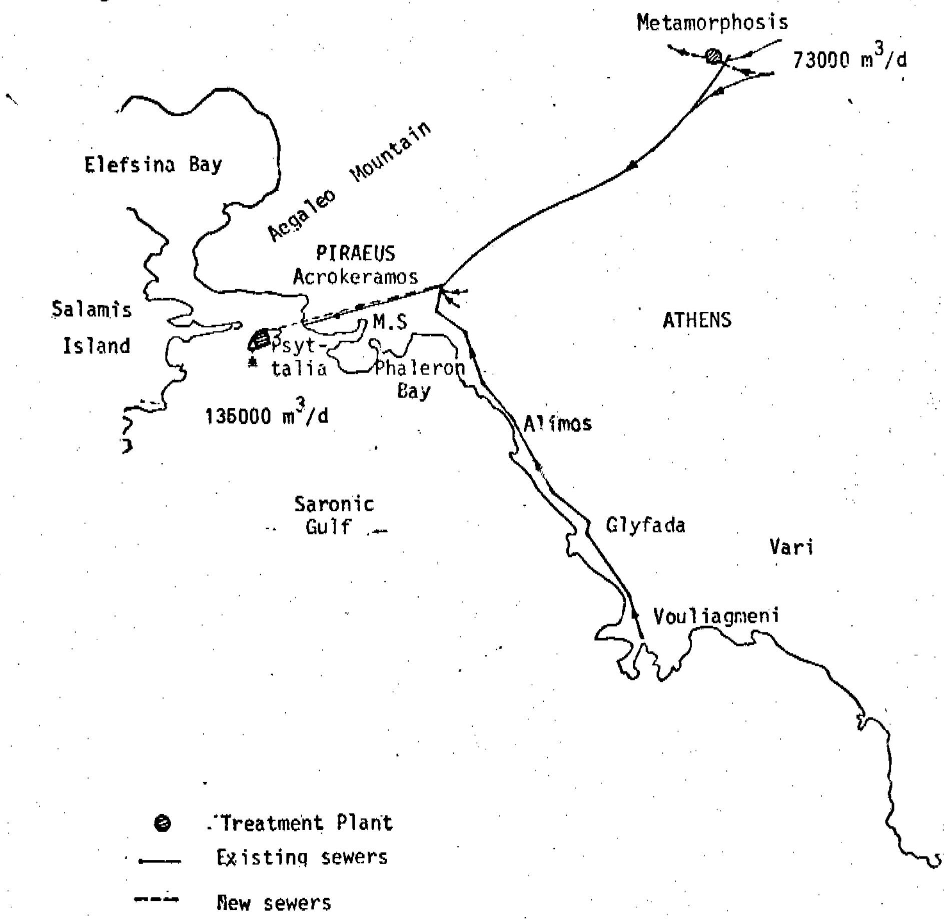


Fig 1. Alternative Solution I

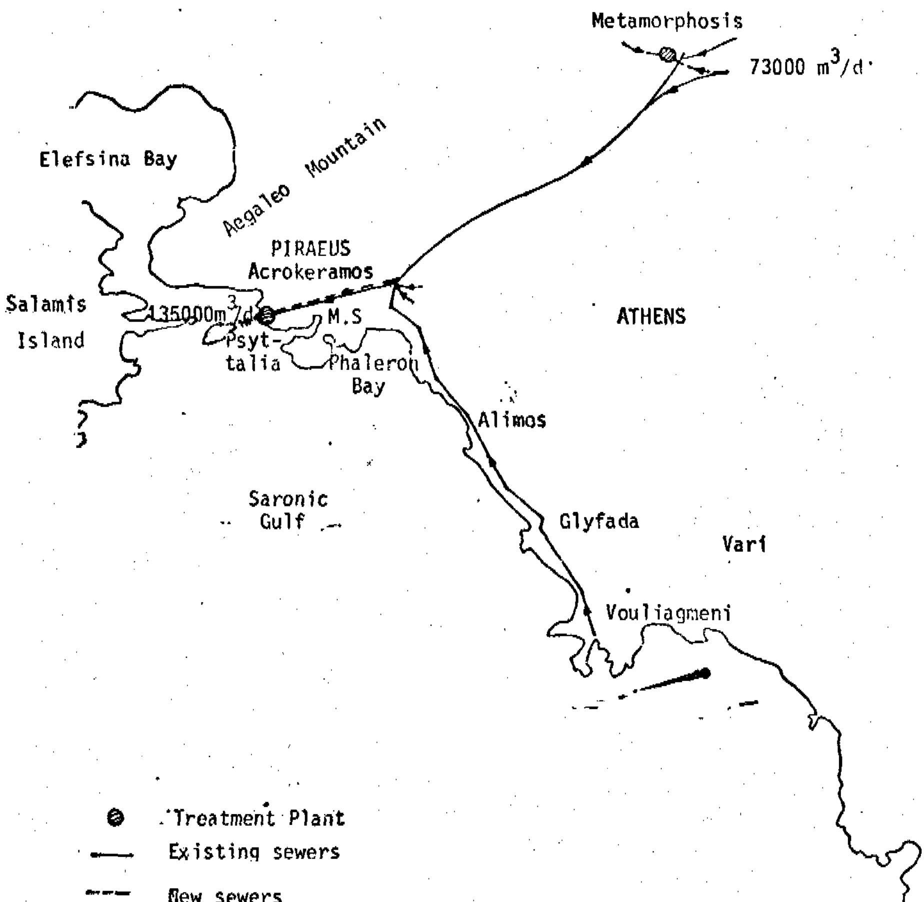


Fig 2. Alternative Solution II

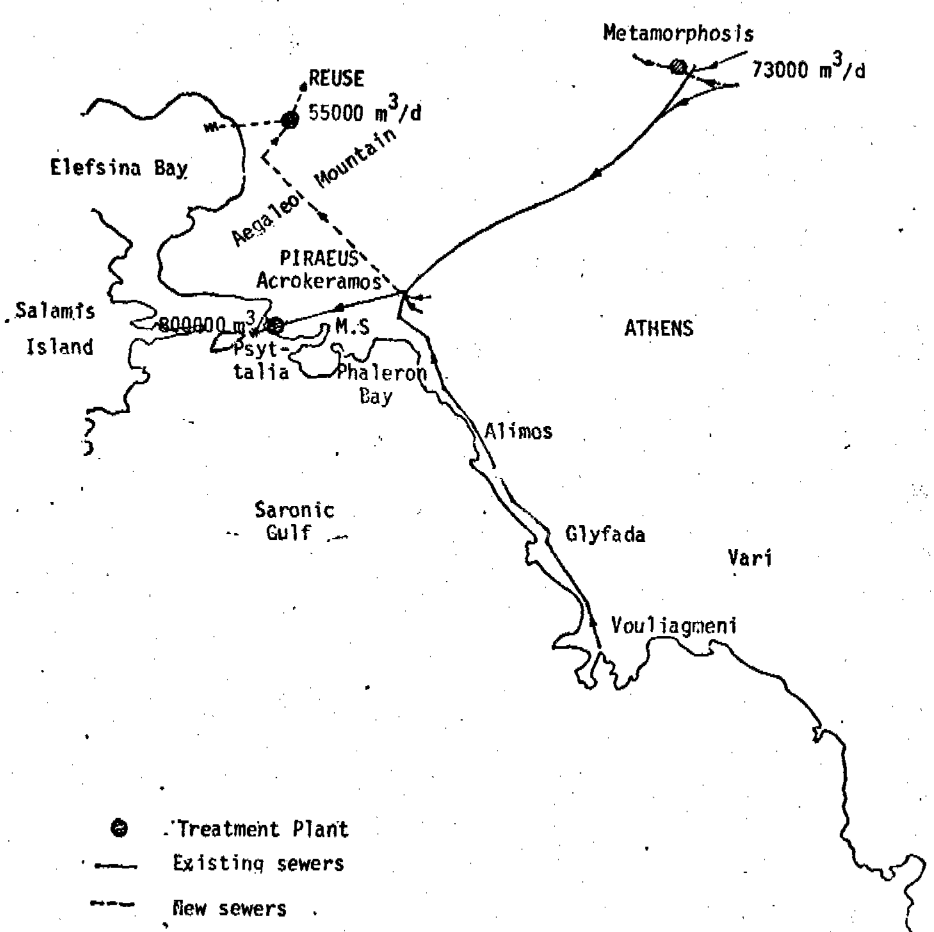
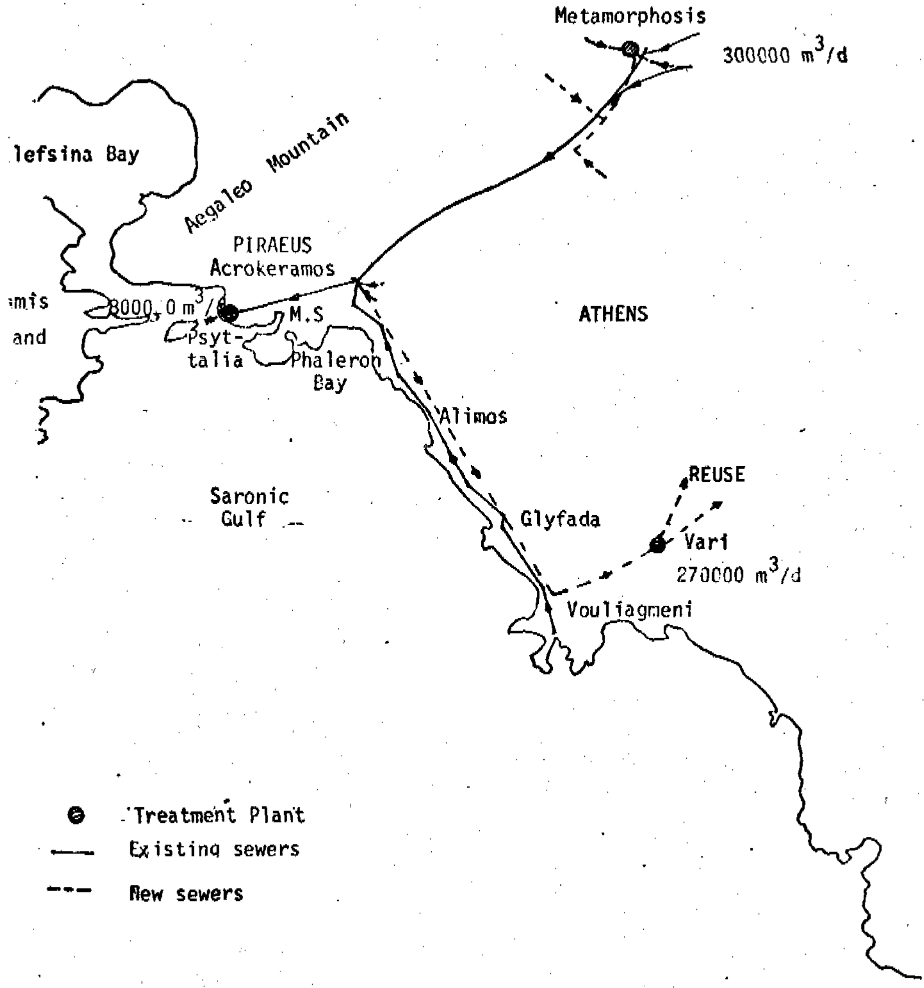


Fig 3. Alternative Solution III



4 . Alternative Solution IV

Table 2. Staged Construction

Alternative	Location	Treatment Scheme	Disposal	Flows (m3/day)		
				Phase 1	Phase 2	Phase 3
I	Psyttalia	Biological Treatment, Standby Disinfection	Saronic Gulf	825,000	375,000	150,000
	Metamorphosis	Biological Treatment, Disinfection	Kifisos	73,000	-	-
II	Acrokeramos	Biological Treatment, Standby Disinfection	Saronic Gulf	825,000	375,000	150,000
	Metamorphosis	Biological Treatment, Disinfection	Kifisos	73,000	-	-
III	Acrokeramos	Biological Treatment, Standby Disinfection	Saronic Gulf	800,000	-	-
	Elefsina	Biological Treatment, Nutrients Removal, Filtration, Disinfec.	Elefsina Bay and land	180,000	220,000	190,000
	Metamorphosis	Biological Treatment, Disinfection	Kifisos	73,000	-	-
IV	Acrokeramos	Biological Treatment, Standby Disinfection	Saronic Gulf	540,000	240,000	100,000
	Metamorphosis	Biological Treatment, Nutrient Removal, Disinfection	Kifisos	190,000	80,000	30,000
	Vari	Biological Treatment Filtration, Disinfection	Land	165,000	85,000	30,000

Table 3. Economical Comparisons

Cost in millions of Drachmas

Altern-ative	Treat-ment	Trans-portation	Land	Replac. of E-M Equipment	Opera-tion	Total	1st Phase
I	7120	2410	310	400	4190	14430	8400
II	7360	1380	2010	400	3940	15090	8910
III	8450	1900	1670	500	5670	18190	11210
IV	9370	3420	1500	590	7290	22170	11730

a) The treatment plant in solution I is not in the vicinity of inhabited areas as in solution 2.

b) The effluent is discharged farther from the coast.

c) The extensive earth fills which are needed for solution II, though feasible, may present technical difficulties and consequent economical burdens, which are difficult to foresee.

d) The availability of land on Psyttalia gives possibilities of expanding the plant if needed (e.g. due to underestimation of future loads).

e) The location of the treatment plant at Acrokeramos is only feasible through a reduction of the required area from 34 ha to 22 ha. The means by which this can be achieved (multistorey tanks, Lamella plates or tube settlers, use of pure oxygen, pumping of sludge to another location for treatment) may create additional operational problems.

The cost of alternative solutions III and IV are significantly higher, by 27% and 54% respectively. These cost differences are too high to justify their selection on the grounds of the reuse possibilities described earlier.

Both solutions include the construction of a treatment plant at Acrokeramos, for approximately 800,00 m^3/day, therefore the disadvantages related to solution II (particularly a, b and c) still stand.

Finally the construction of a long tunnel (10 km) under the mountain Aegaleo and the discharge to the heavily polluted Elefsina

Bay are additional but prominent disadvantages related to Solution III.

In conclusion the alternative solution I is the more beneficial regarding social, environmental, technical and economical aspects. If however it is not adopted it is difficult in our opinion to select any of the three remaining on the basis of this preliminary study without further careful investigation of the related social, environmental and technical consequences. However, the construction of a plant with a capacity of around 800,000 m^3/day at Acrokeramos can commence since it is included in all three solutions.

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PRELIMINARY INVESTIGATION OF LEAD CEMENTATION BY IRON IN WASTEWATER

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INTRODUCTION

Lead is one of the most widely used nonferrous metals in industry. In consequence, lead is present in the wastewates of many industries, often at high concentrations (Table 1). Lead's adverse effects on public health[2], increased the interest of researchers to find out efficient metods for it's removal from wastewaters.

Table 1. Industrial Wastewater Sources of Lead[1]

Battery Manufacturing
Plating
Television Tube Manufacturing
Mine Drainage
Mining Process Water
Lead Smelting
Ammunition Manufacturing
Tetraethyl Lead Manufacturing

The conventional treatment methods for lead removal from wastewaters are precipitation, coagulation, ion exchange and activated carbon treatment[1,3]. Organic lead, from gasoline additives producing industries, demands more complicating methods such as chlorination-precipitation, ozonization - precipitation e.t.c[3]. These methods have significant disadvantages such as high cost of operation and construction or production of large volumes of sludge which requires special disposal facilities.

The cementation treatment is now used for recovery of copper from spent plating baths and sub - marginal copper ores[4] and removal of copper from wastewaters combined with reduction of hexavalent chromium to trivalent [5]. This treatment has many advantages such as recovery of copper in an essentialy pure matallic form, simple control requirements and low energy utilization[6]. Cementation of copper on iron has been studied by many researchers [5-14] but only a little work has been made on cementation of other heavy

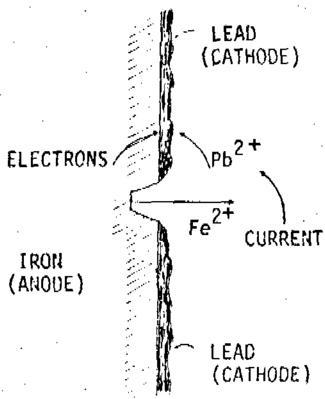

Fig.1.Simplified galvanic cell model for lead cementation.

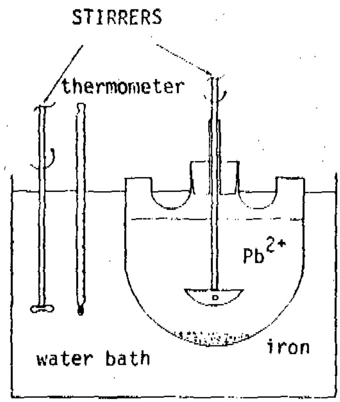

Fig.2.Apparatus for the cementation of lead on iron.

metals on iron. This research is a preliminary investigation on the use of cementation treatment for the removal of soluble lead from wastewaters.

Cementation is the recovery of an ionized metal from solution by spontaneous electrochemical reduction to the elemental metallic state, with consequent oxidation of a sacrificial metal such as iron. The reaction, for lead and iron, is given in Equation 1.

$$Pb^{+2} + Fe^{0} \longrightarrow Pb^{0} + Fe^{+2} \qquad (1)$$

The process can be predicted in terms of electrode potentials. The potential (E°) for Equation 1, under standard conditions, is + 0.314 volts[15]. The metal with more positive oxidation potential in the electromotive series will be oxidized and pass into solution.

This is the sacrificial metal. Iron is often chosen as the sacrificial metal, due to its availability and low cost.

The cementation process generates electrodeposits without external current. For example, an electropotential sufficiently large to deposit lead is produced, in case lead ions and an iron surface are present in aqueous solution. The iron acts as a sacrificial anode, and by dissolution replaces the lead ions in solution. The process, pictured in Figure 1, can be described as a galvanic corrosion cell[14]. A cathodic lead deposit covers the anode except for the submicroscopic regions from which iron is being dissolved[14]. Electrons flow from the anode to the cathode through the basic metal, in the manner of a short - circuited galvanic cell. These anodic sites effectively migrate around the surface of the iron ; therefore the entire piece of iron can be consumed[16].

The small electrode potential (+ 0.314 volts) for Equation 1 compared with + 0.777 volts for the similar pair copper - iron indicates that a large iron surface with many active sites must be used in order to have a significant removal of lead in an economically accepted time period.

Table 2. Side Reactions of Iron in Cementation Treatment[6,11]

Reaction	E^0 cell (volts)
Metallic Iron	
(2) $Fe^0 + 2Fe^{+3} \longrightarrow 3Fe^{+2}$	+ 1.21
(3) $2Fe^0 + O_2 + 4H^+ \longrightarrow 2Fe^{+2} + 2H_2O$	+ 1.67
(4) $Fe^0 + 2H^+ \longrightarrow Fe^{+2} + H_2$	+ 0.44
(5) $Fe^0 + Pb^0 + 2H^+ \longrightarrow Fe^{+2} + Pb^0 + H_2$	
(6) $2Fe^0 + 6H^+ \longrightarrow 2Fe^{+3} + 3H_2$	+ 0.04
(7) $4Fe^0 + 3O_2 + 12H^+ \longrightarrow 4Fe^{+3} + 6H_2O$	+ 1.27
Soluble Iron	
(8) $4Fe^{+2} + 4H^+ + O_2 \longrightarrow 4Fe^{+3} + 2H_2O$	+ 0.46
(9) $2Fe^{+2} + 2H^+ \longrightarrow 2Fe^{+3} + H_2$	- 0.77
(10) $Pb^0 + 2Fe^{+3} \longrightarrow Pb^{+2} + 2Fe^{+2}$	+ 0.89

The stoichiometry of Equation 1 indicates a molar ratio of unity for iron sacrified per mole of lead removed. This translates to an Fe : Pb ratio of 0.27, on a weight basis. Thus, according to Equation 1, each 100gr. of lead removed consumes 27 gr. of metallic iron. However, there is excess iron consumption associated with the process, due to side reactions of iron in the wastewater (Table 2).

The ratio of iron consumed to lead produced is generally referred to as the "can factor" and in praxis has a higher value than 0.27 Disadvantages of excess iron consumption include wastage of the metallic iron reactant, and production of unnecessary amounts of iron sludge upon precipitation treatment.

EXPERIMENTAL PROCEDURES

The apparatus used is shown in Fig. 2. A three - necked distillation flask of 500 ml capacity was used as a reaction vessel. A stirrer with paddle was introduced through the central neck of the vessel. The stirrer was always placed at the same depth in the solution to have always the same stirring conditions. The shaft of the stirrer was from glass and the paddle from polyethylene. The whole assembly was immersed in a constant temperature water bath (± 0.5° C).

Reagent - grade lead nitrate was used to prepare the lead ion solution. In order to prevent oxidation and hydrolysis of iron and formation of ferric hydroxide, a buffer solution of glycine hydrochloride - glycine was used. This buffer maintained a reaction pH approximately 2. At this pH value all dissolved iron was in the ferrous condition.

Experimental data were obtained by measuring the amount of lead and iron ions in solution at succesive time intervals. The initial volume of the solution was 500 ml, 5 ml aliquots removed each time for chemical analysis. Because the total volume change of the solution was significant, correction was used for solution volume change.

Samples of the following materials were used :
- pure iron powder 150 μm (- 100 mesh) with specific surface 0.05 - 0.07 m^2/g (Merck Eisen gepulvert reinst Artikel 3800)
- filings of common steel (80 mesh)

Collected samples in all experiments were filtered before chemical analysis. Soluble lead and total iron were analyzed by atomic absortion.

RESULTS AND DISCUSSION

Stirring Speed and Reaction Order

A series of experiments were carried out in the reaction vessel at various stirring speeds. The results of lead removal are shown in Fig. 3. The data are plotted according to first - order kinetics where logarithm of C/Co is plotted vs time in minutes[12]. The quantities C and Co refer to lead concentrations at any time t and at t=0, respectively. The data of Fig. 3. are for Co ≃ 250 ppm, temperature= =25°C, pH ≃ 2, 1 gr. of iron powder and aerobic conditions. First -

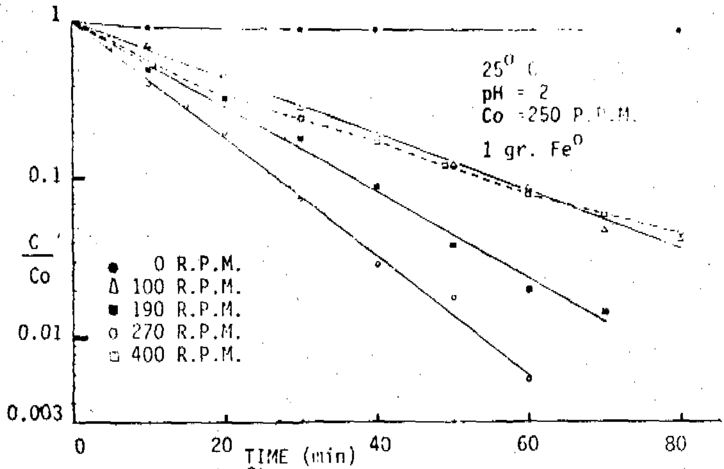

Fig. 3. Removal of (Pb^{2+}) from solution for various stirring speeds

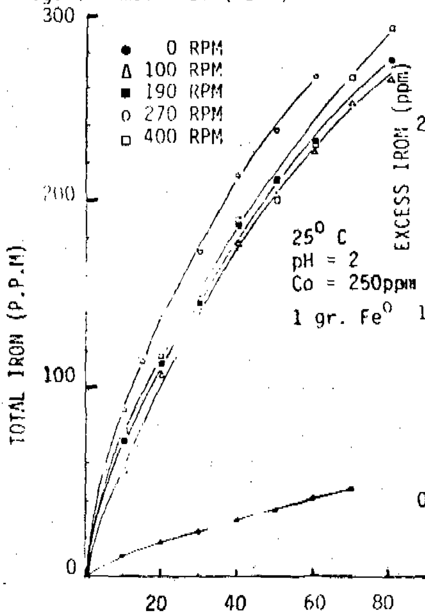

Fig. 4. Total iron in solution for various stirring speeds

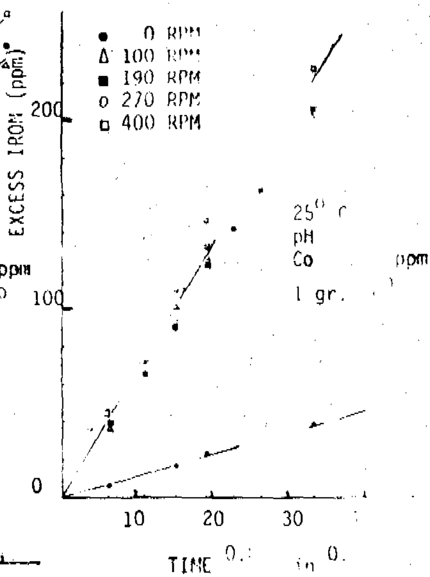

Fig. 5. Excess [illegible] in solution for [illegible] stirring spe[illegible]

order kinetics were followed for stirring speeds of 100, 190 and 270 R.P.M. At 400 R.P.M. the kinetics deviated from firt order and the rate of cementation decreased. A similar decrease was recorded for copper cementantion on iron[4] at high stirring speeds due to the deposit morphology. At all stirring speeds iron powder was not dispersed in the vessel but it was coagulated at the depth of the vessel with metallic lead removed from the solution. At 400 R.P.M. the high stirring speed was responsible for the formation of small compact balls of iron powder and cemented lead. The formation of these balls minimize the active surface area of iron in contact with solution and so the rate of reaction was reduced. This most propably explains the deviation from first - order kinetics.

The specific rate for firts order kinetics is given by Equation 11:

$$K = \frac{\bar{V}}{A} \cdot \frac{1}{t} \cdot \ln \frac{Co}{C} \qquad (11)$$

where K = specific rate (cm x min^{-1}), $\bar{V}$ = average volume of the reaction solution (cm), A = initial iron surface area (cm^2), t = time of reaction (min), Co = initial lead concentration, C = lead concetration at time t. K values are shown in Table 3. The rate of cementation increased with stirring speed up to 270 R.P.M. In this region diffusion of lead ions in bulk solution was propably the rate - controling step of reaction.

The lead ions concentration C at time t can be obtained by rearrangement of Eq. (11) :

$$C = Co\, e^{-\frac{K \cdot t \cdot A}{V}} \qquad (12)$$

To confirm first - order kinetics and Eq.(12) a comparison is made between values of C measured experimentaly and calculated from Eq (12) in Table 4. The measured values are accuretely predicted from Eq (12). In Table 3 is shown that at a short time between 30 and 60 min a satisfactory removal of lead up to 99% was taking place.

The results for total iron in solution are shown in Fig. 4. The total iron concentration is plotted vs time. As shown in Fig.4 stirring speed has a slight influence on total iron concentration. This is in agreement with recorded results for copper cementation[11]. Total iron in solution consists of two parts, iron consumed for cementation and excess iron consumed by side reaction (Table 2) :

$$C_T = C_c + C_E \qquad (13)$$

C_T = total iron in solution at time t, C_c = iron consumed for cementation at time t, C_E = excess iron in solution at time t.

Table 3 Results for Lead Cementation at Various Stirring Speeds

Stirring speed (R.P.M.)	K (cm x min^{-1})	K′ ($min^{-0.8}$)	% Lead Removed 30 min	% Lead Removed 60 min	"Can"factor 30 min	"Can"factor 60 min
100	0.032775	0.0031704	71.8	91.3	0.85	1.02
190	0.050300	0.0030927	81.9	97.9	0.70	0.92
270	0.068859	0.0037713	92.5	99.4	0.74	1.06
400	0.038086	0.0033124	76.0	91.5	0.76	1.00

Table 4 Comparison of Experimental Data and Data Calculated from Eq. (12), (17), (18)

TIME (min)	LEAD (ppm) A	LEAD (ppm) B	EXCESS IRON (ppm) A	EXCESS IRON (ppm) B	TOTAL IRON (ppm) A	TOTAL IRON (ppm) B
5	176.5	167.5	36.7	27.3	57.4	50.5
10	103.5	110.0	48.3	47.6	88.6	86.2
15	73.1	72.1	65.4	65.8	114.0	114.6
20	49.7	47.0	84.7	82.9	139.6	138.5
30	19.1	20.0	110.2	114.6	173.4	177.5
40	7.4	8.4	147.2	144.3	213.4	210.3
50	3.0	3.5	170.3	172.5	237.7	239.8
60	1.4	1.4	199.6	199.5	267.5	267.4

A:Measured Values
B:Calculated Values

Iron consumed for cementation can be predicted from the stoichiometry of Eq (1):

$$C_c = 0.27 \ (C_o - C) \qquad (14)$$

C_o = initial lead ion concentration, C = lead ion concentration at time t. Combining Eq (12) and Eq (14) results to :

$$C_c = 0.27 \cdot C_o \cdot (1 - e^{-\frac{K.t.A}{V}}) \qquad (15)$$

Excess iron can by found from the difference :

$$C_E = C_T - C_E \qquad (16)$$

Experimental data shown in Fig. 5 indicate that excess iron kinetics follows Eq (17) :

$$C_E = C_o' \cdot K' \cdot t^{0.8} \qquad (17)$$

C_o' = initial metallic iron concentration (mg/l), K' = specific rate of excess iron dissolution (min $^{-0.8}$), t = time of reaction (min)

So the total iron in solution can be predicted from the overall Equation (18) ;

$$C_T = 0.27 \cdot C_o \cdot (1 - e^{-\frac{K \cdot t \cdot A}{V}}) + C_o' \cdot K' \cdot t^{0.8} \qquad (18)$$

The results of Eq (17) and (18) are confirmed in Table 4 by comparison between measured and calculated values.

Specific rates for excess iron in Table 3 indicates that stirring speed has a slight influence on excess iron consumption.Surface reaction or boundary film diffusion will be the rate controling step for this reaction. Stirring speed has also a slight effect on "Can" factor as shown in Table 3.

A comparison was carried out between iron powder and common steel filings under the same conditions. After 60 min of reaction the percentage of lead removal for filings was 98.6% compared with 99.4% for iron powder.

Temperature Effect - Arrhenius Plots

A series of experiments were carried out at various temperatures. The results for lead removal are shown in Fig. 6. The data are plotted according to first - order kinetics for stirring speed = 270 R.P.M., Co ≈ 250 ppm, pH ≈ 2, 1 gr. of iron powder and aerobic conditions. At 35° C, 45°C, 55° C and 65° C after a short time period the kinetics deviated from first order kinetics. This phenomena propably due to the increased rate of lead cementation on iron and consequently to the reduction of iron effective surface. Specific rates calculated from experimental (Table 5) indicate a significant increase of the cementation rate at high temperatures (116% from 25° C to 65° C).

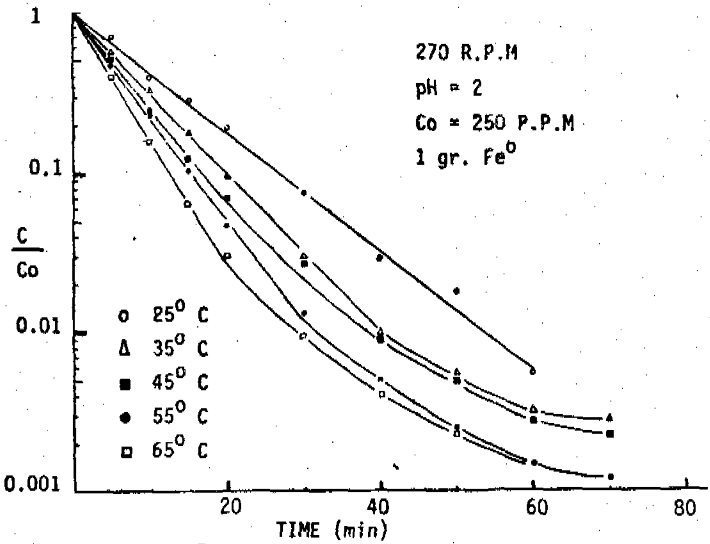

Fig. 6. Removal of (Pb^{2+}) from solution for various temperatures.

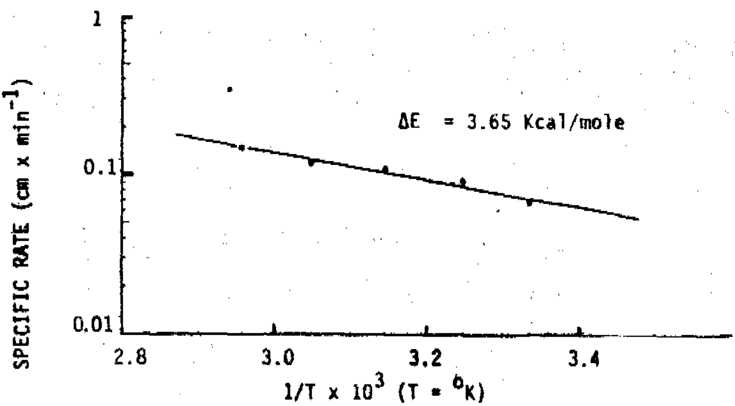

Fig. 7. Arrhenius plot of specific rates of lead cementation

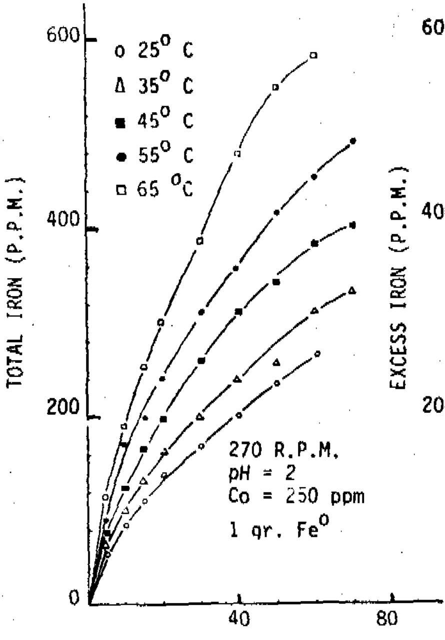

Fig.8.Total iron in solution for various temperatures

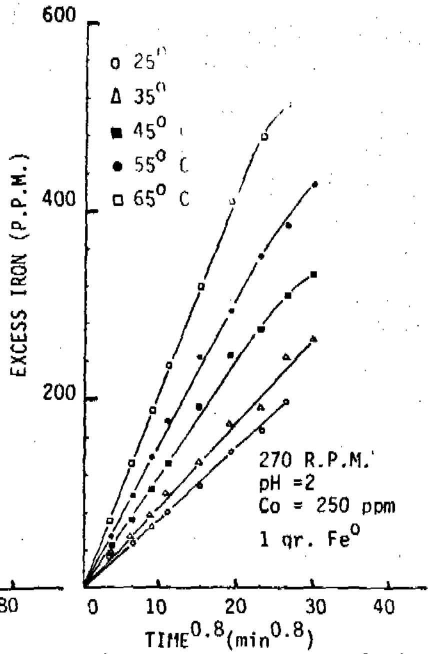

Fig.9. Excess iron in solution for various temteratures

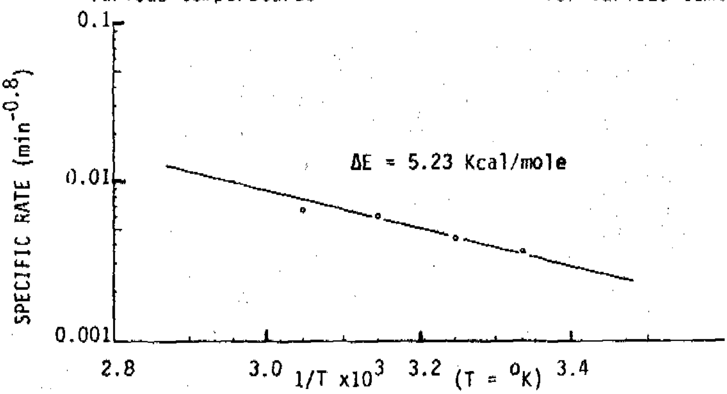

Fig. 10.Arrhenius plot of specific rates of excess iron in solution

The specific rates for the cementation reaction at various temperatures were plotted on an Arrhenius plot as shown in Fig. 7. The experimental activation energy ΔE was 3,65 Kcal/mole. The value of the activation energy is consistent with that expected for solution diffusion as the rate controling step.

Table 5 Results for Lead Cementation at Various Temperatures

Temperature °C	K (cm x min^{-1})	K' (min$^{-0.8}$)	% Lead Removed 30 min	% Lead Removed 60 min	"Can" factor 30 min	"Can" factor 60 min
25	0.068859	0.0037713	92.5	99.4	0.74	1.06
35	0.092556	0.0044676	97.0	99.7	0.82	1.25
45	0.112627	0.00[illegible]756	97.3	99.7	1.06	1.52
55	0.120586	0.0077635	98.7	99.8	1.28	1.84
65	0.148847	0.0105229	99.0	99.9	1.57	2.33

Concernig iron, total and excess iron are shown in Fig. 8 and 9 respectively. Temperature has a major influence on iron consumption. As shown in Table 5 specific rate for excess iron increases 180% from 25° C to 65° C, the same happens with "can" factor.

Arrhenius plot for specific rates of excess iton is shown in Fig. 10 . The experimental activation energy ΔE was 5.23 Kcal/mole. This confirms diffusion as the rate controling step for excess iron consumption.

Effect of Different Quantities (Surface Area) of Metallic Iron

A series of experiments were carried out with various quantities of metallic iron. The results for lead removal are shown in Fig. . and for total and excess iron in solution in Fig. 12,13. The increase of the quantity of iron powder added increases the rate of cementation due to the increase of the active surface area. Excess iron consumption also increases as shown in Table 6.

The specific rates for lead removal and excess iron (Table 6) are approximately constant. This means that the rate fo cementation and excess iron dissolution are direct proportional to the iron active surface area.

Effect of Initial Lead Concentration

A series of experiments were carried out at various initial lead concentrations. The results for lead removal and for total and excess iron are shown in Fig 14,15,1[illegible] Initial lead concentration had a slight influence on the rate of cementation and excess

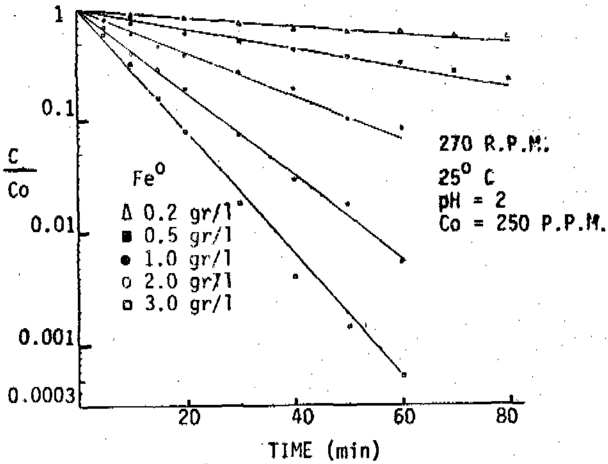

Fig. 11. Removal of (Pb^{2+}) from solution for various quantities of metallic iron.

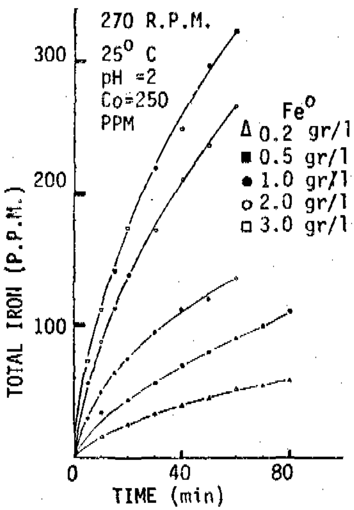

Fig. 12. Total iron in solution for various quantities of metallic iron

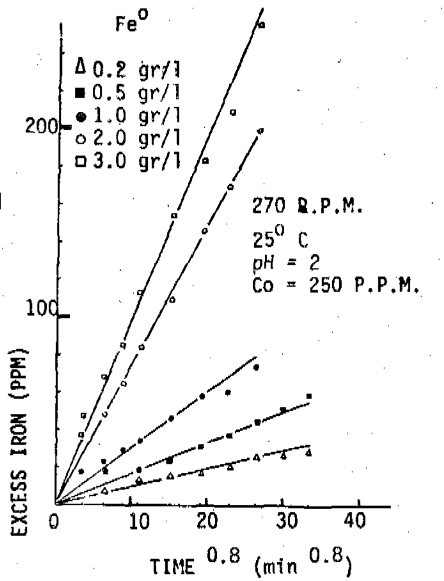

Fig. 13. Excess iron in solution for various quantities of metallic iron

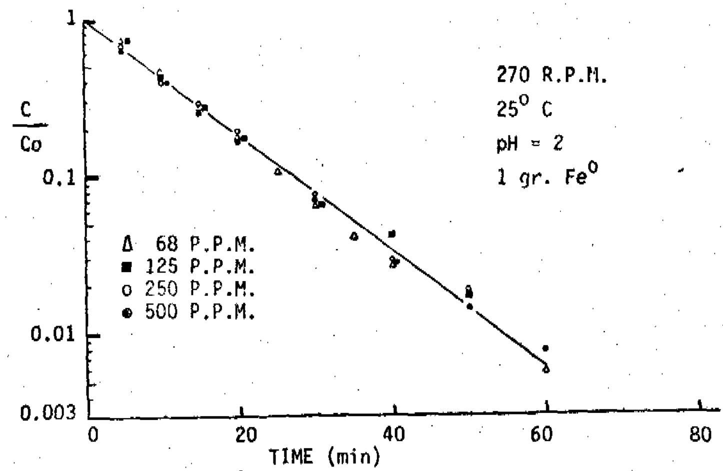

Fig.14. Removal of (Pb^{2+}) from solution for various initial concentrations of lead anion.

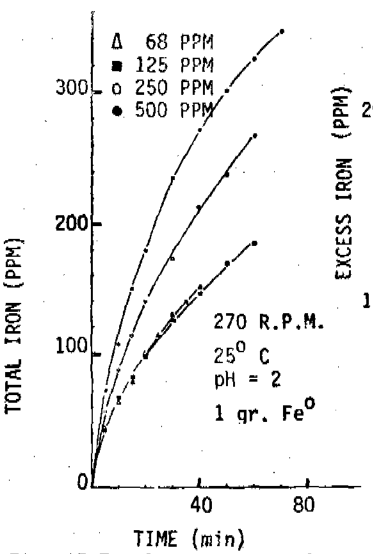

Fig. 15. Total iron for various initial concentrations of lead ion

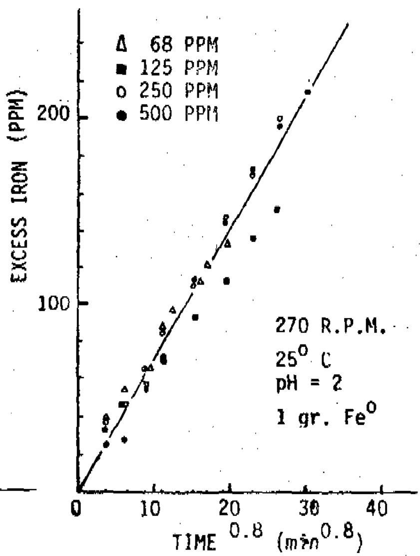

Fig. 16. Excess iron for various initial concentrations of lead ion

iron consumption. This conclusion is confirmed from the values of specific rates shown in Table 7.

Table 6 Results for Lead Cementation for Various Quantities of Metallic Iron

Metallic Iron (gr/l)	K $(cm \times min^{-1})$	K′ $(min^{-0.8})$	% Lead Removed 30 min	% Lead Removed 60 min	"Can" factor 30 min	"Can" factor 60 min
0.2	0.072886	0.0048757	25.8	39.0	0.51	0.53
0.5	0.069355	0.0033274	48.4	67.5	0.46	0.54
1.0	0.073184	0.0030778	72.5	91.7	0.53	0.60
2.0	0.068859	0.0037713	92.5	99.4	0.74	1.06
3.0	0.066991	0.0034588	98.2	99.9	0.90	1.30

Table 7 Results for Lead Cementation at Various Initial Lead Concentrations

Co (ppm)	K $(cm \times min^{-1})$	K′ $(min^{-0.8})$	% Lead Removed 30 min	% Lead Removed 60 min	"Can" factor 30 min	"Can" factor 60 min
68	0.068702	0.0037644	93.5	97.3[a]	2.04	2.27[a]
125	0.065215	0.0031879	93.3	98.9	1.05	1.47
250	0.068859	0.0037713	92.5	99.4	0.74	1.06
500	0.071435	0.0035786	93.2	99.2	0.52	0.68

[a]Reaction time 40 min

Table 8 Results for Lead Cementation at Various pH Values

pH	K $(cm \times min^{-1})$	K′ $(min^{-0.8})$	% Lead Removed 30 min	% Lead Removed 60 min	"Can" factor 30 min	"Can" factor 60 min
1.5	0.070689	0.0074377	92.9	99.0	1.23	1.76
2.0	0.068859	0.0037713	92.5	99.4	0.74	1.06
2.5	0.064693	0.0028137	91.1	98.4	0.63	0.84
3.0	0.055153	0.0024034	87.4	96.5	0.59	0.77

But "Can" Factor is greatly affected from initial lead concentration and decreases as initial concentration increases.

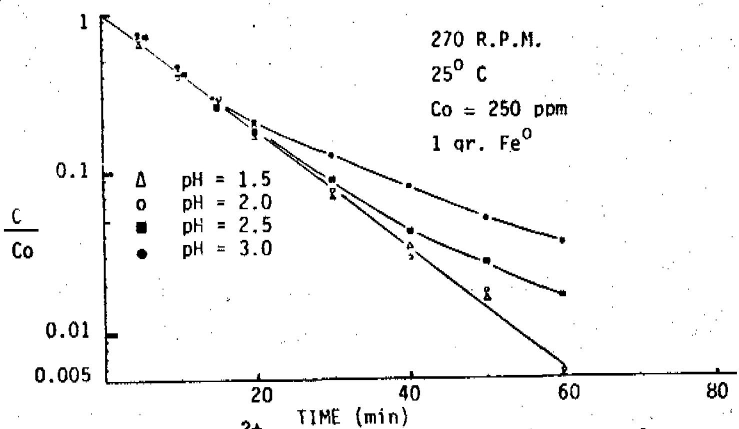

Fig.17. Removal of (Pb^{2+}) from solution for various pH values

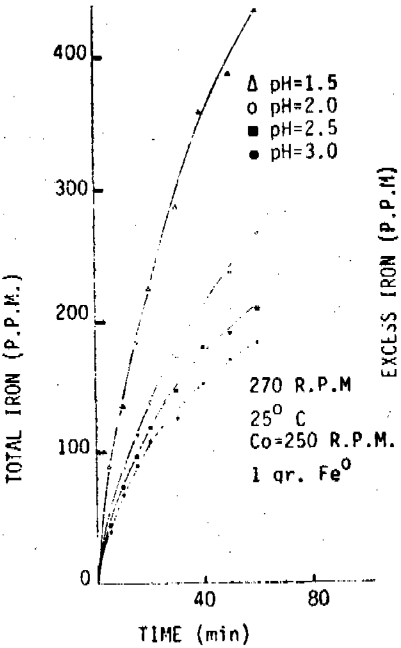

Fig.18. Total iron for various pH values

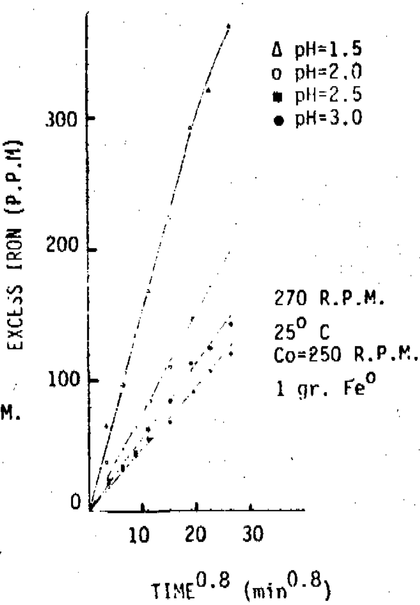

Fig. 19. Excess iron for various pH values

Effect of pH Value

A series fo experiments were carried out at various pH values. The results for removal and total and excess iron are shown in Fig. 17,18,19. Specific rates are shown in Table 8. At pH 2,5 and 3 a deviation from first - order kinetics and a decrease of the rate of reaction was observed. This phenomena may due to a less effective cleaning of the iron surface by acid as happens in copper cementation by iron". At pH 1,5 a slight increase in cementation rate was observed but this is accompanied by a strong increase in excess iron consumption (about 100% in relation to pH 2).

CONCLUSIONS

- Iron in small particles (filings etc) can be effectively used for lead removal from wastewaters.
- Lead cementation is a firts - order kinetic reaction with respect to the removal of lead from wastewater.
- Excess iron consumption can be described by the Equation :

$$C_E = Co' \cdot K' \cdot t^{0.8}$$

- Total iron consumption can be predicted from the previous Equation and first - order kinetics equation for lead remonal.
- The rate increases with agitation. The rate - controling step is clearly solution diffusion in this region.
- At high stirring rates the Kinetics deviate from first - order and the rate decreases.
- The experimental activation energy found, supports diffusion as the rate - controling step for lead cementation and excess iron dissolution.
- The rate increases significantly with temperature but the same happens with excess iron dissolution.
- The rate depends on the iron metal surface area.
- The rate is independent from initial lead concentration.
- pH values between 2 and 2,5 are optimum for lead cementation.

Further work is in progress in the research of the decrease of excess iron consumption and recovery of cemented lead.

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WASTE MANAGEMENT: A MEANS OF ENVIRONMENTAL POLLUTION CONTROL WITH ECONOMY

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ABSTRACT

Waste is a valuable resource disguised as a nuisance worldwide. If left unmanaged, it can pollute various phases of human environment. And if managed properly, it can be an endless source of energy and useful materials. Waste management is an important aspect of environment health and needs to be integrated with the total environmental planning of a country. Good management system of waste disposal for producing energy and useful materials represents a viable means of conserving natural resources in these days of energy and materials crisis, preserving the quality of human environmeent and thereby resolving a critical waste disposal problem.

In this paper, the author discusses from his experience the operational parameters, organizations and administrative infrastructure, technologies, economic analysis and resource recovery of waste management systems. The paper also highlights the salient features of the waste management systems of some selected countries including Singapore.

INTRODUCTION

All human activities generate waste (solid, semi-solid and liquid) of varying quantity and quality. Each country generates a substantial quantity of wastes (Tables 1) creating difficult disposal problems. Waste disposal problem is a basic and universal problem which besets not only developed countries but the rest of the world as we . Explosive population growth coupled with extensive urbanization and industrialization has generated more waste thus imposing a financial burden on governments for the efficient collection and safe disposal of waste.

Table 1 Types of wastes and quantities generated in some selected countries (Wilson, 1981)

Description	Approximate quantities (million tonnes per year)									
	Britain	W.Germany	France	Netherlands	Belgium	Italy	Sweden	Finland	Japan	USA
Municipal wastes (household and commercial)	20	20	12.5	5.2	2.6	21	2.5	1.1	35	150
Industrial wastes:										
similar to municipal		8	24					2.5	13	
production wastes	45	13	16	2	1	19	2	-		60
sludges		7	8					-	125	
hazardous wastes	5	3	2	1	-	-	-	0.4	-	57
Pulverized fuel ash	12	-	-	-	-	-	-	-	13	-
Mine wastes	60	80	42	-	-	-	-	-	-	1890
Quarry wastes	50	-	75	-	-	-	-	-	-	-
Wastes from construction and demolition	3	96	-	6.5	-	-	-	0.3	75	-
Agricultural wastes	250	260	220	1	-	130	32	-	44	660
Sewage sludge	20	36	6.2	3	3	-	4	1.4	44	-

Everyday of the year, enormous waste is generated in each city that needs to be collected, transported and disposed of efficiently, economically and with the minimum of environmental hazards. If the whole operation is to function properly and efficiently, a good management system is required.

Waste management is concerned with the generation, collection, transfer and transport, processing and disposal of waste in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental conditions. It also encompasses all administrative, financial, legal, planning and engineering functions involved in solving the problems of waste thrust upon the community by its inhabitants. Ideally, waste management should be viewed as a unity with integrated quality control directed to all three waste receiving media namely air, water and land.

Problems associated with the management of the waste in today's society are complex because of the quantity and diverse nature of the waste, the development of sprawling urban areas, the funding limitations for public services in many large cities and the impacts of technologies. If the waste management is to be accomplished in an efficient and orderly manner, the waste collection and disposal systems chosen must be most appropriate for the local conditions and operated in an optimum way. The operational parameters and their relationships involved must be identified and understood clearly. Public attitude and concerns are to be regarded as crucial for the development of a sound waste management system.

A set of criteria for the assessment of waste management will normally encompass economical, technical, environmental, political, use and conservation of resources as given in Table 2. After all, the overall objective of waste management strategy is the disposal of waste at the least possible cost to the community with due regard to the safeguarding the environmental quality and the use of waste as a resource.

OPERATIONAL PARAMETERS

Various activities associated with the waste management from the point of generation to final disposal are grouped into four operational parameters: (1) collection, (2) transfer and transport, (3) processing and recovery and (4) final disposal. By considering each operational parameter separately, it is possible to identify the fundamental aspects and relationships involved in each of parameters and to develop where possible, quantifiable relationships for the purposes of making engineering comparisons, analyses and evaluations. This separation of operational parameters is important because it allows the development of a frame-work within which to evaluate the impact of proposed changes and future technological advancements.

Table 2 Criteria for the assessment of waste management systems (Wilson, 1981)

Economics

Capital costs
Land costs
Operating costs
Revenues:
  Extent of market commitment
  Stability of markets
Net cost per tonne
Net present cost
Sensitivity of costs
Uncertainty in cost estimates
Financing arrangements

Technical

Adequacy of the technology:
  Feasibility
  Operating experience
  Adaptability to local conditions
  Reliability
  Interdependence of components
  Safety
Potential for future development
Flexibility to cope with changes in:
  Waste quantities
  Waste composition
  Source separation of materials
Dependence on outside systems:
  e.g. vulnerability to strikes

Environmental

Public health
Water pollution
Air pollution:
  Dust
  Noxious gases
  Odours
Quality and quantity of residual wastes
Noise
Traffic
Aesthetics

Political

Equity between communities
Flexibility in location of facilities
Public acceptance
Number of jobs created
Employee acceptance

Use and conservation of resources

Products recovered:
  Market potential
Net effect on primary energy supply:
  Energy requirements
Net effect on supply of materials: on supply of
  Raw materials usage
Land usage:
  Volume reduction
  Land reclamation
Water requirements

To solve specific waste management problems, the various functional elements are combined in an integrated manner. The main goal of the waste management is the optimisation of these operational parameters to provide the most efficient and economic solution, commensurate with all constraints imposed by the users of the system and those affected by it or controlling its use.

ORGANIZATIONS AND ADMINISTRATIVE INERASTRUCTURE

There are often large number of organizations, both government and private who are concerned with waste: either as producers, handlers (collection, transport and transfer, disposal etc.) or recoverers (resource recovery). These likely to include private households, shops, offices and recreational centres, manufacturing industries, agro-based and agro-allied industires, construction and demolition, etc. There are then again the organizations responsibe for waste collection and transport which include the waste collection authority or authorities and private collectors. There are also the organizations with an interest in disposal. These are the disposal authority or authorities, organizations who own sites suitable for waste disposal and organizations (public or private) who may dispose of waste in other ways.

In addition to these organizations, which have specific interest in the waste management, there are the environment, health and other agencies whose activities are relevant. They include air and water pollution control authorities, landuse planning authority, energy and natural resources authorities, housing and urban renewal authorities, utility services authorities, and public health and social welfare authorities.

The above list is far from comprehensive but it does provide an indication of the wide variety of organizations and their possible interest in waste management. The administrative infrastructure of each of the organizations involved in the waste management is very complex and country specific depending upon the country's interest in preserving the environmental quality (Bidwell 1978, Wilson 1981).

TECHNOLOGIES

An enormous variety of technologies are either available or potentially available for the management of wastes. These technologies may be rationalized under a number of headings: (1) processes for final disposal, either of all the wastes or of any residue remaining after treatment, (2) treatment to achieve volume reduction prior to final disposal, (3) separation of the organic fraction of the wastes, (4) recovery of materials from the inorganic fraction, (5) recovery of materials from the organic fraction, and (6) reclamation of the organic fraction to produce either a fuel or a chemical product.

Fig 1 shows various waste management technologies along with their products and end-uses.

Thermal Processes

Thermal process includes direct combustion and pyrolysis. Direct combustion uses refuse derived fuel (RDF) as the source of greater than 50% of the heat input to the steam generator (Russell, 1977). This requires a steam generator designed specificially for the combustion of refuse when using RDF in its unprocessed form. Incineration is a direct combustion technique of refuse utilization for energy. Pyrolysis is a process of physical and chemical decomposition of organic matter present in the waste brought about by the action of heat in the absence of oxygen. The energy produced by pyrolsis processes generally varies according to the operating characteristics of a particular system. The efficiency of the pyrolysis system generally varies between 50% and 80%. Organic materials can be broken down into compounds which are either gases, liquids, or solids which can be used as a fuel source to generate power and steam.

Incineration is a proven method handling over 1,000 tonnes of wastes a day with considerable resource recovery (Anderson 1972, Wong 1977, Lau, 1980). The feasibility of energy recovery through incineration depends primarily on the properties of the wastes. The process becomes economical if the combustion is autothermic, i.e. if the waste can itself sustain combustion without addition of auxiliary fuel. The properties of waste which determine its potentiality as a fuel are its calorific value, moisture content, combustible and incombustible contents. Generally, combustion difficulties arise in an incinerator if (i) the nett calorific value of the waste decreases below about 4000 kJ/kg, (ii) the moisture content increases above 55%; and (iii) the incombustible content rises above about 25% (Fernandes 1977; Wong, 1977, Tehobanoglons, 1977, Aziz 1983).

Bioconversion Processes

Bioconversion process includes mainly composting, biological hydrolysis, anaerobic decomposition or digestion and sanitary landfill. Of these various methods, the anaerobic digestion method has been proved to be effective and economically advantageous for producing energy (alcohols, methane gas, etc) and other useful materials.

Composting is a bioconversion process whereby the organic omponent of the waste is biologically decomposed under controlled conditions to a state in which it can be handled, stored and/or applied to the land without adversely affecting the environment. The energy potential of this method is very difficult to tap but its final products (compost, humus and algae) have useful applications. This method has been found

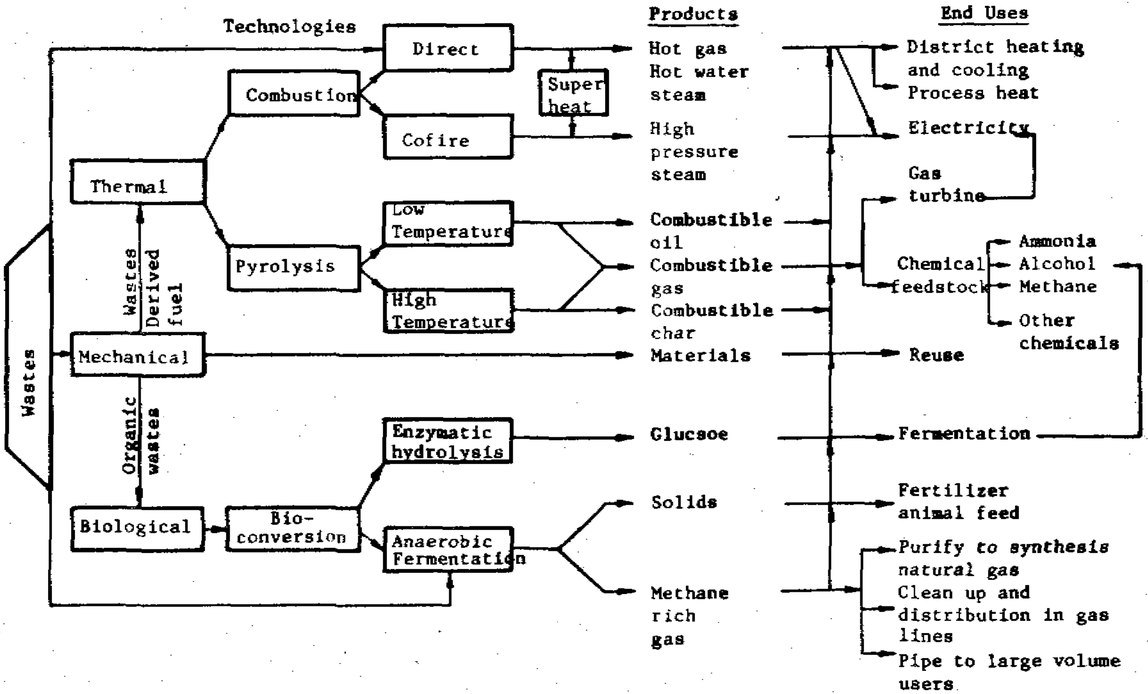

Fig. 1 Schematic diagram showing various waste management technologies, their products and end uses.

to be satisfactory for stabilizing parks and garden debris, cannery wastes, dairy and feedlot manure and human excreta as found in the so-called compost toilets. (Gottas 1956, Tietjen and Hart 1969).

Biological or enzymatic process of bioconversion of the wastes so far has been carried out on small pilot scale and the process designs are largely tentative in nature. The biochemistry of the process is very complex and a fair treatment of this aspect has been given by Rosenbluth and Wilke (1970). The process is divided into several steps and includes two basic inputs, namely, nutrients for the fungus and the waste organics to be hydrolysed. Studies by Mandels et al (1975) indicate that the greatest recovery of sugar is obtained when the waste is ball-milled. The enzyme production step, which is the major one in the process, involves microbial growth and subsequent enzyme production. The hydrolysis or saccharification step is accomplished by the enzyme solution which catalyses the hydrolysis of waste organics to a glucose product. Finally, the glucose solution is separated from the unhydrolysed waste organics by means of filtration. The glucose solution may be used as a carbon source in the production of yeast as a feedstaff for animals or for the production of ethanol through fermentation. The concept of reclaiming waste organics to an energy source in the form of ethanol by fermentation of sugar through enzymatic hydrolysis is relatively a recent one suitable for organic wastes.

Anaerobic decomposition or digestion is a term commonly applied in organic waste treatment to a process in which the wastes are stabilized through biological activity in absence of atmospheric oxygen within a specific temperature range with the concomitant production of methane and carbon dioxide. The process is usually carried out in a closed container known as digester. Of all the bioconversion processes, the anaerobic digestion process has been proved to be very effective and economically attractive for producing energy (alcohols, methane gas, etc) and other useful by-products from organic wastes (solid, semi-solid and liquid). The gas from this process is popularly known as "biogas". May studies have been carried out in the recent past regarding biogas mechanism and technology (Aziz 1982). Biogas plants are currently in use in many Asian countries and elsewhere. At present there are over 7 million biogas plants in China, 70 000 in India, 30 000 in Korea and 9 000 in Taiwan. (Polprasert and Thanh, 1979). Fig. 2 shows a multipurpose system of anaerobic bioconversion of wastes.

Land disposal of solid wastes in the form of sanitary landfill has been proved to be the most economical and environmentally acceptable method where sufficient land is available. Wastes placed in a sanitary landfill unergo a number of simultaneous biological, physical and chemical changes (Techobanoglous 1977). Among the more important of these changes are (a) biological decay of organic putrescible matter, either aerobically or anaerobically, with evolution of gases

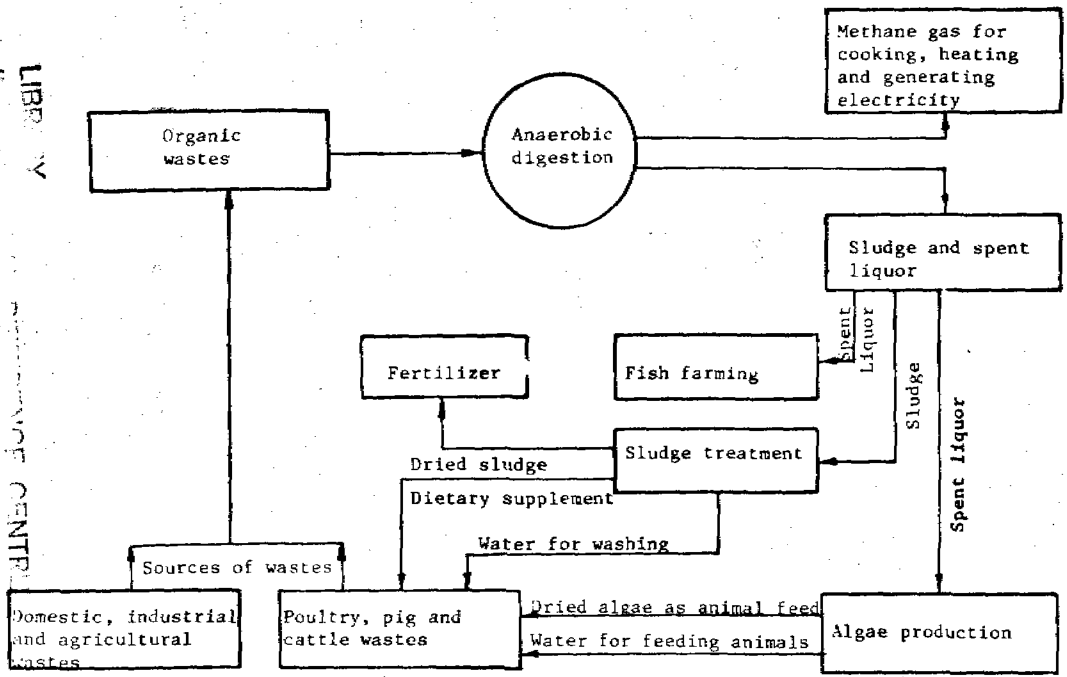

Fig. 2 Schematic diagram showing production of methane gas and useful by-products from anaerobic digestion of organic wastes

and (b) chemical oxidation of materials. The performance of the method depends on many factors such as composition of wates, degree of compaction, amount of moisture present, presence of inhibitory materials, rate of water movement and temperature. Gases produced in sanitary landfill include ammonia, carbon dioxide, hydrogen, hydrogen sulphide, methane, and nitrogen. Carbon dioxide and methane are the principal gases known as biogas which can be collected through properly located vent pipes for the production of energy. The process has got some draw-backs such as leachate contamination of groundwater, etc, but through proper planning, analysis, and design of modern landfill systems involving the application of variety of scientific, engineering and economic principles, the process can recover significant amount of methane gas for energy production.

ECONOMIC ANALYSIS

Economic analysis is one of the fundamental tools required in waste management. It is concerned with the assessment of the costs and benefits that are attached to any particular course of action in waste management programme. It provides a framework for bringing together the various functional elements that need to be taken into account in waste management from methods of handling waste to the amount of finance available and from environmental impact to the rate of cost inflation. By setting out systematically what are the costs and benefits of possible actions, the advantages and disadvantages of different waste management strategies can clearly be identified in order to find out the best solution to specific problems. The value of economic analysis is not only that it gives a guide to the best course of action by calculating the net costs or benefits of the different options availabele. Equally important is the fact that economic analysis provides a logical framework within which waste management problems can be examined. It shows clearly the significance of the different functional elements and so helps to enlarge understanding of the key issues and problems in the overall waste management programme of a country (Mason 1978).

RESOURCE RECOVERY

The energy and materials crisis has caused economic problems for many countries worldwide, esepcially poor countries that depend a great deal on imported oils. Waste is not only a contributor to the environmental pollution but also a valuable resource which is an alternate source of energy and useful materials. Many countries in Asia, America and Europe have been producing energy from wastes thereby preserving environmental qualtiy. The following are some examples of environmental pollution control through the production of energy and useful materials from wastes:

The waste treatment for pollution control and energy recovery system for the Bacardi Corporations Rum Distillery in San Juan, Puerto

Rico, uses anaerobic digestion to treat distillery wastes and to produce methane gas for use as the boiler fuel (ASCE 1984). The system currently supplies the equivalent of 800 million Btu's daily, providing an annual estimated fuel saving of US$1 million. Simultaneously, the total waste loads for disposal have been reduced considerably and thereby the operating cost is very low. This system of treatment and energy recovery has a good promise for its widespread applicability for producing energy from organic by-products discarded by manufacturers and processors of food and fruit products, alcohol, grain products, paper, pharmaceuticals and other organic materials. In fact, the process has vast potential for many industries for producing energy and solving environmental polution from wastes generated by them.

America's biggest garbage dump (sanitary landfill) located about 22 km South-East of Los Angeles has been turned recently into an electrical generator producing enough power (2.8 MW per day) for 5,600 homes by burning the methane gas emitted by 10,000 tonnes of trash per day (Whittier 1984). This Puente Hills landfill methane station uses a new power producing technology which burns methane gas in turbine engines similar to jet engines. The plant expects to earn US$3,000 per/day by selling power to the Southern California Edision Co. Within two years, the dump is expected to produce enough power to supply power to 50,000 homes and in five years, should be earning nearly US$9 million per year. Many other US cities' dumps (landfills) are expected to go on line, before the end of decade, to produce power from their garbage. Garbage is, in fact, highly polluting but its pollutional characteristics can be controlled by processing it to recover energy.

Japan has pioneered some of the technologies for converting various waste materials into energy. It has been producing 750,000 to 2,500,000 m^3 of gas per year with a methane content of 50 to 60 percent, mainly fermenting industrial wastes, particularly from the alcohol distilleries, in large digesters capacity ranging from 660 m^3 to 5,000 m^3. The gas is used to heat boilers to produce steam and also partly it is used for generating electricity. In addition, Japan has started producing energy from other forms of waste materials like various agricultural, forestry and fisheries wastes, sewage sludge and other agro based and agro-allied industrial wastes. Moreover, Japan has been producing a substantial electric power by incinerating about 70 percent of its total garbage generated daily. Mention may be made of "Stardust '80", an experimental pilot plant built at a cost of US$180 million in order to recycle garbage to produce gas, paper pulp and compost (Hiraoka, 1983). Japan's main target is to control environmental pollution through the recycling of wastes and thereby making pollution control facilities economically attractive.

China has been successfully managing its huge wastes by producing methane gas and fertilizers. At present there are over 7 million biogas plants all over the country to take care of the wastes benefitting about 30 million people with gas and electricity for heating, cookig and lighting (UN/ESCAP 1975).

Singapore case

Singapore, an island-city state, generates a substantial quantity of wastes (solid, semi-solid and liquid) through various industrial, commercial, agricultural and other human activities. Current daily generation of refuse alone is more than 3000 tonnes. In addition, over 800,000 local pigs generate around 14 million litres of wastewater daily from their sites which can produce a year more than 6 000 tonnes of BOD, 20000 tonnes of COD, 1500 tonnes of nitrogen and 600 tonnes of phosphorus (Aziz 1983). In addition, it can generate substantial quantity of methane gas which can be tapped to yield more than 5,000 kilo-calories per cubic metre of energy. Huge quantity of fowl waste produced from over 12 million local poultry needs a number of lorries daily to cart them away. Moreover, a substantial quantity of waste is also generated daily from food and fruit processing plants and from varieties of industrial processes along with a huge of quantiry of domestic and industrial wastewaters.

Singapore has developed a well-planned waste management system in order to utilize its huge wastes for the recovery of energy and useful materials and thereby solving acute waste disposal problems. In Singapore's waste management system, two techniques namely thermal destruction (incineration) and anaerobic digestion have been adopted.

Singapore has currently one incineration plant consisting of 4 boiler units, 400 tonnes capacity each. The plant is currently producing about 16 MW of electricity from a steam flow rate of about 120 tonnes/hr along with around 32 tonnes of scrap iron and 200 tonnes of incinerated residue by incinerating 1600 tonnes of refuse per day (Leong and Ching, 1984). Total expenditure of the plant was about US$60 million. Total annual recurrent operating expenditure amounts to around US$2.40 million while the annual revenue from the sale of electricity, scrap iron, and refuse disposal fees collected from private waste-carriers totals around US$2.50 million. The sale of electricity alone contributes around the 88% of total revenue received. The current cost for incinerating one tonne of refuse is around US$12 (Leong and Ching, 1984).

Another US$110 million incineration plant of 2000 tonnes capacity per day is under construction and it will be under operation by the end of 1986 (Ching 1983). The two incinerators jointly will be able to handle around 3600 tonnes of refuse per day.

Singapore has also been producing considerable amount of methane gas and fertilizers by digesting sewage sludge from is wastewater tratment plants which currently generates 40 to 60% of the power required by the plants themselves (Hang, 1981). It is also expected that a significant quantity of energy will be produced by decomposing anaerobically the wastewaters from pig firms which have been relocated in a designated area to control environmental pollution. By the end of this year, each pig firm will have a modern waste treatment facility which will be able to produce methane gas, fertilizer, and algae. (Gamboa 1983, Taiganides 1983).

Useful materials (toilet rolls and wrapping papers) are also produced in Singapore from waste papers. Some local Waste Paper Co. processes about 30 tonnes of waste paper per day to produce about 5 tonnes of white toilet tissue, 6 tonnes of wrapping paper and 10 tonnes of single-ply white tissue paper. The price of one tonne of waste paper ranges from US$220 for the poor quality mixed paper to US$250 for the highest quality pure white waste paper. But the price per tonne of finished products are as follows: US$365 for the brown wrapping paper, US$820 for the first grade pure white tissue, US780 for the second grade, and US$635 for the third grade. (Aziz and Tay 1983).

CONCLUSIONS

Waste management technologies have advanced significantly in recent years. Properly planned waste management programme can have profound impact on shaping the economic growth and social pattern of a country and also on safeguarding public health and environmental qualtity. It requires many difficult and complex trade-off decisions to adopt appropriate technologies in the total waste management programme of a country in order to balance various environmental parameters within economy. These decisions should be based on sound judgement, judicious organizational and administrative infrastructures, objective technologies, appropriate standards, and design criteria, and cost-benefit ratio, and should only be made after proper evaluation of relevant aspects. The prudent approach in waste management programme should be to utilize the country's total waste for useful purposes in order to make the waste disposal safe, efficient, eonomically attractive and environmentally acceptable.

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TREATMENT OF WASTEWATERS OF DYE MANUFACTURING FACTORY : AN APPROPRIATE TECHNOLOGY - CASE STUDY

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INTRODUCTION

In most developing countries, the protection of the environment against pollution caused by industrial wastes is considered as a difficult and expensive activity which may need the import of foreign technology. This idea usually leads the responsible administrators of industrial establishments to avoid from taking any action against pollution, unless they are forced by the official authorities to do so. One exception to this general trend was the DYO/YASAŞ paint-varnish plant in Dilovası-İzmit, which is one of the first factories in Turkey to build a wastewater treatment plant before starting production.

The main idea behind the whole project was to make a treatment plant which would fit into the local conditions, and would have minimum dependence on foreign equipment. The method of approach followed for the realization of this project is summarized in this paper.

GENERAL INFORMATION ABOUT THE FACTORY AND CHARACTERISTICS OF THE WASTES

The factory employs 220 persons and produces synthetic and emulsion paints and PVA with a total capacity of 1000 tons/month.

The main constituents of the paints produced are pigments, filling material, PVA and water. The amount of wastewater was estimated to be 25 m^3/day of domestic and 35 m^3/day of industrial origin.

Since the factory was not in operation, it was not possible to collect samples for the determination of the characteristics of the wastes. According to the information obtained from the factory personnel, there were large variation in the manufacturing process and a large number of constituents were used in the production. For these reasons, typical values cited in literature for the wastewater characteristics of a paint manufacturing plant were not considered as reliable. Information obtained from dye experts indicated that 98% of the industrial wastes originate from the washing of the tanks in which the paint is prepared. Usually the water used in the washing process contains 0.5 to 1% by volume of the product produced.

PRELIMINARY TREATABILITY STUDY

Before a detailed design of the treatment plant was made, a treatability study was performed by Curi et al. (1983) upon the request of the factory administrators. In this study, the most appropriate coagulant was determined and the treatability of the supernatant after coagulation by biological means was examined.

a) Coagulation Studies

Artificial wastewater samples were prepared by mixing the dyes produced by another dye manufacturing plant using a similar process. 1 part red, yellow, green, blue, white and plastic dyes, and glue and synthetic mortars, and a combination of all these were mixed with 99 parts of water to obtain a sample having a 1% strength. Jar tests were performed using $Al_2SO_4 \cdot 18H_2O$, $FeCl_3 \cdot 6H_2O$, $FeSO_4 \cdot 7H_2O$, $Ca(OH)_2$ and $Al_2SO_4 \cdot 18H_2O$ and $Ca(OH)_2$ and Celite Floc 231 (polyelectrolite) as coagulants. Results obtained indicated that $FeCl_3 \cdot 6H_2O$ was the best coagulant with the optimum dosage varying between 35-70 mL/L for a 10 g/L $FeCl_3 \cdot H_2O$ solution. The optimum dosage was determined as 60 mL/L for the combined artificial wastewater.

The characteristics of the supernatant remaining after the completion of coagulation and sedimentation are given in Table 1.

Table 1. Characteristics of supernatant after coagulation (mg/L)

Product	BOD	COD	Total Iron	Nitrate	Nitrite	Orto-Phosphate	pH
Green Dye	510	1220	0.2	1.5	-	0.35	6.8
Blue Dye	630	1892	0.1	1.7	-	0.6	6.8
Red Dye	720	1912	0.25	3.5	0.01	0.2	6.4
White Dye	360	1111	0.05	1.25	0.01	0.6	6.4
Yellow Dye	840	2095	0.13	1.75	-	0.25	6.6
Glue	330	1381	0.3	1.5	-	0.2	6.4
Syn. Mortar	210	814	0.08	2.0	-	0.1	6.4
Composite	480	1156	0.05	1.0	-	0.3	6.4

Curi et al. (1983) have recommended the reuse of the effluent from the coagulation process for cleaning the dye mixing tanks. It was claimed that this will not only minimize the amount of water used, but will also decrease the amount of coagulants required and the amount of pollutants discharged. They have also recommended the investigation of the reuse of the sludge produced at the end of the coagulation process.

b) Biological Treatment

Treatability of the supernatant remaining after coagulation by biological means was investigated by Curi et al. (1983) using a laboratory scale activated sludge model. Mixing this supernatant with domestic sewage in a ratio of 1:1 and aerating the system by diffused air has resulted in a COD removal efficiency of 85%.

TREATABILITY STUDY PERFORMED BY ENVITEK A.S.

After studying the report by Curi et al. (1983), ENVITEK A.S. has decided to investigate in their own laboratory the possibility of treating a mixture of industrial and domestic wastes (1:1 ratio) by biological means without any pretreatment such as coagulation. The results obtained have shown that such an approach would not give satisfactory results.

DESIGN CRITERIA

Using the information obtained through the preliminary studies, ENVITEK A.S. has decided to use the treatment system whose flow diagram and outline are given in Figure 1. As the biological treatment, the extended aeration process was chosen because it minimized the sludge disposal problems and due to the relatively small flowrate big reaction volumes were not required. The main concerns in the design were to minimize the energy requirements; to use locally available machinery as much as possible; and, to minimize the overall cost of the plant. To achieve these objectives, the following steps were taken:

a) The mixers used in the coagulation tanks were constructed locally;

b) The coagulation tanks where the mixing was taking place were also used as sedimentation tanks;

c) Diffused air system was chosen as the aeration technique. The diffusers were simple galvanized iron pipes with small holes opened at close intervals. Although this was not the most efficient way of aeration, it was considered as the most reliable method of aeration that could have been applied, using only materials available in Turkey.

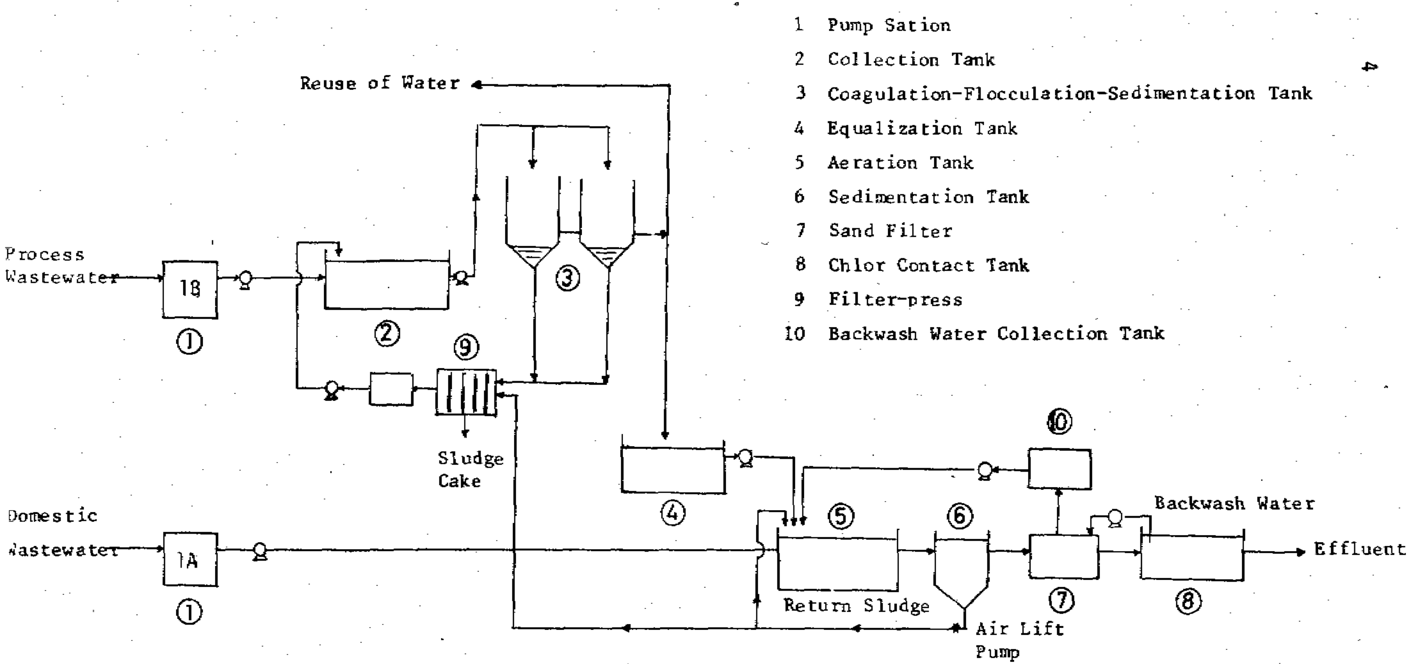

Figure 1. Flow Diagram of Treatment Process

d) Filter-press was used for drying the sludge produced. The main reason for choosing this method was the availability of filter-press in Turkey. It is interesting to note that the filter-presses produced in Turkey were used mainly in the soap and oil industries. The availability of these presses were not known to environmental, neither the filter-press manufacturers were aware of the possibility of using these machines for sludge disposal. This lack of information has prevented the use of filter.press in wastewater treatment, and according to the knowledge of the author, this was the first time that such an application was realized in Turkey.

The factory authorities not desiring to have any automatic control mechanism, the whole system was prepared to be controlled manually. Thus, the lack of an automatic dissolved oxygen control system occasionally results in a superfluous energy consumption. To overcome this difficulty dissolved oxygen levels are determined and the oxygen requirements are manually controlled.

TREATMENT PLANT CONSTRUCTION

The treatment plant was constructed using entirely local technology and personnel. The coagulation tanks were made of steel, while the remaining tanks were made of concrete. All motors, pumps, compressors, etc. were procured from the local market. So the plant was constructed by using 100% Turkish materials.

OPERATION OF THE PLANT

It is interesting to know that the operators of the plant are people having only primary education. ENVİTEK A.S. being aware that this will be the quality of man-power available has prepared a very comprehensive operation and maintanance manual (ENVİTEK A.S.,1984). This manual attracted the attention not only of the operators, but at the same time of other engineers in the factory. Thus, the basic knowledge required was conveyed. Furthermore, an on-the-job training program was also realized. Now, the personnel is able to operate the plant satisfactorily. Results obtained have indicated that the effluent of this treatment plant has the following characteristics.

BOD_5 = 30 mg/L

COD = 84 mg/L

SS = 5 mg/L

This is a clear indication that the plant is operating with an efficiency of 95% (BOD removal).

CONCLUSION

The design, construction and operation of DYO/YASAŞ wastewater treatment plant indicated that

a) The design of such a plant using only local technology and personnel is possible; and,
b) The proper operation of a treatment plant even by primary school graduates is possible, provided that proper supervision and training are given.

The approach followed to solve the wastewater treatment problem of this paint-varnish factory, is an example indicating that wastewater treatment may be achieved by the technological means available in developing countries.

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ENVIRONMENTAL CONSIDERATIONS IN PLANNING, DESIGN AND MANAGAMENT OF DAMS

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SYNOPSIS

As a consequence of the launching of the International Water Decade many new dams will have to be built. It is essential that attention be given during planning, investigation, design and management of these structures to their environmental effects.

The introduction of a dam creates changes in the valley upstream and downstream; stored stationary water replaces a flowing stream which consequently changes the marine population and the flora and fauna in the vicinity. People who have lived and toiled in the valley to be submerged will be displaced and require sympathetic consideration. For drinking water supply storages it is necessary to remove trees in the area to be submerged. Timber from this operation should not be wasted. Tree cover or lack of vegetation of the catchment has an effect on the run-off and on the micro climate. Anthropological and archaeological treasures must be protected against submergence. A policy must be established with regard to the recreational use of the catchment area, the man-made lake and the dam site. The flora and fauna around the dam will be changed and native species will need protection. Tourism is likely to be introduced and will need to be catered for. The authority responsible for the new dam must ensure that adequate provisions are made for drought conditions and for flood mitigation. Awareness of dam safety is becoming increasingly important. To make a dam a multi-purpose project, including hydro-electric use of the water resources, is environmentally desirable. The aesthetics of the various aspects of the dam and the approaches to it must be given attention.

If the many multi-disciplinary aspects of environmental implications of the dam to be built and the storage to be managed are kept in perspective and given due consideration at all stages, a structure beneficial to the river basin as well as providing life-giving water, can be created and maintained.

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THE INTERNATIONAL WATER DECADE

The International Water Decade was officially launched in a special ceremony at the General Assembly of the United Nations in New York on 10th December 1980. During the ten years following the declaration a dramatically increased effort in the field of drinking water supply and sanitation is intended so that by the end of the period everyone, notably people in the developing countries, will have access to safe drinking water and adequate sanitation facilities. About 2000 million people, who are without water or sanitation facilities now, will be reached [1]. The Decade will assist in the essential advancement of well being of people throughout the world. The development will demand significant work by water supply engineers in all countries. Many new dams will need to be constructed for the abstraction of available surface waters. These dams will be built under the direction of engineers, concerned essentially with technical requirements.

In the last decade or more there has been a growth of recognition of the importance of environmental factors. Laws for the protection of the environment were introduced, and protection agencies and procedures were established in many countries. [2] and [3]

Arising from these developments, it is important that, where dams are proposed, their environmental implications are considered. Where dams are in existence they have to be maintained and attention to the environment is still tantamount. If attention is given to the environmental effects of the dams it will further enhance their value to society.

Building dams and their management will not be the only activity of the Water Decade.

DAMS AND RIVER BARRAGES

As is common knowledge, dams are erected to ensure that water is available for people's usage whenever needed independent of seasonal fluctuations. These barrages will be arranged at suitable locations in the course of the river with facilities for water draw-off as required. In such installations careful consideration is given to the technological aspects of positioning them and their construction. Extensive investigations are correctly devoted to establish geological strata, topography, hydrology, access, relative costs, etc. It is essential that the environmental implications in ecological, social, meteorological, anthropological and aesthetic aspects are also given consideration in the analysis.

Once the location has been fixed it must be anticipated that the construction of the dam will bring about certain changes in the river basin upstream and downstream and a man-made lake will develop.

CREATION OF THE LAKE

The submergence of the valley upstream of the dam causes swamps, agricultural, forest and grass land to disappear and to be replaced by an expanse of water which may extend many hectares. The previously running stream becomes a lake with almost stationary water. Different types of fish and marine population now replace those that formerly dwelt in the flowing river. The consequences of this ecological change is environmentally significant and deserves special attention in management.

The social effects of submergence can be catastrophic to the people who have gained their livelihood from the land for many generations. The flooding of the valley forces them away from their traditional land and homes. This enforced displacement, even where resettlement is provided, is distressing to the population involved. Early action to advise these people and guarantee of adequate compensation is therefore paramount. This has not always been adequately observed.[4] There are, however, also many examples where the disturbance of land ownership has had little adverse affect on the farming community.[5]

TREE REMOVAL AND TREE PLANTING

Where water storage is planned to provide drinking water it is essential to clear most of the trees from the area to be submerged because:

(i) the drowning, rotting trees would affect the quality of the water;

(ii) logs and dead branches would be likely to drift downstream to the dam where they might cause damage to the outlet works or obstruct flood gates.

This tree removal can be a major task, depending on the size and accessibility of the area, topography, age and density of the forest. The cleared timber should be used extensively for construction and other purposes and no effort should be spared to ensure that the logged timber is not wasted.

Around the periphery of the top water level of the storage the retention and possibly planting of additional trees is desirable. This will give protection against bank erosion and will enhance the lake aesthetically.

The retention of trees and forestry operation throughout the catchment has important environmental results and needs extensive investigation. Much has been written about the effects of agriculture and silviculture on run-off. The effects of land use on water quality including aspects relating to tree growth was recently examined for Australian conditions by the Water Research Foundation of Australia [6].

The hydrological influence of extensive tree cutting is difficult to assess and can be influenced by rock stratification topography and many other details. A relationship exists between the micro-climates of forested and denuded land. Little research has been done on the climatic effects of introducing man-made lakes. It is an established fact that run-off from cleared areas is much greater than that from forested lands. Studies of this aspect date back to at least the turn of the century, the earliest known being the Wagon Wheel Gap Study of 1911 in Colorado, U.S.A.[7] Since then a great number of observations have been made throughout the world. [8]

Horticultural management can play an important role in the maintenance of quantity and quality of the water available throughout the life of the project.

ARCHAEOLOGICAL & ANTHROPOLOGICAL RELICS

The prevention of the loss of archaeological and anthropological relics is historically important. The most famous example of this being successfully achieved is the case of the Temples of Abu Simbel, removed bodily and reassembled on higher ground so that they are not flooded by the waters of Lake Nasser.[9] & [10] In other places, locally important monuments such as Australian Aboriginal relics were allowed to be submerged.[11]

Recently construction had to be halted on a hydro-electric project in Sweden to protect Sami (Lapps) archaeological finds. [12]

Greater awareness in this sphere has brought about a thorough archaeological survey in the vicinity of the recently completed Mangrove Creek Dam in N.S.W., Australia. As a result of the survey many Aboriginal shelters, artefacts and tools were found and records of occupation going back at least 14,000 years where established. [13]

In most states in Australia it is now accepted practice to investigate areas which are to be used for dam construction to locate Aboriginal sites and carry out archaeological and anthropological work. This practice of preparing a thorough survey of archaeological and anthropological relics should be adopted in all countries.

RECREATIONAL ACTIVITY

The possibility of recreational uses of the introduced body of water is significant, bringing many managerial problems which may be solved in a variety of ways. Many local conditions will influence the choice of solution. To completely bar the public from the water, the shore and a wide strip of land from the water's edge is an extreme form of management. The other extreme is to give general access and allow any and all sorts of water sports on the lake. Between these extremes there is a variety of alternatives. The choice must give environmentally suitable results without detriment to the water quality. The correct decision will require good environmental judgement, foresight and technical expertise.

Once the lake is made available to the public for recreational activities such as swimming, fishing, boating and sailing amenities for visitors must be made available. The construction of a dam with well engineered roads leading to it will attract sight-seers to inspect the new technological feature. This will create tourism with transient visitors being drawn to areas which were previously out of their reach. The need for the provision of facilities for these temporary visitors is essential. Special areas must be provided and equipped with tables, benches, toilets, etc. to prevent pollution of the shoreline of the lake and the water.

The development of catchment areas as national parks is advantageous and will need to be planned at an early stage, but might be achieved by management later.

Land use must be constantly monitored in established catchments to avoid erosion of the land and shore of the lake as well as preventing pollution of the storage.

Multiple usage of reservoirs, particularly recreational use has been the subject of extensive international discussion. [14]

FLORA AND FAUNA

A change in the flora and fauna in and around the introduced water is inevitable. Adequate protection of the native animals and efforts to prevent the introduction of feral cats, pigs, dogs and goats is important. This is especially necessary when the area is likely to be developed as recreation or national park land. Great care is essential to ensure the prevention of bush-fires and should any start they must be promptly put out. Provision for fish to pass upstream beyond the dam for spawning and return to the sea after hatching needs careful consideration. Construction of fish ladders is very costly and may in some cases be considered unwarranted.

THE VALLEY DOWNSTREAM

Flood mitigation is an important function of the water intake structure. The necessity of installing some form of flood protection is paramount because omission can lead to tremendous environmental and economic damage as well as loss of life. It is essential that flood gates are consistently and correctly operated. By keeping inundations to a minimum agriculture can be significantly encouraged in the usually rich soil of the flood plains.

Hydrological analyses based on streamflow data and compared with precipitation and evaporation records are a familiar technological method to ensure sufficient reserves in the water storage in the event of drought and to minimise inundation of the valley downstream due to flooding. Clear instructions for correct operation of spillway gates on the dam in the event of anticipated or occurring floods are essential. The successful management of this part of the structure will result in minimal losses of stored water and/or little disturbance of agriculture. [15]

The introduction of a dam or river barrier with water being diverted for community or other uses will significantly alter the regime of the river downstream. Consideration must be given to the consequences of reduced flow in the valley below. Insufficient dilution of polluted discharges and tributaries and the denial of riparian right to agricultural users along the stream are important aspects which must be dealt with. Bypass conduits with controls can be incorporated in the dam and operated as required.

DAM SAFETY - MULTIPURPOSE USE

The size of dams has increased steadily in recent years and the valleys below have become more densely populated and existing dams have shown evidence of ageing. Dam safety is important as its neglect is a threat to people and the environment. This has been pointed out by international committees [16] and in Australia [17]. "The recent catastrophic failures overseas at such modern dams as Malpasset, Vaiont and Baldwin Hills should remind engineers ... that the price of safety is continual vigilance."[18]

The danger to life and environment from any threat of a dam failure is evident. Much research work has been done to improve dam safety. The first study of dam failures was published by the International Commission on Large Dams (ICOLD) in 1974.[19] A consequent reduction in dam failures during the last three decades has been observed.[20] Continuous vigilance is constantly required and much work is carried out under the auspices of national committees on Large Dams.

To make any scheme a multi-purpose project is not only environmentally desirable but provides economic gain.[21] The incorporation of a hydro-electric power station in dams presents a more complete use of the resource.

Regular operation of a hydro-station where appropriate will also contribute to more regular river flow downstream. Hydro-electric power stations are used essentially at times of peak demand only, thus saving much installation and operating cost. Energy from these power stations is almost instantly available to be fed into the grid.

Where the storage is essentially for drinking water supply, the use of water for power generation reduces the capacity available for protection against depletion in drought conditions. The extent of water available for hydro-electric energy production needs to be subjected to review from time to time. Consideration of multi-purpose use of a dam to be built can bring about important economic and environmental benefits.

AESTHETICS

Aesthetic effects though difficult to define are environmentally important. In the construction of Libby Dam in U.S.A. the architect was commissioned "to prepare a basic plan that combined the beauty of the site with the forcefulness and simplicity of the dam structure", thus making aesthetics environmentally significant.[22] At the same dam, details of the relocation of the roadways to suit the newly created lake were also examined with regard to environmental effects of their construction and final location.[23] Good management involves a constant watch on likely inroads on aesthetic qualities of the site.

A USEFUL PUBLICATION

The International Commission on Large Dams (ICOLD), Committee on Damming and the Environment, recently published "Dams and the Environment".[24]

This publication provides a vast amount of useful information and guidelines for an approach to the examination of environmental considerations where a scheme for the damming of a river is proposed or in management of such a structure. It is in both English and French, like all ICOLD publications.

"Dams and the Environment" is a useful booklet for the analysis of the influence to be expected from the introduction or existence of a dam on its environment. It is easy to use and is highly recommended. It could be used to advantage by authorities engaged in building dams and organisations maintaining such structures.

Recently some of the items mentioned in the brochure have been expanded and commented on by the author.[25]

POLITICAL INVOLVEMENT

Recently in Australia considerable agitation was caused by an instrumentality which insisted on trying to build a dam within a World Heritage area. This and the lack of adequate investigation of environmental aspects caused serious concern. A large percentage of the population of the whole of Australia became involved in the question of whether or not to build the dam. The originally political question was finally settled by a majority decision of the High Court of Australia which determined that work on the Gordon below Franklin Dam was illegal.[26]

SUMMARY AND CONCLUSIONS

Throughout man's history river barrages have been most important in river basin development. In this brief analysis some of their environmental implications have been examined. These implications require attention in many disciplines.

The introduced structures will affect the ecology of flora and fauna in the river basin. The water quality upstream and downstream of the dam will be altered and if the water is to be used for drinking water supply, regular careful chemical and medical scrutiny is essential. The structures have social and economic implications for the community. The whereabouts of ancient historical monuments and relics in the vicinity may not always be known and their location must be established. Where they are threatened by inundation, construction and other consequent activities, it will be necessary to move or protect them. They must always be treated with respect.

The use of the man-made lake for recreation and access to the catchment area are important considerations which require detailed planning at an early stage. Sound environmental management of the completed structure will enhance its value to the community it serves. Monitoring of the lake and the catchment are important tasks which should be maintained throughout the life of the dam. Other aspects which are environmentally significant to the river basin development are the incorporation of a hydro-electric power station in the dam, safety of the structure, flood protection and management to ensure that adequate storage is available for possible long-term drought conditions. Many of these considerations are not mutually compatible.

In most countries throughout the world many new laws to protect the environment have been introduced in the past decade. Many will have a bearing on the new and existing structures and need careful examination. The aesthetic design of the functional engineering structure becomes a significant architectural obligation.

Some useful guidelines for environmental analysis are available from ICOLD. Lack of consideration of the environment can have serious political implications.

If these multi-disciplinary aspects are given appropriate priority and are fully explored in the planning of the river basin development before the project hits the drawing board, the environmental implications of the completed structure can be expected to be beneficial and not detrimental. Similar vigilance needs to be maintained to achieve successful management of the completed structure.

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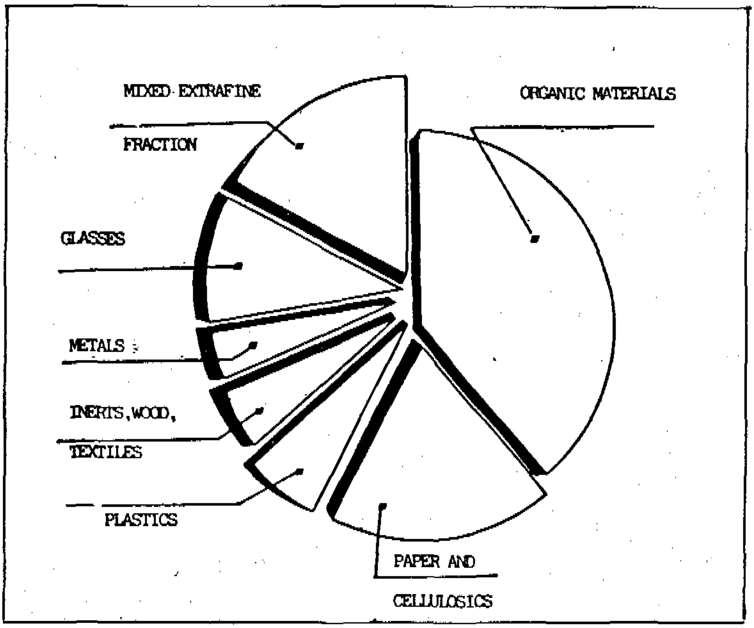

FIG.8- AVERAGE COMPOSITION OF ROME MSW

ANALYSIS OF FUNCTIONALITY OF THE PROCESSES

Finally the causal, spatial and temporal distribution of the production shutdowns were examined.

This permits the reliability to be assessed of the various section of recycling plants which, due to their nature and to the differing types of material, have operational levels which cannot be compared with other industrial sectors.

The assessment system used is basically statistical. Fig. 14 illustrates the temporal utilization in different operating conditions (measured as hours of monthly activity) corresponding to process, management or plant engineering choices, both theoretical and real, while Figs. 12 and 13 give a breakdown of the main groups of reasons for production shutdowns (reductions for losses, values (4) per sector and

...ECTS AND BUDGET OF M.S.W. RECYCLING IN ROME PLANTS

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SUMMARY

Studies and research on solid-waste recycling are appearing with ever increasing frequency in specialized literature; few of these serve as a cognitive support on an industrial scale.
This work, on the contrary, presents the results of an analysis carried out directly on the Rome disposal plants, and therefore has a particularly significant documentary value. The summarized technical indications provide, in the authors' intentions, new and more up-dated information on the major Italian recycling plants.

FOREWORD

In the constant evolutive process of industrialized society and of its production technologies, new remedies and new combinations are continually appearing in every sector concerning raw materials, aiming at obtaining products which accomplish the same functions in the different techniques of material life at a minor cost.
During the succession of tecnological changes which accompany this growth new goods appear on the scene, others disappear with different rhythms and on different scales, thus influencing the many segments of the production structure in an unequal manner.

The final sector of the "life" of a good, its "refuse" stage, is consequently subject to rapidly variable influences of indication, intensity and direction, especially if one thinks that by now it is universally agreed that it should in some way be reinserted in the cycle.

Focussing on the disposal of solid waste, one sees how both the routine management and development prospects of a complex of reclamation-recycling plants are connected by numerous functional links, upstream with the production of goods (which have become refuse) and downstream with the market of recovered products (which have become values).

The economic and production choices in this particular industrial process are based on three categories of judgement: economic, technical and finally that on which sanitary engineering is based.

Even so, it is difficult to generate concrete decisions when one has to tackle phenomena which move at varying speed on three axes of reference: quantitative or that of dimensions (quantity, volume, consumption, costs, etc.), qualitative or that of characteristics (chemical and physical, product class, states of aggregation, etc.) and temporal or that of variability on which the previous parameters modify and evolve.

PRESENTATION OF ROME PLANTS

Those who wish to have an outline of the reasons for the choice of recycling and detailed information on the main features of the system can find them in works [1, 4.1, 8.3]; in fact in this study the results of a three-year management of the Rome MSW treatment plants are discussed.

It is however helpful to describe them briefly: they involve two industrial complexes situated on opposite sides of the city centre, set up in successive stages from the first years of the Sixties. They currently comprise nine production sections, linked up to each other, for the automatic selection from urban solid waste (MSW) of paper pulp, compost, ferrous materials, plastic and technological steam at 7 atm. They have been managed since 1979 by So.Ge.In., a limited company with mainly municipal public capital, which has over 500 employees.

AIMS AND METHODOLOGIES USED

The elements gathered by the Technical Direction of the Rome MSW disposal plants during this first three-year management period were originally collected and analyzed with the aim of redesigning the treatment lines, which had become less reliable due to the progressive ageing and the modifications undergone by the recycled products market [1, 3, 6]. The operation meant that new, less aggregate cognitive data could be supplied on the normal "recycling cost" in Lit/tonnes disposed off to those who have to put into practice the three typical aims of the sector: "always and anyway" disposal, minimum cost of treatment, industrial entrepreneurial aspect integrated and corrected by the public worth of the service.

This survey-diagnosis was returned in quantitative, economic and energy terms. However, [1, 3, 4.3., 6] and [8.2] should be referred to for information on the basic problems of the Rome plants. Each of the analyses carried out on the complex MSW treatment system operating in Rome has allowed us to render even more evident some of the already-known phenomena [4.1, 7, 8.2 and 8.3.] (Fig. 1).

Of these phenomena, the first is linked to the quantitative measurement of the flows involved and their evolution in time, the second concerns the measurement of the processes in energy terms, and the third the technico-management and sanitary reliability of the structures.

This work can have a particular documentary interest in this stage of the "market" of solid-waste treatment, in relation to the recent law 915 passed in Italy, which will have both the effect of speeding up the implementation of treatment plants and re-opening (if it has ever been closed) the technical debate on the technologies available, their problems and the cost-benefit balances.

It should not be forgotten how the "dioxin" case and the renewed interest for environmental impact have dispersed technicians in the sector over a wide range of options and "schools", also as regards the lack of data available and measured on the various methods and on scarcity of comparisons with real cases [8.3].

QUANTITATIVE ANALYSIS

The city of Rome and the surrounding municipalities produce and deliver to the plants about 900,000 tons of MSW annually (fig. 6 and

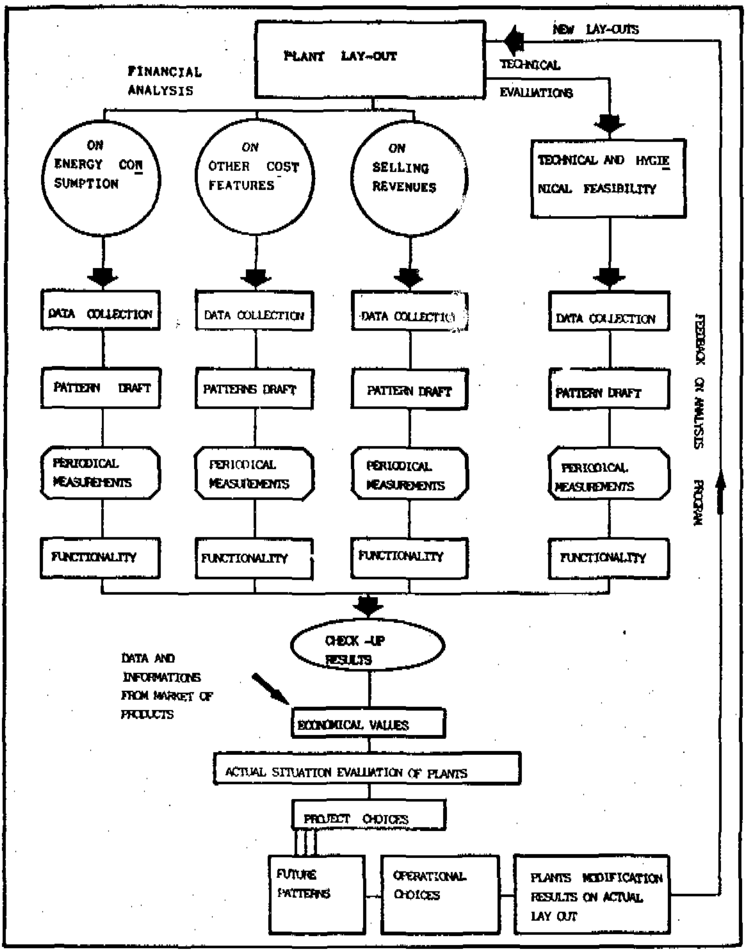


FIG.1- ANALYTICAL METHODOLOGY USED

7); if we add to these bulky waste, those selected upstream of the undertakings or private firms and those which are "indipendently" disposed of, we reach a total of 1,000,000 t/year equal to about 900 g/pop.die.

Together with this amount, there is the regional quantitative availability of at least 200,000 t/y of MSW, given the polar function of the Rome plants in a territory such as that of Lazio which has no other waste disposal technological plants [2,3,8.2.] We are now in the operational stage for exploiting economies of scale offered by Rome in a provincial project of waste disposal 8; in fact, 30 municipalities and more than 40 boards and industries currently send their MSW to the Roman plants [2].

The MSW production goes, by trucks, for six days a week, to the two treatment poles "A" and "B" in which two types of output flows are formed: commercial products and sundry discards.

Taken for known the technologies used in the plants under examnination [1] summarized in figures 2 and 3, the division of the flows of materials in plants "A" and "B" can be seen in figures 4 and 5, whilst the monthly progress in tons of solid waste entering and those of recovered products is given in figures 6, 7, 9 and 10 during 1982 and 1983.

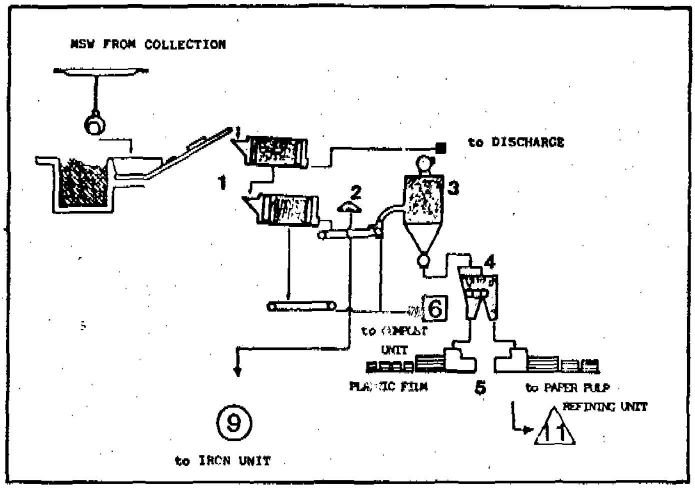
The mean material composition resulting from series of repeated surveys and which it is possible to assume for the MSW in input is given in table 1 and fig. (8).

TABLE 1: -

MEAN PERCENTAGE OF ROME MSW COMPOSITION:

- Organic material	38.5
- Paper and cellulose	18.8
- Plastic	5.5
- Wood, textiles	5.9
- Ferrous and metals	3.6
- Glass	10.7
- Under 20 mm	17.0
Size	100.0

There were no significant differences found between plants "A" and "B".



1 SCREENING
2 ELECTROMAGNETIC SEPARATION
3 AIR CLASSIFICATION OF LIGHT FRACTION
4 PAPER -PLASTIC SEPARATION
5 BALES PRESSING

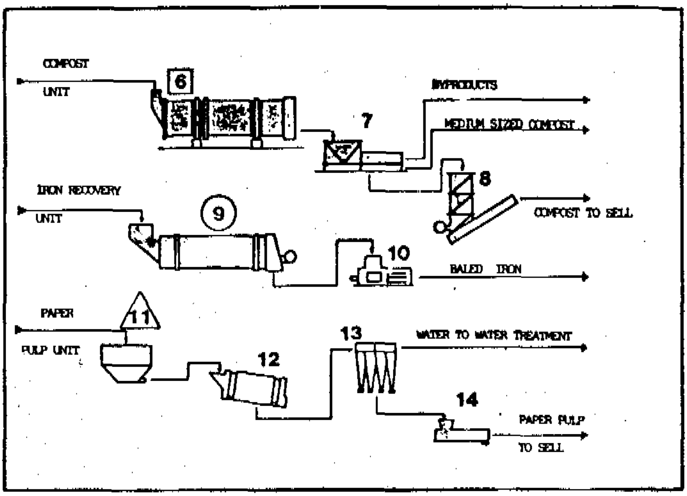
FIG.2 RECOVERY FRONT ENDTECHNICAL SCHEME- AUTOMATIC SELECTION

An examination of figures (9) and (10) provides indications for determining the yield levels of the plants.

A more in-depth determination of this parameter is contained in references [5] and [6].

It should however be pointed out that the low recovery levels shouwn up in this work depend on the contemporary inactivity for technical end economic reasons of the fodder production lines, the considerable stagnation of the paper sector and the fact that the "medium compost" has not found a place on the market which immediatly means the production of discard [9, 11, 16].

Going back to [4.1] and [5], for a more thourough examination, the mean recovery yields of the individual lines fed withe MSW of the commodities composition of table 1 are indicatively:



6 BIOACCELERATORS (DANO SYSTEM)
7 SCREENING
8 COMPOST REFINING (deglassing)
9 ROTARY KILN
10 BALES PRESSING
11 PAPER PULPING
12 SCREENING AND REFINING
13 UPPER GRADE REFINING
14 DEWATERING PRESS

FIG.3- REFINING SYSTEM OPERATING ON DIFFERENT FLOWS FROM FRONT END PRIMARY SELECTION (See fig.2)

- Paper: 45%
- Plastic: ·0%
- Organic: 60%
- Ferrous materials: 90%

The high production of discards depends partly on the structure of the roman MSW disposal complex, consisting of nine different recycling systems interconnected in various ways [5].

The simultaneous presence of compulsory routes fo· ·· ·vered products inthe complex industrial recycling system of worked ··terials which often conditions the internal production stage · ·l the neces sity for multiple internal functional connections to g· ·ntee the service in any eventuality, means that the Rome syste· ·s con· ·ioned down-stream [8.2]. That is, the management (and planning· ch· · must

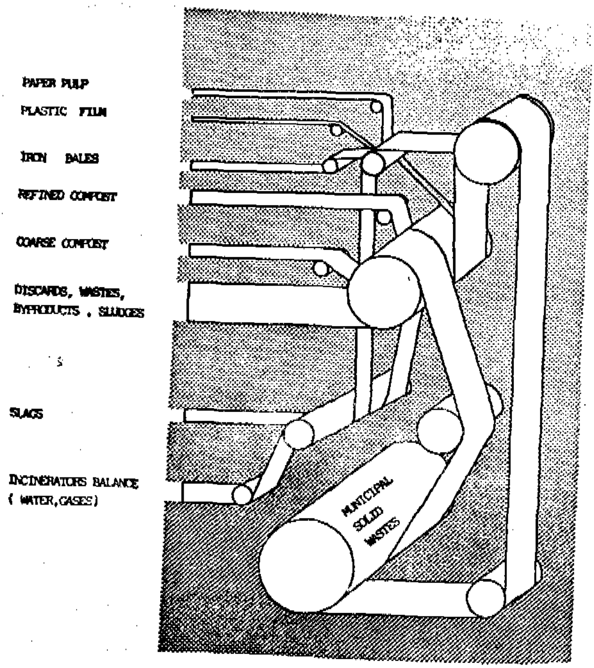


FIG.4- PLANT"B" SCHEMATICAL DISTRIBUTION OF MSW INPUT INTO DIFFERENT FLOWS OF RECOVERED PRODUCTS

be made more with reference to the compositions in output than to those entering the plant [6].

ECONOMIC ANALYSIS

The Rome plants, given their dimensions, require a considerable financial outlay for their running [5]. The economic values of the balance are given, divided into types, in Italian liras per tons disposed [10].

Losses

- Energy and fuel	1,800
- Good and services - maintenance	8,780

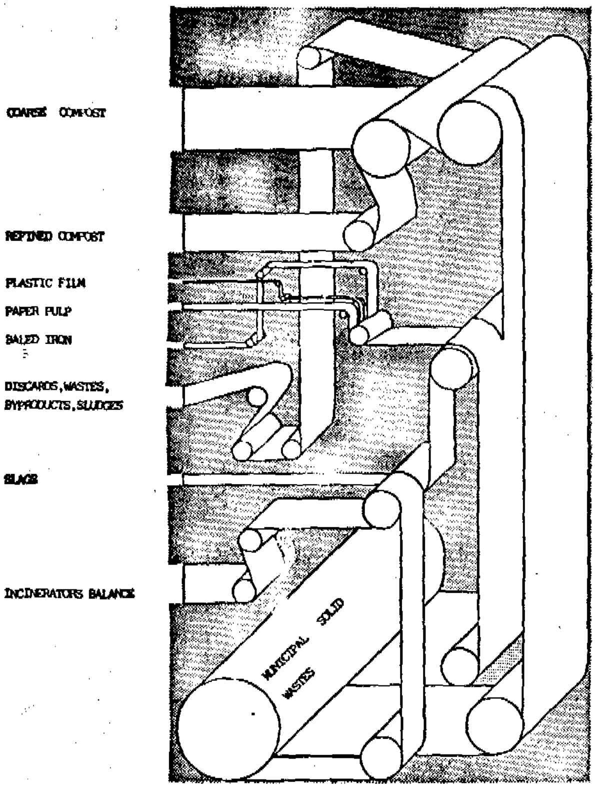


FIG. 5- PLANT "A" SCHEMATICAL DISTRIBUTION OF MSW INPUT INTO VARIOUS FLOWS OF OUTPUTS

- Personnel and contributions	17,270
- Unloading of discards	7,400
- Sundry expenditure and charges	1,450
- Taxes (VAT not deductable)	1,390

<u>Profits</u>

- Contract rates (Municipality of Rome, Municipalities of Lazio, private boards)	33,400

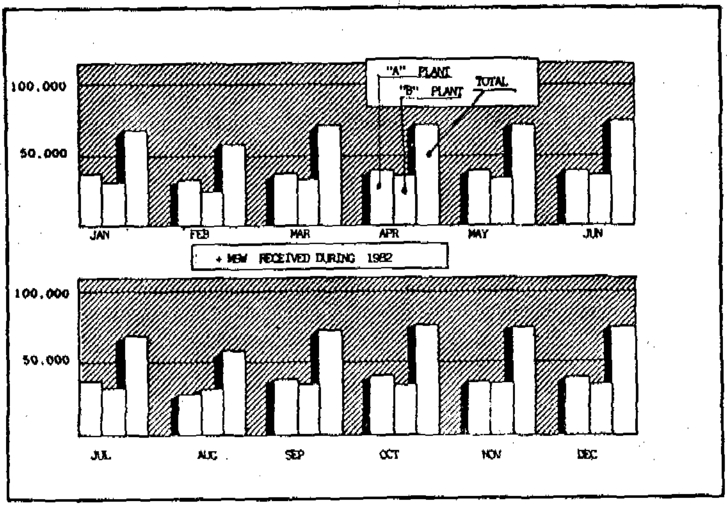


FIG.6- MONTHLY DIAGRAM OF MSW ROME PRODUCTION DURING 1982 (M tons)

- Sale of salvaged products	1,900
- *Sundry income*	2,790

ENERGY ANALYSIS

An important index is summarized in fig. 11 in which the electricity consumption of plant "A" is indicated both as an absolute value (over 7.6 Gwh/year) and as a specific one per ton disposed (mean value about 17 KWh/ton; this latter value, translated into consumptions per ton recovered, becomes more than 160 kWh [2, 8.3.]).

The energy consumption of the second plant has also been assessed which, although less than the first one, is still considerable (6.0 GWh/year).

The notable differences between the months of the year are imputable to numerous causes, including the different request for products, the city production of MSW, energy consumption, the dispersion of steam produced by incineration, the request for heating, the different state

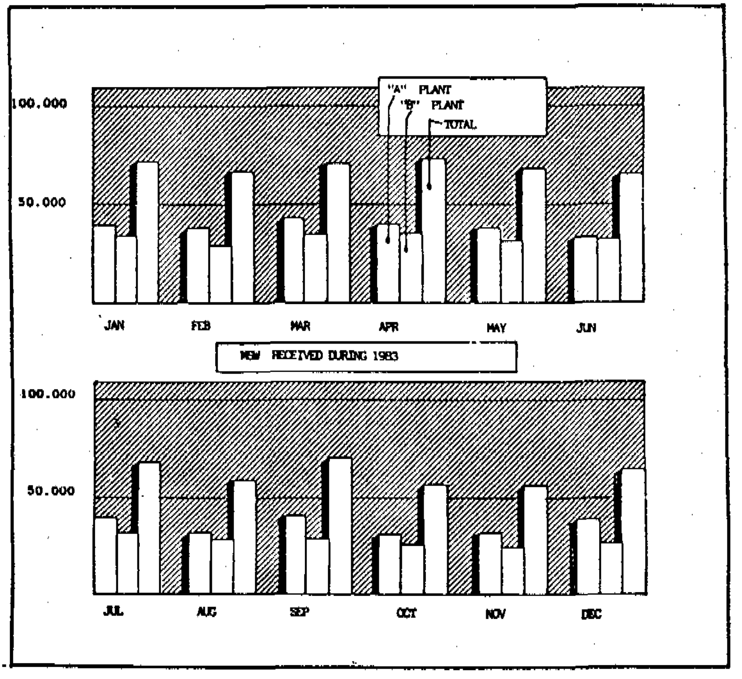


FIG.7- MONTHLY DIAGRAM OF MSW ROME PRODUCTION DURING 1983 (M tons)

of MSW in input, the lack of seasonal production of certain divisions, and non-assessable time gaps between the monthly measurement of consumptions and the accounting of MSW and product flows 4.3.

Table 2 gives an idea of the high absolute and specific energy requirements of the various reclamation works on first selection recovered products.

TABLE 2: ANNUAL MEAN ABSOLUTE AND SPECIFIC ELECTRICITY CONSUMPTION PER PRODUCTION SECTION:

	GWh	Consumtion %	Unit capacity 10^3 t/a	Specific consumption KWh/t
Primary selection	1.72	25.4	216	8.9
Incineration	1.68	22.5	192	8.8
Composting	1.35	17.8	360	3.8
Prados (*)	-	-	27	25.2
Ferrous materials	0.48	6.3	12	40.0
Paper pulp	1.39	18.4	27	51.5
General services	0.75	9.2	450	1.7
TOTAL	7.57	100	450	16.9

(*) Production of animal fodder; presently inactive - 1980 data

Alongside this it must be remembered that MSW is bivalent as regards energy, or better it contains both the negative sign of consumption and the positive one of productivity [13, 16].

Any form of energy saving which tends to the autonomy of the plants is immediately interesting, given the potential contained in the waste in input (theoretically of the order of 270 GWh/year, if one considers all the waste transformed into energy, potentially more than 130 GWh/year). This evolution of the plants can take advantage of financing from recent legislative provisions both for energy saving on the existing lines and for the production of energy for selling. In this latter case the possibility is considered of producing fuel as a development of the activities of selection and reworking of the urban solid waste of Rome [2, 3].

Technological research has for a long time faced the possibility of recovering the fraction of MSW rich in energy, that is refuse derived fuel (R.D.F.) [7, 8.1.].

The experiments and estimates carried out up to now have demonstrated that RDF can be produced in the measure of about 20% in weight with respect to the initial waste, for a total of 160,000 t/year without prejudice to the present material salvage processes [11, 8.1, 14.]
It is possible to concentrate in fuel 55 ÷ 60% of the potential energy attributable to the entire quantity of MSW treated; indicatively, 6.4 10^8 MCal/year are available equal to 745,000 MWh producible in a cogeneration plant of the type with condensing turbine and alternator, employing 8,000 hours/year [3, 10].

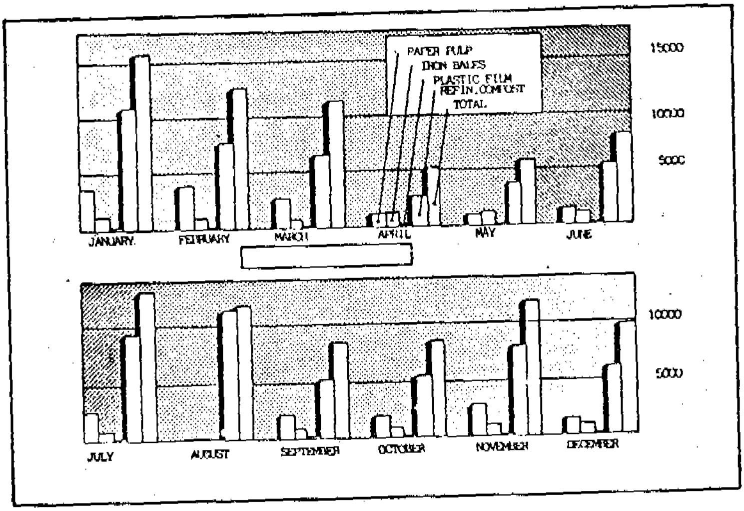


FIG.9 - MONTHLY DIAGRAM OF RECOVERED MATERIALS DURING 1982 (M tons)

for both plants).

The aim is to provide a quality estimate per process line. On the other hand, more accurate and specific analytical instruments are used for programming the maintenance operations on the various lines.

CONCLUSIONS AND PROSPECTS

Some indications have been drawn from the analysis work:

- the present features of the Rome plants allow recovery of materials from MSW for about 20% of the total MSW treated and this value includes 2/3 of fine compost [4.1, 6, 8.3];
- the plants are structured in such a way that the quantities discarded because they cannot be considered as products (17.2%) or incinerated (31.6%), are discarded (51.2%) but at least as regards their commodity classification, are very similar to the incoming waste; they therefore contain potential salvageable goods when submitted to additional reworkings or recycles as in [8.2, 11, 12, 13];
- the various components of the Rome plants have an average age of 8 ÷ 10 years and the plants have undergone successive modifications and updatings around a basic nucleus designed in the full economic boom,

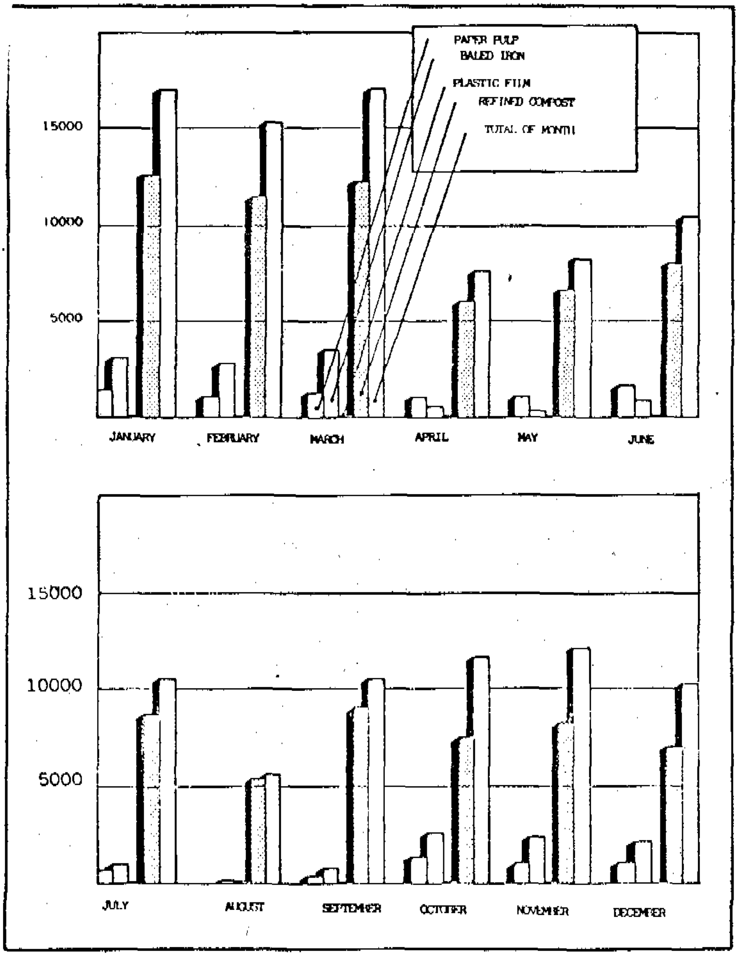


FIG. 10 - MONTHLY DIAGRAM OF RECOVERED PRODUCTS DURING 1983 (M tons)

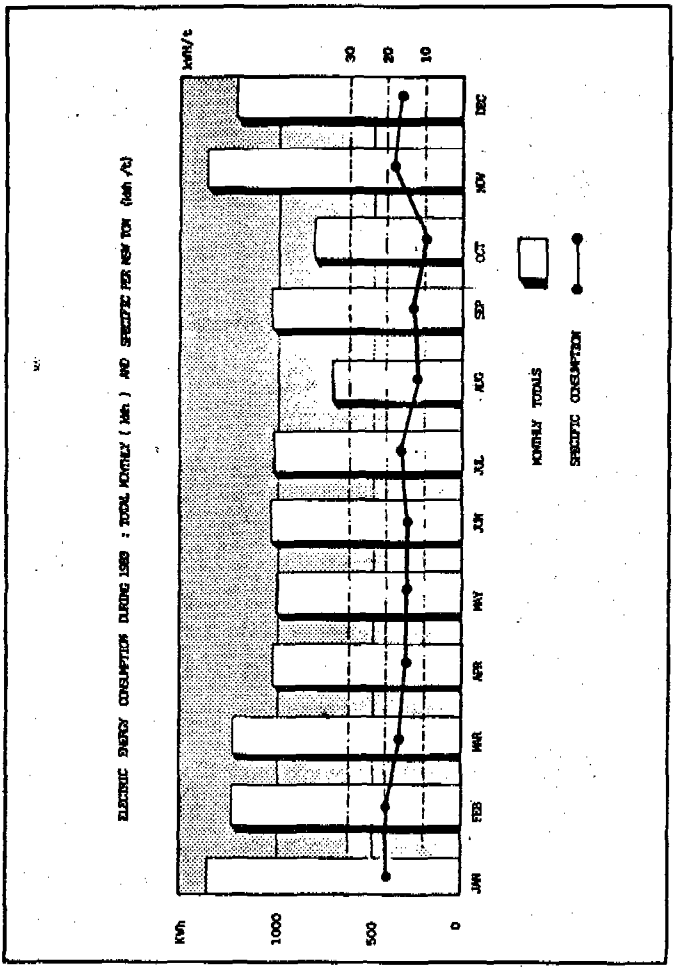


FIG.11- ELECTRIC ENERGY REQUIREMENT OF "A"PLANT IN 1983

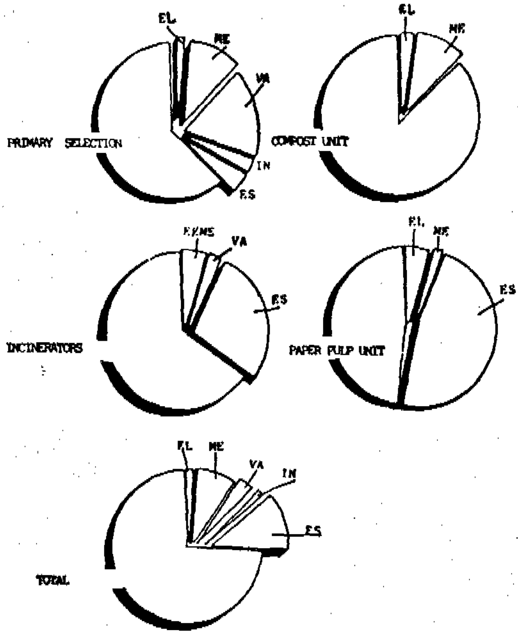


FIG. 12- TECHNICAL SHUTDOWN OF "A" PLANT WITH RESPECTIVE CAUSES (See Legend)

LEGEND OF TECHNICAL REASONS FOR SHUTDOWN - FIGS. 12 AND 13

EL = Electrical failures
ME = Mechanical failures
MP = Ordinary programmed maintenance
VA = Sundry reasons
ES = Reasons outside the division or plant
IN = Clogging of transport networks

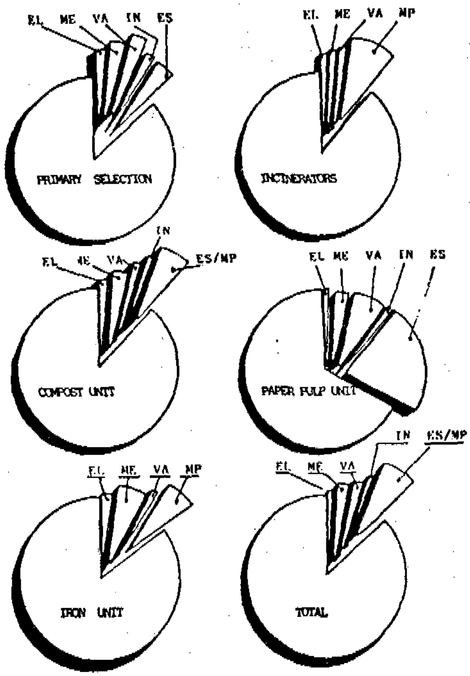


FIG. 13 -TECHNICAL SHUTDOWN OF "B" PLANT
WITH RESPECTIVE CAUSES

when energy cost a lot less [5, 10];

- the market and the state of the trade in the sector pose problems and allow solutions which were unthinkable not log ago [2, 3, 6, 12];
- to produce certain goods one needs less energy if one starts with worked salvageable material: consequently alonside the last energy content of the MSW recovered (that which can be generated by combustion), a positive difference of economic potential of the salvaging recycling of materials is established which partially inverts the direction of the discard current, as in [3, 8.1, 14];
- the main "limiting factor"for the acceptance of the recovered materials in the production cycle is the relative degree of purity of

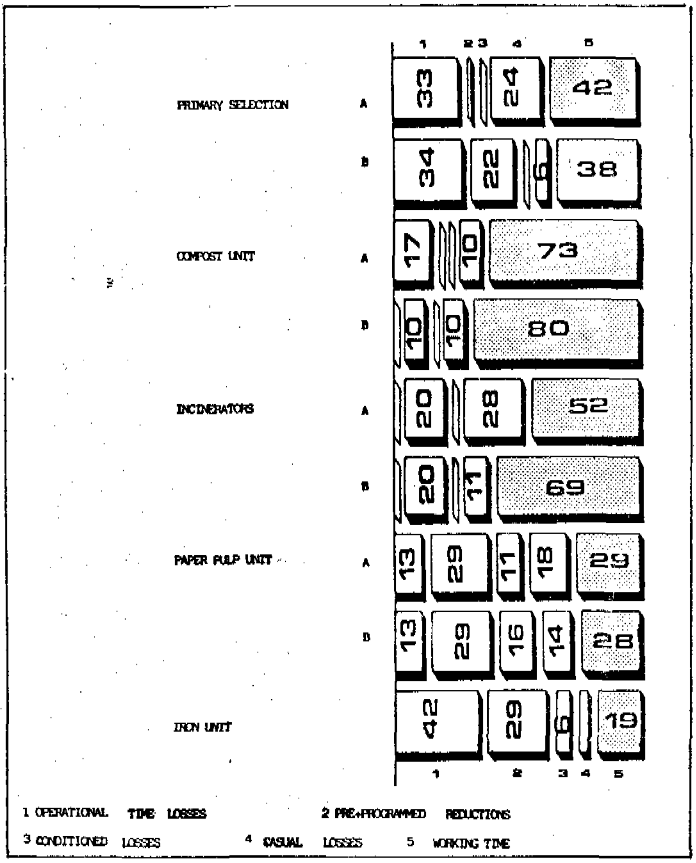


FIG. 14 - TIME UTILIZATION PERCENTAGES IN VARIUOS UNITS

LEGEND TO FIG. 14

The different ways for reducing the utilization of the plants include:

- Operating reduction: which allows passing from potential operation to optimal operation (values indicated with (1) in fig. 10).
- Programmed reduction: passing from optimal operation to programmed operation (values (2)).
- Conditioned reduction: passing from programmed operation to conditioned operation (values (3)).
- Real reduction: due to losses (values (4)) when deducted from the conditioned operation, it supplies the value of the real or production operation (values (5)).

The running conditions considered are the following:

Potential operation:
the maximum theoretically possible.

Optimal operation:
reduced with regards to the previous one for the realistic assessment of working ability (material available, plant capacity, holidays, etc).

Programmed operation:
reduced with regards to the previous one due to contingent factors (the market for recovered products, maintenance, etc.).

Conditioned operation:
reduced with respect to the previous one by factors outside the division or even outside the plant. Can only be foreseen in the short term.

Real operation:
calculated by deducting the shutdowns due to failures or process stops which involve at least 51% of the division, which anyway cause considerable reductions in production or finally which require a by-pass to other lines.

the worded materials with respect to the unworked ones [9] which, in plant economy, means an energy consumption curve which tends upward to guarantee each increase of a degree of purity of the product recovered with respect to its pollutants, as in [8.2, 9, 14];

- the R.D.F production is equally governed by these two opposite phenomena, with the difference of recovering and making available one or more energy sources (electricity, steam, heat) usable anywhere and therefore realistically and profitably comparable with the raw materials they substitute [3, 8.1, 11, 13].

The statistical and functional analysis of disposal plants, on which [3, 4.1, 6] and [9] give ample information, is the basic element for guiding decisions on future developments; these, briefly, envisage recovering energy and *composting* as solutions to the problems arising with the transformations undergone both by MSW and by the disposal technologies with respect to the original planning of the Rome plants. (Fig. 1).

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A LOW TECHNOLOGY TREATMENT ALTERNATIVE FOR A SOFT DRINK AND FRUIT JUICE BOTTLING PLANT WASTEWATERS

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INTRODUCTION

Soft drink and fruit juice consumptions in Turkey are showing similar trends to those in the western world; and per capita consumption is steadily increasing. As a result, and to meet the increasing demand, number of bottling plants along with the quantities of wastewater they generate are increasing. Since the demand is seasonal and it reaches peak values during the warmer summer months, the quantities of wastewater generated during these months are also higher.

One such plant, "ANSAN" near Ankara, has been discharging its un-treated wastewaters into a nearby stream since its establishment. The point of discharge is located some distance upstream of an inpounding reservoir on the same stream which provides part of the municipal water demand of Ankara.

Recently, with the passing of the new Environmental Law the plant was required to treat its wastewater and, as a result this study was undertaken by the authors at the request of the plant management.

The study consisted of two parts. In the first part, sources, quantities, physical-chemical characteristics of the wastewaters generated at the plant and total pollution load on the receiving stream were determined. In the second part, the results from the first part were compared to the existing discharge standards to determine the degree of treatment necessary; formulate alternatives to achieve this; and determine the design criteria to be used with the alternative recommended.

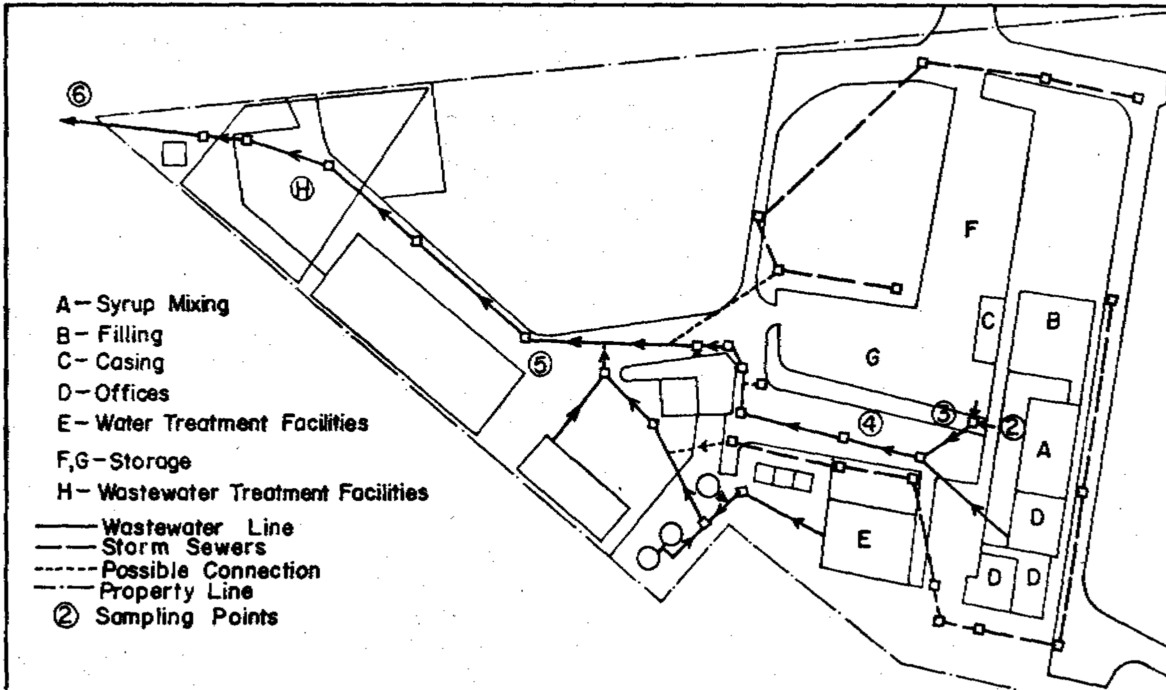

Fig. 1. Plant layout, storm and wastewater drainage system, and treatment facilities.

BACKGROUND

Location

The ANSAN plant is located at about 18 km. from the city center of Ankara and has a total land area of about 28 decars. Site plan showing the locations of physical facilities, wastewater and stormwater drainage system is presented in Figure 1.

Process

The production of soft drinks involves essentially the introduction of water, carbon dioxide, and a syrup into generally a clean glass bottle. In ANSAN plant carbonated soft drinks (i.e., Coca Cola and Elvan) and fruit juices (i.e., Has) with different flavors are produced. The process flow diagram is presented in Figure 2. As shown in the Figure, this is basically a bottling plant where fruit concentrates from other plants are processed; and it consists primarily of units for water treatment, bottle washing, syrup preparation, syrup dosing-filling crowning of bottles, and casing. During the filling operation CO_2 is added to the soft drinks. On the other hand, a hot-filling process is used for bottling the fruit juice.

Water Supply and Treatment

Most of the water required by a plant is utilized for washing of used bottles. For this purpose, water of low hardness is preferred. On the other hand, a water of relatively high purity is required for the production of soft drinks. The water used in ANSAN plant is obtained from two deep wells located within the plant property and the wells have a total net yield of 12 l/s. However, based on the information obtained from the plant management, only about half of this water is presently being used in production and the rest is wasted. Before it is used in production, the water is passed through a treatment facility consisting of: coagulation, flocculation, sedimentation, filtration, ion exchange softening, chlorination, and deaeration units.

Sources of Liquid Wastes

Possible sources of wastes from the manufacture of soft drinks in ANSAN plant are depicted in Figure 2. As can be seen from this Figure, they come ma ly from following activities: a) bottle washing ; b) syrup pre ration; c) filling, emptying and cleaning of syrup tanks; d) r treatment; and e) floor and equipment washing. Like in other similar plants, nearly all of the wastewater in ANSAN plant comes from bottle washing operation. Amount of liquid waste coming from the water treatment facility was found to be 0.4 - 0.6 l/s using the chronometer-bucket method. These wastes do not contain toxic element.

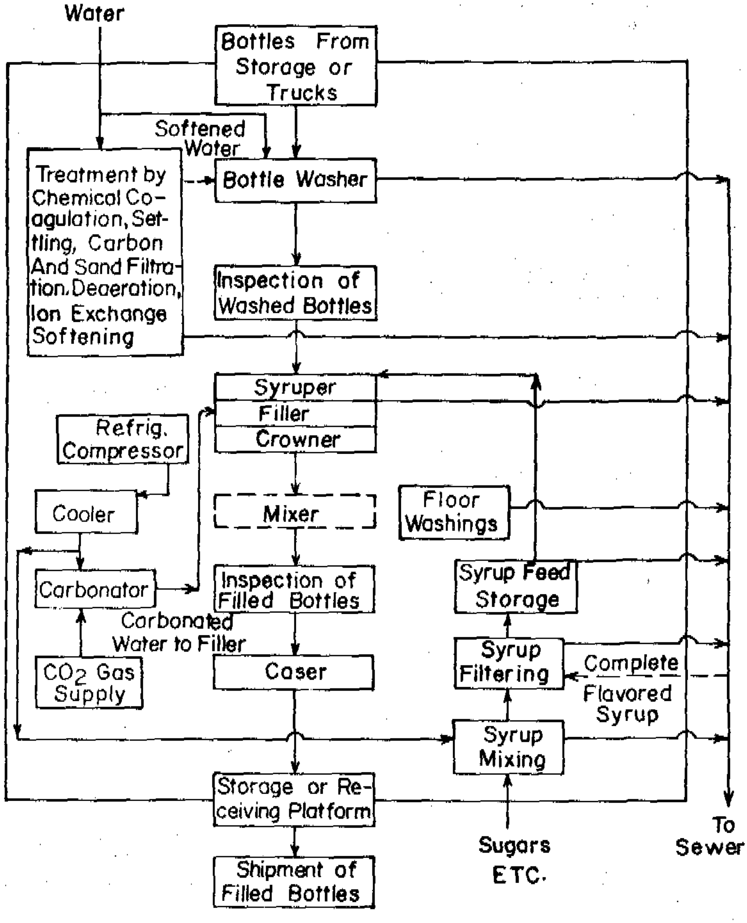

Fig. 2. Flow chart for Ansan soft drink bottling plants.

Sewer System

The plan of the ANSAN plant's sewers does not exist, but as far as it could be determined, it has a combined system carrying process, domestic and storm waters as shown in Figure 1. It was also observed during the pipe location efforts that there is considerable amount of ground water infiltration into the system due to pipe laying practice used and also due to high ground water table especially, during wet periods.

METHOD OF STUDY

Liquid wastes from the ANSAN plant were evaluated by the authors at the laboratories of the Environmental Engineering department of the Middle East Technical University in Ankara.

To determine the quantities and characteristics of significant liquid waste streams of the ANSAN plant six sampling stations were selected as shown in Figure 1. At each sampling station wastewater characterization was based on nine series of 24 h/day composite samples collected over a period of 47 days. Sampling program was set up in such a way that, except for saturday and sunday, samples for the normal workdays of the week could be obtained at each station. The samples were taken over 24 h periods, stored and transported to the laboratory in ice boxes at 4°C, brought to the laboratory at the end of each sampling period, and analyzed as soon as they arrived at the laboratory. Since the times involved in bringing the samples to the laboratory were short, it was not necessary to use any additional sample preservation method. The samples were analyzed for 15 liquid waste characterization parameters which included: 5-day 20°C biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), ammonium nitrogen (NH_3-N), orthophosphate phosphorus (O-phosphate P), total solids (TS), suspended solids (TSS), settleable solids (SS), chlorides, salinity, conductivity, alkalinity, pH, dissolved oxygen (DO), temperature (T), and detergents (ABS). The laboratory analyses were performed according to "Standard Methods" (1).

Because of the unsuitability of the sewer system, out of the six sampling station only at stations 2, 3, 4, and 6 satisfactory samples could be obtained and thus, analyzed at the laboratory. For each one of these stations concentrations determined for the important design parameters such as BOD_5, COD, NH_3-N, O-Phosphate-P, Total suspended solids, and settleable solids were evaluated. This evaluation involved determining arithmetic mean values; and using statistical analysis, determining probabilistic values for each parameter at each sampling station. Thus, concentrations corresponding to 50, 60, 70, 80, and 90 percentile values were determined.

Wastewater flow could only be measured at the plant outfall

Table 1. Waste Analysis of the Effluents from the ANSAN Plant

Sampling Station	Arithmetic Mean Values			
	BOD_5 (mg/l)	COD (mg/l)	TSS (mg/l)	SS (ml/l)
2	608	980	183	3.06
3	686	1144	152	2.96
4	764	1344	238	2.74
6	740	1352	346	1.45

using a 90° triangular weir placed at the plant outfall.

Concentrations of the design parameters found at station 6 were multiplied by the plant flow as measured at the outfall to calculate the plant's waste load on the receiving stream.

Results obtained were compared with some literature values and design waste flow and characteristics were determined. Comparisons of the design values accepted and the discharge standards dictated the degree of treatment to be provided. Then, a number of possible alternative treatment systems were considered and one of them was selected as suitable and meeting the requirements and limitations. Finally, design criteria to be used with the selected alternative were formulated and the units of the treatment system were dimensioned.

RESULTS

Analyses of the liquid waste from plant operation during the eriod of study are presented in Table 1. The pH of the wastes were

Table 2. Waste Analysis of the Effluents from Soft Drink Plants

Plant	Range of Daily pH	Alkalinity		5-day BOD (mg/l)	Suspended Solids (mg/l)
		Phenol. (mg/l)	Total (mg/l)		
A	10.6-11.4	230	390	380	170
B	10.0-11.2	100	250	660	160
C	10.4-11.2	110	220	250	340
Avg.	-	150	290	430	220

Table 3. Waste Analysis of the Effluents from the ANSAN Plant

Sampling Station	90 Percentile Values				
	BOD_5 (mg/l)	COD (mg/l)	TSS (mg/l)	SS (ml/l)	Flow (l/sec.)
2	810	1280	250	13.5	-
3	960	1570	300	11.5	-
4	900	1700	240	12.8	-
6	870	1660	370	9.4	-
Plant Outfall	-	-	-	-	12.0

high and varied from 9.0 - 11.3. The BOD_5 varied from 300-1470 mg/l. The COD varied from 500-2890 mg/l. The TSS varied from 0-976 mg/l and SS from 0-20 mg/l.

As was expected and normal to this type of operation, the composition of the samples varied appreciably. The maximum daily BOD_5, COD, TSS, and alkalinity exceeded the average for the individual station by as much as 200 per cent; and the minimum values approximated 50 per cent of the average results. This is in agreement with the literature[2].

Waste analyses of the effluents from soft drink plants found in the literature[2] are presented in Table 2. These results show that soft drink plant effluents have high pH (10. - 11.4) and average BOD_5, TSS, and total alkalinity concentrations of 430 mg/l, 220 mg/l, and 290 mg/l respectively.

Concentrations corresponding to the 90 percentile values for BOD_5, COD, SS and TSS for ANSAN wastewaters are presented in Table 3.

Laboratory determinations made on some carbonated soft drinks

Table 4. Flow Measurement at the ANSAN Plant

	Mean Daily Flow, l/sec.	Comments
Mean of low flows	7.1	Dry period
Mean of high flows	10.5	Dry period
Mean of all flows	8.7	Dry period

Table 5. N:P and C:N:P Ratios for ANSAN Wastewaters

Sampling Point	Average Values			Ratios	
	BOD_5 (mg/l)	NH_3-N (mg/l)	O-Phos-P (mg/l)	N:P	C:N:P
2	608	0.74	1.06	0.70	100:0.001:0.002
3	686	0.81	1.26	0.64	100:0.001:0.002
4	764	1.40	1.38	1.01	100:0.002:0.002
6	740	0.76	1.02	0.75	100:0.001:0.002

found in the literature[2] show that they have low pH (2.4), and average values for BOD_5, total solids, and total acidity are given to be 71200 mg/l, 116200 mg/l, and 1870 mg/l respectively.

Results of flow measurements at ANSAN plant's outfall are presented in Table 4.

Nutrient concentrations of the ANSAN wastewater are presented in Table 5.

DISCUSSION

Inspection of the plant indicated that waste from the bottle washing machine would constitute the major source of the BOD_5 and TSS load discharged to the sewers. Also, part of the BOD_5 and TSS load of the total plant can be attributed to residual drink and debris left in the bottles by the consumer.

Results at Station 3 which represent the overall process waste stream showed higher average BOD_5 concentration (686 mg/l) than the value for similar plants (430 mg/l) reported in the literature[2]. The reason for this may be due to in-plant mixing and blending of syrups; larger quantities of left over drinks in the bottles by the consumer; and to some leaks in the production system. Total suspended solids varied from 0-956 mg/l and averaged 152 mg/l which was lower than the literature[2] value (220 mg/l). This may be due to the fact that no labels are used in ANSAN products. This BOD5 and TSS concentrations of the daily composites varied with differences in daily clean-up schedules and to a lesser extent on the quantities of water employed for rinsing of used bottles and clean-up operations.

COD at Station 3 varied from 720 - 2040 mg/l and averaged 1144 mg/l. No data could be found in the literature for comparison.

Alkalinity and pH of the wastewater are relatively high due to carry-over of alkaline detergent solution to final rinses and pri-rinses. Daily composites of the spent waters had pH values ranging from 9.0 - 11.3; and contained 94 to 234 mg/l as $CaCO_3$ total alkalinity.

Water requirements depend an individual plant operating practices, particularly with respect to bottle washing, and to a lesser extent, on the costs of raw water and costs of liquid waste dispcsal. Most of the water is used in the continuous pre-rinses and final rinses of the bottle washing machine. As such, most of the waste load comes from these operations. However, water can be conserved by reusing part of the final rinse water as pre-rinse and thereby, reduce the wastewater volume.

It was observed that a large portion of the BOD in the plant waste originates from the pri-rinse discharges containing drainings of unused drink from incoming bottles. The bottled liquids contain about 10 % sugar and have a BOD of approximately 70,000 mg/l. consideration should be given to disposing of these liquids in some other fashion. The wastewater from the bottle washing machine should be passed through adequate screening devices to remove suspended solids such as mold, cigarette butts, straws, and miscellany.

The alkaline cleaning solution used during bottle washing operation contains 1.5 - 2.0 % NaOH and therefore, the wastewater from this unit has a very high pH. Total caustic bath volume is about 47 m^3 and the entire solution is wasted into the sewer system once in every 10 days, causing the pH of the wastewater to rise abruptly.

In a biological treatment system, for the microorganisms to grow and function properly, C:N:P ratio should roughly be 100:5:1. However, as can be seen from Table 5, ANSAN wastewaters fail to meet this criteria and as such, based on a design BOD_5 of 1000 mg/l, 50 mg/l N and [illegible] to be added to the wastewater. To this end, some chemi[illegible] in N and P were found to be available and eco[illegible]

Disposal

The bulkiness [illegible] long distance shipment uneconomical. Therefore, [illegible] ink manufacturing plants are or will be located within close [illegible] imity to centers of population and use municipal waste handling facilities. Discharge to municipal sewers is one of the best means of [illegible] handling from a plant standpoint, because treatment and ultimate disposal then become a function of the municipal system. Generally, this will have no undesirable effects on the sewers and efficiencies of the various treatment units in the municipal plant provided the units have adequate capacity[3]. However, location of the ANSAN plant is not suitable for this type of waste handling and therefore needs to build its own treatment facilities.

Based on the information collected in the waste characterization studies; and comparison of these with the existing requlations, it was necessary to treat the liquid wastes before discharging them to the receiving water.

Degree of Treatment Necessary

Based on the laboratory analysis of the ANSAN liquid wastes , it was decided to take the 90 percentile values for BOD_5 and TSS and add a margin of safety to come up with the design values. Thus, for BOD_5 1000 mg/l and for TSS 400 mg/l were chosen as the design values. Also, a design wastewater flow of 10 m/sec was selected.

Public Law 1380 (Water Products Law), put in effect in February of 1983 has brought some limitations to the discharges into receiving waters. Article 11 of this Law limits the BOD_5 (20°C) concentration in the discharge to 50 mg/l and TSS to 200 mg/l.

Thus, a BOD_5 removal efficiency of 95 % and a TSS removal efficiency of 50 % would need to be achieved. Based on design flow, these correspond to removals of 821 kg BOD_5/day and 173 kg TSS/day.

Suggested Treatment System

Although they recognize the importance of wastewater treatment for the protection of their environments, developing countries are not able to give high priority to investments in this field because of their limited economic ,resources. Therefore, in selecting treatment systems, in addition to the economic factors: availability of trained manpower to operate such systems; climate; and availability of energy,equipment and supplies need to be considered.

In treating wastewaters, biological systems are preferred. These biological systems may be divided into two groups: conventional systems such as the biological filters and activated sludge units which require trained manpower and more energy to operate;and simpler, more economical systems. Later is a result of research on achieving low investment, easy to operate treatment schemes without sacrificing treatment efficiency.

Therefore, considering the conditions in Turkey, in choosing a treatment system for ANSAN following points were kept in mind:

i. It should be constructed using nationaly available materials and technical capabilities as much as possible.
ii. It should be simple and easy to operate.
iii. It should have low energy consumption.

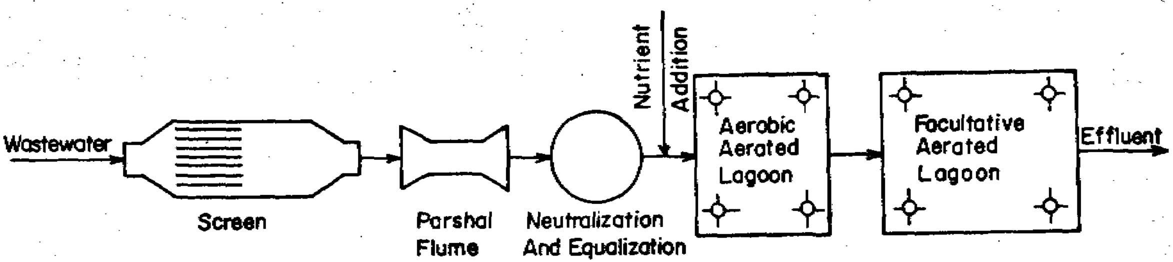

Fig. 3 . Suggested treatment system.

iv. It should be able to meet the performance requirements.
v. It should be economical to construct and operate.
vi. It should fit the limited space available.

Treatability studies had shown that ANSAN wastewaters were -logically treatable provided that prior to treatment pH was neu-lized and N and P necessary for biological treatment were added. -refore, after the proper pre-treatment, a biological treatment -stem satisfying the requirements mentioned above was recommended.

Because of the limited land area, it was not possible to use oxidation ponds for biological treatment which happens to be one of the simplest and cheapest system, Instead, another simple biological treatment system known as "aerated lagoon" is selected. The aerated lagoon system takes up relatively much less area than oxidation ponds, but require some electrical energy to operate. Thus, recommended treatment system consists of following units and processes as shown in Figure 3.

- Screening
- Flow measurement and control
- pH adjustment (neutralization using H_2SO_4)
- Nutrient addition (N and P)
- Aerated Lagoon for biological treatment

A two stage biological treatment is recommended in this design. First stage will be an "aerobic aerated lagoon", and second stage will be a "facultative aerated lagoon". Using the facultative lagoon as the second stage will eliminate the need for a final settling tank. Based on the information presented up to this point, it was found that units with following dimensions would be adequate to provide the degree of treatment necessary.

Design Flow: 10 l/sec.

Inflow		Effluent (winter conditions)	
BOD_5	TSS	BOD_5	TSS
1000 mg/l	400 mg/l	45 mg/l	33 mg/l

Screen: Mechanically cleaned; 30°C angle with the horizontal; width of channel = 50 cm; channel depth = 30 cm; length of bars = 60 cm; diameter of bars = 2 cm; clean opening = 2 cm; number of bars = 17; headloss through the screen = 1 cm.

Flow Measurement Device:
Parshall flume with 7.5 cm throat width. Capable to measure flows up to 31.2 l/sec.

Caustic Bath Wastings:
Volume 48 m^3 (8.0 x 3.0 x 2.0 m)
Bleeding period 10 days

Neutralization System:

Tank: Det. time = 15 min; two cylindrical tanks with 1.8 m in diameter and 1.8 m water depth;

Mixer: 3-blade; 45 cm in diameter; 360 rpm; G = 400/sec; 1.5 hp

Chemical: H_2SO_4 to lower pH down to about 8

Nutrient Addition System:

Chemicals: Ammonium nitrate containing 26 % N: 166.2 kg/day. Triple super phosphate containing 43 % P_2O_5: 45.4 kg/day.

Tank: cylindrical; diameter = 135 cm; water depth = 140 cm; Det. time = 4 hrs.

Mixer: 6-blade turbine; 45 cm in diameter; G = 242/sec; 0.24 hp; 120 ppm.

Feeder: rotodip or constant head; rate = 0.122 l/sec

Aerated Lagoons

	Aerobic Lagoon	Facultative Lagoon
Surface Area	900 m^2	1275 m^2
Bottom Area	144 m^2	400 m^2
Side Slopes	2/1	2/1
Depth	4.5 m	4.5 m
Aerator used	1x25 H.P.Aqua-Jet Aerator	1x2 HP+1x1 HP Aqua Jet Aerators
Sludge Accumulation	-	480 M^3/year

SUMMARY

Wastewaters of ANSAN soft drink bottling plant were sampled and analyzed for characterization and treatment.

Liquid wastes emanate from bottle washing, water treatment, washing of equipment, and housekeeping. Most of the waste load comes from the continuous rinses of the bottle washing machines.

The ANSAN plant was found to discharge a wastewater with average 90 percentile values of 12 l/s flow, 900 mg/l of 5-day BOD and 400 mg/l of suspended solids. The pH is approximately 11.0 and the total alkalinity averaged 200 mg/l as $CaCO_3$. The nitrogen and phosphorus concentrations of the wastewater were very low. Thus, the wastewater of ANSAN were found to be deficient in nutrients (N,P), high in pH, but much stronger than domestic wastewaters. However, these wastewaters are biodegradable provided that the pH is adjusted and the nutrients (N,P) necessary for biological treatment are added. Therefore, a two stage biological treatment system consisting of aerated lagoons (an aerobic lagoon followed by a facultative one) following pH adjustment and nutrient addition was recommended to meet the existing discharge standards.

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AN OPTIMIZATION APPROACH TO TRICKLING FILTER DESIGN

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INTRODUCTION

Engineers have been designing sewage treatment plants and trickling filters for a long time. However, most of these designs have been based on "the standards" found in books or adopted. Most of us engineers like them and use them quite often because they make our work easier and the facilities are believed to be working to our satisfaction and to that of the regulatory agency. However, these "standards" need to be constantly questioned and tried to be improved.

One of the purpose of this paper is to show a possible way of improving "the standard design". The other purpose is to illustrate to practicing engineers how an optimization method could be applied to a practical design problem. Here, the main idea is to find a way to get the most "benefit" out of the money spent.

FORMULATION OF THE PROBLEM

First, the design problem needs to be defined. Then, the limitations and the desired ends wanted to be achieved within these limitations should be listed. Finally, a way(s) to solve the problem numerically needs to be found.

To illustrate, the problem can be stated as: "size the trickling filter which will meet a given set of requirements and limitations and at the same time be the cheapest possible filter for the conditions specified." The following will be used as the limitations and other information pertaining to achieve the desired ends:

1. Plant Capacity in million gallons per day (MGD) Q_i, ($1 < Q_i < 20$)
2. Strength of Settled Sewage in ppm of BOD, L_a, ($L_a = 100$)
3. Strength of Filter Effluent in ppm of BOD, L_e ($18 < L_e < 20$)
4. Per cent BOD Removal Desired in the Filter and final Settling Tank, $100 \times (L_a - L_e)/L_a = 80$ %
5. Limit on Hydraulic Loading Applied to the Filter in million gallon per acre per day (MGAD) Q_a, ($9 < Q_a < 44$)
6. Limit on Organic Loading Applied to the Filter in lbs BOD/day/Acre, CON, ($3500 < CON < 37000$)

One way to solve this problem would be to use some optimization technique, which will be the topic of the following sections.

A SOLUTION TO THE PROBLEM

To be able to formulate and solve the problem stated in the previous section, first, a series of mathematical expressions describing the filter behaviour as closely as possible needs to be developed. The same needs to be done for the kinds and amounts of costs associated with the filter. Then, using these mathematical expressions and the information from the previous section an objective function(s) will be defined and solved using an appropriate numerical method to come up with the answer (i.e. best filter design) which will satisfy all the constraints.

Selection of the Filter Behaviour Model

There are a variety of mathematical models proposed in the literature for describing mathematically what happens in a trickling filter and how the organic matter gets removed in a biological treatment system. Needless to say that one can choose any of these as one pleases.

For the sake of illustration, a model suggested by Brown[1] will be used here. This model suggests that the rate of transport of waste from the liquid film to the slime surface covering the filter media is the rate controlling factor in BOD removal in a trickling filter. For the treatment system shown in Figure 1 and assuming laminar flow conditions, Brown suggests Equation 1 to describe the filter behaviour.

$$L_a/L_e = e^x (1 + R) - R \qquad (1)$$

where:

L_a = BOD concentration of settled sewage, ppm
L_e = BOD concentration of filter effluent, ppm
R = Recirculation ratio

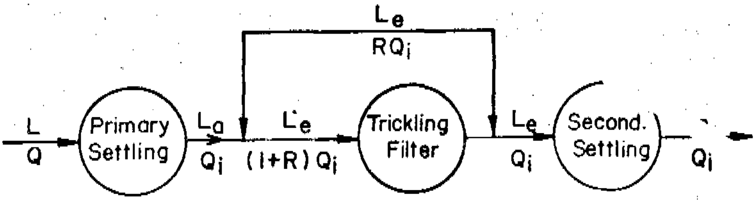

Fig. 1. Treatment system used in developing filter behaviour model.

$x = 0.366\ D/Q_a^{1/3}$ for laminar flow conditions
D = Depth of filter, ft
$Q_a = (1 + R)\ Q_i/A$ = hydraulic loading of filter
Q_i = Plant capacity, MGD
A = Surface area of filter, Acres

Development of the Filter Cost Function

Cost function is obtained by adding different costs that are associated with the filter. Some of these include: 1) Distributor cost; 2) Media cost; 3) Cost of underdrainage system; 4) Cost of filter wall; 5) Cost of recirculation piping; 6) Cost of recirculation equipment; 7) Cost of power used in recirculation; 8) Cost of excavation for filter foundation; 9) Cost of land; 10) Miscellaneous. In developing individual costs following symbols were used:

T = Filter diameter, ft
D = Filter depth, ft
A = Filter area, ft^2
V = Filter volume, ft^3
Q_i = Plant capacity, MGD
R = Recirculation ratio

It should be pointed out here that the equations developed in this section were based on information obtained in U.S.A., for there is not enough data available on this subject in Turkey at this time. This is also the reason for expressing costs in U.S. Dollars and the parameters in English Units.

a) Distributor Cost (CD): Based on the raw data obtained for different sizes of distributors, labor costs incurred in installing them, etc. this cost is formulated as follows:

$$CD = 916 \times (T)^{0.7} \qquad (2)$$

b) Media Cost (CM): The media cost is divided into two parts. One part is the cost of rock media and the other part is the placement cost. Therefore, this cost it formulated as follows:

$$CM = 0.26 \times V \quad (3)$$

c) Cost of Underdrainage System (CUD): This cost was also considered in two parts namely: the cost of concrete floor (6 in.) and channels; and tile and placement cost. Thus:

$$CUD = 4 \times A \quad (4)$$

d) Cost of Filter Wall (CFW): Filter Wall is assumed to be 6 inches thick. Also, except for the foundation the whole filter is assumed to be built on the ground. Thus:

$$CFW = 4.37 \times T \times D \quad (5)$$

e) Cost of Recirculation Piping (CRP): The cost under this category includes the cost of different size pipes required in the recirculation system; and different types and sizes of valves needed. Thus:

$$CRP = (Q_i \times R)^{0.4} \times 5000 \quad (6)$$

This cost is incurred only when there is recirculation in the system otherwise, it is zero.

f) Cost of Recirculation Equipment (CRI): This includes the cost of pumps, motors and other electrical equipment used in recirculation. This cost can be estimated by the following relationship:

$$CRI = (R \times Q_i)^{0.7} \times 10000 \quad (7)$$

As in the case of (e) above this term becomes zero when there is no recirculation.

g) Cost of Power Used in Recirculation: The cost associated with this category is very small in comparison to the other costs and to the total cost. Therefore, it is left out in this problem.

h) Cost of Excavation for Filter Foundation (CEXC): Eventhough the filter will be sitting on the ground it was decided to allow excavation up to three feet for the purpose of putting in filter slabs. Thus:

$$CE \times C = 0.222 \times A \quad (8)$$

i) Cost of Land Taken up by the Filter Plant (CLND): It has been assumed that a sewage treatment plant with a trickling filter, a primary settling tank, a secondary settling tank and other facilities which are necessary to have (e.g. laboratory space, etc) will take up land area equal to about twice the size of the trickling filter itself. Thus, the total land area required by this plant will be three times the area of the trickling filter. Another assumption is that the treatment plant is located outside the town and the land is not more expensive than $ 2000 per acre. Thus:

$$CLND = 0.14 \times A \qquad (9)$$

In Summary:

Cost of Distributor = CD = $916 \times T^{0.7}$
Cost of Media = CM = $0.26 \times V$
Cost of Underdrains = CUD = $4 \times A$
Cost of Filter Wall = CFW = $4.37 \times T \times D$
Cost of Recirculation Equipment = CRI = $10000\ (R \times Q_i)^{0.7}$
Cost of Recirculation Piping = CRP = $5000 \times (R \times Q_i)^{0.4}$
Cost of Foundation Excavation = CEXC = $0.222 \times A$
Cost of Land = CLND = $0.14 \times A$

A sensitivity analysis was run on the cost function and the effects of several cost components on the total cost were found. As the result of this sensitivity analysis, the cost components and some terms of these were dropped since the presence or absence of them did not alter the overall cost significantly. Thus, the filter cost function, Y, to be used for illustration becomes:

$$Y = CD + CM + CUD + CFW + CRI + CRP + CEXC + CLND$$

All the cost data used in deriving above relationships were valid for 1971. They were obtained through personnal communications with some of the consulting engineering firms active in this field and located in the State of North Carolina, U.S.A.

OPTIMIZATION MODEL

To be able to use some of the optimization techniques it is necessary to formulate an objective function and a set of constraints, if any. Since the main concern is to find the filter which will meet some pre-determined specifications and at the same time be the cheapest possible; then, the objective must be to minimize the filter cost which satisfies the constraints. Therefore, the objective function will be the total cost function. On the other hand, the constraints will be the limitations on: 1) The hydraulic loading of the filter; 2) The organic loading of the filter and; 3) The desired filter efficiency. Then, the problem will become:

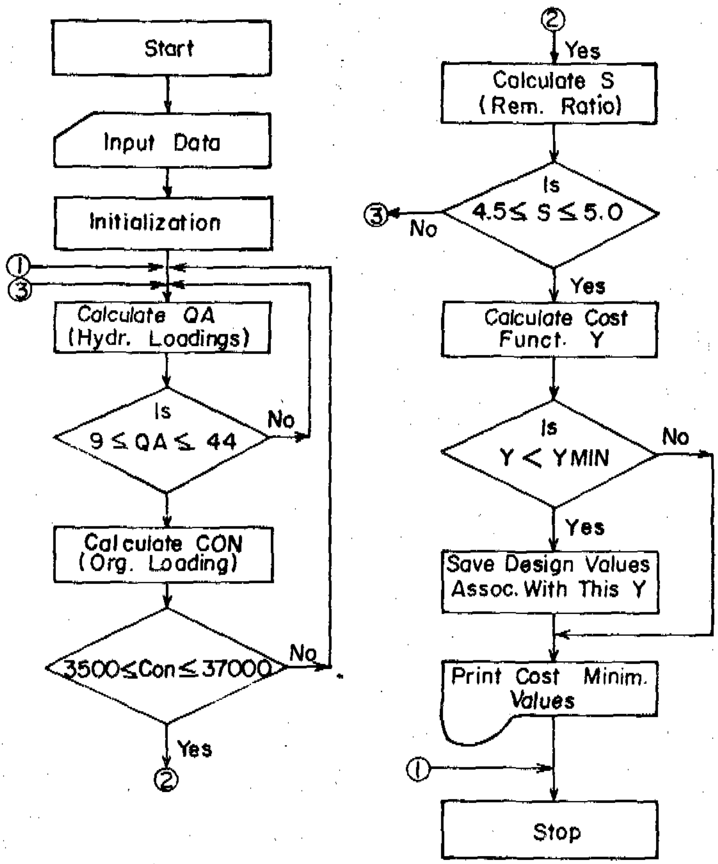

Fig. 2. Flow chart for the computer program.

Minimize Y_t = CD + CM + CUD + CFW + CRI + CRP + CEXC + CLND

subject to:

1) $9 < Q_a < 44$
2) $3500 < CON < 37000$
3) $4.5 < s < 5.0$
4) $D < 20$

where:

Q_a =Hydraulic loading of the filter, MGAD
CON =Organic loading of the filter, lbs of BOD/day/acre-ft
s $= L_a / L_e$

The problem will be solved by the use of a computer program discussed in the next section.

COMPUTER PROGRAM

Since the objective function and the constraints were non-linear, linear methods of optimization could not be used. Instead, computer program was written (in Fortran) to solve this problem. The flow diagram; computer program, and a sample output are presented in Figures 2, 3, and 4 respectively.

First time through, the program picks up a value for Q_i and for that value of Q_i it tries to find an optimum combination of T, D and R which satisfy all the constraints and thus, make Y a minimum (i.e. minimum cost.) After this is done, it goes back and picks up a new value for Q_i and goes through the same procedure as before until it finds optimum combination of T, D and R for the new case, and so on.

In order to make the solutions more practical and more meaningful, the values of Q_i, T and D were specified to be whole numbers. The rest of the variables did not have any restrictions as such but, only two places to the right of the decimal point were allowed.

There are few programming tricks that were used in this program in order to select the minimum and maximum values of Y and the values of other parameters associated with these among the values computed. This made it is possible to print out only those values which were of interest to us rather than all the possible combinations, and to save print out time.

SUMMARY

Here a practical design problem was taken and application of an optimization method of solution was shown. For this purpose:

```
10 INTEGER QI, T, D
20 DO 300 QI=1,20,1
40 YMIN=5E76
50 DO 200 T=30,200,1
60 DO 200 D=1,20,1
62 R=-0.5
64 DO 200 I=1,10,1
66 R=R+0.5
70 A=0.786*(T**(2))
80 QA=43560*QI*(1+R)/A
90 IF (QA-44) 11,11,200
94 11 CONTINUE
96 IF (QA-9) 200,12,12
100 12 CONTINUE
102 V=A*D
105 CON=32696136*QI/A
107 IF(CON-37000) 75,75,200
110 75 CONTINUE
112 IF(CON-3500) 200,80,80
115 80 CONTINUE
120 Y=(0.[illegible]8*D)*(QA**(1/3))
125 S=[illegible]
130 IF (S-0.5) 200,25,25
135 25 CONTINUE
136 P=S-4.3
137 IF (P-0.5) 90,90,200
140 90 CONTINUE
141 CRP=5000*((R*QI)**(0.4))
142 CD=916*(T**(0.7))
144 CM=0.26*V
146 CUD=4*A
148 CFW=4.37*D*T
150 CRI=10000*((R*QI)**(0.7))
152 CEXC=0.222*A
154 CLND=0.14*A
160 Y=CD+CM+CUD+CFW+CRI+CEXC+CLND+CRP
190 IF (YMIN-Y) 200,200,62
192 62 DMIN=D
193 RMIN=R
194 QAMIN=QA
196 TMIN=T
198 QIMIN=QI
    SMIN=S
    YMIN=Y
    CONMIN=CON
    [illegible] CONTINUE
    PRINT 5,QIMIN,YMIN,TMIN,DMIN,RMIN,QAMIN,CONMIN,SMIN
      FORMAT(3X,I3,F14.2,2(2X,I3),2X,F5.1,2X,F4.2,2X,F10.2,2X,F5.2)
    PRINT [illegible]
      CONTINUE
```

Fig. 3. Listing of the computer program

Answers:

QI	X	T	D	R	QA	CON	S
1	22029.94	36	15	0.0	42.76	32097.33	4.81
2	34595.09	51	15	0.0	42.61	31986.26	4.82
3	45492.07	62	15	0.0	43.25	32464.73	4.78
4	55494.03	71	15	0.0	43.98	33007.85	4.74
5	66486.68	80	15	0.0	43.30	32498.54	4.78
6	75727.17	87	15	0.0	43.93	32975.14	4.74
7	85575.66	94	15	0.0	43.90	32954.61	4.74
8	96034.85	101	15	0.0	43.46	32622.79	4.77
9	105487.70	107	15	0.0	43.57	32700.08	4.76
10	115392.17	113	15	0.0	43.40	32577.44	4.77
11	123991.67	118	15	0.0	43.78	32850.	4.75
12	132906.13	123	15	0.0	43.96	32994.76	4.74
13	148136.04	128	15	0.0	43.97	33006.33	4.74
14	151681.89	133	15	0.0	43.86	32922.94	4.74
15	161544.10	138	15	0.0	43.65	32764.76	4.76
16	169661.90	142	15	0.0	43.98	33007.85	4.74
17	180094.51	147	15	0.0	43.60	32725.64	4.76
18	188669.09	151	15	0.0	43.75	32839.19	4.75
19	197446.95	155	15	0.0	43.83	32897.59	4.75
20	206428.24	159	15	0.0	43.84	32908.62	4.74

Fig. 4. A sample output

the problem was formulated; the conditions which had to be satisfied, were listed; a mathematical model to predict the behavior of the filter was formulated; an optimization model (a filter cost function which needed to be minimized subject to some constraints) was developed and the problem was solved with the help of a computer program written for this purpose.

CONCLUSIONS

After a close look at the results, it can be conclude that:

1. The model predicts the optimum solution to be always associated with zero recirculation ratio. This is very much contrary to the present and conventional design practice.
2. For a given degree of removal, the filter depth is independent of plant capacity, but it is dependent on recirculation ratio and filter diameter.
3. If there were no restrictions on the diameter of a trickling filter, minimum cost filter will be obtained when the recirculation ratio was zero.
4. If the recirculation ratio were zero then for any Q_i the filter depth would be constant, and in our case equal to 15 ft.
5. The model predicts the best filters to be fairly deep, smaller in diameter and have no recirculation. All these are completely contrary to the present common practice.
6. Designers are cautioned against using the cost function developed here directly, since they may differ from place to place. This does not mean however, that the model or the optimization techniques are not valid.
7. Further experimental work should be carried out on the filter behavior model to test and see whether the model is a fairly good representation of what goes on in a filter. If the model seems to be appropriate then the design standards should changed accordingly.
8. The total cost per MGD treated decreases from $ 22023 for 1 MGD plant to $ [illegible]350 for 20 MGD plant.

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EVALUATION OF HYDRODYNAMICS AND PERFORMANCE OF AN INTERNALLY CLARIFIED ACTIVATED SLUDGE UNIT USING TRACERS

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INTRODUCTION

In so called "Internally Clarified Activated Sludge Processes" aeration, final settling and recirculation functions are performed in a single unit called "Aeroaccelator". For this reason, the performançe and efficiency of these units are quite sensitive to operating conditions and require a close control of the hydrodynamics of the unit. One of the more common causes of failure in the aeroaccelator performance is the inability of these units to separate the bio-solids from the liquid in the cell separation stage. This, in turn, is mostly due to facutly reactor hydrodynamics.

The plant where this study was conducted was originally designed to treat combined petrochemical-municipal wastewater with 526 l/sec industrial and 88 l/sec municipal flow; and started operating in 1964.

In early 1965, the aeroaccelators were modified in order to increase the oxygen transfer efficiency and remove more organics. The modifications included an additional rotor at mid-depth, additional baffles connected to the floor of the units in the mixed zone (target baffles), and smaller sparger orifices.

In late 1974, as a result of a study by a consulting firm[1], the industrial and domestic streams were separated. In addition, the target baffles from the West Aeroaccelator and the additional rotor from the East Aeroaccelator were removed[2]. Since then, the plant has been treating only the municipal wastewater which undergoes screening, grit removal, primary clarification, pre-chlorination, and bio-treatment in the aeroaccelators. Primary sludge is thickened and subsequently dewatered by vacuum filtration while secondary sludge is pumped to holding pond for disposal. A flow diagram of the system is presented in Figure 1.

Basis of Design

The original design was based on the flow and strength of the combined wastewater shown in Table 1. However, the units have been used in treating domestic wastewater since 1974. The design values recommended by the manufacturer for treating domestic waste are as follows[3]:

- Surface Loading — 28.5 m^3/m^2-day at average flow
- Organic Loading — 3-5 kg BOD_5/day/m^3 aeration volume
- Air Requirement — 30-35 m^3/kg BOD_5 removed

OPERATION

Cross sectional view of an aeroaccelator is presented in Figure 2[4]. The waste enters the unit at the bottom center below a hood forming the aeration zone. At this point air is also introduced through a sparger ring and is dispersed by the turbine which also acts as a radial flow type of pump. The intense agitation produced by the rotor insures complete mixing of waste, air and activated sludge and circulation of the mixture within the aeration zone. Also, the large bubbles of incoming air are broken up by the rotor into very fine bubbles for rapid oxygen transfer. The lifting action of the air bubbles then conveys the mixed liquor into the clarification section, and a throughput volume of clarified effluent is displaced from the mixed liquor.

Important operating variables which need to be controlled include: 1) Rate of internal recirculation; 2) Air feed rate;

Table 1. Design Influent Wastewater Characteristics

Parameter	Average Values: Municipal	Average Values: Industrial
Flow, l/sec	88	525
BOD_5, mg/l	200	1300
COD, mg/l	-	3400
Temp., ^oC	22.7	33.8
pH	7	10
SS, mg/l	200	350

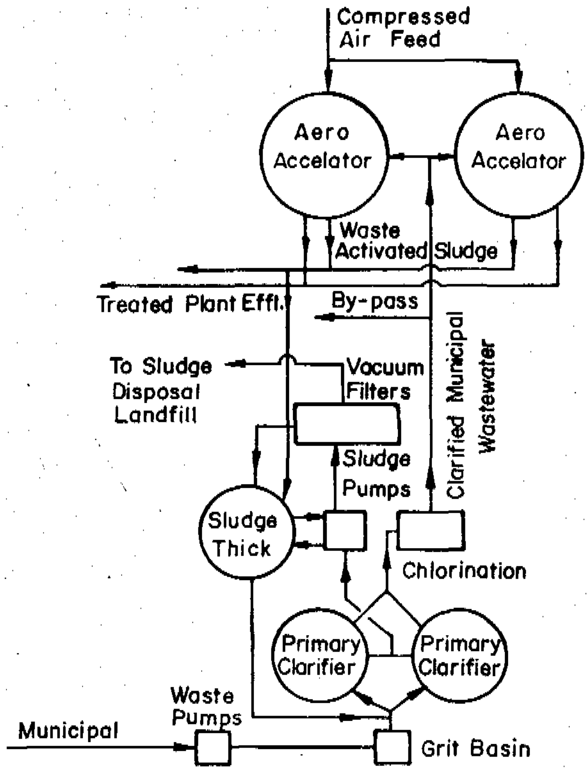

Fig. 1. Flow diagram for domestic waste treatment works.

3) Rotor speed; 4) Rate of throughput; 5) Mixed liquor suspended solids (MLSS) concentration; 6) Dissolved oxygen (D.O.) concentration in the mixed liquor; 7) COD of the clarified effluent; 8) pH; 9) Sludge volume index (SVI); and 10) Temperature.

Reasons for Conducting the Study

Performance of the treatment plant has been very unpredictable and inconsistent. At times, it had been very difficult to meet the effluent discharge standards set for the plant.

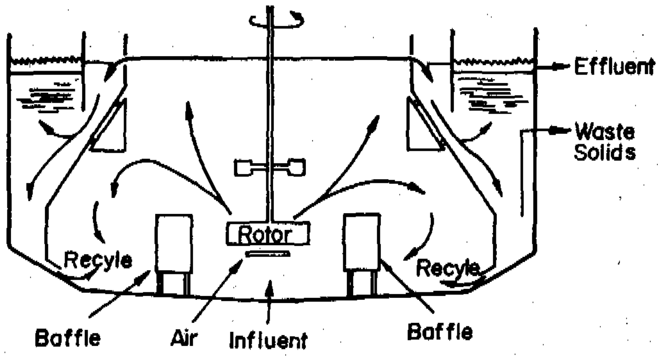

Fig. 2. Aerator - clarifier unit

Figure 3 shows average daily flows; and Figures 4, 5 and 6 show total suspended solids (TSS), settleable solids (SS), and total chemiçal oxygen demand (T COD) in the influent and the effluent of the aëroaccelators during the months which the study was conducted. As can be seen from these figures, to a great extent, the failure of the system is due to the failure in the aeroaccelator performance. More specifically, these units are unable to separate the bio-solids from the liquid in the cell separation stage. Based upon the observations of the treatment plant personnel, R/D personnel, and past records, the problem was hypothesized to be associated with the hydrodynamics of these units. Thus, at the request of the plant management this study was proposed and conducted.

Objectives of the Study

1. To improve the performance of the clarification section and thereby , reduce the TSS concentration in the effluent.
2. To determine the hydrodynamic behavior of the unit under different operating modes.
3. To formulate a relationship among four enternally controllable variables (A-Throughput rate; B-Turbine speed; C-Air flow Rate; and D-Recirculation port opening).

Approach

A series of designed experiments presented in Table 2 (two level factorial design in four variables and eight experiments)was prepared to determine the performance controlling variable(s).

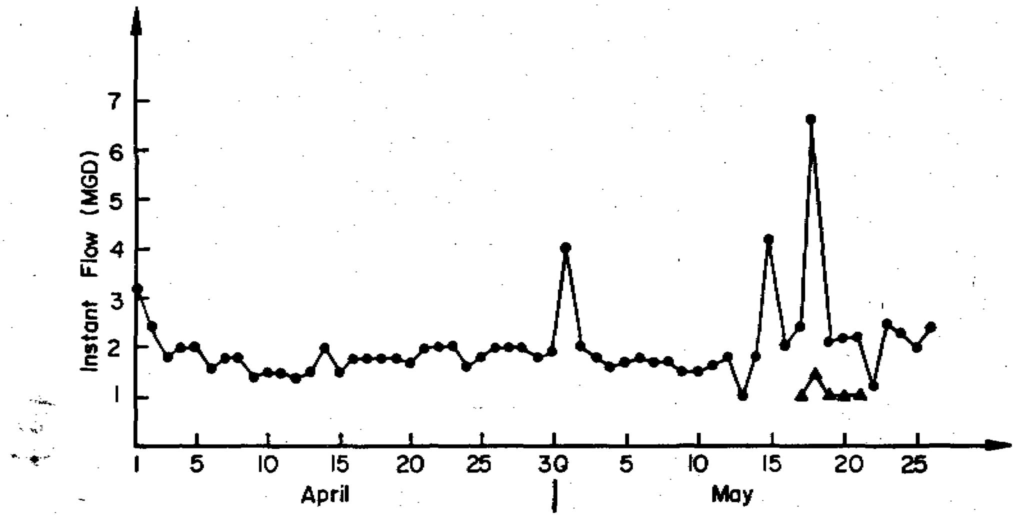

Fig. 3. Average daily flows (instantaneous) for april and may.

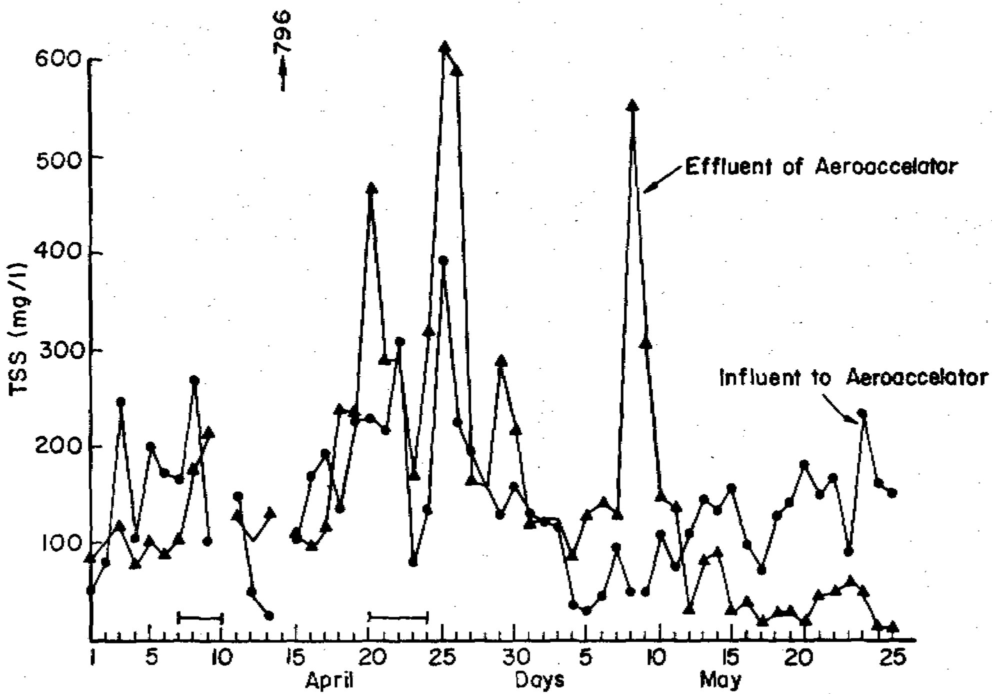

Fig. 4. Aeroaccelator influent and effluent TSS for april and may.

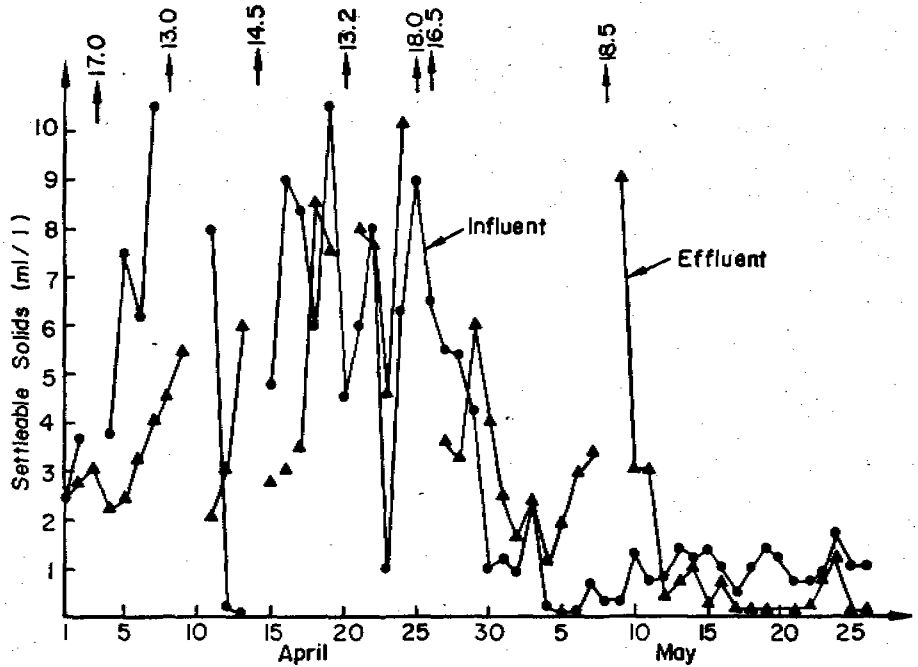

Fig. 5. Aeroaccelator influent and effluent settleable solids for april and may.

HASARAN

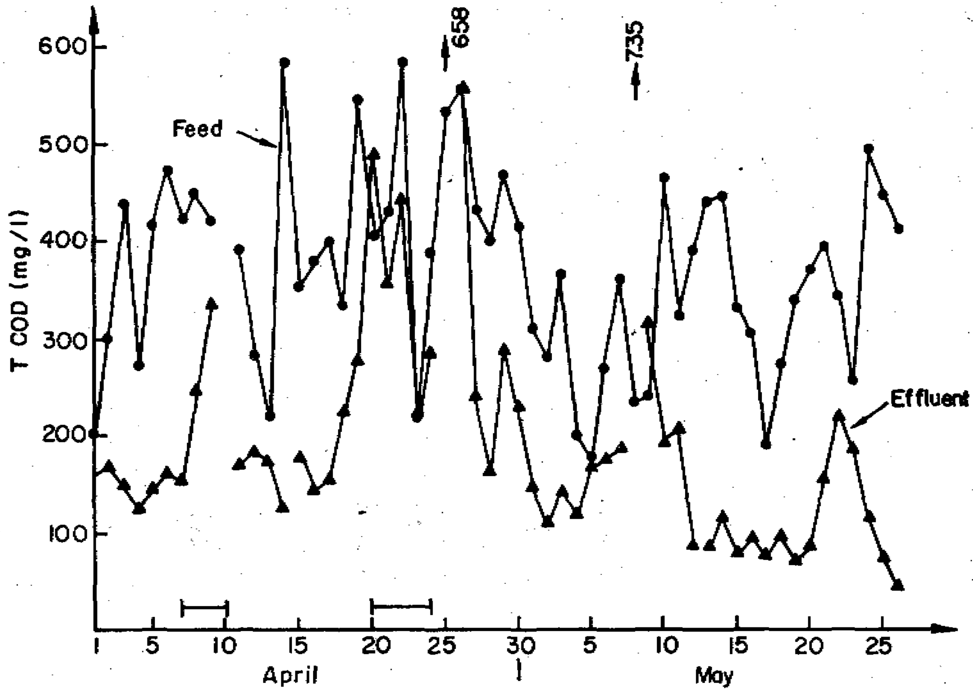

Fig. 6. Aeroaccelator influent and effluent total cod for april and may.

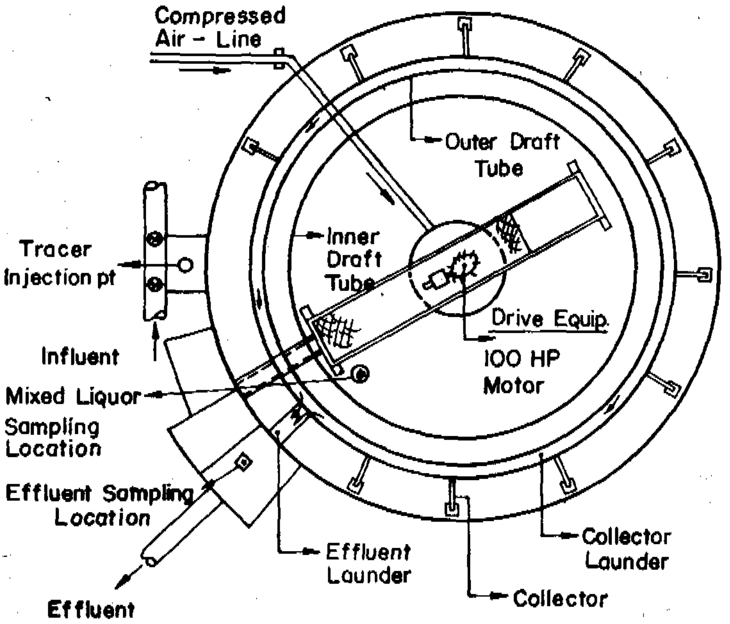

Fig. 7) Location of sampling points and dye injection.

The runs 1E and 2W were run under very similar conditions to determine the effect of the structural differences between the East and the West aeroaccelators. However, the response showed these units to be not too different from each other. It should be pointed out here that during the runs 1E and 2W there was no primary treatment.

Based on the mechanical reliability, the plant management advised that the designed experiments should be run on the West aeroaccelator. Therefore, the runs 2W, 3W and 4W were run using the West aeroaccelator. Purpose of these runs was to find out the changes in the hydrodynamics and effluent suspended solids with changes in the operation of these units. The results of 2W and 3W indicate that the unit's performance is very similar under both conditions. On the other hand, the run 4W indicates a dramatic change both in hydrodynamics and effluent suspended solids levels.

Table 2. Experimental Design (two level factorial)

Experiments/Variables	A	B	C	D	R
1 (4)	-	-	-	-	
2 (1)	+	-	-	+	
3 (7)	-	+	-	+	
4 (6)	+	+	-	-	
5 (2)	-	-	+	+	
6 (3)	+	-	+	-	
7 (5)	-	+	+	-	
8 (8)	+	+	+	+	

NOTE: -The numbers in parenthesis indicate the running order of the experiments (a randomization process).
-R is the response (e.g., % TSS removal)

During each designed experiment, a tracer would be injected into the unit and the residence time distribution (RTD) would be determined to characterize the hydrodynamics under these conditions. Two tracers, Lithium and Rhodamine-B, were used. Rhodamine-B provided a visual guide in deciding on a sampling duration and overall flow distribution. The samples were analyzed for Li using atomic absorption spectrophotometer and these results were used in computing the RTD. The tracer was chosen based on its (a) ease of application; (b) non-reactivity with the system; (c) economics, and (d) ease and accuracy of analysis at low concentrations.

Due to the large number of samples involved, time and manpower constraints, and complexity of data analysis, it became necessary to develop a general purpose computer program to analyze the tracer data. The program is capable of computing four different types of RTD's (E, I, F, L) and plot the results. Listing of and instructions to use the program may be obtained from the author upon request. Interpretation of E, I, F, and L may be found in most of the chemical engineering texts and literature.

RESULTS AND DISCUSSION

Figure 7 presents the locations of the sampling points and tracer injection. Table 3 presents the results of the study in a concise form. The mixed liquor (ML) refers to the completely mixed inner zone, whereas the effluent refers to the whole aeroaccelator (i.e., completely mixed, recycle, and clarification zones).

Table 3. Summary of Results

Run	Turbine Speed rpm	Air Feed Rate	Port Opening	$\bar{t}$, min.	σ_θ^2	D/ul	% M	% P	LAG
IE	17	H	0	599.1	0.742	0.371	100	0	0.125θ
2W	17	H	0	655.3	0.838	0.419	100	0	0.148θ
3W	17	L	C	677.6	0.870	0.435	100	0	0.110θ
4W	9	L	C	1005.8	1.108	0.554	100	0	0.020θ
IE	17	H	0	776.2	0.623	0.312	95	5	0.07 θ
2W	17	H	0	743.2	0.598	0.299	95	5	0.07 θ
3W	17	L	C	887.9	0.477	0.238	95	5	0.07 θ
4W	9	L	C	1510.7	0.445	0.222	80	20	0.05 θ

NOTE: Air Feed Rate - (H-High, M.L. D.O. of 7-9 ppm; l-low, M.L. D.O. of 1-3 ppm)
Port opening - (O-fully open; C-fully closed)
E - East Aeroaccelator
W - West Aeroaccelator
$\bar{t}$ - Mean Residence time, min.
σ_θ^2 - Variance of the RTD
D/ul - Dispersion coefficient
% M - Percent completely mixed
% P - Percent plug flow
LAG - Lag in response

Based on this run, the best combination of completely mixed to plug flow, for the unit as a whole, seems to be 80/20. This is somewhat different from the manufacturer's claim that the unit should function as a completely mixed reactor[2] . In addition, it is interesting to note that 80/20 is exactly the same ratio one would obtained if one computed the ratio of theoretical completely mixed volume to the quiescent volume.

CONCLUSIONS

Based on the results of the study, the following conclusions can be made:

1. Hydrodynamics has a great impact on the level of effluent suspended solids.
2. Hydrodynamics can be altered significantly using the right combination(s) of overflow rate, turbine speed, air feed rate and recirculation port openings. However, the exact relationship among these parameters could not be determined due to time constraint.
3. Mixed liquor zone approximates a perfectly mixed reactor with small lag.
4. The aeroaccelator can be controlled to achieve different degrees of "completely mixed" and "plug" flows. The optimum combination seems to be 80 % completely mixed and 20 % plug flow.
5. The East and the West aeroaccelators showed very similar performances under the conditions tested in this study.

In addition, based on the manufacturer's recommendations (application to domestic waste treatment) the following conclusions can be made:

6. Maximum throughput rate should be about 108 l/sec/unit (based on a surface loading of $<28.5\ m^3/m^2$-day).
7. Mixed liquor zone has five times the volume needed (based on an organic loading of 3 kg BOD_5/day/m^3 of aeration volume).
8. Air required/unit is about 42.5 m^3/unit (based on an influent BOD_5 = 200 mg/l; 95 % removal; and 35 m^3/kg BOD_5 removed/day).

RECOMMENDATIONS

As a result of this study, the following is recommended as a standard operating procedure (SOP) in operating these units.

1. Adjust the air feed rate such that the residuel D.O. level in the mixed liquor is about 2 mg/l. This level should be checked at about one metre below the water surface and at least twice a day. Presently, there is no sure way of

determining and controlling the air feed rate to each unit.

2. Adjust the turbine speed such that no large air bubbles and/or vortex appear around the shaft. (Usually about 75 % maximum speed). Presently, it is very troublesome and unreliable to operate in this mode; so, proper action needs to be taken and revisions made.
3. Keep recycle at about two times the inflow. It should be noted, however, that increasing the air feed rate will increase the recycle. Therefore, it would be necessary to re-set the recirculation port openings and turbine speed. Proper port opening is usually determined by the absence of air bubbles and solid clouds in the clarification zone.
4. Keep a food-to-microorganisms (F/M) ratio of 0.3 - 0.4, based on TSS.
5. Keep a mixed liquor suspended solids (MLSS) concentration of 2000 - 4000 mg/l.
6. Solids should be wasted from the mixed liquor zone to the primary clarifier(s) or thickener; and more frequently. Presently, solids are withdrawn infrequently from the recycle zone.
7. If it is desired to find the exact relationship(s) among the variables considered in the experimental design, experiments 2, 3, 5, 6, 7, and 8 need to be completed.

SUMMARY

The treatment plant where the study was conducted was designed to treat a combined petrochemical-municipal wastewater with 526 l/sec petrochemical and 88 l/sec municipal wastewater flow. Performance of the treatment plant had been very unpredictable and inconsistent. At times, it had been very difficult to meet the effluent discharge standards set for the plant. To a great extent, this was observed to be due to the inability of the internally clarified activated sludge units (Aeroaccelators) to separate the bio-solids from the liquid in the cell separation stage which was related to the mixing and flow characteristics (hydrodynamics) of these units.

Four tracer studies were conducted to assess the hydrodynamics and performance characteristics of the Aeroaccelators in the treatment plant. The study confirmed the reason for high effluent suspended solids concentration to be the result to faulty mixing and folw characteristics of these units. A standard operating procedure is recommended to correct the situation.

A general purpose computer program was also developed to analyze the data from any tracer study and plot the resulting residence time distribution(s). These distributions include E, I, F, and L.

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THE EFFECT OF AIR POLLUTION ON THE FLORA AND FAUNA IN THE REGION OF TITOVA MITROVICA

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This study is continuation of the previous work where the air pollution of Titova Mitrovica and its surrounding area was studied, here we will show our observations on the influence of pollutants on experimental plants and animals in the viciniti of the industrial plants.

I. THE SOURCES OF POLLUTION

These have been described in the previous report.

II. THE INFLUENCE OF POLLUTED AIR ON FLORA

Flora which is considered a true indicator of pollution, shows the presence of air through damage and various diseases. In this research we studied the influence of polluted air on Pinus Nigra (Pine) and Robinia Pseudoacacia Variabila Umbraculifera (Acacia). As mentioned the influence of industrial pollutants on vegetation is great, therefore the aim of investigation was through the obtained results and observations to discover where, on which species and in what way the damage occurs, from toxic gases and various metals expeled from the factory chimneys. During this observations it was discovered that air pollution does not equaly affect all species of vegetation. On most species the effect of pollution is obvious by the edges of the leaves and on some species it can be seen in spots of various shapes and size scattered over part of or the whole of the leaf

These are the symptoms of Necroza which is the characteristic damage caused by sulphur dioxide. It is known that this gas causes two stages of damage,acute and chronic

Acute damage is caused by high concentrations of sulfur dioxide in the air, which causes bad injury to the edges and veins of the leaves. After fumigation these areas become dark and have the appearance of having been scalded, the leaves become limp and have a grey-green colour while the rest of the leaf is usualy green and looks normal. Conifers are more sensitive than deciduous because their needles dont fall annually so they are under the influence of air pollution much longer. Maximum sensitivity to sulfur dioxide pollution is in the late spring and early summer, so conected with the physiological activity of the plants. The observed Pinus Nigra shows early symptoms when the normal green colour turns to light green, than certian areas change to yellowish-brown and finally redish-brown giving the needle a striped effect.

The chronical damage occurs after absorption of lower amount of sulfur dioxide, a slow long absorption of a subtle amount of gas, which accumulates until the buffer capacity of the leaf is overcome. This damage causes gradual chlorophille damage, abnormal photosynthesis and stunded growth. The damage to coniferous vegetation, besides the concentration of gas also depends on the length of time of exposure and the speed of absorption which varies according to the age and type of tree. By the symptoms of leaf damage, very often it is possible to determine not only the instigator but also the degree and extension of air pollution. This reaction to toxic gases could be of practical value, as it can be used for diagnosis.

3. THE EFFECT OF POLLUTED AIR ON FAUNA

3.1. ANIMALS IN NATURAL HABITAT

The harmful influence on livestock becomes more obvious with the development of industrial plants in Titova Mitrovica.

In this research we will show the great influence of air pollution on lambs in their natural habitat, which are affected by pollutants. During the spring at lambing time breeders in the area, notice illnesses amongst the sheep and paralasis amongst the lambs. Until recently there were a great many sheep in the area, but within a short time they have rapidly reduced in number. (i.e. in the villages of Rudare, Zitkovac, Šupkovac, and Mali Kićić). They become ill, especially during the months February to April, they loose weight, lambs become deformed after birth. The hind legs criple followed by the fore legs then the head twists to the side and shakes. Compared to healthy animals they are smaller and lighter, they are inactive and weak, the wool is stiff and sparse.

But if the animals are transported out of the area away from the influence ofpollution, or kept in enclosures with special care and attention the deaths can be avoided. By Toxicological analasis a high concentration of lead can be detected in the blood, after-birth and internal organs particularly the bone marrow. Lead and a number of other pollutants are absorbed into the body via the digestive and respiratory systems.

3.2. EXPERIMENTAL ANIMALS

Besides the pasture animals, experimental animals were exposed to the very high polluted air in working areas with the aim of studying the negative effect of air pollution on the weight, natality and mortality on animals.

As experimental animals, laboratory rats (RATUS NORVEGICUS) were used, these were placed in specially built metal cages, with large holes for air circulation and separated into three sections. In each section a small cage containing animals was placed.

One group of animals was placed in the Directing Cabin of the Roasting Plant and another in the Roasting Plant Furnace where they were kept for 5 months. All animals were fed with standard feed. Lead in the blood of the animals was measured every 30 days, 3 rats from each cage were used for detection, newborn and dead were always removed from the cages. Results of these experiments are given in the presented tables.

In table 1 the working area, starting weight and changes in weight over the given period is shown. In table 2 The average concentration of lead in the blood of experimental animals in working areas is given. The concentrations are high as the working areas are highly contaminated.

TABLE 1

WEIGHT LOSS OF EXPERIMENTAL ANIMALS IN WORKING AREAS

WORKING AREA	SMALL CAGE	STARTING WEIGHT	MONTH				
			V.	VI.	VII.	VIII.	IX.
DIRECTING CABIN OF ROASTING PLANT	A1	250	240	240	D	–	–
	A2	240	235	230	D	–	–
	A3	240	240	230	220	D	–
	A4	230	200	D	–	–	–
	B1	190	180	D	–	–	–
	B2	200	210	215	200	D	–
	B3	210	200	200	D	–	–
	B4	190	D	–	–	–	–
	C1	310	310	315	305	295	D
	C2	310	300	310	310	29[illegible]	D
	C3	290	290	270	D	–	–
	C4	280	275	265	D	–	–
ROASTING PLANT FURNACE	D1	1[illegible]0	D	–	–	–	–
	D2	17[illegible]	D	–	–	–	–
	D3	145	145	140	D	–	–
	D4	175	170	160	D	–	–
	E1	210	190	D	–	–	–
	E2	225	200	D	–	–	–
	E3	220	220	210	D	–	–
	E4	230	230	225	D	–	–
	F1	290	280	270	D	–	–
	F2	280	260	D	–	–	–
	F3	270	255	D	–	–	–
	F4	295	295	29[illegible]	2[illegible]0	[illegible]	D

D = died

TABLE 2

THE AVERAGE VALUES OF LEAD IN THE BLOOD OF EXPERIMENTAL ANIMALS IN WORKING AREAS

MONTH	ROASTING PLANT FURNACE	DIRECTING CABIN OF ROASTING PLANT
V.	69.7	48.8
VI.	[illegible]2.7	[illegible]
VII.	98.8	75.4
VIII.	112.	[illegible]
IX.	124.[illegible]	[illegible]

S U M M A R Y

In this work Robinia Pseudoacacia Variabila Umbraculifera (Acacia) was used for the detection of the degree and extension of air pollution to vegetation in the area. Also studied was the effect of air pollution on the animals in their natural habitat as well as experimental animals in working areas.

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STUDY OF AIR POLLUTION IN THE REGION OF TITOVA MITROVICA

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Air, which is the most important natural source and indispensible to all life forms is imperiled in large industrial areas such is Titova Mitrovica.

The town population, about 100 thousand, is positioned between two industrial complexes. Smelting plants, refineris, flotation plants etc. lie to the north and zinc metalurgy plants, battery plants and chemical industry plants to the south. Near the industrial complex lies the so colled "Old Sterile Mass" dump which is one of the major sources of pollution. Besides the mentioned industrial complexes, the towns heating plant with its chimney's together with private heatings systems and exhaust fumes form other sources off pollution.

Environmental pollution grows in intensity every day, we cant stop it but we can influence it, therefore our task should be towards better control of environmental pollution. Taking into consideration that Titova Mitrovica is under the heavy influence of various pollutants it was necessary to form a bureau to observe the degree of pollution. This was done several years ago and cooperates with other institutes concerned with pollution.

Our study of air pollution was conducted at 16 measuring stations, which are positioned north, south, east and west of the town, and they are divaded into three zones. The first zone is near the industrial plants and has seven measuring stations. The second and third zones, still under the pollutant influence contain other measuring stations.

During this study the folowing pollutants were detected: Total sediment, soot, sulphur dioxide, hydrogen sulphide, lead, zinc, cadmium and fluor. This was conducted from october 1982 till october 1985. The results are shown in tables 1 - 6.

Total sedimental material determined at all measuring station is shown in table 1. The data shows minimum and maximum monthly concentrations in mg/m^2 per day, also average yearly concentration.

In order to get a clear picture of the degree of pollution at some measuring stations, it must be mentioned that the maximum allowed concentration for the total sedimental material is 500 mg/m^2 per day.

From table 1. it can be seen that the measuring station called Malo rudare is the most endangered with 851.79 mg/m^2 per day. Next is Zvecan with 787,9 mg/m^2 per day, very high concentration were detected at the stations V. Banasevic, Supkovac and the Childerns Clinic, with 719.8 mg/m^2, 676,20 mg/m^2 and 624,90 mg/m^2 per day respectively. As this places are nearest to the industrial plants it therefore goes that they are the most polluted, while those further away become less polluted, as can be seen from the table.

In table 2 the monthly amount of soot and sulphur dioxide that was present in the air, at three measuring points is shown. Also the maximum concentration of sulphur dioxide and soot in the air for each day in the month at the same three stations, is shown in table 3.

Table 4 shows the number of days in the month when the concentrations of sulphur dioxide and soot were higher than allowed.

From the presented results it can be seen that the concentration of sulphur dioxide and soot in the air are several times higher than the allowed concentrations e.g. sulphur dioxide in higher concentrations than allowed was present during 164 days of the observation period at the childerns clinic which is in the vicinity of the industrial plants. A similar situation is present at the measuring station Supkovac, also near the plants. The amount of soot in the observed areas is also high and follows the concentrations of sulphur dioxide. The detection of lead, zinc, cadmium, fluorine and hydrogen sulfide was continually observed in the air of T. Mitrovica and vicinity at 10 measuring stations during the same period. Results are given in table 5 and 6.

From table 6 for example, the amount of lead in the air basin around Childrens Clinic totals 325.50 mg/m^2, if this amount is divided into 12 (No. of samples) the average monthly value 27.12 mg/m^2. To obtain the factor of pollution this value must be divided by the maximum allowed concentration for lead which is 0.7 mg/m^2. In this case the factor of pollution is 39.

Usualy the concentration of lead is followed by the amount of zinc. To get a clear picture of the state of pollution of Titova Mitrovica and the vicinity a general picture is given in table 6, where the total yearly concentrations of lead, zinc, cadmium , fluorine and hydrogen sulfide at each measuring station is presented.

TABLE 1.

Total Sedimental Material mg/m^2/day.

	MEASURING STATION	MINIMUM CONCENTRATION	MAXIMUM CONCENTRATION	AVERAGE CONC.
1.	M. RUDARE	February 199.7	October 19[illegible]	[illegible]1.[illegible]
2.	ZVEČAN	January 1[illegible]3.7	November 1[illegible]4.0	[illegible]7.[illegible]
3.	V. BANAŠEVIĆ	August 222.[illegible]	February 1[illegible].2	71[illegible].
4.	ŠUPKOVAC	August 261.2	January 12[illegible]7.1	[illegible].2
5.	CHILDRENS CLINIC	September 261.[illegible]	July 119[illegible].7	[illegible]
6.	BAIR	February 3[illegible].7	March [illegible]27.1	577.4
7.	HOSPITAL	August 208.0	October 1[illegible]01.[illegible]	[illegible]7.9
8.	LEPOSAVIĆ	August 50.4	December [illegible]	[illegible]
9.	V. [illegible]IĆIĆ	August 228.9	February 9[illegible].	[illegible]11.8
10.	VUČITRN	August 125.[illegible]	February 11[illegible].7	47[illegible].2
11.	[illegible]	August [illegible]7.6	October 1243.1	4[illegible]0.2
12.	ŠIPOLJE	August 110.4	January [illegible]97.[illegible]	551.2
13.	[illegible]. TUNEL	December 11[illegible].5	May [illegible]50.[illegible]	3[illegible]4.5
14.	S. TRG	August 90.5	December 701.9	29[illegible].[illegible]
15.	VINARCE	August [illegible]9.9	May 5[illegible]2.2	[illegible]62.1
16.	Z. POTOK	November 57.1	October [illegible]17.2	27[illegible].[illegible]

TABLE 2

THE PRESENCE OF SULPHUR DIOXIDE AND SOOT IN THE AIR mg/m^3

		V. BANAŠEVIC		ŠUPKOVAC		CHILDRENS CLINIC	
MONTH		SO_2	SOOT	SO_2	SOOT	SO_2	SOOT
X/82	a	7407.0	1588.0	6979.0	1543.0	6201.0	1680.0
	b	258.9	51.2	289.6	49.7	200.0	54.2
XI	a	5932.0	1475.0	6915.0	1524.0	6612.0	1667.0
	b	197.7	49.2	230.5	50.8	220.4	55.6
XII	a	7239.0	1400.0	9369.0	1462.0	9284.0	3062.0
	b	233.5	45.2	302.2	47.2	299.5	98.8
I/83	a	10111.0	1777.0	9076.0	1740.0	12724.0	2705.0
	b	326.2	57.3	292.8	56.1	410.4	87.3
II	a	6559.0	1501.0	6583.0	1292.0	8202.0	2515.0
	b	233.5	53.6	235.1	46.1	292.9	95.4
III	a	8254.0	1688.0	8561.0	1642.0	7827.0	2628.0
	b	266.3	54.4	276.2	52.9	252.5	84.8
IV	a	8379.0	1794.0	6626.0	1569.0	10996.0	2953.0
	b	279.3	59.8	220.8	52.3	[illegible]	98.4
V	a	6710.0	2092.0	6673.0	1334.0	7421.0	2988.0
	b	216.4	67.5	215.2	43.0	239.4	96.3
VI	a	7787.0	1754.0	7116.0	1593.0	7464.0	2904.0
	b	259.5	56.8	237.2	53.1	248.8	96.8
VII	a	7895.0	2455.0	5817.0	2328.0	11571.0	2352.0
	b	254.6	79.2	187.6	75.1	373.2	75.9
VIII	a	2289.0	536.0	1228.0	590.0	2300.0	619.0
	b	73.8	17.3	39.6	19.0	[illegible]	19.9
IX	a	1851.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	b	61.03	[illegible]	71.8	54.1	117.9	57.7
YEARLY TOTAL	a	[illegible]	19405.0	79079.0	[illegible]	94158.0	27901.0
	b	[illegible]	[illegible]	[illegible]	597.9	[illegible]	919.1
MONTHLY AVERAGES	a	[illegible]	[illegible]	[illegible]	1470.1	[illegible]	[illegible]
	b	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a MONTHLY TOTAL

b MONTHLY AVERAGE

TABLE 3
MAXIMUM DAILY VALUES OF SO_2 AND SOOT

		CHILDRENS CLINIC		V. BANAŠEVIC		DUPROVAC	
MONTH		SO_2	SOOT	SO_2	SOOT	SO_2	SOOT
X/82	mg/m^3	1700.0	256.0	1499.0	205.0	1660.0	270.0
	day	25	13	10	8	25	4
XI	mg/m^3	1380.0	228.0	1700.0	205.0	1700.0	260.0
	day	15	15	12	23	16	5
XII	mg/m^3	1001.0	182.0	1425.0	125.0	1750.0	250.0
	day	15	18	19	6	25	5
I/83	mg/m^3	1511.0	162.0	1511.0	176.0	1700.0	175.0
	day	20	22	12	1	19	[illegible]
II	mg/m^3	1268.0	182.0	1219.0	238.0	1520.0	296.0
	day	21	4	4	7	4	7
III	mg/m^3	1301.0	175.0	1602.0	285.0	[illegible]	265.0
	day	18	25	20	7	7	7
IV	mg/m^3	1500.0	160.0	1480.0	160.0	1620.0	156.0
	day	12	18	4	30	12	4
V	mg/m^3	1199.0	148.0	1200.0	246.0	1560.0	250.0
	day	14	25	3	21	25	5
VI	mg/m^3	1280.0	166.0	1502.0	260.0	1690.0	265.0
	day	9	26	15	5	6	25
VII	mg/m^3	1700.0	230.0	1580.0	141.0	1550.0	275.0
	day	8	9	15	2	6	7
VIII	mg/m^3	152.0	41.0	110.0	32.0	59.0	41.0
	day	18	1	1	7	31	7
IX	mg/m^3	199.0	117.0	105.0	150.0	182.0	72.0
	day	21	26	7	25	26	22

TABLE 4
NUMBER OF DAYS WITH CONTENT OF SO_2 AND SOOT GREATER THAN MAXIMUM ALLOWED CONCENTRATE

	CHILDRENS CLINIC		V. BABASEVIC		SUPROVAC	
MONTH	SO_2	SOOT	SO_2	SOOT	SO_2	SOOT
X/62	7	7	12	8	14	7
XI	10	10	8	7	12	8
XII	25	26	15	7	20	[illegible]
I/63	19	21	22	15	16	15
II	19	19	11	10	12	7
III	18	19	1[illegible]	10	18	8
IV	21	25	16	12	14	16
V	16	26	11	17	11	6
VI	22	24	15	15	10	16
VII	–	–	–	–	–	–
VIII	20	15	14	24	12	1[illegible]
IX	7	1[illegible]	–	8	1	5
TOTAL DAYS	184	206	135	129	140	101

TABLE 5 SPECIFIC HARMFUL MATERIAL mg/m^3						
DATE	Pb	Zn	Cd	Pb	Zn	Cd
	CHILDRENS CLINIC			V. BANAŠEVIC		
2. X. 1982	3.0	6.0	0.9	19.7	6.0	0.14
3. XI. 1982	95.2	8.2	0.05	18.1	21.2	0.12
4. XII. 1982	6.1	6.0	0.03	2.3	5.9	0.19
6. I. 1983	21.6	6.3	0.01	0.6	5.4	0.13
1. II. 1983	29.9	5.9	0.19	84.3	9.1	0.32
4. III. 1983	5.3	7.1	0.02	7.0	20.9	0.15
7. IV. 1983	20.6	6.9	0.11	16.5	6.9	0.11
4. V. 1983	30.9	8.0	0.13	8.0	8.0	0.13
8. VI. 1983	7.1	19.5	0.36	20.2	19.5	0.36
3. VII. 1983	96.1	21.4	0.21	85.1	21.4	0.21
4. VIII. 1983	4.1	5.9	0.10	0.5	5.9	0.15
5. IX. 1983	7.6	6.1	0.13	2.4	6.1	0.13
	ŠUPKOVAC			BAIR		
2. X. 1982	8.5	8.3	0.22	13.1	13.0	0.08
3. XI. 1982	15.2	25.8	0.24	3.9	10.1	0.05
4. XII. 1982	13.1	11.1	0.03	43.1	5.9	0.04
6. I. 1983	33.4	13.6	0.01	3.8	10.1	0.01
1. II. 1983	30.1	10.3	0.30	23.0	18.1	0.02
4. III. 1983	14.2	22.4	0.13	10.9	5.6	0.03
7. IV. 1983	13.2	24.9	0.20	4.9	[illegible]	[illegible]
4. .. 1983	17.1	18.4	0.23	14.1	9.2	[illegible]
. V..1983	29.1	14.1	0.22	29.0	11.1	0.04
3. VII. 1983	38.4	23.6	0.26	44.1	19.1	0.08
4. VIII. 1983				2.0	3.0	0.01
5. IX. 1983	10.1	6.1	0.02	3.1	5.1	0.01

TABLE 5 cont'd						
DATE	Pb	Zn	Cd	Pb	Zn	Cd
	HOSPITAL			ZVECAN		
2. X. 1982	11.4	3.1	0.02	40.3	10.1	0.04
3. XI. 1982	8.3	5.1	0.04	9.5	24.3	0.09
4. XII. 1982	9.2	6.0	0.01	9.2	6.2	0.79
6. I. 1983	5.5	8.7	0.02	122.0	7.1	0.09
1. II. 1983	3.0	4.9	0.01	10.1	44.0	0.02
4. III. 1983	4.1	6.4	0.02	20.1	16.2	0.50
7. IV. 1983	8.5	3.8	0.02	11.5	12.1	0.11
4. V. 1983	7.5	7.7	0.01	13.5	15.2	0.42
8. VI. 1983	10.2	7.0	0.01	50.3	26.0	0.42
5. VII. 1983	13.4	10.6	0.03	125.0	48.0	0.65
4. VIII. 1983	1.0	2.1	0.01	4.5	2.2	0.02
5. IX. 1983	2.0	3.0	0.01	6.5	3.8	0.06
	LEPOSAVIC			STARI TRG		
2. X. 1982	9.1	8.1	0.01	4.2	6.0	0.02
3. XI. 1982	4.5	5.1	0.02	0.3	5.9	0.01
4. XII. 1982	6.0	4.8	0.03	4.9	6.4	0.01
6. I. 1983	11.1	8.1	0.01	1.7	1.9	0.01
1. II. 1983	9.0	5.1	0.03	2.9	6.5	0.02
4. III. 1983	11.4	5.8	0.02	8.7	2.9	0.01
7. IV. 1983	10.1	7.8	0.03	8.8	7.8	0.02
4. V. 1983	9.8	5.2	0.01	9.0	8.0	0.02
8. VI. 1983	11.9	8.6	0.02	9.9	5.9	0.01
5. VII. 1983	13.8	9.5	0.03	11.5	7.5	0.03
4. VIII. 1983	2.0	2.8	0.01	0.4	1.9	0.01
5. IX. 1983	3.1	3.2	0.01	1.0	2.8	0.01
	VUCITRN			ZUBIN POTOK		
2. X. 1982	3.0	5.0	0.02	4.3	7.1	0.01
3. XI. 1982	9.2	5.4	0.01	4.0	[illegible]	0.02
4. XII. 1982	13.1	7.1	0.02	5.1	7.1	0.01
6. I. 1983	1.2	4.8	0.01	1.3	2.8	0.02
1. II. 1983	0.4	5.2	0.01	5.4	7.6	0.01
4. III. 1983	0.9	5.4	0.03	10.2	3.5	0.02
7. IV. 1983	3.0	6.4	0.02	8.3	9.1	0.02
4. V. 1983	1.9	5.9	0.01	5.8	5.9	0.02
8. VI. 1983	9.2	7.2	0.02	4.3	3.	0.02
5. VII. 1983	13.3	9.2	0.03	6.1	[illegible]	0.02
4. VIII. 1983	0.2	1.0	0.01	0.1	1.8	0.01
5. IX. 1983	0.3	2.4	0.01	0.2	2.9	0.02

TABLE 6
TOTAL AVERAGE OF SPECIFIC HARMFUL MATERIAL mg/m^{3}

MEASURING STATION	Pb	Zn	Cd	F	H_2S
CHILDRENS CLINIC	325.[illegible]	7[illegible].7	2.4	5[illegible].	[illegible]
V. BANAŠEVIČ	2[illegible].7	1[illegible]7.2	2.1	[illegible]47.[illegible]	2[illegible].1
ŠUPKOVAC	288.9	162.6	1.8	967.7	[illegible]4.7
BAIR	195.[illegible]	12[illegible].0	0.4[illegible]	892.[illegible]	504.0
HOSPITAL	83.5	69.1	0.2	377.6	25[illegible].[illegible]
ZVEČAN	422.[illegible]	219.2	3.03	470.9	208.7
LEPOSAVIĆ	101.[illegible]	74.1	0.24	361.4	[illegible]2.8
STARI TRG	62.[illegible]	[illegible]	0.18	1[illegible]1.[illegible]	2[illegible].4
VUČITRN	[illegible]	6[illegible].0	0.[illegible]	600.[illegible]	[illegible]4[illegible].4
[illegible] POTOK	50.8	64.2	[illegible].18	[illegible]7.[illegible]	[illegible].2

S U M M A R Y

An investigation was caried out by the Environmental Protection Office at the 16 measuring stations for observation of the number of industrial pollutants which are emited from the chimneys of "Trepča" in an urban area as a product of industrial metabolism.

It can be concluded that in the air of Titova Mitrovica and vicinity are high concentrations of lead, zinc, cadmium, fluorine and hydrogen sulfide which are several times higher than the maximum allowed concentrations.

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CORRELATIVE STUDY OF WATER BORNE DISEASES AND MICROBIAL CONTAMINATION IN POTABLE WATER SUPPLY TO BHOPAL CITY

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INTRODUCTION

The health is affected by an ingestion of contaminated water with organisms such as bacteria, viruses and protozoans that cause common water borne diseases like typhoid, paratyphoid, bacillary dysentery, gastroenteritis, cholera, diarrhoea, viral hepatitis, poliomyelitis, amoebiasis, giardiasis etc. Recent study indicates that addition of disinfectant agent like chlorine in potable water is inadequate to protect from viral or bacterial infection. The frequency with which enteroviruses are being isolated in recent years from the chlorinated plant effluents and increasing reports of resistance of bacteria to chlorine inactivation are causing mounting concern (Erickson and Foulk, 1980; Stanley and Cannon, 1977; Malakhova, 1977; Davis, 1977; Carberry and Stapleford, 1979, Garba and Stagg, 1979). It has been pointed out that increase in alum doses to reduce turbidity of water can cause increase in microbial colonies (Belsare, 1982) for which chlorine is probably inadequate as disinfectant agent.

Surveys conducted in various parts of India (Ghai et al, 1969) reveal that child population is the target group affected by water borne diseases. Studies made by Moore et al (1965) and Chakraborty (1980) in developing countries indicate that the provision of safe drinking water can make a major breakthrough in occurrence of these diseases. The present study was, therefore, undertaken as a surveillance of drinking water in order to correlate the seasonal frequency of occurrence of water borne diseases in urban area of Bhopal and the microbial contamination of potable water supplied to it.

MATERIAL AND METHODS

The present study was carried out in the industrial based tropical cases. The statistical analysis of the cases having water borne disease was done in relation to age and season.

The water samples were taken from the reservoir (The Upper Lake) and two protected water works which provide potable water to the industrialized and non-industrialized areas. The sampling was done once a week. The bacterial colonies (viable count) were counted by the efficiency plate count (EPC) method (APHA, 1971) and most potable number (MPN) for coliforms according to the method given by Collins and Lyne (1969). A record of alum doses was also noted from the logbook entries of the water works authorities.

OBSERVATIONS

The overall incidence of water borne disease as compared to the total admission in the medical college hospital is 21.47%, whereas in the industrial hospital it is 28.05%. The order of frequency is gastero-enteritis 13.09%, enteric fever 5.9%, bacillary dysentery 3.5%, amoebiosis 2.7%, infective hepatitis 1.6%, and poliomyelitis 0.16% (Fig. 1).

71% of the gasteroenteritis cases belong to the age group of infancy i.e., below 2 years of age, 68.2% cases of poliomyelitis occur below 2 years age group whereas there is not a single case of this disease in 6 years age group and above. On the contrary the maximum cases (63.3%) of the enteric fevers are noted in children above 6 years of age. Similarly 65.9% of cases of infective hepatitis occur in 2 to 6 years age group. Although not a single case of amoebiasis is observed in infants, its peak incidence (91.6%) is noted in more than 6 years age group. The bacillary dysentery, however, is of almost equal incidence in all the age groups from 0-2 years, 2-6 years and above 6 years age group.

The seasonal occurrence of these water borne diseases indicate that the gastroenteritis (40%) and enteric fevers (40%) occur throughout the year with same frequency, whereas cases of hepatitis (55%), poliomyelitis (5.5%) and dysentery (45%) are maximum during rainy season and hot period. A bacteriological study of raw water and treated water in the two protected water works indicates that both MPN and viable counts of the bacterial colonies increase (Fig. 1) during hot period (March-June) and rainy season (July-September), whereas their number is considerably less during cold period (Nov-January). In the case of chlorinated filtered water, the MPN counts are 150/100 ml in July and 70/100 ml in December. The corresponding values of viable counts during these months are 10000/ml and 4000/ml.

A correlative study of bacterial colonies and alum doses indicates that initially the coliform increase to maximum at an alum dose of 10-15 mg/litre and thereafter declines when alum of 25-30 mg/litre is applied. When still higher doses of alum are applied, the coliform counts from the clarifiers increase. The higher doses are generally used during rainy season to reduce the turbidity of water.

DISCUSSION

It is seen that the common diseases that occur in children are gastroenteritis, enteric fever, infective hepatitis and bacillary dysentery and amoiebiasis. The frequency of these water borne diseases is more during rainy season and hot period. Incidentally the doses of coagulant are also many fold during this period in order to reduce turbidity of water. Since they result in increased bacterial counts (Belsare, 1982), the chlorination of filtered water has to be perfect to reduce their number. The persistance of more bacterial colonies in post-chlorinated water during rainy season and hot period

Table 1. Age Groups Variation in water borne diseases

Disease	(Non-industrial area)					
	0 - 2 yrs		2 - 6 yrs		7 yrs	
	No.	%	No.	%	No.	%
Gastroenteritis	521	71.8	138	18.6	66	9.6
Poliomyelitis	43	68.3	20	31.7	0	0
Enteric fever	6	5.5	34	31.2	69	63.3
INF hepatitis	5	11.3	29	65.9	10	22.8
Amoebiasis	0	0	1	8.4	11	91.6
BAC dysentery	38	40.0	30	31.3	27	28.7
Worm infestation	9	45.0	5	25.0	6	30.0

Table 2. Water borne diseases in non-industrial (Hamidia hospital) and industrial (B.H.E.L.) area

Diseases	Summer		Rainy		Winter		Summer		Rainy		Winter	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Gastro-enteritis	233	32.2	278	38.3	214	29.5	154	44.0	111	31.0	85	25.0
Enteric fever	36	33.2	41	37.6	32	29.2	24	15.0	70	43.9	66	41.1
Poliomyelitis	16	25.4	38	60.3	9	14.3	2	50.0	2	50.0	0	0
Infective hepatitis	9	9.9	22	50.0	18	40.1	10	23.2	28	65.2	5	11.6
Amoebiasis	5	41.6	2	16.8	5	41.6	24	34.4	31	44.5	15	21.1
Bacillary dysentery	27	28.4	40	42.4	28	29.5	27	30.3	45	50.5	17	19.2
Worminfestation	68	40.0	10	50.0	2	10.0	4	50.0	3	37.5	1	12.5
Total	334	31.1	431	40.1	308	28.8	245	33.84	290	40.06	189	26.1

may be assigned to its insufficient chlorination that probably result in the occurrence of diseases caused by them. Further deterioration of water quality may also occur during transit between the place of production and the users (Rossie, 1975; O'Connor et al, 1975). Whether or not the present dosages of chlorine are sufficient to kill bacteria or viruses is difficult to explain as no further analysis of water reaching the consumer is made. Clarke and Kobler (1954) and Kelly and Sanderson (1957) observed that about 7 to 46 times more chlorine is required to inactivate coxsackie virus as is required to destroy Escherchia coli. The human enteric viruses are shown to be more resistant to disinfection with chlorine than bacteria (Kenneth et al, 1980). This may explain the occurrence of poliomyelitis in children in industrial area of Bhopal.

In order to reduce the incidences of the water borne diseases, not only the distributory system be properly protected and monitored properly (Biras and Lambin, 1980), but also the water treatment processes should be manipulated on the basis of seasonwise raw water quality for which an ecologically designed hydrologic programme is suggested (Belsare, 1982).

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Technical Concept for the Rehabilitation of Accra City Waste Collection System

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Figure 1 shows the overall concept of AC's rehabilitated waste disposal system. In the evaluation of the most suitable approach the following basic objectives were taken into account :

- utilisation of existing plants and equipment
- minimisation of transport performances
- application of operationally secure and wear and tear resistant technologies
- integration of the inhabitants into the pertinent activities to the greatest possible extent
- linkage of income levels and waste disposal fees by the application of different disposal methods (Figure 1).

For the latter purpose, wherever possible, Accra was divided into homogenous income level areas with correspondingly chosen disposal techniques.

1. Collection Systems

The concept comprises the following methods of refuse collection :

- house-to-house collection
- collection at central points
  - -- central container collection
  - -- collection at mini-composting plants
- nightsoil collection.

Thereby, house-to-house collection, accounting for 8 % of the total refuse disposal in 1984, will reach 26 % in 1988; it will then cover 90 % of the high income areas and 30 % of the middle income areas. Central container collection, accounting for 13 % of the total refuse disposal in 1984, will account for 20 % by the end of the project period and cover 30 % of the middle, and 20 % of the low income areas.

1.1 House-to-House Collection

High income areas and certain middle income areas are best suited to this type of collection practice for infrastructural reasons. Moreover, particularly high income groups are expected to be able and to be prepared to pay a comparatively high fee for this type of collection.

Refuse collection is suggested to take place every two days. The size of dustbins should be uniform, i. e. of 30 - 35 l volume. Their boxes are to be located outside the premises' borders so that may be emptied by the scavenging labourers without difficulty and delay.

As already set forth in previous studies [1], ACC has a series of vehicles at its disposal of different make and age. Besides side loaders of unsophisticated technique, though with a rather high loading border (abt. 1.60 m), most vehicles are compactors Daimler Benz 1621, model 1978, with Ochsner body. However, only four were operable

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1) J. Ringeltaube: Report on the refuse and sewage situation in Accara, Ghana, Dec. 1980/Jan. 1981
M. Bendick, ibid

at the date of inspection. In accordance with KfW recommendations [2] these vehicles should be rehabilitated within an emergency program, whereby they are expected to serve for another 5 years if adequately maintained.

Each collection vehicle needs besides its driver, three scavenging labourers. As far as the required vehicles are concerned, assuming :

- 2 trips per working day
- 6 t performance load
- 25 % outfall for repair
- 300 working days per year

their number is appraised as follows :

Table 1 Vehicles Required in House-to-House Collection

Refuse (t/d)	1984	1985	1986	1987	1988
High Income Area	39.6	57.8	68.7	80.4	83.4
Middle Income Area	-	17.1	36.7	59.1	63.2
Total	39.6	74.9	105.5	139.5	146.6
No. of Vehicles Required	5	9	13	18	19

This means that until 1985 incousively, the number of vehicles required will not exceed the amount of DB Ochsner compactor vehicles, at present at AC's disposal.

2) KfW: Ghana, Müllbeseitigung Accra, Projektführungsbericht, 1981

The advantage of this procedure ist obvious : with only one vehicle type, the spare part stock and pertinent costs will be comparatively low. Car mechanics must be trained for only one type of vehicle.

However, the available Glover and S.D. compactors, of which three were operable at the time of inspection, should serve as emergency vehicles.

1.2 Collection at Central Points

Two different performances are covered by this system, i.e. the traditional central container collection, and, as a new and growingly important component, refuse collection at mini composting plants.

1.2.1 Central Container Collection

As Figure 1 shows, both middle and low income groups will be attached to this collection system. They will take their waste to the nearest public container. Such containers are located at central, easily accessible places, like public toilets, road crossings, bus stops, etc. This systems is expected to reach its projected share in refuse collection, i. e. 20 %, already in the third project year.

In the following, the serviceability of the existing 19 m^3 (25 cu yds) containers will be evaluated. At a collection interval of 3 days, the daily waste accrual would be :

$$19 \text{ m}^3 \quad : \quad 3 \text{ d} \quad = \quad 6.3. \text{ m}^3/\text{d}$$

At a specific density of 0.5 kg/m^3, this is :

$$6.3 \quad x \quad 0.5 \quad = \quad 3.16 \text{ t/d}$$

Assuming 0.4 kg daily per caput refuse accrual [1)] and an average population density of 120 I/ha, the following calculation may be set up :

$$\frac{3,160}{0.4} \quad = \quad 7,920 \text{ I/container}$$

$$\frac{7,920}{120} \quad = \quad 66 \text{ ha/container}$$

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1) In order to simplify the calculation and in view of the fact individual income levels in the areas concerned are difficult to differentiate 0.4 kg are assumed as overall average per caput refuse accrual.

Assuming the 66 ha in the form of a circle, the inhabitants' distance from their domicile to the nearest container would be 460 m as a maximum. However, this distance is considered too long. Prior investigations in this field 2) showed that 300 m is the maximum distance that an inhabitant may be expected to carry his refuse. Under this assumption, a container would cover an area of abt. 30 ha.

Therefore, containers of 10 m^3 capacity would be sufficient, since at the mentioned population density of 120 I/ha[2], 3 day collection interval, and 0.4 kg daily per caput refuse accrual, the exact calculation runs as follows :

30 ha x 120 I/ha x 0.4 kg/I, d x 3 d = 4.32 t/d

or :

4.32 t/d : 0.5 t/m^3 = 8.62 m^3/d.

In the longer run, the existing 19 m^3 containers should, thus, be replaced by 10 m^3 containers. Besides their adequate capacity, they allow the use of smaller vehicles of greater mobility.

As far as the required vehicles are concerned, each of which should have one driver and one scavenger, assuming

- 4 trips per day
- 25 % outfall for vehicle breakdowns
- 90 % container capacity utilisation,

their number ist calculated in Table 2. They cover the removal of household-like hospital waste.

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2) Dr. W. Bidlingmaier : Erneuerung der Abfallbeseitigung in Bhaktapur, GTZ-Studie 1982

3) In cases of higher population densities, the number of central collection points might have to be increased.

Table 2 Vehicles Required in Central Container Collection

	1984	1985	1986	1987	1988
Refuse (m^3/d)	123.6	164.8	211.6	224.2	237.2
10 m^3 Container	41	55	64	67	71
No. of Vehicles Required	4	6	7	8	8

All in all, at the end of the project period, 71 10 m^3-containers and 8 vehicles will be required.

1.2.2 Collection at Mini Composting Plants

As in the case of central container collection, the nearby inhabitants deposit their refuse at these plants, but instead of being collected and transported to a central landfill, the refuse is composted on site.

This system is intended to be introduced on a pilot basis in the first project year, to cover 13 % of the total refuse disposal in the second project year, and to be continually extended to 44 % by the end of 1988.

The set-up of mini composting plants involves :

- transformation of the particular toilet into a VIP [1)]
- fortification of the surface
- contruction of a workshop
- cultivation of hot-beds
- purchase of equipment (sieve, shovels, brooms, mats) plus one container per plant.

1) Dr. W. Bidlingmaier : Waste Disposal ... ibid

In the course of the project period 1984/88, 52 mini composting plants should be set up in all. The average daily refuse quantity that may be collected per plant amounts to 1,700 kg. This corresponds to a total of 257 t/d, i. e. 44 % of Accra's total disposal in 1988.

The reason why this system is intended to be extended to the furthest possible extent is the number of advantages it involves. The most important ones are the following :

- **Reduction of transport performance :**
  The rotting process releases CO_2 whereby the composting material is reduced by abt. 25 %. The compost obtained after the second rotting amounts to 50 % of the original refuse quantity. As this compost is intended to be handed back to the refuse producers, the residue that is finally to be transported to a landfill amounts to merly 30 % (77.2 t/d in 1988) of the originally deposited refuse quantity.

- Basis for nearby plant cultivation [1) :]
  Plant beds of 40 cm with onwards may be set up by the refuse producers around their nearby buildings by means of the collected compost.

  -- Besides providing a more attractive environment, the coverage of walls with plants represents a protection against heat, as plants absorb solar radiation and produce cooling effects by evaporation. In fact, the heat in the pertinent building may be reduced by 30 % (Figure 2).

  -- The turning of the leaves creates a convective chimney between the walls and their plant cover. The resulting draught improves the surrounding climatic atmosphere (Figure 2a).

  -- The plant cover acts as wind break (Figure 2b).

  -- Plant covers reacting to sound waves by parallel movements reflect the sound (up to 5 decibel) and produce energy (Figure 2c).

  -- Plants produce oxygen.

1) Doernach : Das Naturhaus 1982

-- Plant covers serve as filters and absorb up to 70 % of dust, whereby inherent bacteria and viruses are eliminated (Figure 2d).

-- Falling leaves become additional compost to the flower beds after a certain rotting time.

-- Fruit or vegetable producing plants grown around the building will provide the inhabitants with additional nutrition.

All in all, besides representing a considerable relief in the transport sector, this system will teach and motivate the refuse producers to usefully utilise their waste.

As mentioned above, the residues at the mini composting plants amount to 30 % of the deposited refuse and develop over the project period as shown in Table 3.

Table 3 Residue Accrual at Mini Composting Plants

Year / Plants/Res.	1984	1985	1986	1987	1988
No. of Plants/ = Containers	3	13	18	44	52
Compost Residues (t/d)	2.1	19.6	41.4	65.7	77.2

Thus, 77.2 t/d will accrue as a total at the 25 mini composting collection points. It is suggested that each plant be provided with one container, - of the existing 19 m^3 ones until 1986 and from then onwards, by 10 m^3 containers - , for the disposal of the compost residues. These may be collected and replaced by the existing Sisu container trucks, so that no additional vehicle will be involved in the transport of the residues.

1.3 Nightsoil Collection

As there are no prospects, even in the long run, that the Accra sewerage system will experience an extension, more stress has to be laid on the collection of nightsoil by vihicles.

The necessary vehicle fleet for the removal of nightsoil has been calculated on the assumption that the tipping station will be closed immediately after the completion of the first drying bed near the Central Composting Plant. While septic tanks will be emptied by cesspool emptiers, the contens of pan latrines will be transported by container trucks and that of VIP-toilets by tipping trucks.

The transformation of public pan latrines into VIP toilets and the construction of additional toilets of that type ist urgently recommended, not only because much of their residues may be used in the production of compost, but above all because their contents, compared to that of pan latrines is reduced to less than one tenth (0.547 m^3 per caput and annum production in pan latrines against 0.04 m^3 in VIP toilets).

The annual septic tank, latrine and VIP-toilet volumes to be transported are shown in Table 3.

1.3.1 Septic Tank Collection

The volumes of septic tank nightsoil between 1984 - 1988 (Table 4) are calculated on the basis of the population forecasts and 0.3 l nightsoil production per person and day.

Table 4 Septic Tank Nightsoil Volumes by Income Area 1984 - 1988 (m^3/d)

Septic Tanks	1984	1985	1986	1987	1988
High Income Area (m^3/d)	39.5	41.2	42.9	44.2	46.3
Middle Income Area (m^3/d)	47.6	51.3	55.2	59.1	63.2
Total (m^3/d)	87.1	92.5	98.1	103.3	109.5

At the time of on-site inspection ACC's cesspool emptier vehicle park consisted of two old Albion lorries and six brand new vehicles, delivered by Leyland in January/February 1983.

To each cesspool emptier, one driver and 2 conservancy labourers should be assigned. As far as the available cesspool emptiers' transport capacity is concerned, at

- four trips per day
- 6,840 l (1,500 gallons) capacity
- 90 % capacity utilisation

it is calculated as follows :

$$4 \times 6.85\ m^3 \times 0.9 = 25\ m^3 \text{ per day and vehicle.}$$

The transportable nightsoil quantity of 200 m^3/day exceeding by far the quantity subject to being transported, even in 1988.

1.3.2 Pan Latrine Collection

The volume of pan latrine contents between 1984 and 1988 (Table 5) is calculated on the basis of the population forecast and 1.5 l nightsoil production per caput and day.

Table 5 Pan Latrine Nightsoil Volumes by Income Area 1984 - 1988 (m^3/d)

Latrines	1984	1985	1986	1987	1988
Middle Income Area (m^3/d)	60	64	69	74	79
Low Income Area (m^3/d)	229	361	379	379	415
Total (m^3/d)	289	425	448	471	494

As far as the required vehicles are concerned, they should be of the same type as those assigned to central container collection and, besides one driver, be accompanied by 5 conservancy labourers. Assuming

- 4 trips per day
- 25 % outfall for vehicle breakdowns
- 90 % capacity utilisation,

their required number would rise from 10 in 1984 to 17 in 1988.

Table 6 Number of Vehicles Required at 1-Shift Operation

Year	1984	1985	1986	1987	1988
Number of Vehicles	10	15	16	16	17

However, the project manager should make every effort to introduce a system of two 8-hours shifts/day, whereby the number of vehicles required would be reduced as indicated in (Table 7) with a respectively increased number of personnel. In this case, nightsoil would have to be removed not only during the night as was the case at the time of on-site inspection, but also during the day.

Talbe 7 Number of Vehicles Required at 2-Shift Operation and container needs

Year	1984	1985	1986	1987	1988
Vehicles	5	7	8	8	9
Containers	40	60	62	65	69

1.3.3 VIP-Toilet Residues

In view of the mentioned volume reduction at VIP latrines and the accruing comparatively small quantities of residues, the assignment of 1 tipping truck until 1986 and 2 tipping trucks thereafter is considered adequate.

1.3.4 Nightsoil Disposal with Regard to Geological Characteristics and Water Supply

The upper geological layers in Accra consist mainly of clay, shale and sandstone. Both layers, even the clay shale, are pervious to water. Nevertheless, the city's water supply is not jeopardized by possibly nightsoil polluted groundwater, since it has no water sources of its own but is supplied from sources located in the North and Northwest of the capital. The groundwater current itself flows towards the sea on account of the natural inclination of the Accra hinterland area towards the beach.

DISPOSAL OF CHEMICAL EFFLUENTS IN 80's-

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ABSTRACT

The land disposal method of chemical waste disposal is becoming more widely practiced as one alternative to conventional or un-acceptable techniques. Each chemical waste has to be considered and evaluated on an individual basis on account of their diverse chemical and physical nature. Various issues are to be considered regarding (1) planning and programming of investment (2) operation and maintenance (3) manpower development (4) financial soundness (5) the need for an appropriate user interface (6) administrative improvements. The group of industries or each major industry should form a single unit. Such groups or units may be given technical and financial assistance through nationwide institutions.

A comprehensive study of land cultivation practices is necessary. Documentation of the current use of land cultivation method and projection of future use is recommended. It is imperative to identify waste types amenable for disposal by soil incorporations. This shall also include identification of site design and operational considerations. Evaluation of actual or potential impacts from soil incorporation activities is also necessary. It is necessary to have a conceptual design for a land cultivation disposal site and estimation of costs to implement and operate a site with information and analysis of hazard elements of pollutants.

INTRODUCTION:

The chemical industry has become the most dynamic segment of the economic growth and progress in India. The first plant was established in 189(at Konnagar for manufacture of sulphuric acid. There is imperative need for imaginative design features and process innovations to deal with environmental problems. It is necessary for optimisation to achieve maximum advantage taking into account, the men, material and technical know how.

The waste disposal investigation must include personal interviews, case study investigation for site selection consideration and site conceptual design of chemical waste disposal by land cultivation. There is great need for safeguarding ground water resources againstpollution because groundwater is tapped for water supply and is polluted through sewage leakage, sewage disposal, sludge disposal besides leachates from discharges percolating into groundwater. Information on analysis of hazard elements of pollutants of groundwater is necessary with particular stress on quantum of trace elements in such pollutants.

The industrial chemical wastes are continuously discharged into rivers and the degree of pollution is very high in cities like Agra, Ghaziabad, Delhi, Allahabad, Banglore. Other chemical industries discharge their wastes into lakes and ponds besides being leached to groundwater and stream flows. All these pose great hazard to life and health. It is necessary to identify and analyse suchpolluted ground water sources and adopt remedial measures. It is more difficult and costly to purify ground water as it is not exposed to natural purification system that regulate and clean the surface water. The aesthetic consideration for prescribin the limit of these trace elements in ground water and limits to surface water is necessary. During the percolation of water through the soil, trace metals exchange site with major elements. This results in retention of trace metals and they do not subsequently reach u to deep ground water table. However, the protection from anions was found inadequate in case studies.

CHARACTERISTICS

These chemical pollutants had different characteristics and varying effects on men, machinery, vegetation, environs and the animals. The tall chimneys of chemical industry emit enough quantity of dust, ...

and fumes pollution the atmosphere upto 2-25Km. The escape of dust and gases from chimneys are not only harmful to men and materials, but also result in enormous loss of material. There is no emission from chimneys and coke oven doors in foreign countries and it appeared as if the plant was not working. The loss of coal through dust and smoke from industry amounted to approximately 0.5% and if this is controlled, industry will not only check pollution of atmosphere but will also save a large amount of material which is flying off in the sky.

Cost

The cost of air pollution control increased, as the degree of control was established, but the damage caused by pollutants is rather high in the beginning and reduced sharply with the degree of control. The amount budgeted in advanced countries is 20% for pollution control measures. The processes in the plant need rennovation by engineers and technologists and cheap methods to control pollution need to be devised.

Parameters

The following parameters are recommended for examining study of chemical pollution:

(1) Analysis of the environment.
(2) Evaluation of choice and preferences over space in an area.
(3) Major environmental problems.
(4) Differences in the variables of environmental perception between actual and perceived environment.
(5) Evolution of a suitable framework for the environment.

Environmental Impact Analysis:

It is necessary to evaluate good and bad impacts to determine the various impacts of chemical industries, so that they can be quantitatively compared. It is necessary to specify limits of tolerance, which must not be exceeded. The methodology for measurement, evaluation and comparison of various parameters must be converted into a common unit so that proper assesment ... decision making process can be obtained. ... would identify the impact of chemical industries on the quality of the various conditions of the environment.

Waste Types

The wastes amenable to detoxification were of the ... (1) Textile Finishing 2) Wood preservatives (3) ... chemical products (4) ... (5) ... nic chemicals (6, Leather tanning and finishing(7) Petroleum refining(8, Soap and derkmmingxandxfinigents(9. Organic fibres; non- cellulosic site selection for disposal was based on water characteristics and quantities with particulars referenc to:

(1) Access(2) Land Use Status(3) Perceived site conditons (4) Flora and fauna(5) climate(6) economics (7) Public acceptance.

Waster disposal:

In land cultivation of waste, the effluent is mixed with surface soil to achieve volume reduction and degradation. The disposal may be done by land spreading, land farming sludge farming, soil incorporation and application of waste into the surface soil. The mass is aerated and exposes the waste to soil microorganisms. Nutrients or other soil amendments like limestone are added during preparation unions like copper.

Copper:

Copper from chemical wastes enhances corrosion of gelvanised iron and steel fittings. It was found to impart a colour and better teste to water tested in Udhipur at levels above 5 mg/litre. Stainning of laundry and plumbing fixtures occurred at copper concentrations above 1.0 mg/litre. The limits for copper (1mg/Litre) is based on its laundry and staining properties.

Iron

At levels of about 0.3 mg/litre, iron was found to stain laundry and plumbing fixtures and caused und-esirable tastes. Ferric iron could be tasted in distilled water at a concentration of 0.1. mg/ litre. The procipitation of excessiron was found to impart on objectionable reddish brown colour to the water. Increase of the connentration of iron in water in distribution signified distribution of iron elements. The presence of iron in conmentrations greater than 0. 1mg/litre caused deposits and in the presence of aluminimm led to dirty water problems and at levels higher than 0.3 mg/ litre led to increased maintenance costs. The limit for iron in drinking water is set at 0.3 mg/litre.

Managanese

Maganese in water is objectionable because at levels exceeding 0.15 mg/ litre, it stained fixtures and laundry At higher concentrations, it caused undersirable tastes. As with iron its presence in water led to accumulation of deposits in the distribution system-. Even at a contentration of 0.05 mg/litre manganese often formed coatings in piping which sloughed off as an embrassing black precipitate. The limit of 0.1 mg/litre is based on its staining properties.

Zinc

Water containing Zinc at concentrations in excess of 5.0 mg /litre has an undesirable stringent taste and is opates-cent developing a greasy film on boiling. The limit for zinc is 5.0 mg/litre based on taste considerations. Criteria limits for metals in water are recommended both on health and aesthetic considerations. The sample surveys have indicated that residents especially children were suffering from respiratory diseses caused due to chemical discharge and affluents. There was noticed disceses of lungs cancer and tubercloses ailments.

Air Pollution;

The extent of air pollution from chemical industires was noted and found to be in alerming proportions as below:

Sl No.	Satation	Mean value of SO_2 microgms/Cu.m	Suspended particulate matter microgms/Cu.m.
1.	Ahmadabad	10.66	306.6
2.	Bombay	47.11	240.8
3.	Calcutta	32.88	340.7
4.	New Delhi	41.43	601.1
5.	Hyderabad	5.06	146.2
6.	Jaipur	4.15	146.1
7.	Kanpur	15.97	543.5
8.	Madras	8.38	100.9
9.	Nagpur	7.71	261.6

Calcutta was found to be the worst affected followed by Bombay. The disposal of wastes led to contamination of rivers and lakes, mainly affecting fish life and adquatic flore and fauna. The inorganic chemicals substances were toxic to fish and human being. They created complex problems.

Lead.

Very heavy concentrations were recorded. The pollution was high in monsoon season due to high source emissions and favourable metrological conditions. A drop in lead concentration was found from morning to evening at Agra. This was due to the wind shift from morning to evening. The particulates and trace elements were found to decrease from low to high elevations due to highwinds. Lead being heavy, metal settled down quickly. This was evident from observations taken at a height of 4 metres, 60,80 and 100 metres. Also it was found that a qualitative analysis by XRF techniue indicated the absence of lead at higher altitudes. High obstacles like high rise buildings prevented the pollution.

SO_2 levels.

The SO_2 levels were found maximum during pre-monsoon season and relativelow low in winter season. The residence time of SO2 in pre-monsoon, monsoon, post monsoon and winter seasons was calculated. The higher SO2 levels in pre-monsoon season was due to longer 12 ST of SO2 in this season. The indexof air-pollution potential for the Naini industrial complex was observed high in pre-monsoon season which did not favour the dilution of the pollutents and it was thecause for relatively higher SO2 level at all the sampling points which were in the downward direction from the industrial zone. Generally in monsoon season the pollution concentration was less compared to other season, because of the washout of the pollutant from the atmosphere due to frequent showers. Surprisingly the SO2 concentration in monsoon season was observed considerably high at New Delhi also. This was explained by the fact that during rain, smoke being pressed down and spread in the near ground layer, and on the other hand it also depended on the pH of the falling precipitation, since the absorption of SO2 in a sour substance was found to be minimum. In the post monsoon seasons, an higher SO2 level was observed at Ahmedabad (10mg/m^3) and relatively lower level at Pune (45 g/M3). The traffic corners received higher levels of SO2.

Pulp Wastes:

Prehydrolysate Liqor (PHL) and prehydrolysate wash (PHW) generated during the prehydrolysis stage were found to be high pollutant wastes. They contributed about 90% of the total 130 D level. These wastes characteristic were found to be acidic in nature, pH range for PHC and PHW being 2.50-3.75 and 2.70-3.50 respectively. The average BoD and COD for PHL were 50 200 and 80500 mg/litre respectively. The corresponding values for PHW being 16000 and 28,000 mg/lit. COD and BOD were mainly contributed by carbohydrates present in the waste. Both PHL and PHW contained nitrogen and phosphorous. However, their levels were inadequate for biological treatment.

Digesters.

Open an anerobic digesters (1.5 litre capacity) in duplicate after proper seeding and adeqate acclamatisation were maintained at a BOD level of 1.6 mg/m^3/day which was found to be optimum. The waster mixture being acidic was neutralised to pH 7.0 by using 10% lime slurry (w/v) and the supervatant, after settling for one hour was fed to the system. Nitrogen and phosphorous were supplemented in the form of $(NH_4)_2HPO_4$ to achieve a BOD : N:P of 100 : 25: 0.5. This ratio was found to achieve excellent BOD reduction.

Equipment:

A wide variety of equipment was utilised for land cultivation of chemical sludges. The type of equipment selected depended on the waste- characteristics and with constraints imposed by regulations. Tank trucks and wagons of various sizes (4-20m^3) were most often used for waste spreading, viscous sludges of petroleum refining industry at Barauni and Mathura were often spread with an earthmoving blade. Relatively low solids content (less than 5 percent sludges) were spread by spray irrigation and overland flow. Subsurface injection equipment was used to apply a variety of sludge types. This method was more costly than alternatives and was used only where the sludge was odorous, noxious or highly votable or if required by regulation.

Personnel

The numbers and types of personnel required at a land cultivation site were a function of the quantity of the waste input. A minimum of one skilled equipment operator was employed at a site. For small scale operations, one person was able to perform all necessary duties. However, because of the safety considerations, it became necessary to employ two or three persons at the site. In this way, help was immediately available if accident occurred.

Waste Storage

Land cultivation was strongly affected by local climate. Field operations were usually curtailed during monsoon when the soils were excessively wet, with the waste stored for application under more favourable conditions. In addition, storage, was necessary during the off season or when an equipment break down occurred. The best location for waste storage facilities occurred and varied with the operator at the land cultivation site. Where the site was ownedand operated by a disposal contractor, storage facilities were normally provided at site. Where the site was owned/leased by the waste generator, storage was provided either at the disposal or the generation site. The site of storage facilities location was generally affected by transportation and public acceptance consideration. Storage at the generation site made transportation relatively independent of waste water generation fluctuation but made waste application dependent on the transportation from the storage facility. Public acceptance of storage tanks or lagoons at the generation site was favoured more often than at the application site.

Site selection:

Criteria were laid down for site selection. The site access depdnded on (1) existing traffic density (2) Road alignment and grades (3) road weight limitations (4) neighbourhood character (5) population density, residential, industrial etc.

The land use status was determined by (1) existing use and adjacent property(2) zoning requirements (3)Location of utilities (4) potential uses after site closure.

Site Conditions:

The site conditions perceived depended on (1)SOIL Cultivation potential (2) Potential for dust generation (3)topography, specially susceptibility to erosion and presence of standing water. Upland flat and terrace, upland crest and valleyside and flood plains and land forms were generally recommended (4) Sub-surface hydrology including depth to ground water directions of ground water flow and water quality characteristics. The climatic considerations were (1) temperature (2) prevailing winds (3) percipitation (4) affect on wastage storage requiremnts. The waste disposal economics considered (1) Site characteristics such as topography, soil conditions, screening or fencing requirements (2) distance from waste generators.

Site Design:

The site conceptual design was a synthesis of the data obtained from site study investigations and related background information. The conceptual design used was intended as a planning tool and information vehicle for consideration of land cultivation as a disposal alternative. The basic management objective assumed was the application of waste materials to the soil so that the soil could assimilate the wastes and to contain the wastes and potentially harmful by-products on the site.

Site Operation.

The site was operated commercially and not by the waste producer. Wastes from more than one source was expected. It is important that the chemical composition of all input wastes streems be analysed and evaluated to ensure that they were safely mixed, both in storage lagoons and in the soil. An additional assumption was that that transport of sludge to the site was not part of site costs, it is an expense item borne by waste generator. The State in which the disposal site is located does not have specific regulations pertaining to land cultivation disposal. Waste and site characteristics assumed were for:

A. Waste Characteristics (1) Potentially hazardous industrial waste water sludge (2) Five percent solids as disposed (3) did not include domestic sewage (4) generation rates of 1,000, 2,000 and 4,000 dry tons (1100,2200 and 4400 tons) per year at 5 percent solids.

B. Site characteristics (1) Scope from 1 to 3 percent, averaging 2% (2) Silty loam soil at least 1.3m (4 ft.) deep (3) Soils were moderately well drained, with a moisture holding capacity of approximately 15% (4) average precipitation of approximately 100 cm (40 in) per year (5) At least 4.5 m. (15 ft) to ground water.

C. Application Rate- 113 dry tons/ha (50 tons/acre) per year.

D. Site Monitoring (1) Six water samples taken quarterly, 2 surface water samples and four ground water samples (2) Two soil samples taken annually- one surface 0 to 30 cm. (0 to 12 in) depth or within flow layer. One sub-surface 30 to 60 cm. (12 to 24 in) depth or (3) ten water quality parameters measured in each sample.

Design: The conceptual design included a lagoon for the interim storage of sludge. Sludge delivery vehicles discharged into the lagoon, from which waste was taken by site equipment for subsequent cultivation to keep delivery trucks off unpaved areas of the site. The site included a paved access road to a sludge storage lagoon.

Monitoring:

The number of well required to adequately monitor groundwater at the site depended on the complexity of the sub-surface hydrology. Four wells were specified at Ahmedabad Chemical Complex. Two wells were located at the upstream boundary of the site to establish background water quality. Two wells were located downstream from the site to establish the distribution and impact of localised contamination on water quality in the aquifer. More wells would bedesirable but cost considerations usually indicated that a plan could be ensured to develop most effectual coverage with the least number of wells.

Soil Programme:

The suggested soil programme entailed taking to soil samples each at the 0 to 30Cm (0 to 12 in). and 30 to 60 Cm. (12 to 24 in). depths prior to the first waste application and at quarterly applications thereafter. The samples of each depth were composited processed and analysed. Date for the soils which have received waste were compared with the results for the controls, samples obtained prior to first waste applications. This comparision indicated any accumulation and the extent of vertical migration of waste constituents, heavy metals beyond the flow layer.

Operation Costs:

In addition to capital related annual costs, actual costs of site application included those for labour, fuel and equipment maintenance utilities, site maintenance and security, monitoring including sample analysis, land cultivation is a land intensive activity often requiring considerable sitepreparations. The capital costs constitute the longest portion of the total annual costs of this design. Disposal fees were structured to recover all costs and provide a reasonable profit.

Analysis:

All wastes should be routinely analysed before and during land cultivation operations to ensure that an accurate record of applied material is developed. Potentially deleterious of incompatible waste was not accepted for disposal. As for land disposal facilities, a site for land cultivation should be carefully selected to afford maximum invironmental protection. An engineered design for a land cultivation site should be prepared to ensure provision and proper configuration of run off facilities, personnel safety features and equipment maintenance sheds. A specific schedule for waste receipt, spreading, mixing, remixing monitoring and trouble shooting should be developed and followed as an integral part of land cultivation operations. A monitoring programme is essential. Routine soil monitoring wherein surface and sub-surface soils are analysed for presence of waste. Constituents can detect any movement of contaminants towards groundwater. Air monitoring is also necessary.

Regulations:

Existing regulations call for consideration of planned land cultivation projects on a project by project basis. However, with increasing use of this disposal method and in light of new pollution control criteria that include coverage of land cultivation practices, specific regulations may be implemented. Land cultivation was viable only where soil climate waste characteristics, permitted. The chemical industries should obtain technically and economically sound projects from waste prevention and control Boards wherever necessary. Some sectoral changes may be considered to induce better management and promote achievement of objectives.

Agra Unit.

In a chemical unit at Agra, the mill was equipped withadequate chemical recovery system. Black liquor (spint liquor) was concentrated in multiple effect evaporators and incinerated alongwithsome fresh sodium sulphide . Sulphate got reduced to sulphide in the furnance and the smelt containing sodium carbonate and sulphide was dissolved in water and the green liquor obtained was consticised with lime to oxidise

Carbonate to hydroxide. The white liquor obtained was used again in the digesters along with fresh raw materials for cooking. The sludge generates from the recausticicing plant was collected and carried away for disposal.

Conclusion

The main obstacle in effluent disposal from chemical industries is the high cost of development. It is necessary to promote the use of local technologies which are labour intensive and the joint manufacture of equipment with other countries. It is further necessary to improve the institutional, legal and policy framework in order to increase the capabilities necessary to absorb and benefit fully from the modern technologies. It is necessary to start planning for the decade at the earliest possible time. The knowledge requirements of the chemical engineering is increasing very fast. Even the best modern institutions in the world are finding it difficult to keep up with these requirements. In Indian context the problem is more serious, since the gap between the academic institutions and industries is very wide. The knowledge of professional engineers can be updated with continuing education courses. Future engineering education must assume the rsponsibility of applying knowledge to needs of the time. Metering and measurements are important. The chemical industries dump their waste bye-products outside of their factories. There should be rigid control on that. Proper regular cleaning of these is very essential. A system may be instailed in a few selected industrial townships and suitable digester of various sizes be installed and operational guidelines be framed.

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LOW-OR NON-POLLUTION TECHNOLOGY THROUGH POLLUTION PREVENTION IN THE PULP AND PAPER INDUSTRY

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INTRODUCTION

This paper is an overview of recent developments in pollution control technology for the pulp and paper industry.

It describes some of the "internal measures" developed for the reduction and/or elimination of the waste before they are sent to the external treatment system.

The Low-or non-pollution technology has been the result of costly, classical external waste treatment in this industry. It is simply management of waste at source, reducing or eliminating the waste, through process or operation modification before or after it is generated.

Following is a brief summary of these developments.

I. PULP PRODUCTION PROCESSES

1. Sulphite Pulping, Sources of Discharge and Abatement Methods :

Pollutants :

Spent liquor, condensates, bleach plant effluents and accidental discharges are the most important water pollutants from sulphite pulping. Most of the air pollution from sulphite mills is caused by sulphur dioxide, which is released in digesters, washing equipment, the evaporation plant and from the combustion of spent liquors.

Pullution load :

Table below exemplifies the discharges of organic substances from acid suphite pulping and NSSC-pulping of different raw materials excluding bleaching effluents :

Raw Material	Process	Yield %	Kappa No.	B_oD_7 kg/t	COD kg/t
Wheat Straw	NSSC	48-49	18.20	280	1380
Eucalyptus	ASID	49	12	300	1300
Birch	NSSC	80	-	120	280
Spruce	ASID	31	35	300	1200
Spruce	ASID	60	-	180	800

Abatement Methods :

The main measures which can be adopted to reduce the environmental impact from sulphite pulp mills are :

- Evaporation and burning of the spent liquor. Collection of spills and condensates.
- Installation of scrubbers to reduce the SO_2-emission.
- Changeover from calcium to magnesium or sodium base to make recovery of SO_2 possible.
- Installation of sufficient capacity for storage and spill collection systems to avoid accidental discharges.
- Installation of oxygen bleaching from which the effluent can be returned to the recovery system.

The introduction of oxygen bleaching in the bleaching sequence means that the part of the effluent not containing chlorine compounds can be returned to the chemical recovery system. Hence the discharge of organic substances is reduced by 50% and the colour is reduced by 70 per cent compared with conventional bleaching in five stages. After oxygen delignification, a further reduction of the effluent load can be achieved by using chlorine dioxide instead of chlorine in the final bleaching stage. Oxygen bleaching also reduces the production of chlorinated compounds which are highly toxic to aquatic life.

When oxygen bleaching is introduced, with recovery of the chemicals and dissolved substances from this stage (85 per cent recovery), the BOD_7 from the bleach plant can be reduced from 15 to 6 kg/t of pulp.

It is also possible to reduce the discharges from the bleach plant by changing the bleaching sequence from CEHD to ECHD and recycling the E-stage effluent to the recovery system. In this case an efficient washing stage must be installed after the E-stage to maximize the recovery of dissolved solids and keep the recycled volume low.

The main discharge from the evaporation plant is contaminated condensates. Major pollutants are acetic acid, methanol and furfural together with dry matter in the spent liquor carried over to the condensates. The loss of dry matter by carry over can be as high as 5-10 kg/t of pulp. This loss can be reduced by the installation of larger separators, which reduce the vapour velocity, or by the insertion of specially designed baffles in the separator or in the vapour line.

Several methods have been developed to reduce the pollution from the condensates :

- Re-use of contaminated condensates as washing liquid or for acid preparation.

- Neutralization of the liquor prior to evaporation.

- Purification of condensates by stripping with steam.

The flue gases from the combustion of sulphite liquors contain particulates as well as gaseous pollutants. The chemical recovery systems used for magnesium-based and sodium based liquors are normally very efficient in reducing the discharges. In the case of calcium based liquors, the chemicals can not be recovered but treatment of the flue gases is required.

The purification of the flue gages from particulate matter is carried out either in mechanical dust separators, in electrostatic precipitators or in wet separators. In the later one the sulfur dioxide is also adsorbed to some extent. The removal efficiency of particulates in calcium-based mills is 75-85 per cent and the residual discharge corresponds to 10-25 kg/t of pulp. In magnesium-based and sodium-based mills, the particulate matter is recovered as the flue gases pass through the recovery system and the residual discharge of the dust amounts to 1 kg/t of pulp.

The SO_2- emission from acid sulphite processes varies between 1 and 50 kg/t of pulp. For bisulhite and NSSC processes the SO_2-emission is normally lower than 2 kg/t of pulp. In calcium-based mills there is normally no SO_2 removal from the spent liquor burning which gives an SO_2 emission of abouth 80kg/t of pulp. For mills with soluble sases (Magnesium or sodium) most of the SO_2 is recovered and used for the preparation of new cooking liquor. The emission can be kept as low as 10-15 kg SO_2/t of pulp from magnesium-based mills. Because of the solubility of sodium compound it is easier to maintain a low emission with a sodium base. The emission may be as low as 5-8 kg/t of pulp.

C(NEI-

In summary, pollution abatement practires and measures to be taken in the sulphite pulp production operation can be outlined as below:

A switch from calcium to magnesium-base requires a more efficient pulp washing technique, such as filter washers. The main investment is the recovery boiler and the MgO recovery system. The MgO recovery system eliminates the need for a flue gas scrubber.

Water pollution from the wet debarking can be almost eliminated by installation of dry debarking drums.

When oxygen bleaching is introduced into the bleaching sequence, the effluents from this part of the bleach plant can be returned to the chemical recovery system.

A great part of the accidental discharges can be avoided by a proper design of the liquor system in the mill, including storage tanks, sewer canals etc. This will cause additional costs, which, however, can be reduced if the measures are planned in connection with major rebuilding of the mill, as for instance in the switchover from calcium to magnesium base.

2. Kraft Pulp Production, Sources of Discharge and Abatement Methods :

Pollutants :

Discharge of spent liqours, condensates, bleach plant effluents and accidental discharges are the major sources of dissolved organic material in the effluent. From the fibre line, discharge of subpended solids in the form of fibres occurs from the washing and screening departments. Inorganic compounds (salts in solid form) are discharged from the recovery section.

The main air pollution from sulphate mills is caused by hydrogen sulphide, methyl mercaptan, methyl sulphide, dimethyl sulphide and SO_2 gases which are released in digesters, washing equipment, evaporation plant, recovery boiler and lime kiln. There are also particulate emissions from the recovery and bark boilers and from the lime kiln.

Pollution Load :

Spent black liquor which results after the cooking operation is the major source of water pollution in Kraft pulping process. It is however processed for recovery of the chemicals, only that portion of the spent liquor which is accidentaly discharged causes water pollution. It is highly toxic and also contain around 300 kg BOD_7 and 1300 kg. COD per ton of pulp produced.

The non-condensable gases released from the digester contain compounds which causes the typical smell of Kraft pulp mills.

Abatement Methods :

- Treatment of blow and turpentine condensates before discharge to the recipient. Two alternatives are possible, i.e. internal treatment in a stripping column or external treatment. If the condensates are treated in a stripping column they may be re-used in the process.

- In a stripping column, Heavily polluted evaporation and blow condensates are freed from 75-95 per cent of the oxygen-consuming compounds and 98-100 per cent of the malodorous gases. External treatment of condensates in an aerated lagoon removes most of the BOD, malodorous compounds and terpenes from the condensate.

- Collection of non-condensable gases. The gases are sent to the lime kiln, a bark boiler or to a special incinerator for burning, thereby converting the malodorous sulphur compounds to sulphur dioxide.

- Imroved washing and closure of screening. Improved washing results in not ony reduced effluent but also increases the chemical recovery and reduces demand for make-up chemicals. Figures given below show the importance of washing efficiency of cooked chips :

The influence of the washing efficiency on the BOD and COD discharge(originating from blac liquor) in chemical sulphate pulping of eucalyptus

Washing efficiency-*	BOD_7 kg/t	COD kg/t	Remarks
o	270	1190	No recovery
85	40	175	In screening effluent
95	15	60	" " "
99	3	12	" " "

To improve the washing efficiency, the amount of washing liquid can be increased, the number of washing stages can be increased or more efficient washing equipment can be used.

From open washing equipment, emission of moist air containing malodorous sulphur compounds occurs. The equipment should include hoods and ventilators to collect the gases and lead them to, a scrubbing stage.

When a new mill is being designed the washing equipment should also be evaluated in terms of environmental requirements.

- Use of bleaching chemicals which cause lower pollution load. In this context, an oxygen bleaching stage is recommended to replace the chlorination stage of the conventional bleaching sequence.

- A bleach plant equipped with an oxygen bleaching stage normally requires a higher invesment than a conventional bleach plant. But using oxygen bleaching reduces the number of bleaching stages necessary to reach a certain pulp quality and hence reduces the difference in investment cost.

Besides oxygen, bleaching chemicals which produce o lower pollution load are peroxides and chlorine dioxide.

- Condensate re-use and treatment.

Some of the oxygen-consuming substances in the black liquor are volatile and flash to combine with the condensate when the cook is blown, or when the liquor is evapored. Thus the combined condensates from cooking and evaporation contain from 10-15 kg/t BOD_7 (grasses and softwoods) up to 20 kg/t (hardwoods).

The most efficient way of reducing the BOD discharge of condensates is a combination of re-use-recycle and treatment by stripping. The best method is to use the clean condensates in the borwn stock washing. Medium contaminated condensates are brought to the causticizing system and heavily contaminated condensates are stripped to remove BOD and malodorous substances. By this method, the total BOD from the condensates can be reduced by up to 70-80 per cent. This requires an investment in piping, tanks and pumps to recycle condensate and also in a stripping column. The stripping medium may either be liquor steam or live steam.

- Prevention of accidental discharges.

Studies have indicated that up to 70 per cent of the total discharge to water is due to accidental discharges. This is true for all types of pulp and paper mills. Accidental discharges are caused by various malfunctions, . Some of the accidental discharges are characterized by a high BOD-value (e.g. losses from the balck liquor side of the recovery system) while others have a high content of fibres.

The major aim of the industry in waste management should therefore be the prevention of accidental discharges. This requires process/production control and buffer tanks with sufficient capacity. Preventive maintenance is also important.

- Air pollution prevention at source.

In the sulphate pulping process and recovery of chemicals the main air pollutants are malodorous organic sulphur compounds formed during the cook, and also sulphur dioxide, hydrogen sulphide and particulate matter emitted from the recovery boiler, from the lime kiln and from the causticizing area. To minimize the emission of malodorous compounds the gases emitted from the cooking, washing, evaporation, tall oil and soap plants should be collected and oxidized by burning in a special furnace or in the lime kiln.

The emission of hydrogen sulphide (H_2S) from the recovery boiler can be kept at a very low level (5 ppm) by maintaining a controlled excess of air to the boiler. The amount of carbon monoxide (CO) in the flue gas has proved to be a reliable indicator of the air supply and burning conditions in the furnace and can also be measured. It is therefore often used as a tool to control the H_2S emission.

The ratio of sulphur to sodium in the balck linquor, the dry content of the liquor and the chemical balances determine the primary emission of sulphur dioxide and particulate matter from the recovery boiler. At high dry solids of the liquor and at low sulphur to sodium ratios nearly all gaseous sulphur compounds primarily emitted will react to sodium salts within the recovery furnace. Increasing the sulphur /sodium ratio will lead to increasing discharges of sulphur dioxide.

3. Waste-Paper Pulp Production

Waste paper is an important raw material for the production of many grades of paper. The greater part of waste paper is treated mechanically. De-inking with chemicals is required for certain paper grades e.g. newsprint and tissue. The most common de-inking methods are washing and flotation de-inking, of which flotation de-inking is the one most frequently used.

Pollutants :

The environmental impact from the waste-paper system is caused by:

- emission of polluted waste water (BOD, COD, fibres)
- reject and sludge from the system.

There are normally no air quality problems connected with secondary fibre systems.

Pollution load :

Table below shows some figures on the fresh water consumption and discharge of organic substances from different waste-paper recovery system.

Examples of fresh water consumption, BOD, COD and S.S. in secondary fibre processing according to different processes

Process	Fresh water consumption m^3/t	BOD_7, kg/t dissolved material	COD, kg/t dissolved material	S.S. kg/t
Mechanical treatment	1	15	40	50
De-inking by flotation	10	25	55	150
De-inking by washing	90	30	65	150

Abatement Methods :

The best method for pollution abatement in the secondary fibre processing is to chose the right process with less environmental impact. As it can be seen from the above table, mechanical treatment should be preferred over the other processes where high quality grades,of paper are not required. In newsprint and tissue production however, flotation method should be considered.

The discharge to water can further be reduced by internal measures by closing of the white water system and thus reducing fresh water consumption.Spill collection should always be practiced.

II. PAPER MAKING

Pollutants :

The discharges consist of dissolved organic and inorganic substances and solids such as fibres and fillers. The BOD discharge from papermaking is much lower than that of pulp making operation (below 10 kg/tonne of paper).

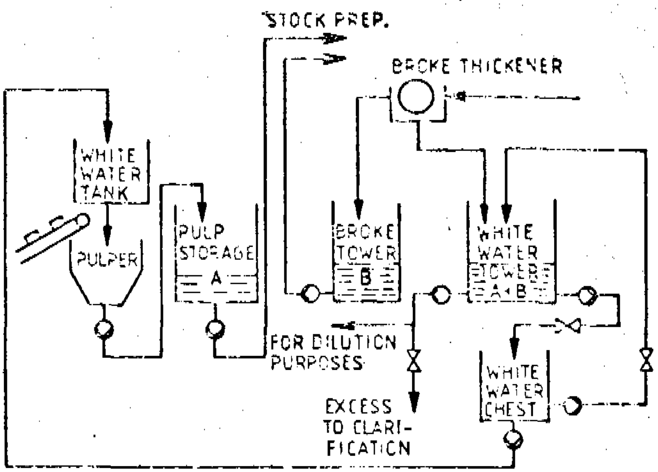
Abatement Methods :

Reduction of the environmental impact /from paper mills is achieved through a combination of internal and external measures. It is important that these measures along with environmental implication should carefully studied an optimized to achieve the required effluent load level at the lowest cost.

The best and the most economical method to minimize pollution from papermaking operation is internal measures for system closure. Following practices should be considered :

- water balance and control in pulp, broke and white water systems
- re-use of white water
- fibre and filler recovery
- reduced fresh water consumption in the shower water system
- reduced fresh water consumption in the sealing water system.
- separation of contaminated and uncontaminated water by separate sewer systems and re-use of each portion in the over all process
- system for collection of accidental dischurges.

Proper design of the central white water system and the pulp/broke system is essential to avoid discharges from the paper mill. The figure shown below demonstrates a well balanced pulp and white water system.



Well Balanced Pulp and White Water System.

Requirements to achieve a balanced central white water system are:

- storage capacity for white water corresponding to the storage capacity for pulp
- control of the white water quantity in the storage tanks so that it corresponds to the variations in the pulp towers (especially in the broke tower)
- addition of fresh water in one position only
- discharge of excess white water from one position only.

Fresh water is used for the following purposes in a paper mill:

a) boiler feed water
b) cooling water
c) sealing water in pumps, agitators, refiners etc.
d) cleaning of felts and vires
e) transportation of raw materials and waste products.

In most cases, fresh water is necessary only in position a) and d).

To reduce the frcsh water consumption, the contaminated water should bu used in positions where fresh water is not required and the uncontaminated water schould be sent directly to the fresh water tank.

In summary, with well balanced central white water system and effective system closure without degrading paper quality, it is possible to decrease the fresh water intake to a level of 5-10 m^3/ton of pulp. Also reduced losses of fibres and fillers, reduced energy cost and reduced investment and operational costs for the external treatment plant are achieved. Table below demonstrates this.

Case	Before		After	
	Effluent, m^3/t	Solids S.S. kg/t	Effluent, m^3/t	Solids S.S. kg/t
A. Kraft paper 100 t/d	72	43	17	6
B. Tissue/writing/ karft, 100 t/d	33	11	23	8

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ENVIRONMENTAL MANAGEMENT - PRACTICE AND POLICY IN A DEVELOPING COUNTRY

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INTRODUCTION

Proper Environmental Management, today, is an undeniable necessity for Developing Countries. This categorical statement is the result of two important dangers which developing countries are facing:

a) The destruction of the environment due to the inproper use of the natural resources during the struggle for the economical development,

b) The attempts made by advanced countries to "dump" or "export" their wastes - especially the hazardous ones - or the industries producing such wastes to the developing countries. The limited, short term economic advantages which the wealthy countries provide with the condition of accepting this "export" is a temptation for the administrators of the underdeveloped world, who either out of need or ignorance are willing to accept "short term benefits" regardless of the "long term dangers" which they may involve (Barovick,1980; Richards,1980; Hamouda,1981).

According to the first principle of the Declaration of the United Nations Conference on the Human Environment which took place in Stockholm in 1972, " man .... bears a solemn responsibility to protect and improve the environment for present and future generations ". Realization of this principle, however, is not always possible in developing countries.

PHASES OF AN ENVIRONMENTAL MANAGEMENT PROGRAMME

A proper Environmental Management Programme should consist of the following steps:

a) Identification of the Problem : Environment has very wide limits,

because of that for an effective management programme, it is necessary to define the priorities, and to limit the programme with well defined objectives, like protection of water quality, etc.

b) Collection of Data - Monitoring : Availability of data is essential for any sound decision in relation to environmental management. Because of that a monitoring programme should start as early as possible.

c) Establishment of Environmental Policy : According to the World Conservation Strategy, the outline of Environmental Management Policy is "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future of future generations".

To satisfy this general goal, other secondary policy decisions should be taken such as,

. preventation rather than treatment - preventive measures are cheaper than corrective ones (Lemas,1977).
. "the polluter pays" principle,etc.

d) Legislation : This, in the form of laws, by-laws and regulations assists the protection of the environment. Adaptation of legislation prepared for other countries always does not give good results in developing ones.

e) Environmental Planning : This phase of environmental management is interchangeable in priority with legislation. A proper planning should be based on cost-benefit analysis and environmental impact studies. It is only after this phase that effective action from the protection of the environment can be taken .

f) Implementation : Monitoring, legislation, planning, etc. do not have any effect on the management of the environment if they are not fallowed by the proper implementation. This phase, however, is the most difficult and the most expensive one.

g) Monitoring, Enforcement and Modification : This is the last step of an environmental management programme. Monitoring is essential to ensure proper application of the planned and implemented programme. According to the data obtained during monitoring those who are not obeying to the legislation will be determined and enforced to do so. Furthermore, modifications on the original programme may be done according to the data obtained.

THE COST-BENEFIT ANALYSIS OF AN ENVIRONMENTAL MANAGEMENT PROBLEM

Generally, but mainly in developing countries there is the wrong belief that "protection of the environment is a very expensive process". This belief usually is not based on any scientific analysis. Although there is the belief that "the more critical the economy the more lenient we must be with environmental protection measures as a whole" (Lemos, 1977). The Ministers for Environment of the OECD countries believe that "in the long run environmental protection and economic development are not only compatible but interdependent and mutually reinforcing" (Ahmad, 1981). Macroeconomic studies for the Council on Environmental Quality and the Environmental Protection Agency in the United States show that for the period between 1970 to 1983 federal pollution-control requirements will cause an average increase in the consumer price index of less than 0.5 percent (UNEP, Industry and Environment, 1981). Furthermore, although there is a belief that environmental restriction contribute to unemployment by preventing the establishment of new industries,, or by inforcing the closing of old ones not meeting the environmental requirements, this is not true. According to the US Environmental Protection Agency "as many as thirty jobs may have been created for every one lost through environmental enforced closures"(UNEP, Industry and Environment, 1981). On the other hand, a study performed in Norway indicated that environmental protection measures will cause a maximum of 0.9 percent increase over a ten year period on the consumer price, while the impact on the price index for industrial goods is estimated to be 2.6 percent (Waage, 1981).

As can be understood from the above statements absence of environmental pollution precaution gives the impression of saving. However this is only a pseudo-saving because absence of a pollution prevention system gives rise to new costs caused by the destruction of the environment.

PROBLEMS WHICH DEVELOPING COUNTRIES ARE FACING IN RELATION TO ENVIRONMENTAL MANAGEMENT

There are several problems which developing countries are facing in relation with their environmental management problem. The most important ones are mentioned below.

. Public ignorence on environmental problems-The people are not properly aware of the effects of pollution, and because of that they do not care for that subject.

. Administrators may not like to take any action for the protection of the environment either because of wrong cost-benefit analysis, or the cost of environmental programs are immediately felt while the benefits are long term, and thus may not have an immediate effect on their reelection.

. Lack of proper organization for the environmental management. Authority interference is something common on this subject in developing countries.

. Appointment not of the best, but of a person who is in friendly relations with the political party in power is an important problem which has a detrimental effect on the environmental management of developing countries.

. Establishment of incompetent companies dealing with environmental problems. Customers not having enough knowledge for differenciating between competent and incompetent environmentalists, they give their work to the incompetent who usually demand lower prices. This, of course, ends up to a failure, which has as a consequence disappearance of confidence to local engineers.

. Planning is many times used in developing countries as a tool to to postpone implementation.

. Research conducted in the universities of developing countries is rarely directed toward "appropriate" technology, which will fit best to the needs of the country. Instead researchers try to deal with sophisticated subjects, although they may not have any practical application in their own country, simply in order to be able to compete with the scientists in the developed word.

ENVIRONMENTAL MANAGEMENT IN TURKEY

Environmental awareness in Turkey was the result of pollution disturbing the every day life of citizens. Although the Universities acted as pioneers and started environmental education in 60's, people, administrators and press started to care about this problem almost ten years later, when the pollution in some areas like the Golden Horn, the İzmit Bay and the İzmir Bay reached an unbearable level, and the air pollution in Ankara started to threaten the public health.

The main problems which todays Turkey is facing in relation to environmental management are the following:

. A chaotic situation in the administrative level. It is not obvious which authority should deal with the environmental problems. Although according to the laws, the Undersecretary of Environment was responsible for the coordination of such activities , it is hard to say that it was successful till 1984, when it was turned to a General Directorate.

. Lack of a proper cost-benefit analysis enables the industries to claim that laws on the protection of the environment will have a detrimental effect on economic development, and thus, they try to influence the governments and postpone taking any action.

. The organizational scheme also is not the most appropriate. Instead of having regional authorities, a model based on "municipality level control" is preferred.

. Implementation of plans related to the protection of the environment is very slow. For example, the DAMOC project related to the wastewater disposal of İstanbul is not realized yet, although it was completed in 1971. The wastes are continously discharged in the Sea of Marmara and its pollution increases everyday while the studies on the modification of this project continue.

. Official agencies are facing serious problem of not being able to find qualified environmental engineers, because they are not able to compete with the private sector who gives high salaries. It is interesting to note that some official agencies dealing directly with the environment do not have even a single environmental engineer in their staff.

. Although qualified engineers and scientists exist in Turkey, there is a lack of intermediate level technicians who are capable of operating treatment plants, performing tests, etc. Although every year more than hundred environmental engineers are graduated from the universities, there is still no attempt for providing the so much needed technicians.

. Lack of any motivation for activities like waste recycling, use of alternative energy sources, etc. which will contribute to the well management of natural resources.

CONCLUSION

Environmental Management is a must for all the countries. The developing world, however, should try to develop the "appropriate technology" instead of fancy and expensive solutions. An appropriate technology with minimum expenditures will prevent the detrimental effect of pollution on the environment.

It is the duty of the governments as well as of the international organizations to encourage the development of a sound "environmental management programme", because the detrimintal effects of the inproper management of the environment are valid for the whole humanity.

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WASTEWATER DISPOSAL ON LAND - AN APPROPRIATE TECHNOLOGY

FOR DEVELOPING COUNTRIES

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INTRODUCTION

The protection of the environment against pollution is one of the major problems which most developing countries are facing today. High initial cost as well as lack of necessary infrastructure for the construction, maintenance and operation of the conventional treatment plants make their use difficult. Because of that, there is an urgent need for a simple and economical, or in other words "appropriate technology for waste disposal in developing countries". Land disposal, which can be defined as"the controlled application of wastewater onto the the land surface to achieve a designed degree of treatment through natural physical, chemical, and biological processes within the plant-soil-water matrix" (EPA, 1981) is one of these techniques. Detailed information about the advantages and disadvatages of land disposal are given by Hernàndez (1979) and summarized in Table 1.

Table 1. Advantages and Disadvantages of Land Disposal

Advantages	Disadvantages
. Low energy requirement	. Exposure of population to hazardous material
. High nutrient recycling capacity	. Danger of concentration of pollutants in ground water
. Conservation of water resources	. Potential for concentration of nutrients in the storm water
. No necessity for skilled personnel	. Difficulties of operation during cold and and heavy rain periods
. Enlargement of green belt area	. Possible concentration of toxic substances in harvested crops

Use of land disposal is gaining importance in developed countries. For example, although the population served by such a system in USA was 0.9 millions in 1940, this number has become 4.2 millions in 1968 and 6.6 millions in 1972 (Thomas, 1983). Similar applications are reported to take place in Israel (Sullivan et al., 1973) and India (Niyogi etal., 1982). Land disposal of wastewater has also been in use in developing countries for many years. This, however has not been practised in a knowledgable way nor with the intention of purifying wastewater. The main reason of that practice was either the scarcity of pure water, or the belief that fertility of the soil increases with such application.

This paper reports the results of a study made with the intention of investigating the variation of wastewater characteristics with time and distance after being applied on land. Among the wastewater characteristics investigated, special emphasis will be put on the removal of Chemical Oxygen Demand (COD).

EXPERIMENTAL SET-UP

In order to imitate the conditions dominating in land treatment, a model was constructed consisting of an inlet tank, a channel and an outlet tank. The inlet tank was constructed so as to continously and uniformly supply raw sewage to the system. The channel which was the main part of the experimental set-up was 25 m long thus being the largest model used for land disposal studies encountered in the literature. In order to avoid turbulance and drag forces during the operation of the system a 1.40 m long equalization chamber was located in the inlet section of the channel. The equalization chamber ended with a wall made of two layers of perforated bricks, located in such a way that the holes permitted uniform entrance of wastewater into the channel. The main channel had the dimensions of 22.20 m length, 0.385 m width and was filled with sand to a depth of 0.35 m. The sand had an effective size of 0.55 mm and a coefficient of uniformity of 3.06. The porosity of porous media was 42%. The channel was covered with concrete cover plates. At about every five meters distance along the outer sides of the channel flexible piezometers were placed. These piezometers were used as sampling points as well. The channel was connected to the outlet chamber with a perforated wall. The outlet chamber had a length of 0.60 m. In exactly the middle of this chamber a concrete block having a 50 mm hole at a distance of 18 cm from the bottom was located. Thus the minimum depth of water in the channel was 18 cm.

WASTEWATER CHARACTERISTICS

The wastewater used in this study was taken from one of the main sewers of Boğaziçi University, carrying mainly the wastewater of the dormitories, kitchen etc. The characteristics of this wastewater are given in Table 2.

Table 2. Wastewater Characteristics

Parameter	Concentration (mg/L)	
	Minimum	Maximum
COD	320	747
Nitrogen	12.8	23.8
Phosphorus	4.4	7.0
Total Suspended Solids	42	232

As can be seen in Table 2, the values of the differnt parameters varied within a relatively wide range.

EXPERIMENTAL PROCEDURE

After the sand was placed uniformly in the channel, it was washed thoroughly with tap water in order to remove impurities as well as salts present in the sand. The wastewater was given to the channel after the washing process of the sand was completed. Wastewater samples were collected from six sampling points, four intermediate points as well as from the entrance and outlet of the chamber. Parameters such as pH, turbidity, COD, phosphorus, nitrogen, solids were determined in these samples. Sand samples were also collected in order to examine the variations of their properties.

COD REMOVAL MECHANISM

Among the various parameters investigated during the experiments, the following observations have been made on COD removal.

1) COD decreases with distance.
2) The COD values of the intermediate points as well as that of the effluent depends on the COD value of the influent.
3) Percent COD removals are almost constant with distance with slightly higher values in the beginning.
4) The overall COD removal achieved was on the average around 84%. This result is in agreement with the findings of Niyogi et al. (1982).

The results have shown that the COD removal through the land disposal system described can be defined by a first order reaction kinetics, i.e.

$$\frac{dy}{dx} = -Ky \qquad (1)$$

where y = COD value at time t and at a time of travel corresponding to distance x from the inlet

K = rate constant

If the value of COD at $x = 0$ is taken as $y = y_o$, then the solution of equation (1) is

$$y = y_o e^{-Kx} \tag{2}$$

In order to consider the long-term effects of waste accumulation in the channel, equation (2) is modified as

$$y = y_o e^{Ct} e^{-Kx} \tag{3}$$

where C is a rate constant defining effects of time on COD removal. It should be noted that daily variations in COD input is not considered in defining the effects of waste accumulation.

It should be noted that since it takes a certain amount of time for wastewater to travel from the inlet to the outlet section of the channel, there is a lag of about 14 hours in the sampling times for the inlet and outlet sections.

RESULTS

The COD data obtained from the samples taken through the sampling points for a period of almost 70 days is summarized in Table 3.

Table 3. COD Data for the Land Disposal System

	Distance (m)					
Time (days)	0	5	10	15	20	25
19	380	320	287	235	105	95
21	320	267	187	160	133	107
27	480	427	380	320	267	107
34	586	400	213	187	133	-
39	453	400	347	293	186	80
46	747	690	587	426	267	200
59	480	400	294	213	107	80
68	587	450	347	267	133	90

The COD data given in Table 3 was proportionally increased in such a way that the COD value at the inlet section was taken arbitrarily as 1000 mg/L. With this modified data, the rate constants in equation (3) were calculated by a least-square technique as

$$C = 0.00012 \text{ day}^{-1}$$
$$K = 0.0550 \text{ m}^{-1}$$

With these values, the linear correlation coefficient between the measured and calculated values of COD was computed as 0.894.

The calculations were then repeated with the exclusion of some COD data which has differed appreciably from their calculated counterparts and the rate constants were then calculated as

$$C = -0.0017 \text{ day}^{-1}$$
$$K = 0.0601 \text{ m}^{-1}$$

The linear correlation coefficient for this case was determined as 0.950.

These results clearly show that the effect of waste accumulation with time on COD removal can be ignored, and equation (2) can be taken as a first approximation defining the COD removal with distance (or time of travel) for this specific experiment, i.e.

$$y = y_0 e^{-0.06x} \qquad (4)$$

where x = distance downstream from the inlet section in meters

OTHER OBSERVATIONS

During the study made, the following observations have also been made.

1) Nitrogen concentration has decreased with length of infiltration, reaching a removal efficiency of 65-75% at the outlet end of the channel.

2) The phosphorus removal efficiency has increased with time, reaching values as high as 92.5 % after 71 days of continous infiltration.

CONCLUSIONS

The most important general conclusions reached from this study are:

1) COD, nitrogen and phosphorus removal by infiltration and land disposal is an appropriate technology for developing countries.

2) COD removal efficiency by infiltration can be approximated by a first order kinetic reaction. The rate constants can easily be determined by least-squares analysis.

3) Effect of accumulation of wastes with time on the COD removal rate is negligible.

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LAWS AND REGULATIONS FOR THE PROTECTION OF ENVIRONMENT IN TURKEY

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INTRODUCTION

Among the different phases of an environmental management programme "legislation" is one of the most important phase. Without a proper legislation, implementation and enforcement on pollution prevention measures are not possible.

The means which force the acceptance of a legislation related to the environment are several, but the most common ones are:

a) the result of public awareness
b) the result of the force exerted by a small group - sometime a powerful single person- of "environment aware" administrators.

One problem which developing countries is facing in relation to environmental legislation is the "adaptation" of inappropriate foreign laws and regulations, or in other terms, "direct translation" of the laws of a developed country. This way does not usually give satisfactory results. Every country should prepare the legislation which is appropriate for its own needs.

In Turkey, the increasing awareness for the protection of the environment has resulted in making several laws and regulations after 1971. Until that time, the existing laws of 1930's had emphasized on the public health aspects of the environmental control, and they were not able to cope with the environmental problems caused by rapid industrialization and urban development. The laws prior to 1971 which has articles on public health and pollution control are basically The Municipalities Law, The Water Law, The Harbours Law and The General Public Health Law. This paper will discuss the laws and regulations which have come into effect after 1971.

THE CONSTITUTION OF TURKİSH REPUBLIC

In the Constitution of Turkish Republic- Law Number 2709, the Article 56 in the Eighth Section states that:

> " Everybody has the right to live in a healthy environment. The betterment of the environment, taking care of the public health and the protection of the environment from pollution are among the duties of the central government and the citizens "

LAW ON THE PROTECTION OF WATER PRODUCTS

On March 22,1971 the Law on the Protection of Water Products, Law Number 1380, came into effect. This law had only one article related to pollution control. Article 20 in the Fourth Section states that:

> " It is prohibited to discharge wastes or construct waste discharge systems in such a way as to harm water products or those who use or consume them near places where produces from water are obtained "

In addition to Article 20, Article 36 in the Eighth Section states that those establishments who do not comply with Article 20 will be closed, and they will have to treat their wastes before discharging.

In accordance with this law, a regulation was published in the Official Gazette. This regulation gave the "receiving water standards and any industry whose wastes caused the violation of these standards were liable to fires, and they could even be stopped from operating. These regulations were criticized by a number of agencies, because

a) most receiving waters were already polluted,
b) whenever there was more than one factory discharging into the same stream, it was difficult to assess the liability of each factory,
c) the concentrations of some of the pollutanks were so low that it was difficult to measure them.

With these ideas, the regulations of the Law on the Protection of Water Products were revised, and receiving water standards were replaced by effluent quality standards. If necessary, the effluent quality standards are revised and modified each year and published in the Official Gazette of the last day of February.

Some of the effluent quality criteria listed in the February 29,1984 issue of the Official Gazette are given in Table 1.

Table 1. Effluent Quality Criteria Givem in the February 29,1984 issue of the Official Gazette

Parameter	Upper Limit (mg/L)
BOD_5 (20 C)	50.0 *
COD	70.0 *
Suspended Solids	200.0
Oil and Grease	
Domestic Wastewaters	30.0
Industrial Wastewaters that contain Petroleum Products	10.0
Phenol	5.0
Total Cyanides	2.0
Free Chlorine	0.5
Total Mercury	0.01
Cadmium	0.05
Lead	0.5
Arsenic	0.5
Chromium	0.5
Copper	0.5
Nickel	0.5
Zinc	2.0

* It should be noted that the upper limits for BOD and COD can be multiplied by the factor

$$\frac{1}{10} \times \frac{\text{receiving water flowrate}}{\text{wastewater flowrate}}$$

if the receiving water flowrate is more than ten times as much as the wastewater flowrate.

According to the author of this paper, the upper limit for COD value of 70 mg/L is unrealistic, and it could not be easily achieved. This value is even lower than the value accepted for discharging into the lakes and rivers in special recreational areas in Europe. Complex and expensive treatment processes are required to achieve such a value.

ENVIRONMENT LAW

On August 9,1983, the Environment Law, Law Number 2872, came into effect. This law has articles on the general management and control of pollution and protection of the environment. It envisages the establishment of a Environmental Protection Council under the direct supervision of the central government as well as local Environmental Protection Councils in each governorate. Polluting the environment is prohibited and punishable by fines stopping industrial operations and jail terms. Environmental impact studies are mandatory and treatment of wastes is compulsory. The regulating agency is the Undersecretary of the Environment. Recently, the Undersecretary of the Environment is replaced by the General Director of the Environment. Although the by-laws and regulations of the Environment Law should have to be published the latest by August 11, 1984, they are not yet published.

REGULATIONS OF THE İSTANBUL WATER AND SEWAGE WORKS GENERAL DIRECTORATE

The Water and Sewage Works General Directorate of İstanbul (İSKİ) has prepared a set of regulations for the discharge of wastewaters into sewers. These regulations were published in the March 13,1984 issue of the Official Gazette. Some important articles from the İSKİ regulations are as follows:

Article 3

In places where there is a sewer network, all wastewater flows must be connected to this network.

Article 5

In places where there is a seperate sewer system, storm waters and other unpolluted surface drainage waters must not be connected to domestic sewers.

Article 6

Unpolluted cooling waters can not be discharged into the sewer system without the approval of İSKİ.

Article 7

It is not permitted to discharge industrial wastewaters into sewers after diluting them with unpolluted waters.

Article 10

In order to discharge industrial wastewaters into sewers, industries must obtain a "Discharge Quality Control" permit from İSKİ. The quality of the industrial wastewaters is assessed either by İSKİ or by institutions approved by İSKİ.

Article 12

Those industries whose wastewaters are found as unsuitable to discharge into sewers must pretreat their wastewaters.

Article 13

Any wastewater source which has a flowrate greater than 200 m^3/day or more than 1% of the total discharge (or pollution load) of the sewer is considered as an "important pollutant". If the characteristics of the "important pollutants" are worse than any one of the quality criteria given in Table 2, than the industries are required to have pretreatment.

Table 2. Water Quality Criteria for Discharge of Wastewaters in Sewers

Parameter	Maximum Permissible Value for a Single Sample (mg/L)
BOD	250
Suspended Matter	350
Total Nitrogen	30
Total Phosphororus	8
Anionic Detergents	5
Arsenic	3
Cadmium	5
Total Chromium	5
Copper	10
Lead	3
Nickel	10
Mercury	1
Silver	5
Total Cyanide	10
Phenols	10
Hydrogen Sulfide	2
Toxicity (bio-assay test), TL_{50}	100%
Temperature	40 C

Article 18

Industries must assess the quality of their wastes at certain intervals.

Article 22

Operation costs of the sewer system are shared by the industries according to the following wormula:

$$\text{Cost (TL/day)} = aV - b\,\frac{C - C_T}{100}\,V$$

where

a = a coefficient (TL/m^3)

V = discharge (m^3/day)

C = actual concentration of the pollutant (mg/L)

C_T = maximum permissible concentration of the pollutant (mg/L)

$b = 1000\ a/C_T$

REGULATING AGENCIES

The agencies responsible for the protection of the environment and control of pollution can be listed as follows:

a) Ministry of Health and Social Welfare
   - General Directorate of Basic Health Services
   - Public Health Director for each governate

b) Ministry of Agriculture Forestry and Village Affairs
   - Directorate of Water Products

c) General Director of the Environment
   - Environmental Protection Council of the Central Government
   - Environmental Protection Council for each governate

d) İstanbul Water and Sewage Works General Directorate (İSKİ)

e) Turkish Scientific and Technical Research Council

f) Universities

CONCLUSION

A number of laws and regulations are available in Turkey. These have resulted as an outcome of the past fifteen years and reflect an appropriate evaluation of the requirements needed for the industries in a developing country. The system developed is flexible enough to make yearly revisions.

The duties of the regulating agencies, however, are not well defined and need to be reconsidered by the central government.

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REMOVAL OF HEAVY METALS BY FLY ASH FROM ACIDIC WASTEWATERS

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INTRODUCTION

Heavy metal pollution has recently become a topic of general public concern as a result of widespread publicity on mercury pollution as well as on other heavy metals. The following list of heavy metals has been classified (1) as having very high or high pollution potential:

1. Very high pollution potential: Ag, Au, Cd, Cr, Cu, Hg, Pb, Sb, Sn, Te, Zn.

2. High pollution potential: Ba, Bi, Fe, Mn, Mo, Ni, U. The pollution potential of these metals is based on toxicity to individual species in a broad spectrum of living things.

The efect of drinking-water quality on cerònic disease mortality has been studied by a number of investigators since Kobayashi showed a correlation between cerebrovascular mortality and the acidity of water supplies in Japan. A number of investigators have contributed evidence supporting hypotheses that areas with hard water tend to have lower death rates and less cardiovascular deseases than soft-water areas. Soft water is generally more corrosive and should contain more metal contaminants, whereas hard water contains greater amonts of calcium and magnesium (2).

In general, conventional biological treatment has been shown to be inconsistent in removal of metals, while physico-chemical treatment can reliable remove those metals that can be precipitated by inorganics coagulant or adsorbed by activated carbon or other adsorbents (3).

The application of activated carbon on wastewater facilities is mainly in the reduction of organic matter, biodegradable or refractory. Very little has been reported on the use of activated carbon for inorganics removal in water and wastewater industries (4).

The present study aims to evaluate the adsorption of the heavy metals that have very high and high pollution potential on fly ash. Adsorption is integral to a broad spectrum of physical, biological, and chemical processes and operations in the environmental field. Adsorption results in the removal of solutes from solution. Extent of adsorption is generally proportional to specific surface area, specific surface area being that part of the total surface available for adsorption (5).

Adsorption can be either physical or chemical. A sharp distinction between the two types is not always possible. A generally accepted criterion is the order of the adsorption energy. Typically, physical adsorption involves energies from 1 .5-25.2 kJ/mol. Energies higher than 12[illegible] kJ/mol are definitely in the region of chemical adsorption (5).

EXPERIMENTAL

Materials and Methods - The fly ash used as an adsorbent for heavy metal removal in the present study was taken from a complex zone of electric power stations in [illegible] Kosova in Obiliq, near Prishtina. To asses the adsorbent properties of this ash we prepared standard solutions of metals Cd, Pb, Zn, [illegible], Mn, Cu and Co and treated them with fly ash.

The industrial wastewater that were treated with fly ash in the present study were taken from an industrial zone of metal and chemical industry in Mitrovic[illegible] and originate from the battery industry, zinc electrolysis and fertilizer industry.

The treatment of the standard solutions of above mentioned metals and industrial wastewater was done by mixing the fly ash and water effluents in a magnetic stirrer in a constant mass ratio. The reaction time for adsorption was constant (2h) for all experiments. For each gram of fly ash we used 100cm^3 of standard solution or wastewater. After 24h the mixture of fly ash and water was filtered and in the filtrate the concentrations of metalic ions which were investigated, were detrmined using a Perkin Elmer Model 370A Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The characteristics of treated wastewater as well as those of used fly ash as an adsorbent are shown in Table 1.

Table 1 Some of the analysed parameters of the industrial wastewater and fly ash

Industries	pH	Analysed metals (mg/dm^3)			
		Pb	Zn	Cu	Cd
1. Battery ind.	1.12	4.0	1.5	0.45	0.02
2. Zinc elect.	2.35	2.2	300	1.58	1.25
3. Fertil. ind.	1.70	1.5	11.1	0.25	0.12
Fly ash		CaO	MgO	SiO_2	Al_2O_3
		41.45%	4.0%	26.75%	4.0%

From the shown characteristics of fly ash it can be seen that the ash of Kosova basin coal is alkaline in its composition and is suitable as a neutralizing media for high acidic wastewater of mentioned industries.

For assesing the adsorption properties of fly ash we firstly treated standard solutions of salts of elements Cd, Pb, Zn, Hg, Mn, Cu, and Co and then decided to use fly ash as an adsorbent for the removal of heavy metals from industrial wastewater. The adsorption properties of fly ash are shown in Table 2.

Table 2 Treatment of standard solutions with fly ash

Ions	Concentrations mg/dm^3	React time	Final concentr. mg/dm^3	Percent rem. of metals
Cd^{2+}	176.20	2h	0	100%
Pb^{2+}	250.24	"	7.99	[illegible]
Zn^{2+}	90.97	"	0	100 "
$[illegible]^{2+}$	101.99	"	1.19	[illegible].81 "
Mn^{2+}	175.90	"	0.36	99.[illegible]4 "
Cu^{2+}	188.98	"	0	100 "
Co^{2+}	181.32	"	0	100 "

The results that were obtained with standard solutions for removing heavy metals with fly ash as an adsorbent (shown in Table 2) suggested the use of fly ash for wastewater treatment.

The characteristics of treated industrial wastewater with fly ash for 2h with constant stirring are presented in Table 3.

Table 3 Some of the analysed parameters of treated wastewater with fly ash

Industries	pH	Percent removal of metals			
		Pb	Zn	Cu	Cd
1. Battery ind.	10.80	90.70	97.97	88.00	51.20
2. Zinc elect.	12.57	84.10	91.42	97.01	95.66
3. Fert. ind.	5.50	88.37	97.93	72.00	50.00

On the basis of the experimental results that were obtained in the study of adsorbent properties of fly ash from Kosova basin coal the following statements can be drawn:

1) Using fly ash of the chemical composition that is shown in Table 1 one can improve the pH media of acidic wastewater from pH 1.12 and 2.35 to pH 5.50 and 12.50.

2) The adsorbent characteristics of fly ash presented in Table 2 show the very high efficiency of ash in removing heavy metals from water solutions. From the studied standard solutions of heavy metal salts the highest efficincy in adsorbing metal ions, fly ash shows toward Cd^{2+}, Zn^{2+}, Cu^{2+} and Co^{2+}.

3) The results shown in Table 3 show somewhat less efficiency of fly ash in removing heavy metals from industrial wastewater of different kinds of industries.

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DACI

VANADIUM CONTAMINATION IN INDUSTRIALIZED AREA OF BHOPAL AND ITS IMPACT ON ROCK PIGEON

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INTRODUCTION

Vanadium is not a common pollutant, but can reach natural waters from burning fuels and fallout or as a waste product of oil refinery. The concentration of this metal in soil and certain plant species is known to increase near various industrial operations (Severson and Gough, 1976; Parker and Sharma, 1978). From the point of view of industrial hygiene, the most important vanadium compounds are vanadium pentoxide, vanadium trioxide, ferrovanadium, vanadium carbide and vanadium salts. The oxides and salts are commonly used in industries in power form which entails the possibility of dust and aerosol formation when the substances are crushed or grinded. The boiler-clearing operations generate dusts compounds. The present investigation was planned to find out vanadium contamination of soil and water in industrial area of Bhopal where bauxite, aluminium and phosphate factories are located.

The rock pigeons are the main residential birds of this area and, therefore, were examined for vanadium effects on their gonadal activity. In order to make sure that these effects are due to vanadium, the common pigeons were fed with vanadium in the laboratory for one month daily and their gonads were examined.

MATERIAL AND METHODS

The samples of soil and water were obtained randomly from the industrial (urban fringe) and non-industrial (urban) areas of Bhopal (India) every fortnight and were analysed in the laboratory for vanadium content. The soil samples were collected in duplicate (a and b) from each locality. The 'a' samples were of the uppermost 5 cm layer of soil after removal of extraneous plant material, whereas 'b' consisted of the centremost portion of the core layer. The coarse fragments and roots were excluded from all samples. A total of 96 soil samples were collected from the sampling stations. Similarly surface water samples were taken from the Upper and Lower lakes of Bhopal and Betwa river (one km area) near Mandideep. 96 water samples were analysed.

Soil material was prepared for analysis by drying under forced air at ambient temperature and then separating and saving 2 mm fractions for the use of all subsequent analytical determinations.

10 ml water sample was extracted for vanadium analysis.

EXTRACTION PROCEDURE

N-m Tolyl-O-methoxybenzohydroxamic acid (N-m-T-O-MBHA) was used as reagent to extract vanadium and was prepared as follows:

0.1% solution of it was prepared in chloroform free from ethyl alcohol. The latter was removed by washing chloroform five to six times with half of its volume of distilled water and was distilled after drying over fused calcium chloride. The middle fraction was used.

The sample was digested with perchloric and nitric acid. It was filtered and centrifuged to remove siliceous residue. The filtrate was evaporated, diluted to 100 ml with 12 M HCL and kept in a separating funnel. To the 10 ml of the solution was added 10 ml of standard vanadium solution and 10 ml of 12 M HCl 0.1 M potassium permanganate solution was added dropwise until the pink colour persists for 5 minutes and then 10 ml of reagent solution were added. The contents were shaken for about 10 minutes and the chloroform layer was allowed to separate. The violet extract thus obtained was dried over anhydrous sodium sulphate to remove moisture and was transferred to a 25 ml volumetric flask, to ensure the complete recovery of vanadium. The aquous layer was extracted twice with 5 ml of reagent and the sodium sulphate was washed with 2 ml of chloroform to remove the last traces of violet colour. Finally the extracts were diluted to 25 ml with chloroform. The absorbance of the violet complex was measured at 550 um wavelength against chloroform as blank.

OBSERVATIONS

The vanadium content in soil and water of industrial and non-industrial areas is summarized in table 1. It is seen that vanadium in soil of industrial area is 355 ppm as compared to 20 ppm in the non-industrial one. Similarly the water in the industrial area also contain 90 ppm of vanadium.

The histological features of gonads in rock pigeons are summarized in table 2 and 3. It it seen that ovary is affected in 70% of pigeons in the industrial area showing degenerated follicles, thin stroma and virtually absence of mature follicles. Similarly, 55% of male birds show hypertrophy of seminiferous tubules and interstitial cells with compact masses of sperm and spermatocytes. Such effects in non-industrial area are seen in 15% of female and 10% of male birds.

In the vanadium treated pigeons under laboratory conditions, the ovary exhibits thin and less vascularized stroma and numerous immature as well as degenerated follicles. In the case of testis, there is hypertrophy of tubules and interstitial cells and compact masses of spermatocytes.

DISCUSSION

Vanadium concentration in the rivers and streams of USA ranges from 70 to 90 ppm (Kopp and Kroner, 1968). Its level in soil is reported in the literature to range from 3 to 300 ppm, while its soil concentrations in USA are at higher end and in Europe at the lowest end of the range (Committee on Biological Effects of Atmospheric Pollutants, 1974). Dubey and Agrawal (1974) reported 300 to 320 ppm from rock samples from the phosphorites of the Mussorie phosphate deposits.

Severson and Gough (1976) however, estimated an average of 98 ppm of vanadium in soil samples obtained at 2 to 4 km away from the phosphate factory in Idaho. It is reduced to 63 ppm in soil samples obtained at 16.64 km away from this factory. In the present investigation it is found that the vanadium content of soil in Mandideep industrial area, where bauxite factory is located, is 355 ppm. In the non-industrialized area, it is due to direct flow of domestic effluent. Thus the industrial area has already approached a dangerous limit of vanadium content. It is, therefore, necessary to estimate its concentration in animals and plants and to survey the health condition of the people living in this area. Agrawal et al (1980) analysed vanadium in plants and animals from the industrial area and reported as 5.75 ug^{-kg} in cabbage, 1.55 ug^{-kg} in tomato and 0.75 ug^{-kg} in peas.

The Betwa river (in industrial area) which serves as the drinking water supply as well as for irrigation of agricultural fields to the rural population in this area is also approaching dangerous limit of vanadium contamination. This limit in USA is 70 to 50 ppm in rivers and streams. Agrawal et al (1980) however, reported very high concentration of vanadium (1530 ppm) in lake water.

The effect of vanadium on animals are not reported under tropical conditions. Such studies are made in temperate regions and indicate that the wintering birds in Corpus Christi, Texas (USA) are accumulating harmful levels of environmental contaminants including vanadium (White et al, 1980). Mitchell (1964) reported that no two plants species growing in the same soil extract have the same quantity of element and this uptake depends upon other factors such as pH, organic matter etc. It is necessary to make regression model for variation in element concentrations in soil, water and organisms in the industrial and non-industrial areas.

Table 1. Concentration of Vanadium in Soil and Water

Item	Vanadium content (ug/l)	
	Industrial area	Non-industrial area
Soil	0.355 ± 0.08	20 ± 0.01
Water	0.09 ± 0.02	Trace

Table 2. Histological features of ovary in rock pigeon (The number of pigeon is given in parenthesis)

Area of sampling	Stroma	Oocytes
Industrial (40)	Thin (28) Thick (12)	Mature (12) Immature (78) Degenerated (28)
Non-industrial (43)	Thin (4) Thick (39)	Mature (397) Immature (4) Degenerated (4)

Table 3. Histological features of testis of rock pigeons. The number of pigeons is given in parenthesis

Area of sampling	Seminiferous tubules	Intestinal cells
Industrial (36)	Compact masses of spermatocytes and sperms (20)	Hypertropied (20)
	Spermatogenesis at various stages (16)	Normal (16)
Non-industrial (37)	Contact masses of spermatocytes and sperm (4)	Hypertrophied (4)
	Spermatogenesis at various stages (33)	Normal (33)

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ENERGY RECOVERY FROM MUNICIPAL SOLID WASTE

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INTRODUCTION

The possibility of exploiting Municipal Solid Waste (MSW) from the standpoint of its energy contents has attracted for many years technicians, public officials and administrators.
Many countries around the world have built units for the overall incineration of raw MSW recovering for reutilization more or less of the thermal energy generated according to the higher or lower efficiency of the system. These units in most cases have satisfactorily performed their primary task, that of disposing of the waste. As regards the energy recovery, instead, a number of reasons have led in recent years towards a serious reconsideration of the Mass Burning Approach as the ideal solution to the MSW disposal problem:
- ECONOMIC REASONS due to the increasing costs of operation of traditional mass burning plants not significantly reduced by the revenues from energy recovery;
- ENVIRONMENTAL REASONS due to the increasing public concern on flue gas emissions from incineration plants burning raw MSW which have led to the shutting down or complete remodeling of a number of facilities;
- ENERGY REASONS connected with the worldwide energy crisis and the need for alternative low cost fuels and for combustion systems capable of guaranteeing a high effective overall thermal efficiency.
These and a number of other erasons have led towards the development of the Refuse Derived Fuel Approach to the energy problem.

REFUSE DERIVED FUEL

The term RDF together with the less common WDF (Waste derived Fuel) indicates a vast variety of combustible materials the only common denominator of which is their origin: SOLID WASTE.
Among the principal factors which differentiate one RDF from another are: the technology employed in the sorting of the fuel and, for certain technologies, the characteristics and composition of the initial raw waste.
Another important consideration is if the production of RDF represents the ultimate aim of the sorting process (as is usually the case in North America), or if it is only a step of an integrated recycling system comprising recovery of materials (paper, plastic film, ferrous metals, etc.).
It is therefore possible to schematically represent the following preparation processes:

a) Raw Waste..RDF-1
b) Raw waste + Shredding + Magnetic Separation..............RDF-2
c) Raw Waste + Shredding + Magnetic Sep. + Air Class.........RDF-3
d) Raw Waste + Shredding + Magnetic Sep. + Screening + Air classification.......................................RDF-3
e) Raw Waste + Screening + Shredding + Magnetic Sep. + Screening + Air Classification...............................RDF-3
f) Raw Waste + Shredding + Magnetic Sep. + Screening + Shredding + Air Class. + Pelletization(or Pulverization)......RDF-4/5

The numbers after RDF refer to the ASTM standard classification.
It is quite clear that each subsequent refining stage is carried out on the RDF with the aim of increasing its fuel value but on the other hand each subsequent refining stage also means an added energy expenditure and a loss of product.
The ultimate goal of the process is to obtain an RDF with acceptable and reliable characteristics spending a minimum amount of energy.

STORAGE OF RDF

The storage of RDF has represented one of the most critical steps in the program of conversion of MSW into energy. In fact we can state that the storage problem has been the main reason which has delayed the industrial application of this process.

With the sole exception of pulverized or pelletized RDF (the production cost of which is however extremely high) all other forms of RDF encounter considerable storage and extraction problems unless we resort to storage pits with the traditional combination of bridge crane and grapple as extraction unit.

FEEDING OF RDF

If the storage problem can be partially solved using normal pits, the dosed feeding of RDF to the combustion units gives rise to whole new series of problems linked to the mechanical and physical characteristics of the fuel.

FIRING OF RDF

Neglecting the mass burners for the manifold reasons previously illustrated, the combustion of RDF can take place:

a) at 100% feedrate in specially designed and constructed boilers (dedicated boilers);
b) in co-combustion with gas, oil or coal

The combustion system can be in semi-suspension or in almost total suspension. In the former case almost 90% of the fuel is burned during its free fall from the feeding inlet to the boiler grate (dump grates). In the latter case approximately 50% of the fuel burns in suspension while the other 50% burns on the grate which is of chain driven moving type. In both cases secondary air is conveyed through the bottom grate.
It is quite clear from what stated previously that the coarser the RDF, i.e. the richer it is in orgnaics and inerts, the higher will be the amount of fuel that burns on the grate and consequently the air blown under the grate will have more problems in permeating the material thus giving rise to a lower thermal efficiency of the process and to a higher amount of excess air required for combustion. In the case of co-combustion, industrial experience accumulated so far indicates that the boilers should be designed for a maximum mixing ratio of 80 to 20% either fuel being the highest (these percentage values refer to the calorific value and not to the weight of the materials and are based on experience using RDF mixed with coal).

COMPARISON BETWEEN COMBUSTION IN MASS BURNERS AND IN RDF BOILERS

We have already dealt with some of the basic differences existing between the combustion of raw waste in a mass burner and the firing of RDF in a suitable boiler.
On the whole it is important to point out that the "Mass Burner" is a machine designed to destroy solid waste thus providing a solution to a considerable problem such as that of the disposal of the rejects of our society which would otherwise end their journey in a landfill jeopardizing the surrounding environment.
On the contrary the " RDF Boiler " is a steam generator which utilizes as fuel a combustible fraction derived from waste (RDF).
From these definitions it is possible to envisage some of the advantages of the RDF boiler over the mass burner which altogether are:

- combustion with less excess air (37-41% versus 80-100%) thanks to the lower layer of fuel on the grates;
- evenness of combustion owing to the homogeneity of the fuel;
- higher temperatures in the combustion chamber;
- lower maintenance and corrosion problems;
- higher thermal efficiency;
- lower volume of flue gas to clean;
- lower investment and operating cost;
- higher reliability for continuous steam generation.

The disadvantages are that the mass burner can incinerate raw waste without any specific pre-treatment, whilst the RDF boiler requires a processed material. However the calories eliminated with the rejects of the RDF preparation process do not actually contribute significantly to the energy balance coming from extremely low calorific value materials (organics, inerts, etc.).
From the pollution control point of view it is necessary to point out that the possibility of diverting from the combustion process both the organic matter and, in some instances, the chlorinated plastics can contribute significantly to minimize environmental and health hazards coming from the flue gas emissions.

THE ROME EXPERIENCE

Sorain-Cecchini, well known for its technology in the field of materials recovery from waste, was one of the first European companies to understand the emerging importance of the exploitation of MSW from the standpoint of energy recovery.
Having soon abandoned the production of pelletized fuel owing to the high energy cost of the process, and after having closely examined the negative features of existing industrial RDF preparation and combustion plants throughout the world, Sorain-Cecchini has developed its own unique technology which envisages the production of a fuel denominated "CALURB" (Combustibile Alternativo Urbano - Urban Alternative Fuel) which presents the following characteristics:

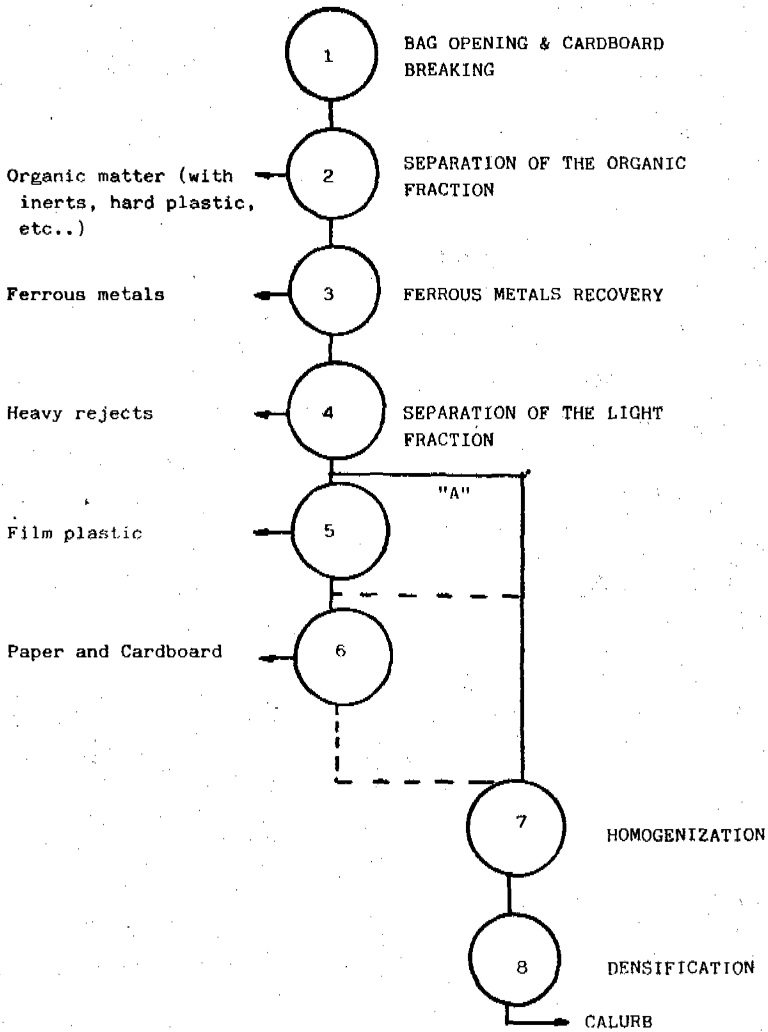
- homogeneous and pure
- small and constant in size
- constant in quality in a considerable range of variation of the initial raw waste
- high Heating Value and low ash content
- sufficient specific gravity to allow for easy handling, storing and firing
- cost competitive thanks to the low energy required for its production.

To obtain this result it has been necessary to design, construct and extensively test on an industrial scale a number of machines and alternative process cycles.
All the tests have been performed in the ROME EAST MSW recycling plant (1200 tons/day) using the raw waste of the city of Rome that with its well known high contents of organics made it considerably difficult to meet the proposed goal.
The industrial process presently operational for the production of CALURB envisages the following basic steps (see Figure 1):

* recieving of raw MSW
* opening of waste bags and of other waste containers
* separation of the organic constituents from the combustible fraction
* ferrous separation from both organics and combustible fractions
* separation of heavy components from the combustible fraction
* homogenization of the combustible fraction
* densification and obtainment of CALURB

Each of the basic steps of the process reviewed above has been carried out employing machinery designed for that specific service with the aim of obtaining extremely low energy consumptions, low operating costs, a high degree of safety and of operational reliability.

FIGURE 1 - FLOW DIAGRAM OF THE SORAIN-CECCHINI INTEGRATED PROCESS LINE



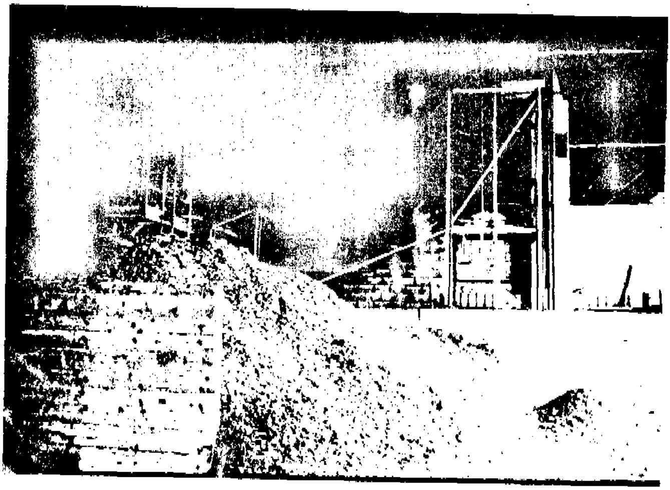
"CALURB" Production Line

Stage one, i.e. the opening of bags and containers,is performed by an extremely sturdy low rotational speed machine designed so as to avoid any significant contamination between the combustible fraction and the organic and inerts fractions. The machine features also the possibility of discharging automatically impossible to break and bulky items without suffering any damage. The low speed of this machine avoids, furthermore any danger of explosions, which can occur and are particularly feared in high speed machines.
The separation of the organic fraction takes place in another specially designed machine which presents the extremely advantageous feature of being self cleaning thus solving the considerable sanitary problems that arise every time an operator must carry out a manual intervention on process machinery. The organic fraction is conveyed directly to the composting line without any further size reduction .
The separation of the heavy components takes place in an air classifier, a machine tested out in over ten years of industrial practice. The homogenization stage, since its only aim is to reduce the size of the bigger pieces without special requirements for the final dimensions, is carried out employing another low speed, low energy machine. Finally the last stage, the densification, is carried out in a machine which exploits a new and unique principle for the rupture of the combustible material reaching results never obtained before, specially when the infeed contains high percentages of plastic film and textiles.
This machine is based on an extremely simple friction principle and operates at low speed (in the range of a few tens of rpm) with low energy consumption and reduced wear on the friction members.
The final RDF is absolutely homogeneous and dimensionally it is kept within a controlled size range and degree of densification. The latter parameter can be prefixed during the machine design stage.

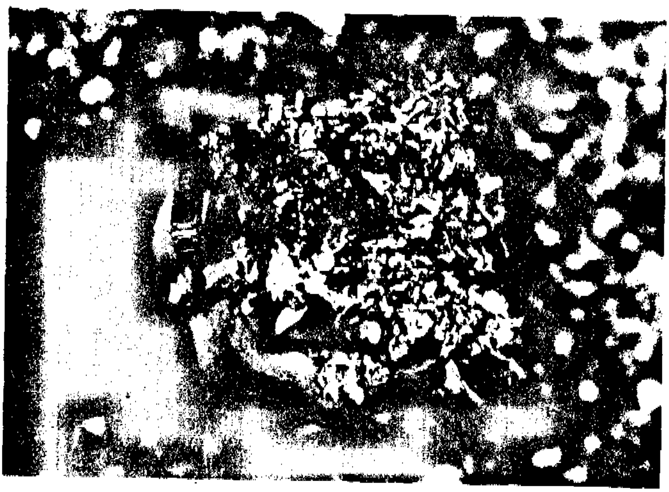
TABLE I - Size distribution and relative density of CALURB

size range (inches)	%	density		
0 - 0.2	10	80 kg/m^3	=	5 lb/ft^3
0.2-0.4	24	100 " "	=	6.2 " "
0.4-0.8	32	120 " "	=	7.5 " "
0.8-1.2	34	150 " "	=	9.4 " "

CALURB production line



CALURB



The aforesaid production line ofers, furthermore, with appropriate by-passes the possibility of directing the process towards the recovery of only RDF or towards a mixed recovery of fuel and materials. The operational possibilities are three: (see Figure)

A) only recovery of fuel (100% CALURB)
B) recovery of paper + recovery of plastic film (polyethylene) + recovery of CALURB
C) recovery of plastic film + CALURB

The rates of recovery and the composition and Calorific Value of the CALURB fraction are illustrated in Table II on the basis of the Rome MSW composition.

TABLE II - Recovery rates and composition of CALURB for different cycles (City of Rome)

MSW composition	%	CYCLE "A"	CYCLE "B"	CYCLE "C"
paper/cardboard	25	21	5	21
film plastic	3.5	3.3	0.4	1.2
hard plastic	3	0.9	0.5	0.9
ferrous metals	2.5	-	-	-
textiles/leather/ wood	3	1.9	1.7	1.9
organic matter	53	2.1	1.0	2.1
glass/inerts	10	0.3	0.2	0.3
	100	29.5	8.8	27.4
HIGHER HEATING VALUE (HHV) Kcal/kg	2000	4000	3600	3545
MOISTURE	47	24	25	25.5

The unitary energy consumptions are of course different from case to case according to the process employed and the composition of the raw waste (the richer the raw waste in combustibles the lower the unitary consumption of energy).
In Table III we have summarized for the Rome MSW composition the energy consumptions relative to cycles "A" and "C". We have neglected cycle "B" since in this case the production of RDF is secondary to the recovery of paper and plastic film.
It is easy to see that the unitary consumptions of cycle "C" are considerably higher than those of cycle "A" since they include also part

of the energy consumption relative to the separation of the film plastic. The latter part of the energy consumption can ,however, be easily subtracted if so desired.

TABLE III - Energy consumption for the production of CALURB using process cycles "A" and "C" (all tons are metric)

CYCLE STEPS	CYCLE "A"		CYCLE "C"	
	KWhxton. MSW	KWhxton. CALURB	KWhxton. MSW	KWhxton. CALURB
1 BAGOPENING	3.5	11.9	3.5	12.7
2 SEP. OF ORGANICS	0.3	1	0.3	1
3 FERROUS RECOVERY	0.2	0.6	0.1	0.6
4 SEP. OF HEAVIES	4.5	15	4.1	15
5 SEP. OF FILM PLAST.	-	-	8.2	30
6 SEP. OF PAPER/CB	-	-	-	-
7 HOMOGENIZATION	3	10	2.7	10
8 DENSIFICATION	10	35	9.6	35
9 AUXILIARY CONS.	1.5	5	1.4	5
TOTAL	23	78.5	29.9	109.3

TRANSPORTATION, STORAGE AND FEEDING OF CALURB

The physical and dimensional characteristics of CALURB make it suitable for storing both in pits and in storage silos. (see photographs on pg) Transportation can be carried out using normal body trucks, where the relative density can reach 320-350 kg/m^3 (20-22 lb/cu.ft.) or if the interest is in reducing transportation costs, in compaction vehicles such as those used for waste. In the latter,from a number of trials carried out, the relative density can reach values of 680 kg/m^3 (42 lb/cu.ft.).

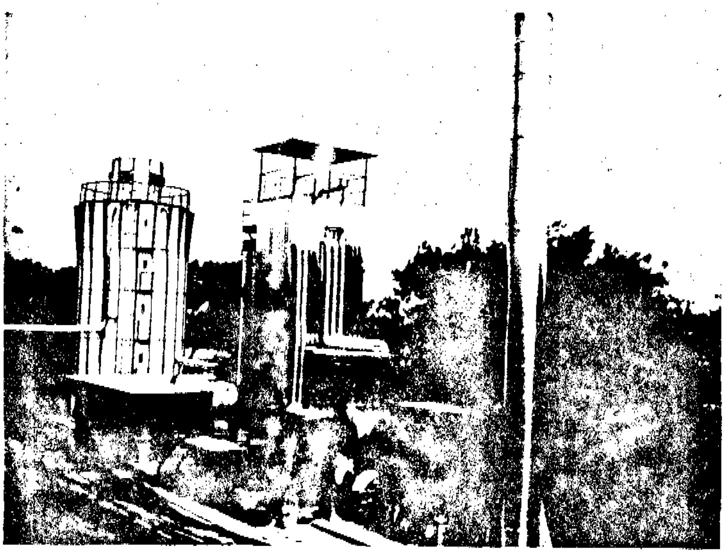
On site storage at the boiler facility can be performed in storage bins of considerable dimensions (up to 300 cu.m.) since the bridging and extraction problems (always present when using fluff RDF) have been solved thanks to the fact that the densified material is semi-granular, and that,since the size of the plastic and textile fragments is quite small (1 to 1.4 inches), they do not create problems to the extraction equipment.

As for the boiler feeding problem, also here the particular physical form of CALURB allows for direct feeding of the boiler from the storage bin with the only addition of a volumetric self-dosing mechanism, already widely experimented.

FIRING OF CALURB

The CALURB produced by Sorain-Cecchini in the Rome Recycling Plants is partially fired on site in a nearly 100% suspension burner connected to a boiler and a power generating unit (see photograph).

CALURB storage and combustion unit - **Rome** *East* **MSW** *Recycling Plant*
(visible from left to right: the 300 cu.m storage bin - white; the housing of the power generator; the burner- partially covered; the vertical boiler with economizer and fly ash extraction - orange bottom; the multi-cyclone flue gas cleaning system; and the stack)



The CALURB is fed tangentially into the circular shaped combustion chamber. During a free fall of approx. 2 meters (6.5 feet) the fuel burns almost completely in suspension while a small fraction consisting of more dense materials finishes its combustion on a bottom grate of the dump type.

Combustion is primed by heating the combustion chamber by means of a standard fuel oil burner to the temperature of about 600°C (1100°F). CALURB is automatically dosed into the unit up to a maximum temperature of 850-900°C (1550-1650°F).

The combustion unit has a capacity of approximately 6 million Kcal/h (about 24 million btu/hr) and uses 70 to 75% excess air to obtain the necessary turbulence.

The boiler is of the vertical convection type and it has been designed in order to guarantee no deposits of fly ash and to avoid as much as possible abrasion by the fly ash itself. Particular care has therefore been taken in the choice of special wear resistant materials and in designing the unit such that the velocity of the flue gas through the pipes is kept low.

The boiler capacity is of 10 tonn./hour of steam at 30 bar (saturated) corresponding to approx. 22,000 lbs/hr at 435 psig.

The steam is conveyed to a counter-pressure turbine with an outlet steam pressure of 3.5 bar (50 psig). The power of the generator is 400 KVA. The low pressure steam is used for the recycling plant inside uses.

UTILIZATION OF CALURB AS FUEL IN CEMENT KILNS

A number of industrial trials have been performed using CALURB mixed with pulverized coal in the cement kilns of the UNICEM cement plant of Guidonia-Rome (approx. 20 km from the Rome East recycling plant). CALURB was used in a proportion of 15% of the total energy supply.

All results were judged positive with regard to the cement quality since the chemical components of the clinker had not undergone any significant alteration and the chemical and physical characteristics such as tensile strenght and set time in some cases were even unexplainably improved.

Emission control tests were carried out by personnel of the University of Rome with positive results with respect to complying to emission standards set by the Government of the Province Of Lazio.

The CALURB was injected inside the coal flame in countercurrent with the cement components.

The feeding and dosing of CALURB was obtained by means of a surge bin fitted on the bottom with two screw conveyors one with fixed speed and one with variable speed discharging into the hopper of a pneumatic transport unit.

TABLE IV - Percentage presence of certain chemical elements in CALURB

ELEMENT	PRESENCE %
C	45-47
H	6-6.5
N	0.7-1.7
S	0.2-0.25
Cl	0.09-0.17

Ash content from analyses carried out in Rome: 5-8% under grate + 5-8% fly ash (contents of SiO_2 approx. 40% - melting point between 1050 and 1100 °C (2000 °F about)

Rome-April 1984

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DUNIN

EARTHEN LINERS FOR WASTE CONTAINMENT

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INTRODUCTION

Earthen liners are commonly used in the construction of low-permeability barriers to contain toxic and harzardous liquids in wastewater lagoons and sanitary landfills. The use of earthen materials is especially desirable where the waste disposal sites are remote or need to be constructed using normal earth moving equipment. Furthermore, earthern liners can be constructed utilizing relatively low level technology. These conditions may be found more often in developing countries making the earthen liners a particularly appropriate means of waste containment. Earthen liners include natural clay, bentonite-soil mixtures, fly ash, fly ash-soil mixtures, soil cement and soil-asphalt mixtures. Of these, fly ash and fly ash-soil mixtures are particularly attractive options since fly ash is basically a waste product itself and using it as a liner would generate significant economies.

Inasmuch as the soil liners appropriate for developing countries, unless carefully designed and constructed, they may easily fail in providing the required performance. Such problems are quite common, even in developed countries. Most construction problems, however, can be eliminated by using labor-intensive procedures and in this respect the soil liners provide a more suitable choice in developing countries. In recent years there has been a greater scrutiny especially with regards to the long-term durability of earthen liners in contact with various waste liquids, in particular, the organic liquids. In the design of a liner, the maximum allowable hydraulic conductivity must be specified for the liner material being used. Prior to construction, the liner material that is proposed for use must be tested to ensure that it has a hydraulic conductivity at or below the specified level. Accurate measurement of hydraulic conductivity for such low-permeability barriers has proven to be a difficult task. Problems are present within the procedural steps and equipment used to measure the hydraulic conductivity. Furthermore, there is laboratory and field evidence that certain chemicals, in particular the organic solvents, can affect the structural integrity of certain soil liners. Therefore, there is a great interest in recent years with regards to the methods of determining hydraulic conductivity and the long-term durability of earthen liners.

This paper provides performance data on a number of liner materials including fly ash, fly ash-sand, and bentonite-sand mixtures. The difficulty and critical factors regarding the laboratory measurement of liner permeability are presented along with recommendations for obtaining a low-permeability barrier.

LINER SELECTION AND DESIGN

The principal requirement for a soil liner is low permeability to water and waste fluids and little or no interaction with the waste which might increase permeability. Absorptive capacity for pollutants and strength initially and after contact with waste fluids are secondary requirements. When earthen materials are properly selected and compacted, they can be made extremely impermeable to the flow of liquids but there will always be some seepage. To achieve an adequate seal in wastewater lagoon/pond or sanitary landfill systems using earthen materials, the following two related criteria are suggested to be satisfied individually (Edil and Didier, 1981):

1. The percolation rate of lagoon/pond water specified shall not exceed 9.36 for municipal waste and 4.68 for industrial facilities in cubic meters per hectare per day, (exfiltration shall be prevented by leachate collection in sanitary landfills), and

2. The coefficient of permeability (hydraulic conductivity), k in milimeters per second specified for this seal shall not exceed 10^{-6} with a minimum seal thickness of 0.3 meter for wastewater lagoons and 1.5 meters for sanitary landfills.

Such a very low percolation rate is obtainable by present day technology and is essential to ensure protection of groundwater. In the selection and design process the first step is to determine if this low level of permeability is achieveable using the available and economically feasible liner materials by performing laboratory permeability tests on samples of compacted earthen liner materials. The second step is to determine if the permeabilities measured in the laboratory tests are likely to remain unchanged in the field as a result of environmental and physico-chemical effects, i.e., the long-term durability of the liner. There are certain difficulties with respect to both of these two steps. Accurate measurement of the coefficient of permeability has proven to be a difficult task with regard to low-permeability earthen materials. Problems are present within the procedural steps and the equipment used to measure the coefficient of permeability. Presently there are no concensus standards available for the permeability tests on low-permeability barriers. The second consideration relating to the durability of liners is recently receiving considerable attention. This aspect is even less developed than the permeability testing. However, it ultimately controls the long-term performance of an earthen liner. A number of possible failure mechanisms for earthen liners have been suggested (Edil, 1982). These mechanisms result in an increase in the permeability of the liner materials as a result of changes in the physical and chemical environment of the liner subsequent to construction. Therefore, even if the liner has the proper impermeability at the end of the construction, it still may be affected subsequently by these factors.

The affect of the failure mechanisms on the liners take place basically in two ways: i) a change in density, and ii) a change in effective pore-size distribution. The physical factors include wetting/drying, freezing/thawing, temperature changes, and stresses. These factors may result in cracking and loosening of earthen liners when, and if, they are exposed to such environmental conditions. Waste fluids may interact chemically with the liner material in a variety of ways. Either organic or inorganic acids and bases may solubilize portions of the clay structure resulting in increased permeability. Pore fluid substitution, i.e., changes in cation type and concentration, dielectric constant, etc., affects the force field around clay particles and the interparticle forces. Consequently, the size of the pores and the resistance to pore fluid movement are affected. These chemical factors result in a variety of mechanisms including volume change (swelling or shrinkage) and fissuring due to the replacement of interlayer water in clay mineralogical structure by organic wastes.

PERMEABILITY TESTING OF LOW PERMEABILITY BARRIERS

There are certain problems common to all of the tests suggested for the determination of the permeability of low-permeability earthen materials. These problems can be placed in one of two categories, equipment or specimen. In some cases, solutions to these problems are readily available; in other cases more research is required. In measuring the coefficient of permeability of a low-permeability material, the most common equipment-related problem is system leaks. With such low-permeability barriers, even a small leak could substantially increase the measured inflow rate or decrease the measured outflow rate. Therefore, a method of checking for leaks is needed. One way of proving that there are no leaks in the system is to perform a water budget analysis, i.e., a comparison of inflow and outflow volumes to show that the inflow rate equals the outflow rate. Equipment-related flow imbalances could be caused by evaporation and the presence of air bubbles in the outflow burette (Edil and Erickson, 1984). There are also specimen-related problems which affect the measured flow rates. The moisture condition of the specimens tested seemsto affect how the permeant passes through them. For instance, specimens of sand-bentonite mixtures compacted near optimum moisture content appear to continue to hydrate as permeability tests progress. As bentonite absorbs more inflowing permeant, zones of differential hydration may develop within the specimen (Edil and Erickson, 1984). In the case of fly ash and fly ash-soil mixtures, moisture is needed to complete the hydration reactions which control the extent of cementation as well as reduction in permeability (Vesperman, Edil and Berthouex, 1984). Another specimen-related problem in permeablity testing is the growth of bacteria on the earthen material within the permeameters. This activity tends to reduce the permeability by clogging the pores.

Application of back pressure has been promoted as an effective procedure for improving the degree of saturation of a specimen during permeability tests (Zimmie, 1981; Black and Lee, 1973). Elevating the pressure at the inflow and outflow burettes by the application of backpressure forces air in the burrettes, lines, porous stones, and the specimen into the permeant, thus saturating the whole system.

Permeability measurements of the earthen barriers can be a long process because of the low flow rates and long-time periods required to reach steady-state conditions. In an attempt to reduce the length of time required to finish a permeability test, hydraulic gradients in excess of 100 have been used and investigated (Mitchell, et al, 1965). There is a controversy about the possible adverse affects of application of such high gradients on the permeability tests results (Zimmie, 1981).

Another source of controversy in permeability testing is the type of permeameter, i.e., flexible wall versus rigid wall permeameters. Flexible wall permeameters have been described as the best type of equipment for performing permeability tests

(Zimmie, 1981). They model in-situ pressure conditions and provide a better seal along the specimen edges. Certain clay specimens may shrink when exposed to certain types of harzardous waste permeants creating a gap or a channel between the specimen and the rigid walls of the permeameter. In conclusion, it seems as though adequate equipment has been developed to perform permeability tests on barrier soils, but the exact procedures have not been defined that will produce accurate results each time. However, careful testing consistent with the best available geotechnical test procedures can produce reliable laboratory permeability test results.

PERMEABILITIES OF TWO EARTHEN LINER MATERIALS

At certain sites there may not be sufficient amount of natural clay material to construct a barrier of sufficient thickness for waste containment. In such cases, the properties of existing natural coarse-grained soils can be modified by the addition of certain finer grained admixtures.

Soil-Bentonite Liners

Bentonite has been used widely as a soil modifier by blending it with existing soils. Bentonite is a commerically available earthen product based in highly swelling clay minerals. Swelling soils are encountered in many localities around the world. Identification, mining, and marketing of soils high in swelling clay minerals locally in developing countries is highly desirable if it has not been already done. In areas where soils suitable for liner materials are not readily available, mixing with a bentonite clay could enhance sealing characteristics in a cost-effective manner. At the same time, however, one has to recognize the relatively higher sensitivity of swelling clay minerals to different chemical constituents of the waste. This aspect perhaps is more critical for the sanitary landfills and certain industrial waste lagoons than municipal wastewater lagoons. The permeability test results using a mixture of 90% Ottawa sand (passing #20 sieve and retained on #30 sieve) and 10% bentonite clay are summarized in Table 1. Water was used to prepare the samples and as the permeant. Specimens were prepared by compaction at moisture contents exceeding the optimum moisture content using the standard Proctor method. Both rigid and flexible wall permeameters were used in a test setup as shown in Figure 1. A pressure of 380 kPa was used in the test involving backpressure. Low and high hydraulic gradients were nominally 29 and 290, respectively. The test results shown in Table 1 indicate that coefficients of permeability lower than 10^{-6} milimeters per second was achievable by adding 10% bentonite to otherwise highly permeable sand soil.

Table 3. Coefficients of Permeability (mm/sec) x10^8

TEST NO.	COEFFICIENTS OF PERMEABILITY			
	LEG 1 1st low i	LEG 2 1st HIGH i	LEG 3 2nd LOW i	LEG 4 2nd HIGH i
RW1	- - -	1.3	0.5	- - -
RW2	4.3	4.2	3.0	3.1
RB1	7.2	380.	- - -	- - -
RB2	2750.	5100.	5490. x 10^{-8}	- - -
FW1	2.4	1.6	2.9	1.5
FB1	4.1	1.7	- - -	- - -
FB2	3.3	1.4	3.4	- - -

Specimen Designation: R: rigid-wall permeameter B: back pressure used
F: flexible-wall permeameter W: without back pressure

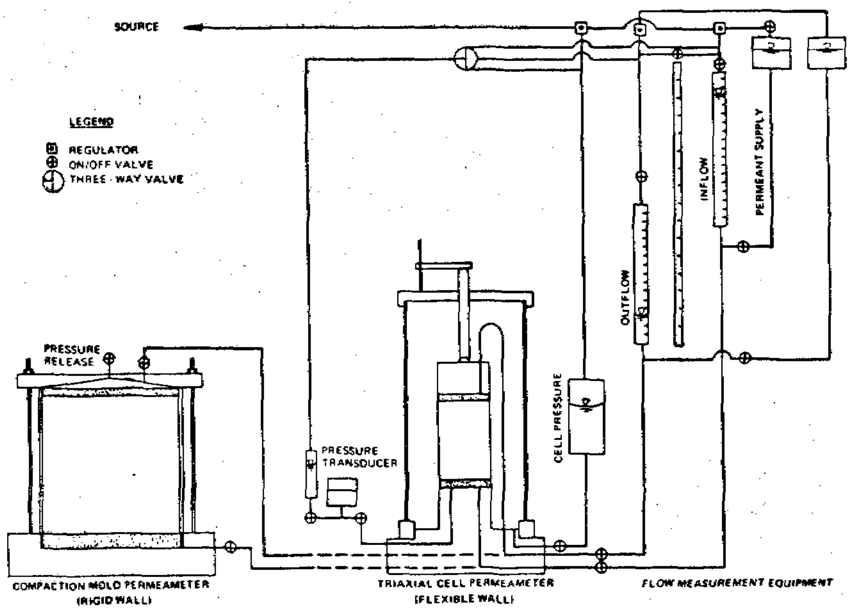

Fig. 1. Schematic of permeameters

The only exception involves the specimens which were tested in a rigid wall permeameter using backpressure. In this case, channeling and drastic increase in permeability occured. Therefore, backpressuring, while results in improvement of saturation in flexible-wall permeameters, may produce adverse effects in rigid-wall permeameters. The results also indicate that rigid or flexible-wall permeameters, when carefully used, may produce similar results unless the specimen is shrinking due to chemical reactions.

Fly Ash as a Liner

A large percent of the electric power generated in the world is produced from coal combustion. This process produces large quantities of coal ash per year. Fly ash, the lighter, smaller particles carried in the flue gas, is collected by electrostatic precipitators, filterback houses, venturi type scrubbers, etc. The fly ash removed is frequently handled "dry" and stored for disposal or utilizatin in storage silos. This dry storage maintains the pozzolanic capabilities of the fly ash (Bahor, 1981). Fly ash stabilized soil may have potential for use as a liner material at fly ash and/or scrubber sludge landfill sites, nonhazardous waste lagoons, e.g., manure pits, wastewater treatment lagoons, etc., and hazardous waste facilities, either alone or in combination with geomembranes. The potential for each of these applications requires, as an initial first step, an understanding of the permeability of the fly ash and fly ash-soil mixtures and what factors affect permeability. In an investigation aimed at this, fly ash-soil mixtures were prepared with different fly ash contents by compaction and were tested for their permeabilities. The soil used in preparing the fly ash-soil mixtures was a commercial fine quartz sand known as Portage sand. The specimens were prepared and stored for 7 days in a humidity controlled environment at room temperature after compaction. Subsequently, specimens were trimmed and placed into the permeameters. Permeability tests utilized a flexible-wall permeameter in a falling head permeability test. Deaired water was used as the permeant and the saturation of the specimens was improved by applying a nominal hyraulic gradient for 24 hours prior to permeability testing. A backpressure of 380 kPa was then established in both inflow and outflow burrettes to remove any trapped air. A gradient of 20 for the low permeability materials ($k<10^{-6}$ mm/sec) and 10 for the high permeability materials ($k>10^{-6}$ mm/sec) was then established. Permeability testing was continued either until approximately one pore volume of permeant was passed through the specimen or, in the lower permeability specimen, at least one half of the pore volume was passed through the specimen. Permeability test results indicate that the 100% and the 40% Belle Ayr fly ash-sand specimens exhibit essentially identical

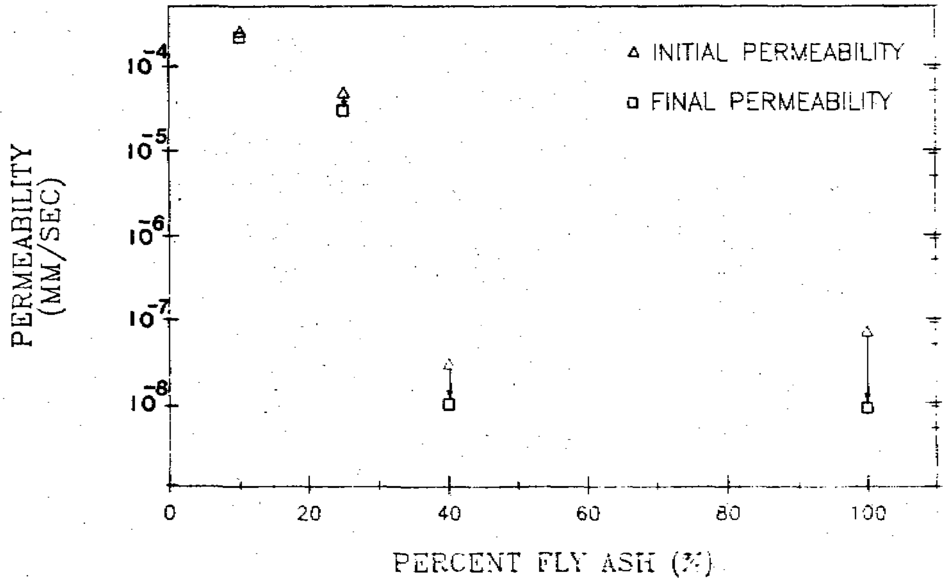

Fig. 2. Permeability of fly ash-sand mixtures

permeability as shown in Figure 2 (in the range of 10^{-7} to 10^{-8} mm/sec). However with less than 40% fly ash the measured permeabilities were 100 to 1,000 folds higher ($k>10^{-5}$ mm/sec). The Belle Ayr fly ash is a highly pozzolanic fly ash with significant self-cementitious properties. Another fly ash from a different coal source, however, exhibited permeabilities between 5×10^{-4} and 1×10^{-5} mm/sec. This latter fly ash while self-cementitious was not as pozzolanic as the Belle Ayr fly ash. This suggests that there is another major factor affecting permeability that involves the pozzolanic reaction products.

SUMMARY

Earthen liners are proposed as an appropriate means of waste containment in developing countries, based on the availability of materials and technology. However, successful performance of such liners throughout the life of the waste disposal system requires care in design, construction, and operation of such liners. This paper provides performance data on a number of earthen liner materials including fly ash, fly ash-sand, and bentonite-soil mixtures. There are difficulties and critical factors regarding the laboratory measurement of permeability of such barriers. These include permeameter type (rigid vs flexible wall permeameters), backpressure application (in order to saturate the sample), and hydraulic gradient magnitude. Factors which control permeability include density, moisture content, soil modifier content (fly ash or bentonite content), and degree of cementation and hydration.

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FATE AND EFFECT OF COPPER ON ACTIVATED SLUDGE PROCESS

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INTRODUCTION

Because of their toxicity to aquatic and human life at low concentrations, possible cumulative and synergistic effects and their tendency for wide distribution from a variety of sources, metals have received considerable attention within the last few years. Regulatory authorities are establishing extremely low allawable concentrations of these metals in effluent discharges to receiving waters.

Since practically a great number of wastewater treatment plants employ activated sludge systems, it is of significance to realize what effect heavy metals will have upon these processes, and what removal might be expected in passing such treatment facilities.

The removal of a wide range of metals in biological treatment processes has been studied by many investigators[1-3]. The wide range of removal efficiencies observed for a specific metal demonstrates the influence of the operating conditions prevailing in the treatment processes[4].

Therefore, the necessity for a better understanding of the factors influencing heavy metal interaction in activated sludge systems is acknowledged.

Because copper is one of the metals which has received considerable attention due to its inhibitory effect on biological process, it was chosen for this study.

EXPERIMENTAL

A continuous laboratory-scale activated sludge system (Manufacture of cole palmer) was used for this study. It consists of 6.2 litre outer cone, 2 litre innercone, resting concentrically inside the outercone, and the clarifying tube hanger is lowered onto top ridge of the inner cone. Air is supplied to the system through three diffusers placed into the outercone. Periodic wastage of mixed liquor controls sludge concentration around 2 $g.l^{-1}$.

To assure uniform waste characteristics and avoid great fluctuations in sewage composition, the system was fed with synthetic sewage at a constant hydraulic load of $8 m^3 m^{-3} d^{-1}$, equivalent to an organic load of 1.8 kg BOD $m^{-3} d^{-1}$. Corresponding detention period in the aeration compartment was 3 hours.

Copper was added as copper sulphate solution, dosed via constant speed peristalitic pump and mixed with the feed prior entry into the system.

Physico-chemical analysis were carried out according to Standard Methods[5]. Copper ion concentrations were measured using atomic absorption spectrophotometer.

RESULTS

As control the system was run without copper addition. Average results obtained during this period are shown in Table 1.

The system was then subjected to increasing doses of copper namely 0.5, 1, 2, 3, 5, and 10 mg copper per litre. The effect of each copper dose was examined for a period of about six weeks after reaching the steady state. Table 2 and Fig 1 summarize the results obtained. From the data it may be concluded that maximum concentration of copper that can be received continuously under experimental operating conditions without affecting the microbial population is 1 mg l^{-1}. Increasing copper concentration in the feed up to 3 mg l^{-1} exerted slight changes in the quality of the effluent. Further increase up to 5 mg copper l^{-1} reduced BOD and COD removal values by 16 and 19 percentage points, respectively. During the 10 mg copper l^{-1} run, BOD and COD removal rates were reduced by 34 percentage points as compared to the control run.

Copper removal varied from 41 to 87% depending on

Table (1) Efficiency of Activated Sludge Treatment of Waste Water Before Copper Addition.

	Feed	Effluent			Filtered Eff.		
	Average	Min.	Max.	Average	Min.	Max.	Average
pH	7.4	7.3	7.9	7.8	-	-	-
Turbidity NTU	42.0	2.0	4.0	3.0	-	-	-
% Removal	-	98.0	96.0	93.0	-	-	-
COD mg l^{-1}	288.0	24.0	35.0	30.0	24.0	25.0	24.5
% Removal	-	89.0	91.0	90.0	89.0	93.0	92
BOD mg l^{-1}	218.0	8.0	20.0	16.0	5.0	20.0	12.5
% Removal	-	92.0	97.0	94.0	92.0	98.0	95.0
Ammonia mg N l^{-1}	15.2	3.0	15.4	5.2	-	-	-
Nitrite mg N l^{-1}	0.6	0.7	4.8	1.5	-	-	-
Nitrate mg N l^{-1}	0.1	trace	0.88	0.2	-	-	-
Organic Nitrogen mg N l^{-1}	14.3	5.4	11.2	9.0	-	-	-
Total phosphate mg P l^{-1}	2.6	0.3	2.4	1.46	0.2	2.1	1.35
mg/l P removed/ mg BOD removed	-	0.54	1.04	0.79	-	-	-
Total Residue 105°C mg l^{-1}	827.0	480.0	690.0	569.0	-	-	-
Fixed Residue 550°C mg l^{-1}	453.0	286.0	486.0	428.0	-	-	-
Suspended Solid 105°C mg l^{-1}	98.0	2.0	18.0	8.5	-	-	-
Sludge Analysis							
Sludge Volume ml l^{-1}	-	200.0	900.0	530.0	-	-	-
Sludge Weight g l^{-1}	-	2.04	2.8	2.26	-	-	-
OVM %	-	70.0	88.0	81.0	-	-	-
SVI	-	85.0	392.0	250.0	-	-	-

Table (2) Efficiency of Activated Sludge System Fed Continuously with Increasing Copper Doses

Copper Conc. in the Feed mgl^{-1}	Average BOD Removal (%)		Average COD Removal (%)		Copper Conc. in the Effluent			
	Unfiltered eff.	filtered eff.	Unfiltered eff.	Filtered eff.	Unfiltered mgl^{-1}	Removal	Filtered mgl^{-1}	Removal
0.0	94	95	90	92	-	-	-	-
0.5	93	95	85.6	90	0.17	65.93	0.13	73.67
1.0	93	95.4	84	90	0.28	71.41	0.18	81.31
2.0	93	97	85	90	0.268	86.58	0.22	88.83
3.0	96	98	89	93	0.379	87.35	0.23	92.19
5.0	78	81	71	85	2.14	57.19	1.05	78.94
10.0	59.8	74.5	56	73.4	5.85	41.41	1.3	86.5

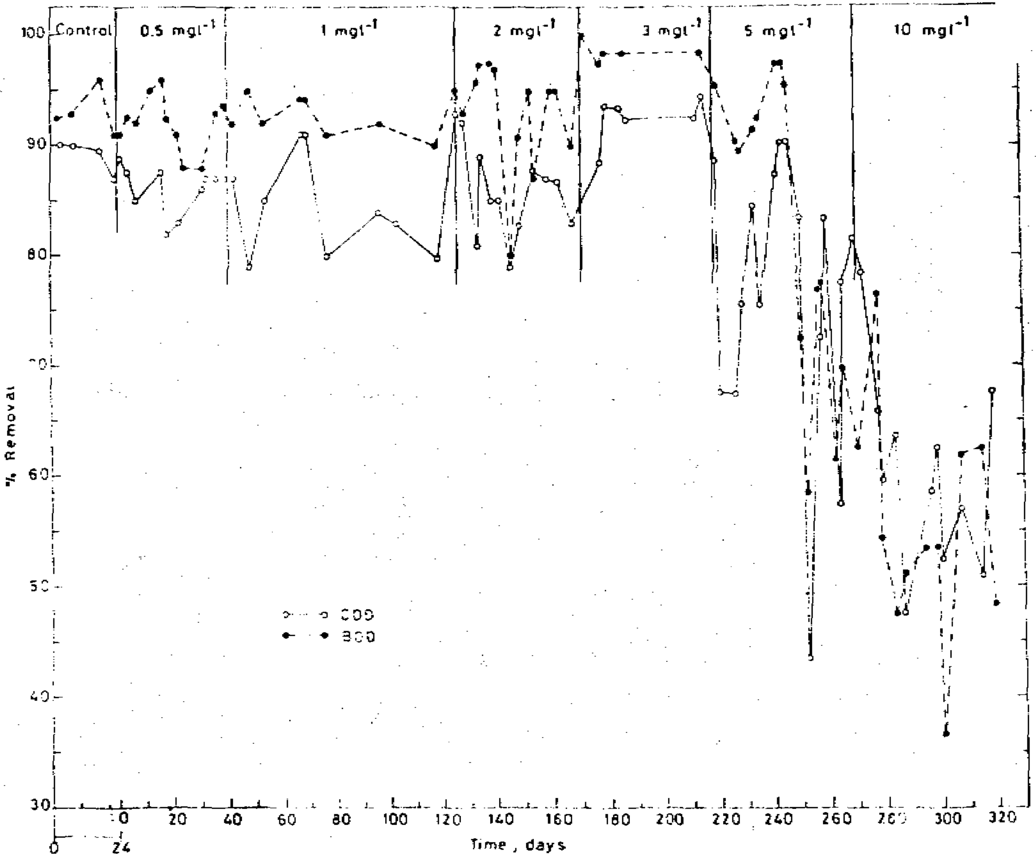

Fig. (1): Efficiency of the activated sludge system before and after copper addition.

initial copper concentration applied to the system. Increasing copper dose in the influent from 0.5 to 10 mg cu l^{-1}, raised both soluble and total copper concentration in the effluent by 10 and 34 times respectively Figs 2 and 3. This indicates the association of copper in the effluent with the suspended solids.

Tracing the distribution pattern of copper in the system indicated the high capability of the biological floc to concentrate copper. Analysis of copper in the activated sludge samples collected during the different runs, indicates the ability of activated sludge to concentrate copper. Copper concentration up to 133.7 $g.kg^{-1}$ dry sludge was recorded Figs 4 and 5.

Microscopic examination of the activated sludge taken from the system when it received 0.5 and 1.0 mg CU l^{-1} showed no variation from that of the control experiment. It was characterized by the presence of good numbers of protozoa and rotifers . During the 5 and 10 mg l^{-1} copper runs, protozoa, rotifers and filamentous organisms almost disappeared. Sludge flocs were fragmented and had dark color.

Effects of a Slug Dose of Copper Sulphate

The effects of a slug dose of 460 mg l^{-1} copper, fed for four hours, on the activated sludge process were studied. Sludge with no history of having previously received copper was used, the effects of this slug dose on the quality of the effluent and the sludge are shown in Figs 6 and 7. A deterioration in the quality of the effluent was recorded reaching its maximum after twenty four hours. Then a gradual improvement took place. Complete recovery was achieved after 96 hr.

DISCUSSION

The results of this study show that reduction in treatment efficiency of activated sludge caused by continuous feeding of copper at concentrations up to 3 mg l^{-1} was low.

Copper removal varied from 41.4 to 66% depending on its concentration in the feed. Similar results were given by Cheng et al[2]. Higher removal values up to 96% were reported by several investigators [6-9]. Th^ ide range of removal efficiency reflects the influence operating conditions on the physical, chemical and biol ical reactions taking place in the activated sludge process.

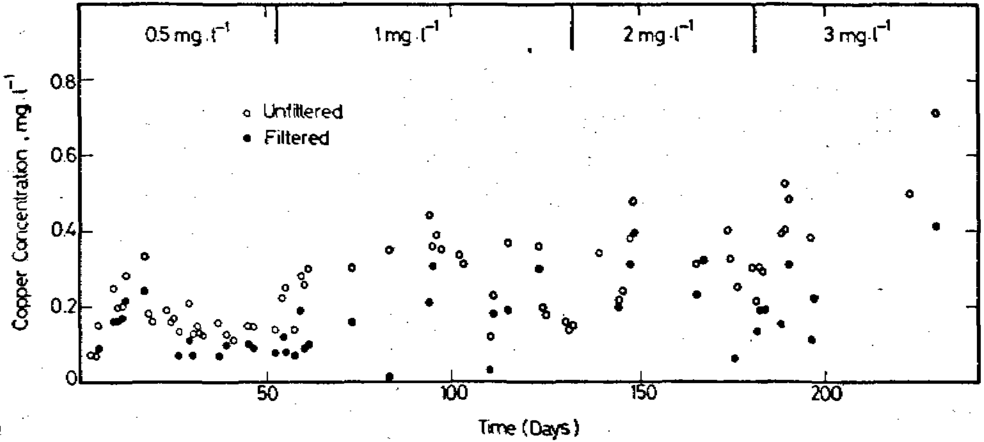

Fig.(2) Residual copper concentration in filtered and unfiltered effluents during continuous feeding of 0.5 , 1, 2 and 3 mg Cu^{++} l^{-1}.

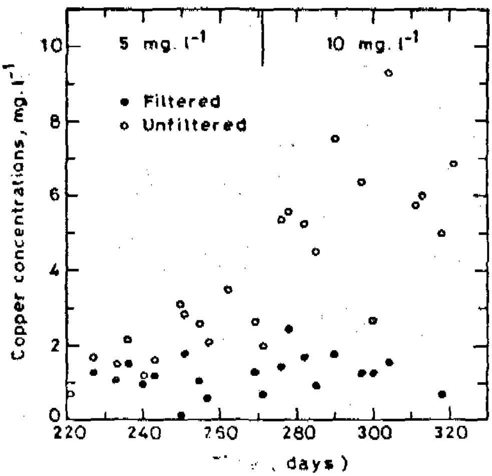

Fig.(3) Residual copper concentration in filtered and unfiltered effluents during continuous feeding of 5 and 10 mg Cu^{++} l^{-1}

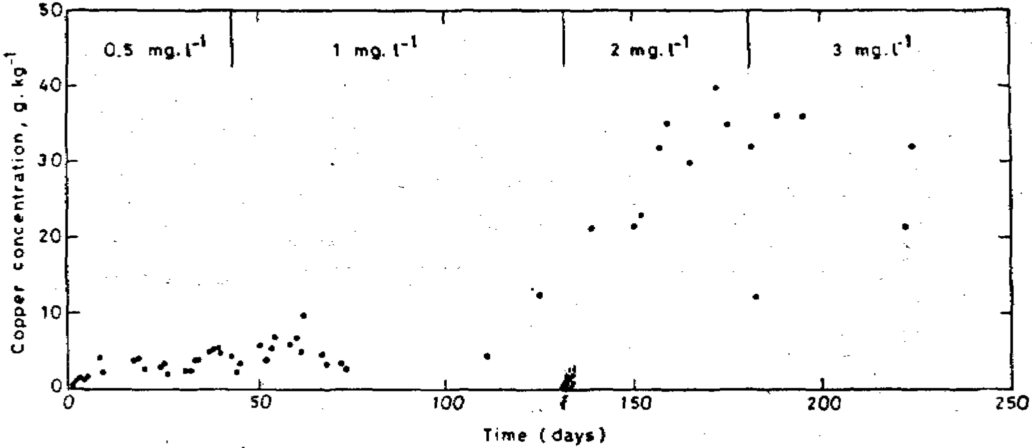

Fig. (4) Copper concentration in MLSS during continuous feeding of 0.5, 1, 2 and 3 mg Cu l^{-1}.

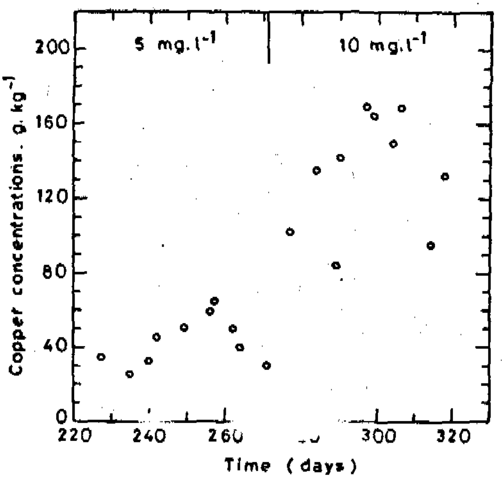

Fig.(5) : Copper concentration in MLSS during continuous feeding of 5 and 10 mg Cu^{++} l^{-1}.

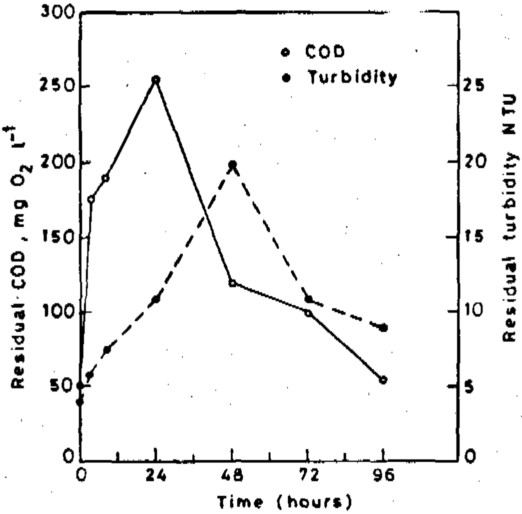

Fig. (6): Effect of slug dose (460 mg.l^{-1}) copper on COD and turbidity of the final effluent.

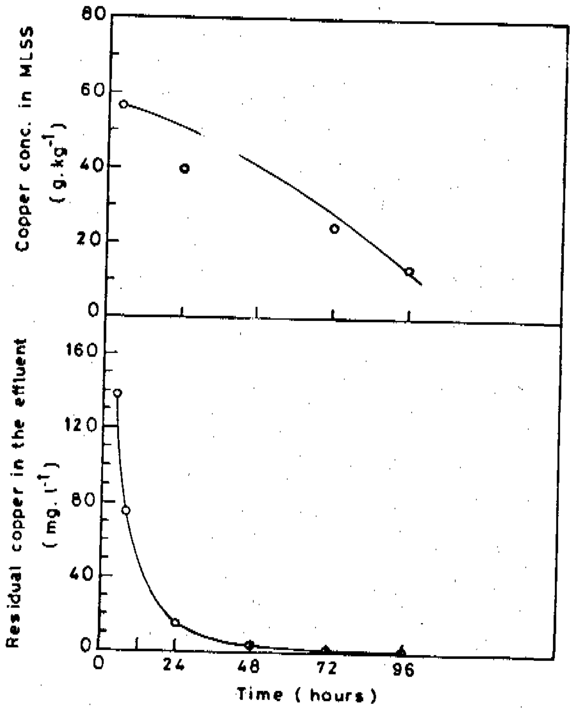

Fig. (7): Fate of slug dose of 460 mg. l^{-1} copper in activate sludge treatment.

Essentially removal is largely dependent on the transformation of soluble forms of metals into insoluble forms. This may occur by adsorption onto sludge solids, biological accumulation by the biomass or settlement of precipitated forms either independently or in association with settleable sludge solids [10 & 11].

After four hours from the start of the slug dose the MLSS was found to contain 53.4 g. cu kg^{-1}, which accounted for 23% of the total copper fed.

When copper was fed over a long period, activated sludge retained up to 133.7 g. copper kg^{-1} dry solids.

From these results, it can be concluded that the fate and toxicity effect of copper depends to a large extent on the operating conditions and wastewater characteristics.

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SOLID WASTE MANAGEMENT IN THE ENLARGED SHUAIBA INDUSTRIAL AREA (ESIA);

PART I: SURVEY AND CHARACTERIZATION OF THE WASTES

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This paper appears in Volume II before Puskas's paper which is the continuation of this paper.

Pesticide Management In Developing Countries

A Case Study of Egyptian Status

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INTRODUCTION

In agricultural systems, soil is the main reservoir of the chemical pollutants. Soil generally has a loose texture and consists of solid mineral and organic matter, water and air spaces. The mineral portion of soil is formed from parent rocks by the weathering action of physical, chemical, and biological processes. The organic portion consists of plant biomass in various stages of decay. High populations of bacteria, fungi, and animals such as earthworms may be found in soil.

The solid fraction of a typical productive soil is approximately 5% organic matter and 95% inorganic matter. However some soils, such as peat soils, may contain as much as 95% organic material. Other soils contain as little as 1% organic matter such as sandy soils.

Types of Pesticides Used in Egypt:

Table 1 indicates types of pesticides used directly by soil or seed treatment. The list covers fungicides, insecticides and weed killers of different chemical structures. These compounds reach the soil indirectly through drift and running off. These are the two main sources for contamination of the Egyptian soil during the agricultural practices. Soil, climate, and pesticide structural properties are three factors primarily responsible for controlling the persistence of pesticides in soils (Kearney, 1977).

Table 1. Pesticides Incorporated in Egyptian Soils.

Compound	Pest to be controlled
Aldicarb (Temik)$^{(R)}$	nematoda, thrips, aphids, and spidermites
Carbofuran (Furadan)	nematoda
Fenamiphos (Nemacur)	nematoda
Carboxin (Vitavax)	nematoda
Captan (orthocide)	Soil fungi
Endrin	crickets and cut worms
DDT/ Lindane (30/9)	onion nursery insects
Kitazin	rice soil fungi
Lindane	sugar cane pests
Diazinon	" " "
Chlorpyrifos (Dursban)	soil insects
Chlordane	" " and termites
Trifluralin (Treflan)	weeds
Fluometuron (cotoran)	"
Butralin (amex)	"
Pendimethalin (Stomp)	"
Linuron (Lorox)	"
Paraquat (gramaxone)	"
Dalapon (Dowpon)	"
Propanil (Stam F 34)	"
EPTC (Eptam)	"
Atrazine (gesaprimar primatal)	"
Bromoxynil (octanoate) (Brominal)	"

Table 2. Relative Mobility of Pesticides In Soils (Kearney (Kearney 1977).

Very low mobility	Medium Mobility	Rapid Mobility
DDT	Monuron	TCA
Lindane	Diuron	Dalapon
Parathion	Linuron	2, 4-D
Chlorphenamidine	EPTC	anitrols
Zineb	azinphosmethyl	Bromacil
Morestan	Diazinon	Piclaram
Benomyl	Atrazine	Dinoseb
Dieldrin	Simazine	MCPA
Paraquat	2,4,5-T	
Trifluralin		
Heptchlor		
Endrin		
Aldrin		
Chlordane		
Toxaphene		

An important factor in assessing the significance of pesticides in the environment is their ability to move from the original site of application. They can move either by vertical leaching down into the soil profile, by erosion and movement of adsorbed pesticides in soil particles, or by the vapor movement of a pesticide off the soil surface into the atmosphere.

In Table 2, the relative vertical mobility of various classes of pesticides down the soil is shown. The insoluble chlorinated insecticides are almost immobile and tend to remain on or near the soil surface. Consequently, they may pose little or no threat to ground water purity but are subject to surface erosion and movement is partly responsible for the appearance of pesticides in the aquatic environment. On the other hand the acid herbicides such as 2,4-D, TCA, dalapon are leached readily in soils and may move to great depths during a normal growing season. Fortunately most of these pesticides are usually degraded fairly rapidly in the environment and are not detected in ground water.

The annual load of pesticides used in the Egyptian Agriculture can be evaluated from the information in Table 3 which presents the total amount of pesticides used during the period 1950-1983 in Egypt. The average annual use is 30,000 metric tons. That means an average dumping of six kgm of pesticides per acre each year (Attia, 1977).

Insecticides are considered 75% of the total imported pesticides in Egypt. Diversity of chemical structure and the rapid shift from one type to another was done under the pressure of the build up of resistance in the cotton leafworm to the different groups of insecticides (El-Sebae, 1981).

Persistence of Pesticides In Soil:

The chlorinated hydrocarbon insecticides were shown to be highly persistent in the soil as shown from results reported by Wattal (1972) and Kearney et al. (1969), indicated the relative persistance values of different types of pesticides at the normal rates of field application (Table 4).

These data confirm the persistence of the chlorinated hydrocarbon insecticides on one hand and the easily dissipated organophosphorous insecticides and the carbamate and aliphatic acid herbicides.

Table 3. Total Active Ingredient Insecticides Released in Egyptian Agricultural Environment During the Years 1950-1983.

Compound	Total a.i. metric tons	Years of Consumption
Toxaphene	54,000	1955-1961
Endrin	9,500	1961-1974
DDT	13,300	1952-1971
Lindane	10,800	1952-1971
Carbaryl	20,000	1961-1968
Trichlorofon	6,200	1961-1966
Monocrotophos	7,800	1967-1973
Leptophos	5,500	1968-1975
Chlorpyriphos	11,500	1969-1983
Phosfolan	6,000	1968-1983
Mephosfolan	7,500	1968-1983
Other OP's	20,000	1968-1983
Methomyl	6,000	1976-1983
Fenvalerate	6,000	1976-1983
Cypermethrin	5,000	1976-1983
Deltamethrin	3,000	1976-1983

Table 4. Relative Persistence of Pesticides In Soils.

Compound	Time for 75% loss
Chlordane	5 years
DDT	4 "
B HC	3 "
Heptachlor and Aldrin	2 "
Simazine	12 months
Atrazine, monuron	10 "
Diuron	8 "
Trifluralin	5 "
2,4,5-T	5 "
MCPA	3 "
2,4-D	1 "
Diazinon	12 weeks
Disulfoton	4 "
Phorate	2 "
Malathion, Parathion	1 "
TCA	12 weeks
Dalapon, CIPC	8 "
EPTC	4 "

The effect of Soil Type on Pesticide Persistence

The physicochemical characteristics of each soil type are limiting factors for the rate of adsorption, leaching, degradation and translocation of each pesticide. Data in Table 5 demonstrates the variation in properites of three Egyptian soil types (El-Sebae et al. 1969). The initial adsorption of Dowpon differed on the three soil types (Table 6) being higher on the sandy type followed by the silty and then the clay type. However, Dowpon was much more lost from the sandy soil due to the higher evaporation and leaching rates. The high percentage of organic colloide in the silty and clay soil types account for their ability to held the left residues for longer periods. Similar data were reported by Ebeling (1963) and Aly et al. (1978).

The pesticides adsorbed on the soil surface can move into the atmosphere in the form of a vapour. This property explains the transport of pesticides and pollutants far away from the original site. Table 7 presents the vapour pressure of different pesticides. The presence of many chlorinated hydrocarbons such as DDT, toxaphene, lindane and Dieldrin in Scandivavian lakes and Baltic sea can be attributed to the transportation of its vapours by the atmospheric air and its precipitation by rain from the mobile particulates.

Table 5. Chracteristics of Three Soil Types

Soil Type	pH	Water Saturation %	Number of Bacteria per gm	Organic matter %
Sandy	7.8	18.9	50,000	0.09
Silty	7.1	38.8	112,000	0.70
Clay	8.0	60.7	211,000	0.75

Table 6. Persistence of Dowpon in Three Soil Types

Soil Type	ppm after storage for			
	0 days	7 days	14 days	21 days
Sandy	29.95	17.5	3.5	0.5
Silty	27.30	20.5	15.5	8.0
Clay	24.85	23.0	17.5	12.0

Organic compounds bound on humic acid and on soil in general are quite stable and give rise to what is called unextractable residue (Khan, 1980 and Manahau, 1979).

Table 7. Physical Properties of Some Insecticides.

Compound	Water Solubility ppm (20-25° C.) (mg/L)	Vapour pressure mm Hg (20-25° C)
DDT	0.0012	1.90×10^{-7}
Dieldrin	0.05	1.80×10^{-7}
Lindane	10.00	9.40×10^{-6}
Ronnel	1.08	8.00×10^{-4}
Chlorpyrifos	0.40	1.87×10^{-5}
Leptophos	0.0047	———
Fenitrothion	30.00	5.40×10^{-5}
Methyl Parathion	55.00	9.70×10^{-6}
Parathion	11.90	3.78×10^{-5}
Malathion	145.00	1.25×10^{-4}
Mevimphos	miscible	2.20×10^{-3}

Levels of Persistent Pesticides In Egyptian Soils:

The concentration of organochlorine insecticides were determined in soil samples from the three governorates: El-Minia. El-Behera, and El-Dakahlia during 1979 by Aly and Badawy (1981) at August and October 1979. The data are shown in table 8. The concentrations of the insecticides were much higher in soil samples than the corresponding water samples in the same investigation. This reflects the tendency for accumulation of the chlorinated hydrocarbons in soils. El-Dakahlia samples were obviously higher in contamination. This reflects differences in the background levels of pesticide applications.

The chlorinated hydrocarbons are shown to be accumulated on sediments of the brackish lakes such as lake Mariut. Data are shown in Table 9 (Abo Elamayem et al. 1979). Similar data were reported by Askar et al (1980) in Burullus lake. Although the chlorinated hydrocarbons were stopped from being used due to the problem of resistance since more than ten years, yet their levels in the environment significantly indicate their impact as persistent environmental pollutants.

Levels of Heavy Metals In Egyptian Soils:

Elsokkary (1978 and 1980) investigated contamination of roadside soils and vegetables in cabbage, and parsley by the heavy metals Hg, Co, Cd, Ni, Pb and Zn along Alexandria- Cairo Agric. Highway. High levels of these metals more than the permissible tolerances were found in soils and plants near the road. The sources of contamination are the vehicle exhaust. Example of these data are shown in Table 10.

Harmful Effects Caused by Pesticides and Heavy Metals In Soils:

Edwards and Thompson (1973) indicated that pesticides in soils affect animals which are non target organisms such as the saprophagous invertebrates (e.g. earthworms, collombola, some Acarina and Diptera larvae which are essential in the breakdown of some kinds of leaf litter into its organic and inorganic constituents leading to deterioration of the structure and fertility of soil.

Table 8. Concentration of Organochlorine Insecticides In Soil Samples at El-Minia, El-Behera and Dakahlieh Provinces, August, 1979.

Samples Location	Concentration in ppb					
	Lindane	Endrin	DDT	DDD	DDE	Chlordane
El-Minia 1	0.15	0.16	1.40	1.40	n.d.	0.26
El-Minia 2	0.24	0.19	1.30	1.10	n.d.	1.30
El-Behera 1	0.70	0.30	0.38	0.55	n.d.	n.d.
El-Behera 2	0.50	0.48	0.40	0.84	n.d.	n.d.
Dakahlieh 1	1.20	1.00	1.54	1.34	n.d.	1.20
Dakahlieh 2	1.25	1.50	1.70	1.50	n.d.	1.24

Table 9. Chlorinated Pesticides In Water and Sediment Samples at Lake Mariut, Alexandria.

Lake stations	Mean Concentrations in p.p.b.			
	Lindane		p,p'-DDT	
	Water	Sediment	Water	Sediment
I	2.06	142.8	3.85	982
II	2.10	74.7	2.54	512
III	1.93	61.6	2.79	715
IV	1.65	120.3	2.80	920
V	1.75	92.2	5.35	796
VI	1.75	52.8	4.31	910
VII	1.79	54.3	6.39	972
VIII	2.76	114.5	4.86	318

Table 10. Average Values of Cd, Ni, Pb, and Zn in ppm of normal Egyptian Soil and their Plantations.

Substrate	Total content (ppm)			
	Cd	Ni	Pb	Zn
Soil	0.30	30.5	11.8	64.5
Cabbage	0.22	1.6	6.7	21.8
Parsley	0.45	2.4	10.0	11.5

Residues of organochlorine insecticides tend to accumulate in earthworms nine times that in soils, and twenty fold in soil snails and slugs. (Gish, 1970). Such soil fauna organisms can be used as targets for monitoring of intensified levels of pollutants. This tendency also causes injury to the earthworms and slugs normal vitality and population.

Cole et al. (1975) demonstrated that subsurface application of aldrin reduction in the height of corn plants due to its phytotoxicity.

Hegazi et al. (1979) studied the effect of the application of a group of pesticides (Temik, Stomp, Dinoseb, Nata, Dursban, and Simazine) on N_2-ase activity in Giza Clay-loam soil under maize cultivation. Field applications of all pesticides showed different inhibitory effects and the effeccts increased with increased doses and incubation period.

Carbamate and organophosphate insecticides were found to cause harmful inhibition of soil-dehydrogenase activity (Khalifa et al. 1980). Similar unfavourable side effects of other pesticides on different essential soil enzymes were reported.

The organochlorine pesticides remain in soils for long periods of time. During that period of time, certain amounts of these compounds are mobile and are translocated and accumulate to new plantations in soil. (Caro, 1969).

The favourable effects of heavy metals, such as copper and Zinc is connected with their functions in enzyme activities and plant growth regulation. However, excessive concentrations of these metals in the soil are toxic to plants (Asshe and Mey 1977) copper at concentrations above 40 ppm in soil appears to have little mobility and is highly phototoxic. It causes blackish brown discolouration of roots, which often develop a syndrome commonly known as "barbed wire", Lead in the soil depresses transpiration and photosynthesis. Zinc has an antagonistic effect on iron and is toxic at concentrations of 125-500 ppm. So far, little is known about the complex and specific effects of these metals when found simultaneously.

Methods for Decontamination of Soils:

Bryce (1973) proposed certain solutions to problems of soil pollution by agricultural chemicals. By cultivation and related techniques chemical pollutants are brought to the soil surface where they are exposed for greater evaporation and photochemical degradation.

Aeration and ploughing are recommended in this concern. Cropping with plants that accumulate pesticides has been suggested as another method for decontaminating soils. For example, uptake by resistant plants such as Johnson grass, maize and sorghum accounted for 25% of the atrazine applied to soil. Heavy irrigation has also been suggested as a means of accelerating the removal of contaminants from soil by heavy leaching.

Adding adsorbent materials has often been suggested as a means of making persistent chemicals less harmful. Adding activated carbon can decrease the activity of chemicals in soils. The possibility of enhancing the ability of microorganisms to degrade pesticides has often been considered. The biodegradation can be stimulated by raising temperature, adding energy rich materials such as sugars or various composts, or by maintaining the soil moist.

Jansen and Assche (1977) carried out a field experiment during two consecutive years to check the influence of selectively working cation exchangers in a soil contaminated with the heavy metals lead, copper, and zinc. After a single application of the cation exchanger of a macroporous polystyrol type, very positive and permanent effect of decontamination was observed.

El-Sebae and Abo Elamayem (1978) found that the activated carbon can be a good adsorbent for most of the pesticides in aquatic and soil systems.

Legislations for Soil Protection:

FAO had published in 1979 a report on environmental criteria for registeration of pesticides. The physico-chemical data required for prediction of hazards of a new pesticide include water solubility, rates of adsorption and desorption on soil, volatility, degradation and leacing in soil system.

The requirement of toxicity data of the new chemical on non target organisms include soil micro-organisms particularly the N_2 fixation bacteria and also the soil macroorganisms with special reference to earthworms and other beneficial soil fauna.

These requirements emphazize the importance felt by legilators in putting criteria for regulation of registeration of the new pesticides with the least hazard to soil fertility and productivity. Such regulations maintain management of chemical pollutants in agricultural soil systems.

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POTENTIAL OF BIOGAS IN DEVELOPING COUNTRIES

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INTRODUCTION

The process of digesting organic matter in an anaerobic environment produces a flammable gas which is commonly referred to as "biogas" in developing countries. The potential of biogas as a renewable energy source has been recognized as early as the end of nineteenth century in England where the gas was used for street lighting (1). In recent years, biogas technology has received a renewed interest, especially from the developing countries, most of which depend for fuel on imported fossil fuels and domestic firewood, and as a consequence, have severe financial and deforestation problems.

The breakdown of organic compounds in anaerobic digesters produces, in addition to biogas, an effluent slurry with significant fertilizer value. The application of the effluent slurry to over-cultivated farmland can restore deficient soils and enrich them with nutrients. Furthermore, biological treatment of human and animal excreta in digesters can destroy most of the pathogenic organisms which are the major cause of enteric diseases in developing countries. One of the objectives of this paper is to present an assessment of the energy, agricultural and health aspects associated with biogas technology for developing countries.

In spite of the advantages outlined above, a number of economic and social drawbacks associated with biogas technology have hampered its dissemination among the developing countries. Additionally, a large number of digesters installed in various countries are now either inoperative or operate inefficiently because of faulty design and construction, or other limitations of the technology. This paper presents a brief review of the technical aspects of the design and operation of the digesters, and a discussion of the economic, social and political implications of the implementation of the technology in developing countries.

ENERGY, AGRICULTURAL AND HEALTH ASPECTS OF BIOGAS UTILIZATION

Energy Aspects

In most developing countries there is a need for non-commercial renewable energy sources. Traditionally, firewood, charcoal and cow patties have been used for cooking. Approximately one-third of the world's population depends on wood for fuel. This dependence puts a strain on the forests, 40 percent of which are estimated to be destroyed by the year 2000 in Third World Countries (2). Furthermore, alternative energy sources must be investigated and adopted to alleviate the financial burden of importing fossil fuels.

Biogas, which is 50 to 75 percent methane, has the potential of providing a renewable and clean energy source for developing countries. The calorific value of biogas is about 6000 kcal/m^3 biogas, or 1 m^3 of biogas is equivalent to about 0.65 L of gasoline or 0.57 L of diesel fuel. The primary domestic use of biogas, which can be obtained from either individual family-size units or a community-size plant, is for cooking and lighting. For a family of five to six people, it has been estimated that a 2-m^3 biogas unit will be sufficient for the family's cooking and lighting needs (3). The fed requirements for a digester producing 2 m^3 of biogas per day can be met from the dung of four or five medium-sized penned animals (3). The addition of human excreta (night soil) into the digester will add approximately 0.025 m^3 of gas per person per day (4). Increased gas yields can be achieved by adding supplemental material, such as water hyacinths and sugar beet leaves. The output of the digester will depend on the nature of raw material as well as the period of digestion and the environmental factors such as temperature and absence of toxic substances. Table I shows the approximate gas yields from various waste material for certain temperature and retention times (1).

Biogas can also be used as a fuel to power farm machinery and to generate electricity after minor modifications in the gas and the diesel engines. One cubic meter of biogas can run a one-horsepower motor for two hours or generate 1.25 kw-hr of electricity (5). Hence biogas can be especially desirable in areas lacking electricity. In India, for example, the cost of electrical hookups is prohibitive: only 14 percent of the households overall and 5 percent in rural areas have electricity. In China, where the electricity is also scarce, biogas is being used to generate 2200 kw-hr per day of electricity at a nightsoil treatment facility in Foshan (6).

Table I. Yield of Biogas From Various Waste Materials (1).

Raw Material	m^3 of biogas per kg of total dry solids	Temperature °C	CH_4 content %	Fermentation time (days)
Cattle manure	0.20-0.50	11-31	-	-
Beef manure	0.86	35	58	10
Poultry manure	0.26-0.30	33	58	10-15
Swine manure	0.49-1.02	33-35	58-68	10-20
Sheep manure	0.37-0.61	-	64	20
Night soil	0.38	20-26	-	21
Forage leaves	0.5	-	-	29
Sugar beet leaves	0.5	-	-	14
Algae	0.32	45-50	-	11-20

Agricultural Aspects

Loss of topsoil and over-cultivation of agricultural land is a severe problem in most of the developing countries. As a country becomes more overpopulated, the available farmland is worked harder to meet economic and nutritional needs. In Haiti, for instance, the ancient practice of burning brush in an area to be planted is common among the rural population. The cleared area is planted for several seasons, and then the farmer moves to another patch and repeats the process. This causes severe loss ot nutrients and topsoil since the humic matter is burned off and nothing is returned to replenish the soil. This practice of shifting cultivation is practiced on 30% of the worlds tillable soils (2).

The slurry discharged from a digester can be applied to agricultural land to restore deficient soils and nutrients. The slurry contains the inorganic nutrients, nitrogen, phosphorus, potassium, various trace minerals, and degradable and refractory organics and solids. Therefore, it stimulates the growth of microorganisms which contribute to the solubility and, thus availability to higher plants, of essential nutrients contained in soil minerals (1).

During the breakdown of organic compounds in digesters, nitrogen is conserved entirely, however the concentration of ammonia nitrogen increases by up to 40 percent (8). Therefore, in the application of biogas slurry to farmland, care should be taken to insure that the slurry is worked into the soil to minimize the loss of ammonia (nitrogen) through volatilization.

A commune in Sindu County in the Sichuan Province of China experienced increased productions by 25, 16 and 15 percent in vegetable, wheat and rice crops, respectively, after using biogas slurry as soil conditioner (8). In other counties, 28, 10, 25 and 13 percent increases were reported for crop yields of maize, rice, cotton and wheat, respectively.

Biogas slurry has also been used as a food supplement for pigs and fish in 5 - 20 percent mixtures (9). At Maya Farms in the Phillipines, the slurry is mixed with regular feed at one to ten ratio. The digested material from the biogas tanks is reported to be high in vitamin B-12 which is an important nutrient for young animals, and is expensive if purchased as a food supplement (7).

Health Aspects

According to a UNESCO report (10), over half of the people alive today have no readily available access to clean drinking water, and even less have adequate sanitation facilities. About 80 percent of the people in rural areas in developing countries lack access to clean drinking water and adequate sanitation facilities (11). As a result, enteric diseases are the leading cause of death and disability in most developing countries. These diseases show up as diarrhea and kill six million children every year (10). Helminths, or worms, infect nearly half the Third World population and kill or cause malnourishment. The Helminth Ascaris, commonly known as roundworm, infects 60-90 percent of young children in developing countries. A single gram of feces from an infected person can contain up to 300,000 eggs.

Improvements in health conditions can only be seen when human and animal excreta are handled and treated properly to destroy the pathogenic organisms. The anaerobic treatment of excreta in biogas digesters significantly reduces these organisms, as shown in Table II, while breaking down the organic matter and producing biogas and a nutrient-rich effluent. The major factors which influence the rate of die-off of pathogens during digestion are the temperature in the digester, the residence time, the pH, the ammonia concentration, the lack of oxygen and physical design characteristics of the digester.

In biogas digesters, Ascaris eggs are typically removed by 90 percent. Chinese data suggest 93 to 98 percent removal for general parasite eggs. Many of the eggs settle to the sludge layer and remain viable for long periods of time. Settling is critical; for example, an improvement in the settling characteristics of a biogas tank in China by adding a drop board at the outlet of the tank caused the removal of parasite eggs to increase from 80 to 98

Table II. Die-off of Enteric Microorganisms of Public Health Significance During Anaerobic Digestion (1).

Organism	Temp. (°C)	Residence Time (days)	Die-off %
Poliovirus	35	2	98.5
Salmonella ssp.	22-37	6-20	82-96
Salmonella typhosa	22-37	6	99
Mycobacterium tuberculosis	30	not reported	100
Ascaris	29	15	90
Parasite cysts (exc. Ascaris)	30	10	100

percent (13). When the digester is periodically cleaned (usually annually), the sludge must be stored for periods greater than 6 months to one year (12). Once the sludge has been removed from the biogas tank, the die-off of Ascaris continues during storage and drying and when the sludge is applied to farmland. Once applied to the field, Ascaris eggs may live from a few hours to several months, depending upon environmental factors and soil type.

Effective removal of Ascaris eggs can only be achieved through heating. Anaerobic systems such as biogas units where the temperature is usually lower than 34°C, are not satisfactory to remove Ascaris eggs. Thermophillic aerobic composting, however, often achieves temperatures up to 55°C, which if maintained for several hours is effective in complete pathogen elimination (12). Hundred percent removal of parasite eggs was achieved when night soil was heated to 60°C by using waste heat from engines fueled with biogas at the power station in Foshan, China (14).

Despite incomplete pathogen elimination, significant community health improvements have been recorded after the introduction of biogas digesters to treat nightsoil and animal excreta. Two years after the introduction of biogas digesters to five communes in China, investigations by the Sichuan Institute of Parasite Disease Prevention showed that the percentage of people infected with hook worm disease decreased from 63.8 to 5 percent (6). The average number of hookworm eggs per gram of human feces decreased from 500 to 50. In another commune in China the incidence of dysentery decreased from 15 cases per year to none after biogas technology was implemented (9). There are also fewer flies and mosquitoes due to the safe disposal of the dung. As stated in report by the National Academy of Sciences in Washington, D.C. (1), ".....There is no other practical method of treating human excreta - whether for disposal or to return nutrients to the land as fertilizer that will reduce the burden of pathogenic organisms as much as anaerobic digestion."

TECHNICAL CONSIDERATIONS

Biogas technology suffers from the lack of understanding of the process fundamentals. There is also a lack of data on full-scale process performance under different operating conditions. However, several factors such as temperature, retention time, mixing, biodegradability of the influent and the environmental conditions, e.g., the pH, alkalinity, availability of macro and micro nutrients and the absence of toxicity are recognized as the most important process parameters which can affect the amount of biogas production, as well as the efficiency of pathogen removal. In general, the efficiency of digestion can be increased by keeping the temperature near 35°C. For domestic units, insulation and construction of a greenhouse over the biogas unit are two simple methods that can be adopted for temperature control. To maintain high efficiency at lower temperatures, the retention time must be increased.

The climate, type of feedstock, economic conditions, gas utilization, agricultural techniques employed and cultural implications may all be important considerations in choosing the proper design for a community. The simplest and least expensive digester to construct and operate is a batch reactor. The unit is filled with organic matter and water, covered and allowed to sit for three to twelve months. Gas production usually commences in about three weeks. In order to maintain a continuous gas supply, several units should be operated simultaneously. Filling and emptying the digesters requires additional labor. Semi-continuous systems, however, are either connected directly to latrines and animal pens, or fed periodically with collected nightsoil and dung.

Chinese designed, fixed-dome units are the most common digesters in developing countries. Agricultural residues are usually loaded twice a year, and animal manure and night soil are usually fed every day. The gas produced is contained within the fixed dome as it displaces liquid in the digester. The high pressure that develops in this type of digester (up to 1.4 psi) has been blamed for high percentage of inoperative digesters due to gas leaks (15). This has led to the development of other designs and gas storage facilities. The water pressure digester, also a Chinese design, uses the same concept as the fixed-dome digester in that the gas produced displaces an equal volume of liquid. However, the gas is stored over top of the unit to reduce the gas leaks.

Most of the biogas digesters in India are the floating-cover design. These units store the gas in a cyclindinal metal cover that traps the gas and forms a water seal with the digester slurry. The corrosion of the metal gas holders by H_2S gas led to the development of fiberglass and plastic covers.

The Taiwanese bag digester sits half below and half above the ground, and is made of PVC, nylon or red mud plastic (a plastic made from aluminum refinery wastes). Production rates in these units can be quite high due to their plug-flow characteristics and their ability to trap incident solar radiation that can increase the digester temperature by 2.7°C over the temperatures observed in the other designs (15). Therefore, 50 to 300 percent higher volumetric gas rates can be achieved. These units appear to be very competitive for developing countries due to their low cost.

Floating-cover and fixed-dome digesters can provide enough gas pressure to use the gas for cooking and lighting purposes. Digesters that use balloons or plastic bags to store the gas cannot be used for these purposes without re-pressurizing the gas. They are convenient, however, to use in conjunction with internal combustion engines which draw the gas in by the action of the pistons.

Several other designs which were not included in this paper are either at the experimental stage, or do not appear to be appropriate for developing countries due to their relatively sophisticated nature. Drexel University in Philadelphia, Pennsylvania, is currently involved in the development of a different design for a Haitian Church.

POLITICAL, ECONOMIC AND SOCIAL IMPLICATIONS OF BIOGAS IMPLEMENTATION

The major advances in the implementation of the biogas technology in developing countries have been due to strong encouragement and support from the governments. In China it has been reported that as many as seven million digesters were built under Mao during the 1970's (14). There are twenty five biogas extension offices set up within different provinces. There are 5000 people within these extensions who train biogas technicians. The 30,000 technicians in the country are split into 6,000 teams to provide experienced help in the construction and maintenance of biogas units (15).

India has experienced a similar push for biogas advancement. Low interest credit and subsidies have been made available and resulted in the installation of five to six thousand digesters per year and a total of 70,000 biogas digesters (16). Other developing countries have also made efforts to utilize biogas. South Korea has built approximately 29,000 units, most of which were installed by the government between 1969 and 1975 (15). There are about 340 units throughout the Philippines, the most impressive of which is located at Maya farms, where the waste from 46,000 hogs is treated in biogas units. The gas generated is used to supply all the energy requirements of the livestock farm and 90% of those for an adjoining processing plant (17).

The developing countries in Latin America and other parts of the world which have started or are investigating biogas development are (15, 17):

Country	Number of biogas units
Brazil	2300
Central America	110
Mexico	150
Andean Countries	120
Thailand	300
Taiwan	1000+
Nepal	400
Kenya	150
Ethiopia	100
Sri Lanka	150
Pakistan	110
Haiti	50

The sucess of biogas technology in Third World countries has been limited. It is believed that 30 to 50% of the seven million digesters in China leak gas and are therefore inoperative (15). In India it is believed that as many as 50 to 70% are inoperative (7). Though the implementation of biogas as a solution to economic problems is heralded as having great potential, it seems that insufficient knowledge and planning have caused the construction of many faulty digesters. Other social, cultural and economic factors accompany the lack of skilled manpower and technicans with biogas know-how. Education is needed to combat the lack of technical understanding at the rural level. Research and development to adopt promising new technologies to local conditions can make the biogas technology more viable. Organization for education and research and development must come from the governments.

Biogas systems offer a decentralized energy source to rural households. The economic advantages for the individual household can not be realized as readily as for an industry. There are also several limiting factors that restrict the feasibility of building family units. An 8-m^3, family-sized unit can cost from 100 to $400, which exceeds annual family income in some parts of the Third World (15). Furthermore, a minimum of 3-5 pigs or cattle are needed for each family-sized digester. In India, only 10-15% of the rural population meet these requirements. Large water requirements for the digesters, i.e., 80-90% water content (4, 5, 6), may limit their use in areas where water is scarce.

Economic advantages can be readily seen in areas where electricity, fuel oil, kerosene, firewood, or charcoal and fertilizers, are already being purchased. These households and communities may convert to biogas to cut their expenses. Other benefits from biogas utilization, such as improved health conditions and reduced deforestation are not economically obvious, although a community that spends a great deal of time and money to treat worms, dysentery, thphoid, etc. may realize the economic advantages from health improvements.

Many of the inhibitions of a community or family to adopt biogas technology lie in the cultural superstitions and traditions. In Haiti, for instance, the cultural taboo prevents a Haitian from handling human or animal excreta. Other cultural inhibitors arise when it comes to eating food that is cooked with gas generated from manure (16).

The need for collection of nightsoil and manure to feed the biogas units and for transportion of the effluent slurry to the fields for fertilizing is another reason for the resistance to the technology. For example, in many areas in China, villagers refused to build digesters claiming that transporting of dilute slurry to the fields requires three times more work than transporting composted and dried manure. Systems designed to channel the effluent directly to the fields might overcome the transportation problems.

It usually takes more time to feed and maintain the biogas digesters than traditional disposal practices. This job is more likely to be performed by the male head of the household. Time saved by using biogas as cooking fuel will be in the collection of firewood, a job reserved for women and children. Other advantages such as clean and smokeless cooking, ease of regulating cooking heat, and lack of soot on pots and pans save time for women as well. These factors, accompanied with the fact that economic decision-making is usually done by men, make implementation of biogas digesters at the rural level more difficult (16).

The communities need to be convinced through education by higher authorities about the potential benefits of the technology, before the idea of building digesters will be widely accepted. Incentives in the form of low-interest loans, technical advice and experienced construction teams are necessary to overcome the reluctance. China's success in building seven million digesters is very likely due to the commune system and the way the government encourages biogas development. Each commune has a committee of 5 to 15 people, selected by farmers, that makes decisions for the entire commune. People are assigned to the specific tasks of cleaning and operating digesters. Many inhibitions are overcome by the fact that the biogas program is instituted on the communal level and people are cooperative with those in charge.

SUMMARY

Biogas has significant potential in developing countries for producing useable energy, destruction of putrescible organic material in excreta with a concommitant destruction in disease-causing organisms and an increase in the quality of public health, and production of an end-product slurry that is suitable as a fertilizer for increasing agricultural production. The main reasons for the lack of more widespread use of biogas are lack of understanding of process fundamentals as they relate to process design and operation, and social, political, and economic considerations specific to each situation. With proper attention to the requirements of bacterial growth such as temperature, pH, and nutritional requirements, and to design fundamentals such as proper mixing, detention time, and reactor integrity (e.g., prevention of leaks), biogas technology will provide the benefits listed above. Governmental support will be required to impliment biogas technology, and education of the local population will be required to overcome sociological barriers.

Biotechnology is a rare type of technology; perhaps no other single technology offers such a wide spectrum of benefits for developing countries. It is affordable, useable, and especially adaptable to the variety of condition found in developing countries. It deserves more widespread support.

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WASTEWATER TREATMENT ON VEGETATED AREA

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INTRODUCTION

In recent years,using the planted area for wastewater treatment gained its importance again.New methods resemble the old land treatment and refuse methods: of treatment in root area (Kickuth,1970),Nitrophyte Method (Niemann,1976), old land treatment method (Kramer,1958), or reed method (Czerwenka,1965; Seidel, 1966; Kraft and Erdin 1984) . Biotope and biocoenose which contains the mixture of plant-water-soil microorganism effect the elimination of nutrient.The harvesting removes some nutrient such as N,P, K .The bacteria which occur in soil eliminate nutriets too.

Overland flow is one of them land application methods from wastewater.Overland flow wastewater treatment is a deceptively simple process. But the land requirement for overland flow systems is large relative to conventional treatment methods.The land requirement are 3.7 - 4.8 ha/1000 m^3 . d including border areas.In addition many components of an overland flow system are similar to irrigation systems and there is a tendency to follow irrigation system practice.Physical desing considerations include slope grade , slope length , distrubution system , and runoff collection system.Desing slope grades are usually selected the range from 2 to 8 percent.Minumum slope grades are used when site topography is relatively flat , and then can be taken slope grades as 0,5 percent.Design slope length can be selected between 30 and 45 m for treatment of primary or raw wastewater.Distributed systems should be used for industrial wastewater containing high BOD_5 and suspended solids concentrations.The wastewater application rates can be used from 0.1 - 0.3 m^3/hr. m .Generally the spray radius have not been standardized . Most existing overland flow systems use unlined ditches for runoff collection.

EXPERIMENTAL PROGRAM

Pilot plant has a 2 m width 30 m length. Soil composition in which plant growth would occur, is consisted of 1/3 sand ,1/3 natural soil , 1/3 manure respectively. A plastic layer which prevents any leacage is used and a 10 cm depth of soil is covered of it. After sometime , ryegrass seeds which consisted of three types , are spreaded over the land . After plant growth occurence, land is watered from the distribution structure. Clamped discharge pipes are used to provide equal distribution. Figure 1 shows the plant of overland flow systems.

Loading rate of overland flow systems was 400 l/hr. The application time 12 hr./d. Hydraulic loading rate was 0,08 m^3 / m^2. d . Detention time as a function of application rate was 28 - 33 minutes.

RESULTS AND CONCLUSIONS

Flow proportioned composite samples were taken from the wastewater which are applied and runoff during each application cycle. Each sample was analyzed for chloride , nitrate (NO_3-N), and ammonia (NH_3-N), BOD_5 , COD , TSS , VSS , SS , fecal coliform, pH , conductivity, total phosphorus, and Kjeldahl nitrogen , potassium ,soduim, calcium ,magnesium and etc. A summary of the analytical techniques is presented in Table 1 and 2 .

Awerage runoff BOD_5 concentrations were below 50 mg / l , SS-concentrations remained below 50 mg/l even during winter. Of the tree forms of nitrogeammonia was the easiest form to remove . Organic nitrogen concentrations (Kjeldahl nitrogen) were reduced by overland flow during some months from 14.50 to 6.70 mg/l. An other analysis showed a variation from 19.0 to 36.9 mg/l for organic -N. Regressionsanalyses was done on charecteristic parameters, regressed and are given their complete variances analyses and the results in Table 3. Figure 2 shows the regression between effluent BOD_5 and effluent COD , figure 3 the one between influent SAR and influent Na-concentration and figure 4 the one between effluent SAR and effluent Na-concentration.

DISCUSSION AND RECOMMENDATIONS

As it is seen in table 1 , BOD_5 values of only 4 effluent samples taken february and march out of 14 samples exceeds 50 mg/l. The other samples meet the water quality standarts but some doubts exist on the treatment efficiency of the treatment plant due to the severe weather conditions in the years 1983/1984 . Also the wastewater coming from the plant is not reused, it is five times more diluted than a same plant located in West Germany. It is not known if the increasing concentration meets water quality standarts.

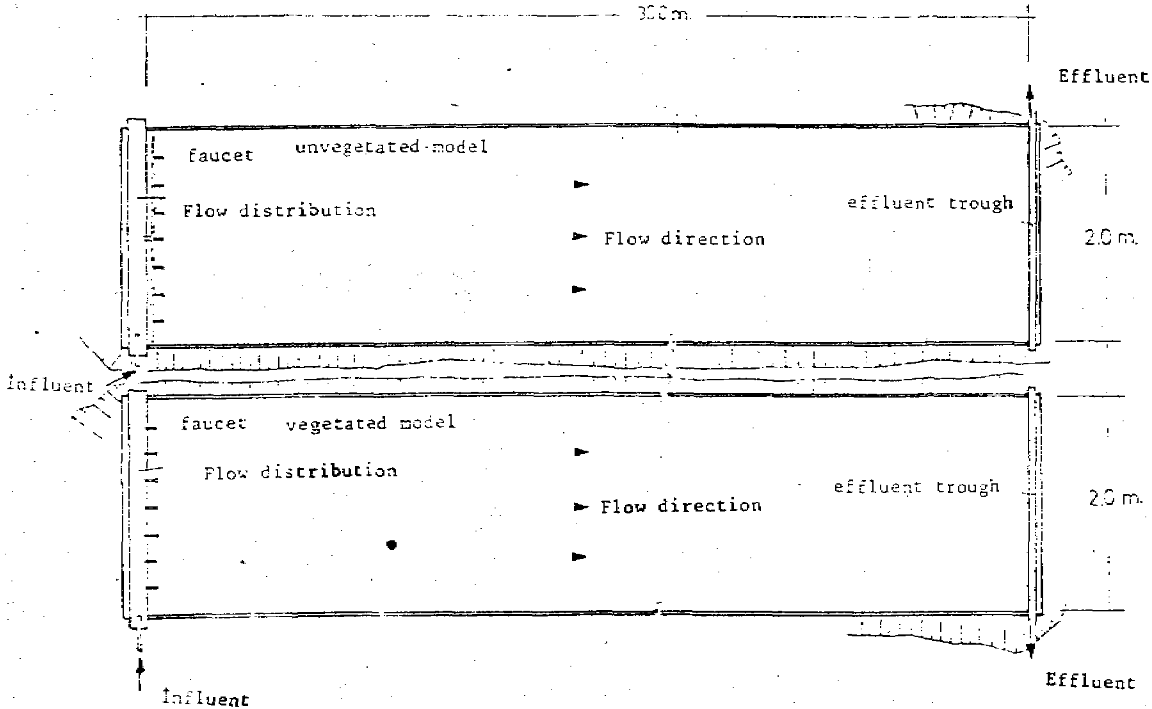

Figure 1 . Plan of pilot treatment system

Date / Parameters	19.10.1983		15.11.1983		16.12.1983		16.1.1984			12.2.1984			7.3.1984			4.4.1984			11.4.1984		
	1	2	1	2	1	2	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
pH	7,[illegible]	7,92	7,40	7,65	9,40	9,33	7,25	8,00	7,95	7,85	8,05	7,95	7,80	7,95	8,35	7,80	8,05	7,85	7,85	8,05	7,90
BOD_5 mg/l	270	35	170	30	220	32	100	[illegible]	106	150	55	95	180	60	105	230	40	180	250	45	190
COD mg/l	320	75	350	75	376	76	310	[illegible]	180	310	85	190	320	90	210	448	80	250	440	90	250
TS mg/l	800	855	864	918	1105	[illegible]	606	1026	1140	764	896	670	820	744	822	856	840	855	922	886	895
SS mg/l	60	44	24	9	[illegible]	0	16	12	12	6	44	40	12	6	6	16	8	12	26	16	22
VSS mg/l	326	301	334	240	[illegible]	116	306	238	250	126	176	186	174	168	184	156	176	162	216	194	206
P mg/l	0,48	[illegible]	[illegible]	[illegible]	0,35	[illegible]	0,71	3,70	0,80	0,80	1,25	0,70	0,9	1,3	0,8	1,2	1,6	1,1	1,15	1,7	1,1
N mg/l	[illegible]	11,20	14,50	6,71	51,6	23,5	14,6	9,6	10,3	19,[illegible]	35,[illegible]	38,0	46,0	53,7	[illegible]1,5	29,[illegible]	25,7	34,8	2,20	46,0	45,0
NH_3-N mg/l	2,[illegible]	1,40	2,4	1,3	1,6	0,5	1,1	0,6	1,4	1,15	0,85	1,10	1,2	0,9	1,1	1,2	10	1,2	1,14	1,1	1,2
NO_3-N mg/l	[illegible]	1,27	[illegible]	[illegible]	3,60	10,05	3,30	2,50	7,20	2,10	1,10	1,85	2,[illegible]	1,2	2,0	2,4	1,2	2,2	2,4	1,5	1,9
NO_2-N mg/l	[illegible]	[illegible]	[illegible]	[illegible]	2,8	1,7	0,9	[illegible]	1,8	0,76	0,45	0,70	0,7	1,5	0,6	0,28	0,15	0,03	0,9 *	0,6	0,8
Cl mg/l	42,5	41,0	[illegible]	45,2	46,[illegible]	36,0	42,[illegible]	39,[illegible]	41,0	42,0	40,0	41,0	43,5	41,0	41,0	41,5	40,0	41,05	43	41	45,5
Na mg/l	95	150	130	170	125	160	97	110	[illegible]	120	130	125	130	140	135	115	125	125	120	130	125
K mg/l	52	46	54	90	45	70	30	72	65	55	45	63	60	50	55	50	50	50	50	60	60
Ca mg/l	56	84	72	110	64	79	57	64	62	65	80	70	72	185	175	70	62	73	71	64	75
Mg mg/l	21	25	22	75	37	77	22	26	28	31	32	31	32	140	135	32	133	31	32	34	132
SAR	2,60	3,69	3,45	3,5[illegible]	3,14	3,3[illegible]	2,80	2,69	2,54	3,03	3,09	3,11	3,19	3,13	3,21	2,80	2,94	3,07	2,97	3,0[illegible]	3,03
ESP	0,41	0,45	0,47	0,4[illegible]	0,40	0,44	0,41	0,3[illegible]	0,38	0,37	0,38	0,39	0,37	0,38	0,39	0,35	0,34	0,38	0,36	0,36	0,36
[illegible]	[illegible]45	0,45	0,61	0,51	[illegible]	[illegible]	0,61	0,51	0,60	0,50	0,50	0,50	0,55	0,45	0,45	0,45	0,46	0,45	0,5	0,5	0,5
EC x 10^6	690	97[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82[illegible]	690	73[illegible]	810	750	790	720	680	760	830	790	790	840	800
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0,05	0,05	0,04	0,05	0,04	0,05	0,04	0,04	0,04	0,05	0,05	0,05	0,05	0,05

Table 1. Water Quality Parameters from treated wastewater of Malt Factory

1: [illegible] 2: Effluent (planted area) 3: Effluent (unplanted area)

Date	19.10.1983		15.11.1983		16.12.1983		15.1.1984			[illegible].1984			7.3.1984			4.4.1984			11.4.1984		
parameter	1	2	1	2	1	2	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Na (meq/l)	4,13	6,52	5,62	7,39	5,43	6,96	4,22	4,78	4,56	5,21	5,65	5,43	5,65	6,09	5,67	[illegible]	5,43	5,43	5,21	5,65	5,43
K (meq/l)	0,82	1,23	1,49	2,30	1,15	1,79	0,77	1,85	2,18	1,49	1,15	1,23	1,54	1,25	1,41	1,26	1,26	1,26	1,54	1,54	1,54
Ca (meq/l)	3,29	4,20	3,51	5 48	3,30	3,94	3,35	4,20	4,10	3,40	4,00	3,50	3,60	4,25	3,75	3,50	4,10	3,65	3,50	4,20	3,75
Mg (meq/l)	1,76	2,09	1,84	2,92	3,10	3 06	1,83	2,16	2,33	2,58	2,67	2,58	2,67	3,33	2,92	2,62	2,73	2,56	2,67	2,63	2,676
Cl (meq/l)	42,5	40,0	50,0	45,0	48,0	38,0	42,0	39,0	40,0	12,0	45,0	41,0	43,5	4[illegible]	41,0	41,5	40,0	40,5	42,[illegible]	41,0	40,5
B (meq/l)	0,45	0,45	0,50	0,50	0,50	0,50	0,50	0,50	1,00	[illegible]	0,50	0,00	0,50	1,45	0,45	0,45	0,45	0,45	0,50	0,00	0,50
Salinity%	0,06	0,06	0,06	0,10	0,06	0,07	0,05	0,05	0,06	0,05	0,05	0,05	0,05	0,05	0,04	0,04	0,05	0,05	0,05	0,05	0,05
Conductivity $EC_{25} \times 10^6$	990	970	972	1620	998	1026	650	920	890	720	510	750	790	720	680	760	630	790	760	840	600
SAR	2,60	3,68	3,45	3,60	3,14	3,72	2,62	2,66	2,54	3,03	3,09	3,11	3,19	3,13	3,21	2,88	2,94	3,07	2,[illegible]7	3,0[illegible]	3,03
ESP	0,41	0,48	0,45	0,45	0,42	0,44	0,41	0,37	0,35	0,37	0,38	0,39	0,37	0,38	0,36	0,36	0,36	0,38	0,36	0,36	0,36

Table 2. Irrigation Water Quality from treated Wastewater of Malt Factory

1: Influent 2: Effluent (planted area) 3: Effluent (unplanted area)

	INFLUENT BOD5	EFFLUENT BOD5	INFLUENT COD	EFFLUENT COD	INFLUENT TSS	EFFLUENT TSS	INFLUENT SAR	EFFLUENT SAR	INFLUENT SODIUM	EFFLUENT SODIUM
COLUMN	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
COUNT	14	14	14	14	14	14	14	14	14	14
ROW										
1	270.	35.	320.	70.	800.00	836.00	2.60000	2.68000	95.	150.
2	190.	45.	245.	80.	920.00	922.00	3.14000	3.03000	120.	125.
3	170.	30.	760.	75.	564.00	916.00	3.45000	3.60000	130.	170.
4	70.	24.	170.	60.	820.00	960.00	3.05000	3.98000	120.	160.
5	220.	32.	376.	76.	1105.00	886.00	3.04000	3.72000	125.	160.
6	190.	44.	230.	90.	894.00	725.00	3.06000	2.69000	135.	142.
7	160.	42.	310.	75.	806.00	1026.00	2.62000	2.66000	97.	110.
8	265.	40.	290.	75.	874.00	1042.00	3.45000	3.20000	130.	135.
9	160.	55.	310.	85.	764.00	896.00	3.03000	3.09000	120.	130.
10	190.	60.	320.	90.	810.00	820.00	2.78000	2.84000	110.	120.
11	180.	60.	320.	90.	820.00	744.00	3.19000	3.13000	130.	140.
12	190.	70.	360.	110.	990.00	810.00	2.99000	3.00000	120.	130.
13	230.	40.	445.	80.	656.00	940.00	2.86000	2.94000	115.	175.
14	250.	45.	440.	90.	922.00	856.00	2.97000	3.01000	120.	130.

— CORRELATION COEFFICIENT BETWEEN: C1 AND C10

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C2	0.112								
C3	0.586	0.186							
C4	0.291	0.865	0.368						
C5	0.265	-0.261	0.316	0.008					
C6	-0.078	-0.525	-0.179	-0.669	-0.067				
C7	-0.057	-0.120	-0.143	-0.100	0.256	0.102			
C8	-0.203	-0.665	-0.231	-0.581	0.218	0.250	0.237		
C9	-0.106	0.029	-0.117	0.128	0.396	-0.298	0.862	0.100	
C10	-0.173	-0.596	-0.159	-0.399	0.322	-0.018	0.445	0.854	0.405

Legend

1= 19.10.83 2= 1.11.83 3= 18.11.83 4= 1.12.83 5= 16.12.83 6= 30.12.83 7= 15.1.84 8= 30.1.84

9= 12.2.84 10= 27.2.84 11= 7.3.84 12= 22.3.84 13= 4.4.84 14= 11.4.84

Table 3. Relationships between influent and effluent characteristics

— REGRESS EFFLUENT BOD5 IN C2 VS EFFLUENT COD IN C4

THE REGRESSION EQUATION IS
Y = -37.00 + 0.9879 X1

	COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	--	-37.0	12.5	-2.96
X1	C4	0.986	0.150	6.56

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 6.26
WITH (14- 2) = 12 DEGREES OF FREEDOM

R-SQUARED = 78.3 PERCENT
R-SQUARED = 76.5 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	1695.7	1695.7
RESIDUAL	12	469.7	39.1
TOTAL	13	2165.4	

ROW	X1 C4	Y C2	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	70.	35.0	40.1	1.8	-5.1	-0.84
2	80.	45.0	42.0	1.7	3.0	0.49
3	75.	30.0	37.1	2.0	-7.1	-1.20
4	60.	24.0	22.3	3.8	1.7	0.35
5	76.	32.0	38.1	1.9	-6.1	-1.02
6	90.	44.0	51.9	2.0	-7.9	-1.34
7	75.	42.0	37.1	2.0	4.9	0.83
8	75.	40.0	37.1	2.0	2.9	0.47
9	85.	55.0	47.0	1.7	8.0	1.33
10	90.	60.0	51.9	2.0	8.1	1.37
11	90.	60.0	51.9	2.0	8.1	1.37
12	110.	70.0	71.7	4.5	-1.7	-0.30
13	80.	40.0	42.0	1.7	-2.0	-0.34
14	90.	45.0	51.9	2.0	-6.9	-1.17

— PLOT EFFLUENT BOD5 IN C2 VS EFFLUENT COD IN C4

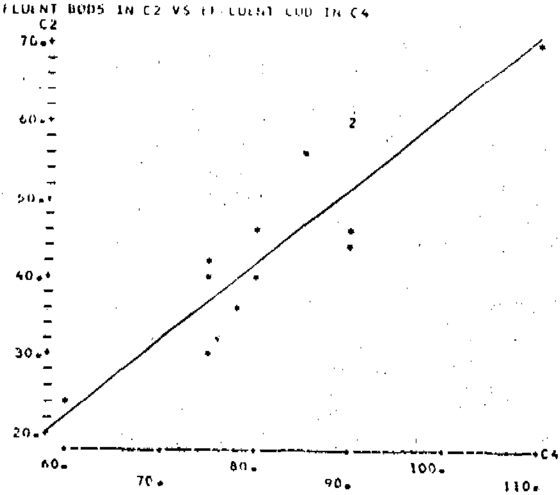

Figure 2.The regression between effluent BOD_5 and effluent COD

— REGRESS INFLUENT SAR IN C7 VS INFLUENT SODIUM CONC. IN C9

THE REGRESSION EQUATION IS
Y = 0.7785 +0.01881 X1

	COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	--	0.779	0.382	2.04
X1	C9	0.01881	0.00320	5.89

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.136
WITH (14- 2) = 12 DEGREES OF FREEDOM

R-SQUARED = 74.3 PERCENT
R-SQUARED = 72.1 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	0.6430	0.6430
RESIDUAL	12	0.2227	0.0186
TOTAL	13	0.8658	

ROW	X1 C9	Y C7	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	95.	2.600	2.566	0.085	0.034	0.32
2	120.	3.140	3.036	0.037	0.104	0.79
3	130.	3.450	3.224	0.050	0.226	1.78
4	120.	3.050	3.036	0.037	0.014	0.11
5	125.	3.040	3.130	0.041	-0.090	-0.69
6	135.	3.060	3.318	0.063	-0.258	-2.13
7	97.	2.620	2.603	0.079	0.017	0.15
8	130.	3.480	3.224	0.050	0.256	2.02
9	120.	3.030	3.036	0.037	-0.006	-0.05
10	110.	2.760	2.846	0.047	-0.068	-0.53
11	130.	3.190	3.224	0.050	-0.034	-0.27
12	120.	2.990	3.036	0.037	-0.046	-0.35
13	115.	2.860	2.942	0.039	-0.082	-0.63
14	120.	2.970	3.036	0.037	-0.066	-0.50

-- PLOT INFLUENT SAR IN C7 VS INFLUENT SODIUM CONC. IN C9

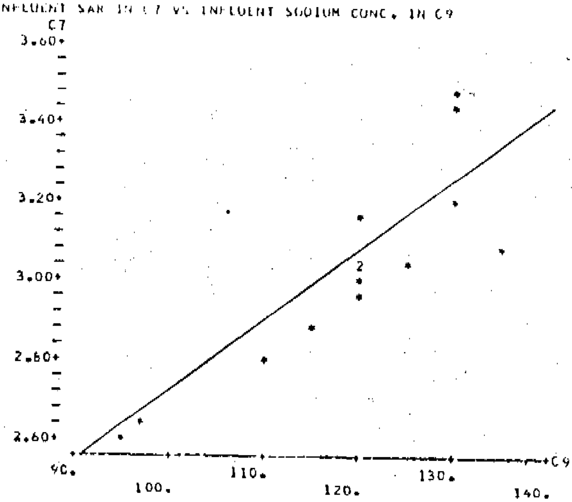

Figure 3.The regression between influent SAR and influent Na-concentration

-- REGRESS EFFLUENT SAR IN C8 VS EFFLUENT SODIUM CONC. IN C10

THE REGRESSION EQUATION IS
Y = 0.4335 +0.02009 X1

	COLUMN	COEFFICIENT	ST. DEV. OF COEF.	T-RATIO = COEF/S.D.
	--	0.433	0.424	1.02
X1	C10	0.02009	0.00306	6.57

THE ST. DEV. OF Y ABOUT REGRESSION LINE IS
S = 0.109
WITH (14- 2) = 12 DEGREES OF FREEDOM

R-SQUARED = 78.2 PERCENT
R-SQUARED = 76.4 PERCENT, ADJUSTED FOR D.F.

ANALYSIS OF VARIANCE

DUE TO	DF	SS	MS=SS/DF
REGRESSION	1	1.5341	1.5341
RESIDUAL	12	0.4271	0.0356
TOTAL	13	1.9612	

ROW	X1 C10	Y C8	PRED. Y VALUE	ST.DEV. PRED. Y	RESIDUAL	ST.RES.
1	150.	3.680	3.447	0.063	0.233	1.31
2	125.	3.030	2.945	0.064	0.085	0.48
3	170.	3.600	3.849	0.111	-0.249	-1.63
4	160.	3.880	3.648	0.085	0.232	1.97
5	160.	3.720	3.648	0.085	0.072	0.43
6	147.	2.880	3.286	0.052	-0.406	-2.24
7	110.	2.680	2.643	0.098	0.037	0.23
8	135.	3.200	3.145	0.051	0.055	0.30
9	130.	3.090	3.045	0.056	0.045	0.25
10	120.	2.840	2.844	0.074	-0.004	-0.02
11	140.	3.130	3.246	0.051	-0.116	-0.64
12	130.	3.000	3.045	0.056	-0.045	-0.25
13	125.	2.940	2.945	0.064	-0.005	-0.03
14	130.	3.010	3.045	0.056	-0.035	-0.19

-- PLOT EFFLUENT SAR IN C8 VS EFFLUENT SODIUM CONC. IN C10

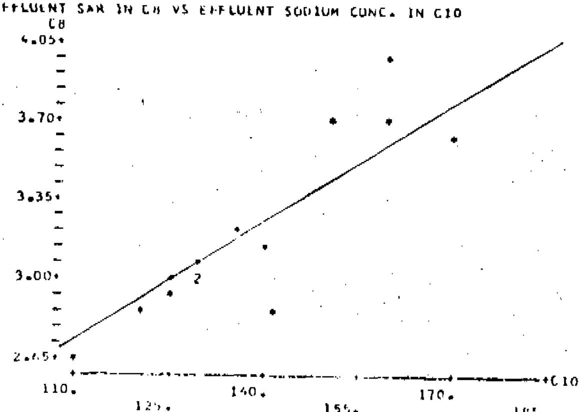

Figure 4. The regression between effluent SAR and effluent Na-concentration

During the research period, a BOD_5 treatment efficiency of 65.7 - 87.0 % , is achieved and a final value of less 50 mg/l is provided. Increasing the length of treatment area from 30 m to 45 m or 60 m, BOD_5 removal efficiency would be increased too. Also , spraying of the wastewater may improve the treatment efficiency. During the nozzling process of wastewater decomposition which takes place on the soil layer till 7 - 10 m length will be prevented. In other words, solid materials which cause decomposition somewhere close to water distribution line will be avaided. If reeds are used instead of ryegrass in the system;

- reeds may be harvested and used as raw material for paper factory in Afyon/Çay,
- continious application of wastewater will be achieved since it grows in the water,
- since watering in every two days is the minimum period for ryegrass, land requirements are 2 to 3 time higher, but using reeds may reduce the land requirement 1/2 - 1/3 times.
- decomposition of roots would not create a problem,
- in addition , when the depth of root layer is increased to 30 cm from 10 cm , treatment efficiency will be increased and decomposition of roots would not occur.

Total coliform, fecal coliform , and total bacteria number increase in effluent comparing to influent. The total coliform count was in the range of 260 - 4,000/100 ml for the influent and in the range of 800 - 7,600 /100 ml for the effluent . The fecal coliform concentration per 100 ml was between 120 - 5,000 for the influent and between 150 - 8,200 for the effluent. The total bacteria count for the influent was between 292 - 5,200 and the total bacteria count for the effluent was between 850 - 7,900/100 ml . For this reason the effluent should be chlorinated before discharging to the receiving body.

When the analysis results shown in table 2 are studied from the point of wiew of water quality , it is understood that the effluent is a second class irrigation water quality . The effluent is rich with respect to Na-ion concentration but a better quality is not observed on the well waters which are obtained in the area of Afyon Malt Factory plant located at Susuz region. This may show that deterioration is not observed on irrigation water.

SUMMARY

Overland flow is a method of land treatment of wastewater which can be uniformly distributed by sprinklers or gated pipes across the top of each parts of area and allowed to flow downslope.

Studies carried out at the horizontal flow type of plant of the Malt Processing Factory showed that removal efficiencies of COD and

BOD_5 65.7 - 87.0 % and 60.9 - 79.8 % respectively when the planted soil used and while unplanted soil is used it is found out that the efficiencies of COD and BOD_5 decreased to 38.8 - 42.4 and 41.4 - 41.9 % respectively.

In Afyon, it is possible to increase removal efficiencies by overland flow on vegetated area, through increasing the plant length from 30 m to 45 m or 60 m and increasing the soil thickness from 10 to 20 or 30 cm and distribute the water by sprinkler having 10 - 15 m sprinkler circles diameter.

In Afyon ,short periods of cold weather can be caused problems in system performance.Therefore overland flow can be used as a polishing process in such cold regions of Turkey after pretreatment process.Most of the overland flow facilities in Turkey can be located in the regions where the winter climate is relatively mild.Generally the overland flow treatment process can effectively use after pretreatment during spring , summer and fall months.

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APPENDIX (the next sides)

Photo 1. Picture shows the preparation from pilot treatment system , 1: vegetated parts , 2: unvegetated parts

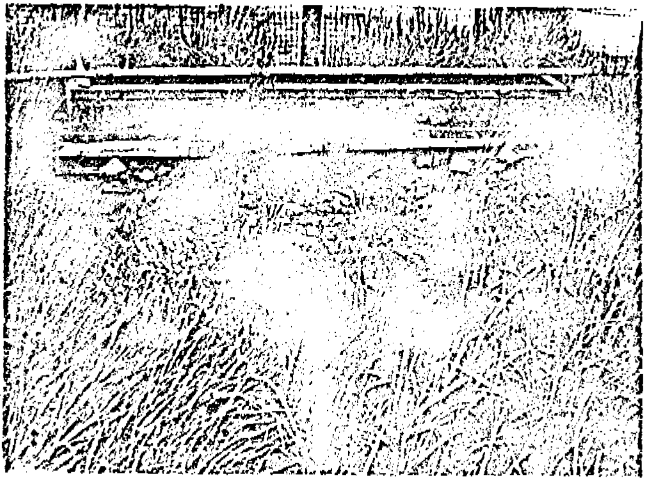

Photo 2. In this picture, it is seen the pilot parts vegetated area and wastewater distribution system in situ, Poa pratensis, Festuca rubra and Loluim perenne were mixed and seeded as 60 gr/m^2 .

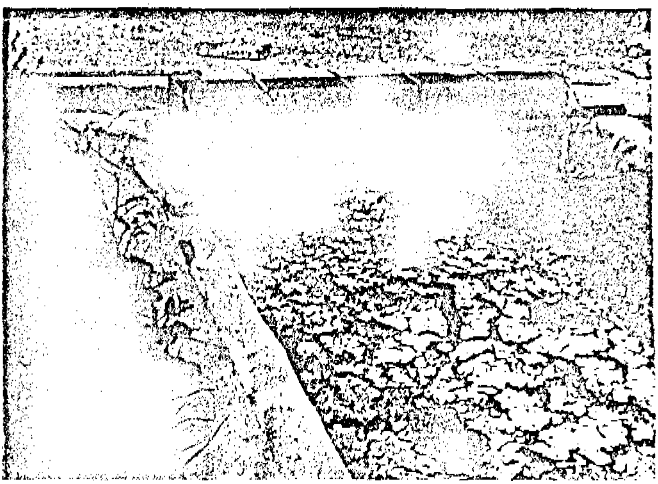

Photo 3. In this picture , it can be seen wastwater distribution system on unplanted area parts of pilot.

Photo 4. It shows formation of rich roots from Poa pratensis, Festuca rubra , and Lolium perenne on the soil of pilot plant in Afyon-Malt Factory.

DESIGN EQUATIONS FOR DECLINING RATE FILTERS

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ABSTRACT

In recent years, for ease of operation, declinig rate filtration as opposed to constant rate filtration is finding wide applications. In this paper, behaviour of water subjected to coagulation in declining rate filters is investigated and regression equations for filter performance are developed. A mathematical model describing the performance of declining rate filters will be subsequently developed.

INTRODUCTION

The final treatment and clarification of both surface and groundwaters involve filtration. In filtration, turbid water flows through a granular medium and the suspended particles in the water are trapped and deposited in the pores of the filter bed. Much research on filtration has been made, and the process has been considerably improved since 1829, where sand filters were used for the first time for municipal water treatment. Although various theories such as straining, bridging, sedimentation, interception, Brownian motion etc. have been cited in the explanation of the capture mechanisms in filtration, none of these have found universal acceptance (Esen and Curi,1984; Ives,1975; Curi,1974).

In recent years, a number of investigators have tried to describe the filtration process through mass-balance equation for the filtered water and the material deposited at the pores. For constant rate filtration the first mathematical model describing the removal process was developed by Iwasaki (1937), and this model was later modified by many researchers among which Ives (1960), Ives and Sholji (1965), Mohanka (1969), and Deb (1970) can be mentioned.

One such model, where the rate coefficient describing the removal of particles is assumed to vary linearly with time, was recently developed by the authors of this paper (Esen and Curi,1984).

For declining rate filtration, the differential equation describing the process are highly non-linear and their closed-form solution is not possible. On the other hand, the mass-balance equations themselves are not well defined since the mechanism of water filtration is complicated involving a large number of physical parameters. Nevertheles, a model is recently being developed by the authors of this paper. A simpler approach however, is to develop regression equations for filter performance based on experimental data. In this study, regression equations are developed for turbidity of filtered water, amount of material deposited in the filter bed, relative concentration of filtered water, and the head loss through the filter bed as functions of the independent variables such as depth of sampling, size of granular material, time elapsed from the beginning of filtration and initial discharge.

In the experiments made, kaolinite flocs not subjected to sedimentation have been used as the source of turbidity. Since filtration of pretreated water may be more efficient, instead of dispersing kaolinite in water it was first subjected to flocculation. The kaolinite floc was filtered through uniform sand in a model filter. Samples of water were collected at various depths in the filter periodically during filter runs and analyzed for turbidity. The resulting data were used in obtaining the regression equations (Esen and Curi, 1984).

DECLINING RATE FILTERS

Declining rate filters are deep filters made of granular particles such as sand, coal, etc. The cleaning process takes place not only at the surface, but throughout the whole depth of the filter. Water passes through the porous medium by filling the pores between the particles. The important parameters involved are the filter media (type of filter material, grain size and size distribution, shape of particles, depth of porous medium, porosity, permeability), the filtered fluid (viscosity, depth of water above the filter bed) and the characteristics of particles in suspension (type, size and specific surface, specific gravity, concentration).

In declining rate filters, the flow at the outlet of the filter is left uncontrolled so that during the filter run, the pores in the filter bed gradually get clogged and with the passage of time the headloss through the filter increases, and the flow rate decreases. The filtration process is terminated when either the headloss or the flow through the filter reaches a certain limiting value. At this point, the filter is backwashed and the procedure is repeated.

EXPERIMENTAL PROCEDURE

The experimental set-up consisted of three parts, namely two cylindirical mixing tanks, a plexiglass cylindirical model filter and a rectangular water storage tank (Esen and Curi,1984). Fig. 1 shows the outline of the experimental set-up.

Dry kaolinite was ground and mixed with water. This solution was added to the mixing tank through a number 200 sieve and it was mixed until the kaolinite particles were uniformly dispersed in water. After this mixing, an appropriate amount of aluminum sulfate solution was added as a coagulant. Five to seven minutes of rapid mixing was usually sufficient to obtain the required coagulation effect. The solution in the mixing tank was then pumped to the storage tank from which the solution was introduced into the filter. The water level above the filter bed was fixed and the value at the outlet of the filter was adjusted to the desired initial discharge. Clean water was passed through the filter until the piesometer level became constant.

Discharge was measured by weight-time method. Headloss was measured by directly reading the level on the piesometers for ten different points. The difference between the water surface in the filter and the piesometer level was accepted as the headloss. Samples were taken through various sampling ports and turbidity, hence the concentration was measured with a Spectronic 20, Bausch and Lomb Spectrophotometer. These measurements were repeated at convenient time intervals for about five to seven hours.

After reaching a reasonably large headloss, the experiment was terminated. In order to determine the specific deposit, sand samples from various depths of the filter bed were carefully removed and dried in an oven. First, this dry sample was weighed and the total sand and clay amount was determined. Then, this sample was placed between two number 100 sieves and washed with water. The weight of the clean sample was determined again after drying. The difference between the first and the second values gives the amount of deposited clay. The specific deposit was calculated from the ratio of weight of deposited clay to that of the clean sand.

REGRESSION EQUATIONS

Multilinear regression analysis was performed for the evaluation of the data obtained from nine experiments. The variables considered in this study are the following:

d_{10} = effective size of sand - the size from which 10% of the particles are finer (mm)

u_c = d_{60}/d_{10} = uniformity coefficient - ratio of the size from which 60% of the particles are finer to the effective size

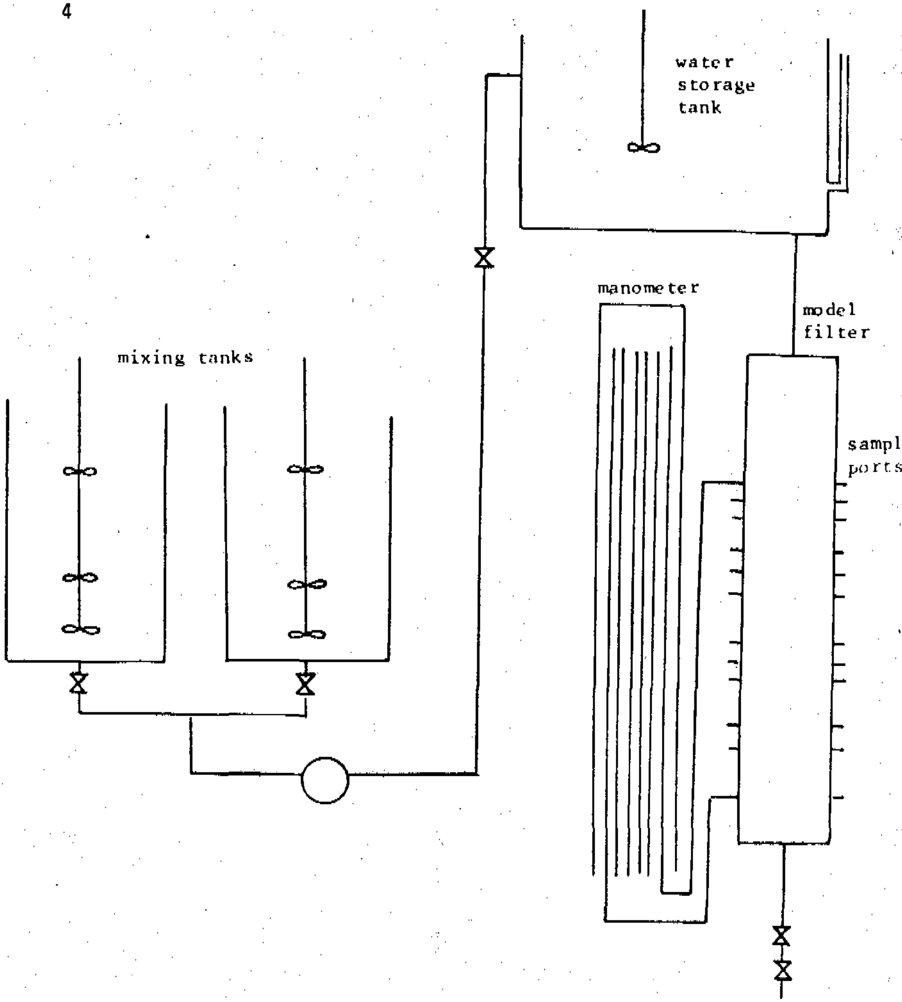

Fig. 1 - Model filter and the experimental set-up.

D	=	depth of water above the filter bed (cm)
Q_i	=	initial discharge through the filter ($m^3/m^2/day$)
Q_t	=	discharge at any time through the filter ($m^3/m^2/day$)
C	=	concentration of particles (mg/L)
C_o	=	initial concentration of particles (mg/L)
σ	=	specipic deposit or volume of deposited material per unit volume of filter
L	=	distance from top of the filter bed (cm)
L_o	=	depth of filter bed (cm)
t	=	time from the start of filtration (min)
h_L	=	headloss through the filter (cm)
i	=	h_L/L_o = hydraulic gradient

The applicability ranges for the independent variables used in the empirical equations developed are given in Table 1.

Table 1. Ranges for the Values of the Variables

Variable		Minimum Value	Maximum Value
d_{10}	(mm)	0.56	1.10
u_c		1.10	1.20
D	(cm)	39	69
Q_i	($m^3/m^2/day$)	91	200
t	(min)	-	420

The regression equations with the highest linear correlation coefficients obtained are as follows:

$$\frac{C}{C_o} = \ln \frac{1.63\, d_{10}^{0.35}\, Q_i^{0.49}\, t^{0.24}}{L^{0.34}} \qquad (1)$$

$$h_L = 1406 - 44.26\, d_{10} + 0.2535\, Q_i + 0.089\, t + 0.094\, L + 13.58\, L/L_o \qquad (2)$$

$$Q_t = \ln \frac{d_{10}^{40.4}\, Q_i^{65.29}}{e^{133.68}\, t^{12.71}\, i^{9.7}} \qquad (3)$$

$$\sigma = \frac{0.631 \quad Q_i^{0\ 344}}{d_{10}^{0\ 598} \quad L^{0\ 556}} \qquad (4)$$

The linear correlation coefficients for equations (1), (2), (3) and (4) are 0.896, 0.941, 0.971 and 0.924 respectively.

EVALUATION OF THE EXPERIMENTAL RESULTS

Equation (1) shows that the value of concentration is inversely proportional to the distance of that point from the top of the filter bed and directly proportional to the distance of that point from the top layer of the filter bed, initial discharge and time. Plots of relative concentration, C/C_o, versus depth for the first experiment are given in Fig. 2. These curves are similar to those given by Curi (1974). Results of the other experiments show exactly the same pattern.

Equation (2) shows that headloss increases with increasing initial discharge, depth of sampling point and time, but decreases with increasing effective size. Headloss versus time values at different depths for the first experiment is shown in Fig. 3.

Variation of discharge is given by equation (3). As expected, discharge varies directly with effective size and varies indirectly with time and hydraulic gradient. Fig. 4 shows variation of discharge with time for the first experiment.

Many investigators have studied the variation of specific deposit with time graphically. However, the only equation available in the literature is that given by Curi (1974). Equation (4) developed in this study shows that the specific deposit is directly proportional to the initial discharge, but inversely proportional to the effective diameter. Fig.5 shows the variation of specific deposit with depth for the third experiment

CONCLUSIONS

Regression equations are developed giving the variation of concentration, headloss, discharge and specific deposit with distance from top of filter, initial discharge, time and effective size of filter material. These equations have shown a good correlation with the actual data obtained.

The uncontrolled declining flow filtration is a method which can be considered for the tratment of water for small or medium size communities, especially in developing countries. The equations developed can be used for the design of treatment units having similar characteristics as those used in the experiments of this study.

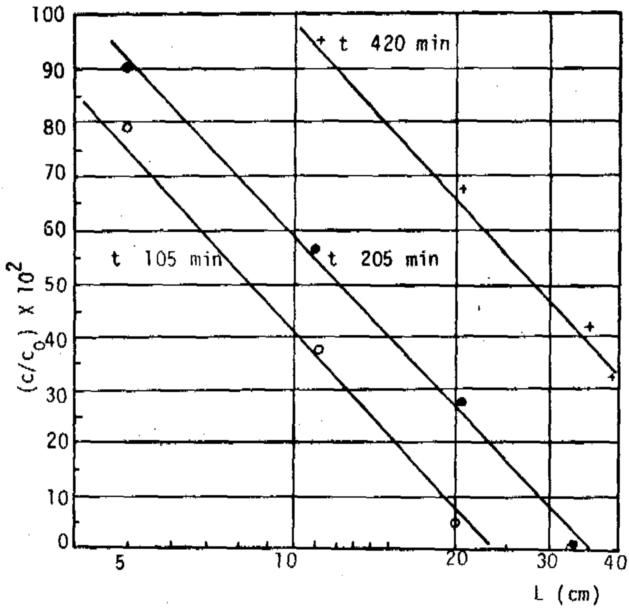

Fig. 2. Relative concentration vs. depth,
Experiment No. 1.

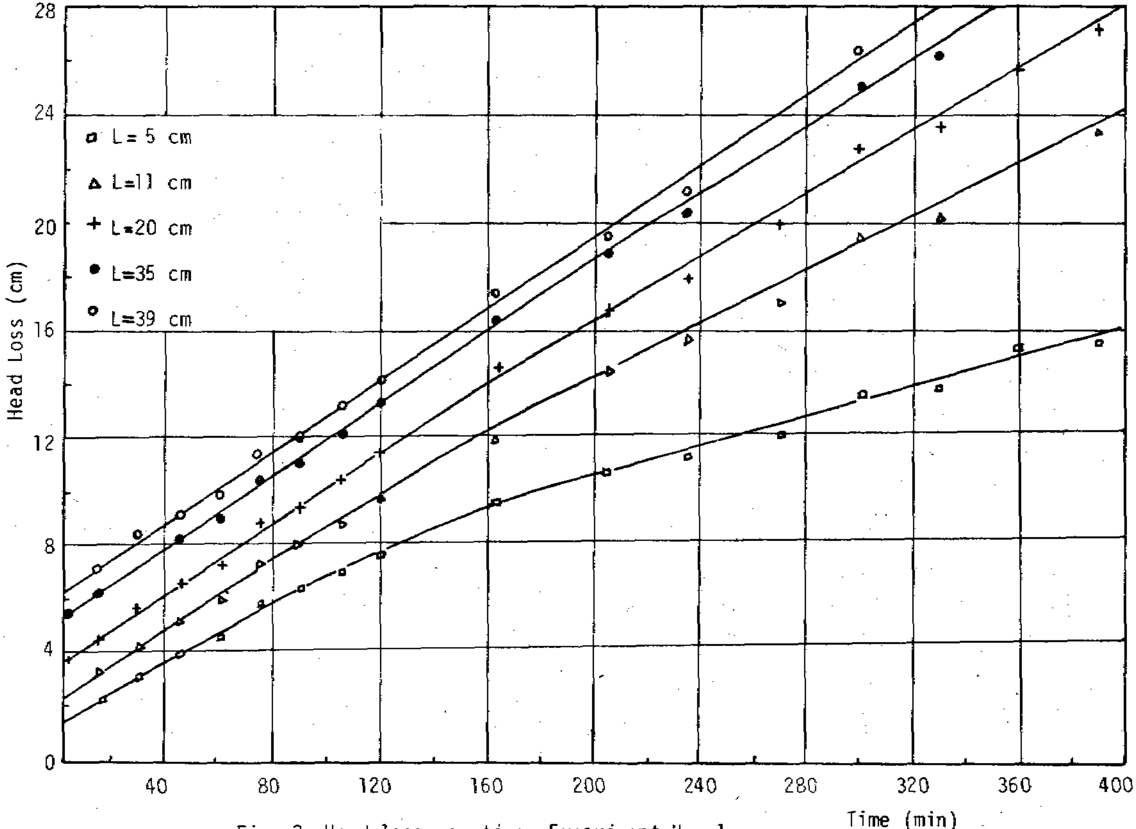

Fig. 3. Head loss vs. time, Experiment No. 1.

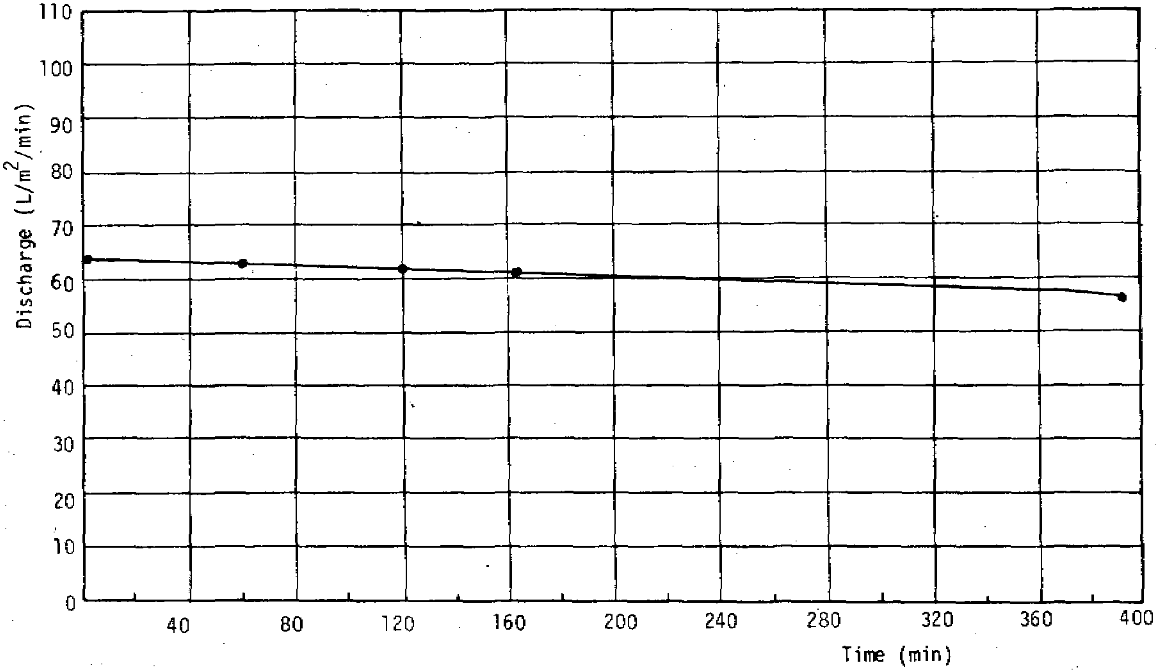

Fig. 4. Discharge vs. time, Experiment No. 1.

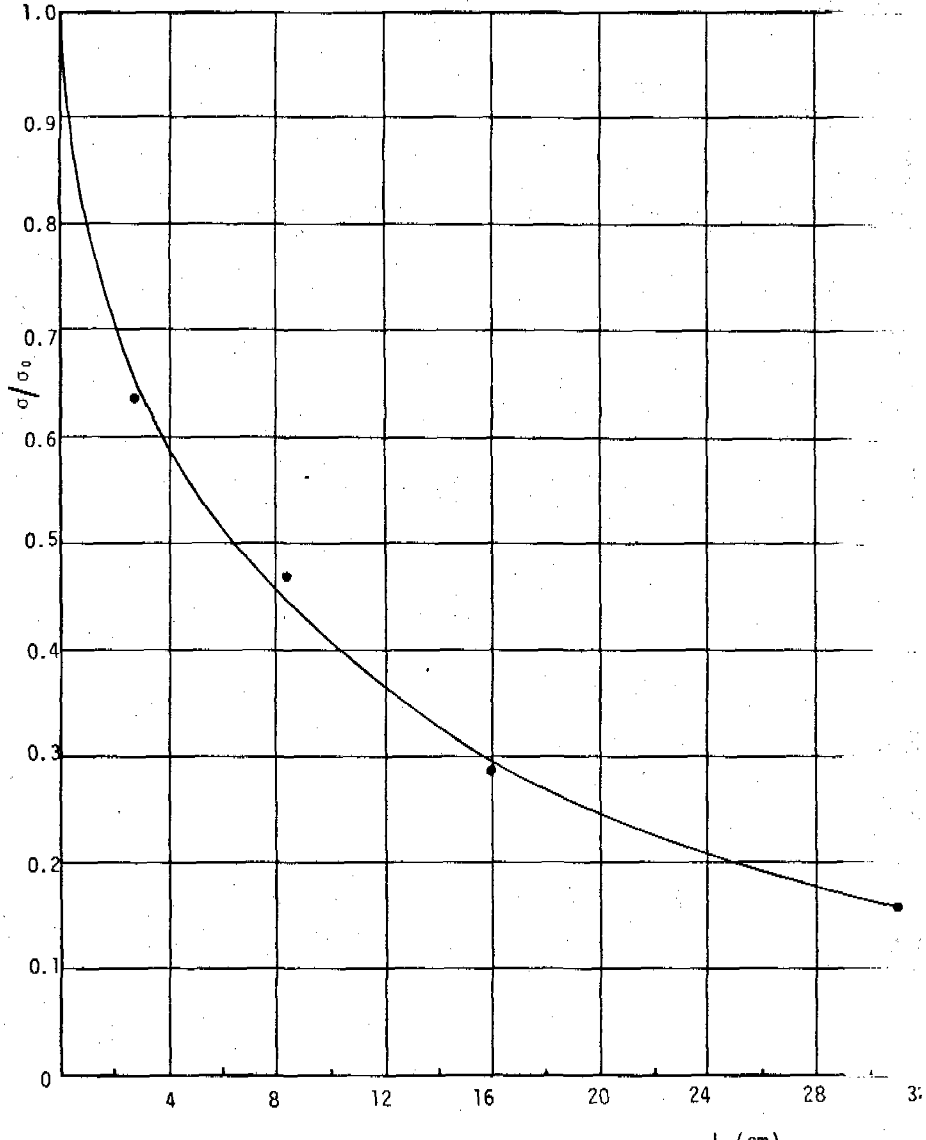

Fig. 5. Relative specific deposit vs. depth, Experiment No.5.

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RESEARCH OF LUNG PROFESSIONAL ILLNESSES IN A METALURGICAL FACTORY

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INTRODUCTION

Involved in the absorbing hospital daily tasks, with no experience in planning works of an epidemiological kind, particularly in what concerns field works, without any easy contact with the populations and having to face some employers who could look on us with distrust, we do feel pleased to have accomplished this small work.

Although we haven't come to very significative conclusions for reasons which will be obvious through this work, we think it is worth being published, at least because we feel we have learned something on doing it, which may perhaps become the starting point for more ambitious future works of this kind.

As we have already mentioned, we can't even hope for the best colaboration of firm owners, which has somehow taken us to choose the firm in which we have worked, which, above all has the characteristics of a small enterprise, which we think to be advisable since we don't possess the necessary experience. Besides, these represent the majority of the means of factories production in our country and however unatractive they may seem for this kind of works, particularly for employing a small number of workers, they have the advantage of being the very place where we can more easily find the consequences of a bad unhealthy environment and where the protection of the worker is most neglected.

MATERIAL AND METHODS

Services II and VII of Hospital Centre of V.N. de Gaia have carried out, in 1982, in a small metallurgical firm which specializes in making taps, an epidemiological study so as to trace professional diseases pertaining to pneumology .

All workers - 82 - have been examined. Eleven have been left out, six because they hadn't been X-rayed and 5 because they have mentioned professional antecedents which could explain a professional pathology - 1 had been a mason, 1 a potter and 3 goldsmith. Each worker has been through an inquiry, an examination, a pulmonary X-ray plate, a functional respiratory study, an electrocardiogram and a Mantoux test to 1TU.

CONCISE DESCRIPTIONS OF THE PLANT AND THE RESULTS OF THE SURVEY OF DUST

The plant occupies an area of 3000m^2,being made up by the following sections: foundry,deburring,power lathe,mechanical burnisher,locksmithery,galvanoplasty,package - final control and treatment of sand - retrieval of metal.

The walls which delimit the central corridor are not complete (they use only to about half of the building). The southwest (principal) and northwest façades have removable windows. The floor of the whole plant is made of cement and the roof in the sections of the foundry, deburring,lathes and corridor is made of a crisp zinc plate and the one of the other sections is made of cement (concavous and convex arches with skylights in the convex part).

Section of treatment of sand - retrieval of metal

This section occupies an area of 110m^2 and communicates with the outside by a small door and with the section of deburring also by a door that is always open. The sands deriving from the cleaning of the furnaces are stored in this section in a small pile as well the handwork of the foundry. The worker who is in charge of the transport also makes the retrieval of metal, putting the work in a mill which separates the sand throwing it to the ground. This sand is swept and mixed up with the remaining sand for a later sifting, which is made in the same place. The ventilation of this section is only made through the door which communicates with the outside.

Section of deburring

It occupies an area of 118m^2, communicates by doors with the sections of foundry,treatment of sand and store of metal pieces. The pieces to be deburred are placed in piles on the floor, and as they are worked, they are thrown into metallic recipients. In this section there are on the ceiling two exaustors. The ventilation is mixed, natural through the doors and artificial through the exaustors.

Section of mechanical lathes and tinsmithing

It has an area of $285m^2$, but it is not completely isolated,as it has a low wall. On one side of the section there are ten working places (ten lathes) and on the opposite side we find the tinsmithing with a lathe bed, three screw-presses and a welding place. The ventilation of this section is a natural one through the existing openings.

Section of foundry

It has an area of $240m^2$ and it is the place where we can find the three furnaces. The middle furnace has a chimney with a natural draft. The emptying of the furnaces is made by hand,with the spoons, into the injection machines, where the molding cores are already placed. In the section of the cores there are two shellmolding machines with three work posts. The ventilation of this section is a mixed, natural one, made through three dumping windows, the door to the deburring and two openings on the ceiling, and artificial through the exaustor placed on the wall that separates it from the deburring.

Section of the authomatic lathes

This section has an area of $360m^2$ with a good mixed illumination and natural ventilation through the windows on the southwestern wall. There are six furnaces and a transfer machine.

Section of mechanical polishers (manual)

The occupied area is of $120m^2$. Distributed all over the room, twelve workers use mechanical polishers, provided with captation of dust incorporated to the machines and connected to a central control of dusty. This section has dumping windows on one window, wich permits natural illumination and ventilation.

Section of power lathes

This section occupies an area of $166m^2$,where are two polishing machines, one with 14 brushes and another with 4 brushes, disposing of a captation - exhaustion system. The ventilation is mixed through exhaustion by machines and through the windows on the southwestern façade.

Galvanoplasty

It occupies an area of $230m^2$, where we can find the baths of trichloroethylene,chromium,nickel and water. There are two posts in the chromo-plating and nickel-plating,and four in the degreasing.

The bath of trichloroethylene disposes of worms refrigerated on their surface for the condensation of steam.

The floor disposes of grates for the drainage of liquids. The ventilation is a mixed, natural one through the windows existing on the southwestern façade and door and artificial through the exhauster placed by the door.

Valuation of some environmental factors

We have obtained some ambient air in the different section to study:

- dusty
- trichloroethylene
- formaldehyde
- phenol
- ammonia

The samples have been made on several days and phases of the factory cycle, and we have chosen places which provided results for the general environment and by the workers we have tested their respiratory organs, in their usual working places.

The presented values as well as the TLV for an exposing of 8 hours a day, mentioned by "American Conference of Governmental Industrial Hygienists" can be found in Table I.

ORGANIZATION AND GATHERING OF ELEMENTS

The inquiry comprised a gathering of information referring to:

- Professional history, personal and familiar antecedents, alchoolic and smoking habits, housing, family income per capita, as well as evidence of cardiorespiratory symptoms.

In the professional history we haven't noticed a great change in the posts along the years. This fact, associated with the reduced number of the sample, induced us to divide the population into 2 groups:

Group A - not exposed individuals - which includes the workers of the sections of office, store, assembly, tinsmithing, power lathes, galvanoplasty and locksmithery.

Group B - exposed individuals - which includes the workers of the sections of foundry/cores, treatment of sand/retrieval of metal, deburring, lathes, mechanical and authomatic polishing.

We have considered relevant personal antecedents: measles and other children's diseases, as for example those which can affect the respiratory organs, the diseases of an estomatologic forum, asthma, tuberculosis and its consequences.

As familiar antecedents: tuberculosis, D.P.C.O.; cistic fibrosis and lung cancer.

The valuation of tabacco habits was done in packets x year/ /day (PYD).

The workers were grouped in 4 grades according to the signals and symptoms.

Grade 0 - non symptomatic
Grade 1 - dry cough or productive cough with viscous sputum
Grade 2 - cough with muco purulent or purulent sputum
Grade 3 - cough with muco purulent or purulent sputum with dyspnoea or wheezing

Radiographyc study

For this study we have taken chest films mainly in postero--anterior projection, [illegible] bserved by 3 independent persons and grouped accordin [illegible] onal classification of radiologyc opacities per [illegible] field, induced by inhalation of mineral dust (Genève [illegible]

Functional breathing study

This study took place during the working time of the factory with a vitalograph. Each worker did three forced vital capacities (FVC), choosing the best result. So we determined the following parameters: FEV_1, FEV_1/FVC, FEF 25-75 and FEF 200-1200.

The results were corrected with BTPS and compared with theoryc results from CECA tables (European Comission of Carbon and Steel).

The peoples with FVC lesser than 80% of theoryc value and with FEV_1/FVC equals or greatter than 70% had a alteration of restrictive type; for FVC equal or greatter than 80% of theoryc value, with FEV_1/FVC lesser than 70% the alteration is of obstructive type.

RESULTS

There were 30 smokers in this population (42.25%) - 28 males and 2 females. The average consumption is 13.6 PYD with a minimum of 2.5 and a maximum of 40.

Within the exposed group there were 13 smokers (48.15%) with an average consumption of 17.5 PYD with a minimum of 3 and a maximum of 40.

Within the non exposed group there were 17 smokers (38.64%) - 2 females with an average consumption of 10.6 PYD and a minimum of 2.5 and a maximum of 30.

It was made the Mantoux Test 1TU to 57 individuals (80.28). Positive (>10mm) 24 (42.11%). Negative 33 (57.89%). In the group of individuals with Mantoux only one showed lung tuberculosis precedents.

We haven't found alterations in electrocardiographic data which may be attributed to lung patology what occasionally can be verified.

In the following Tables (1-9) we report the studied parameters for the entire population and in some cases for the exposed and non-exposed groups.

Table 1 - Concentration values of dusty and trichloroethylene in comparison with the maximum concentration level (TLV) (mg/m3 of air).

Place	Dusty	TLV	Trichloroethylene	TLV
Deburring				
- at the back	3.2- 4.9	10.0		
- at the front	15.7-21.7			
Foundry				
- furnaces	10.2-12.7	4.5		
- machines	10.8-20.2			
Lockmithery	< 0.1	10.0		
Mechanical polishers	13.9-16.5	3.5		
Authomatic polishers	8.5-11.5	2.0		
Mechanic lathes				
- lathes	11.8-20.8			
- tinsmithing	2.9- 4.9	10.0		
- authomatic	4.2- 6.3			
Treatment of sand				
- retrieval of metal	1.0- 7.8	0.5		
Galvanoplasty			14600	535

Values for phenol,formaldheyde and ammonia in the foundry are respectively (in parenthesis TLV values): < 0.7 (19), < 0.7 (3), 2.0 (18).

In Tables 2-9, 1 is the number of cases and 2 is %.

Table 2 - Study of dust

Age	Men		Women		Exposed		N/Exposed	
	1	2	1	2	1	2	1	2
< 20	9	17.65	2	10	1	3.70	10	22.73
20 - 29	15	29.41	4	20	8	29.64	11	25
30 - 39	12	23.53	6	30	5	18.52	13	29.55
40 - 49	10	19.61	6	30	9	33.33	7	15.90
50 - 59	4	7.84	1	5	3	11.11	2	4.55
> 60	1	1.96	1	5	1	3.70	1	2.27
	51	100	20	100	27	100	44	100

	Men	Women
Maximum age	60	60
Minimum age	17	19
Average age	30.06	37.40

Table 3 - Personnel precedents

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
With precedents	33	46.48	13	48.15	20	45.45
Without precedents	38	53.52	14	51.85	24	54.55
Total	71	100	27	100	44	100

Table 4 - Familiar precedents

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
With family prec.	21	29.58	7	25.93	14	31.82
Without family prec.	50	70.42	20	74.07	30	68.18
Total	71	100	27	100	44	100

Table 5 - Work time (years)

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
< 10	31	43.66	9	33.34	22	50.00
10 - 20	32	45.07	12	44.44	20	45.45
> 20	8	11.27	6	22.22	2	4.55
Total	71	100	27	100	44	100

Table 6 - Clinical data

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
Grade 0	36	50.70	15	55.56	21	47.43
Grade 1	7	9.86	4	14.82	3	6.82
Grade 2	5	7.04	1	3.70	4	9.09
Grade 3	23	32.40	7	25.92	16	36.36
Total	71	100	27	100	44	100

Table 7 - Functional breathing tests (Spirometry)

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
Normal	47	66.20	17	62.97	30	68.18
Obstructive	18	25.36	9	33.33	9	20.45
Restrictive	2	2.81	1	3.70	1	2.27
Mixed	4	5.63	-	-	4	9.10
Total	71	100	27	100	44	100

Table 8 - Radiographic data

	Total		Exposed		N/Exposed	
	1	2	1	2	1	2
O	53	74.65	19	70.40	34	77.27
L	11	15.49	4	14.80	7	15.91
P1	5	7.04	2	7.40	3	6.82
P2	1	1.41	1	3.70	-	-
P3	1	1.41	1	3.70	-	-
Total	71	100	27	100	44	100

O - Without pneumoconiosis radiographic images.
L - Numerous linear or netted opacities with a normal lung look or with texture increased or darkened.
P - Pointlike opacities with a size to 1.5mm.
1 - A small number of opacities in an area, equivalent as minimum to two intercoastal spaces and as maximum not bigger than one third of lung fields.
2 - More numerous and diffused opacities than in category one and distributed in great part of lung fields.
3 - Very numerous and profuse opacities that cover all or nearly all lung fields.

Table 9 - Relating precedent data with the state of small breathing canals.

Affection		Total		Exposed		N/Exposed	
	S.B.C.	1	2	1	2	1	2
Normal	No	29	40.85	7	25.93	22	50.00
Normal	Yes	18	-	10	37.04	8	18.18
Obstr.	Yes	18	59.15	9	33.33	9	20.45
Restr.	Yes	2	-	1	3.70	1	2.27
Mixed	Yes	4	-	-	-	4	9.10
Total		71	100	27	100	44	100

Table 10 - Exposed people group

Years work	< 10		10-20		> 20		
	Nº ind.	Nº les.	Nº ind.	Nº les.	Nº ind.	Nº les.	
XR Tests							
0/0	7	0	8	0	2	0	
L/1	1	1	1	1	2	2	
$P_1/2$	1	2	1	2	2	4	
$P_2/3$	-	-	1	3	-	-	
$P_3/4$	-	-	1	4	-	-	
	9		12		6		27
Total		3		10		6	19

Table 11 - Non exposed people group

Years work	< 10		10 - 20		> 20		
	Nº ind.	Nº les.	Nº ind.	Nº les.	Nº ind.	Nº les.	
XR Tests							
0/0	16	0	16	0	2	0	
L/1	5	5	2	2	-	-	
$P_1/2$	1	2	2	4	-	-	
$P_2/3$	-	-	-	-	-	-	
$P_3/4$	-	-	-	-	-	-	
Total	22		20		2		44
		7		6		0	13

Table 12 - Average lesion degree (%)

Years work	Exposed	Non exposed
< 10	33	32
10 - 20	83	30
> 20	100	0
Total	70	30

CONCLUSIONS

With the small sample of individuals studied the relation of data doesn't lead us to significative conclusions in the greater part of cases. This fact leads us to present only the grade of the average lesion per time of work for both considered groups (exposed/non exposed) corresponding the radiologic tests to a scale from 0 to 4.

As we can conclude from the table 12 the average lesion degree is similar into two groups for time of work under 10 years. It is stablein the non exposed group, increases progressively in the other group and triplicates in those above 20 years of work.

The degree of the total average lesion in the exposed group is two point three times the non exposed group.

Yet, the frequency of the lesion in both groups isn't significative.

We suggest as technical prevention measures the following:

- Moving the place of the deburring department where there is risk to the same level as the other one. The dust that affects it, is a result of the captation system of the other burring machine.
- Setting a ventilator in the chimney in the foundry department and isolating the workers.
- Checking the captation system and good mantainance of it in the mechanic and authomatic polisher department.
- The existent manual turners should be reduced to the minimum until further substitution.
- In the sand treatment and metal recuperating department the sift should be authomatically done as well as appropriate masks and gloves must be used.
- In the galvanoplasty department, the machine to shake off the dust must be isolated and the work of the refrigerating serpentine must be checked and setting on the existent ventilating system during the process of work. Try to change the suspending device of the shake off pieces to reduce to the minimum the opening time of machine.

FUEL GAS AND CHARCOAL FROM WOOD WASTES

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INTRODUCTION

The utilization of agricultural and forest residues as raw materials for the production of energy and chemicals is deserving a growing interest.

In Portugal, the energetic potential of these residues alone has been estimated as 2 Mtpe/year. The utilization of this resource in full may not be practical, due to the costs of collection and transportation. However, industrial wastes such as sawdust, wood shavings, pine bark and cork powder are available in amounts larger than 100 t/day[1] and may be used in situ at little or no cost.

The main routes for the conversion of such wastes into energy are summarized in Fig.1.

Among the thermochemical methods, pyrolysis and gasification have been developed to the commercial stage; they are simple, versatile and involve conventional technologies.

Pyrolysis or thermal decomposition under inert atmosphere produces liquid, solid and gaseous products. Gasification, involving reaction with an oxidizing agent such as air, oxygen, steam or carbon dioxide, is used to maximize the production of gases. The latter process consists in a sequence of steps occurring at successively higher temperatures: pyrolysis (573-773K) originating volatile matter and char, secondary reactions of the evolved volatile

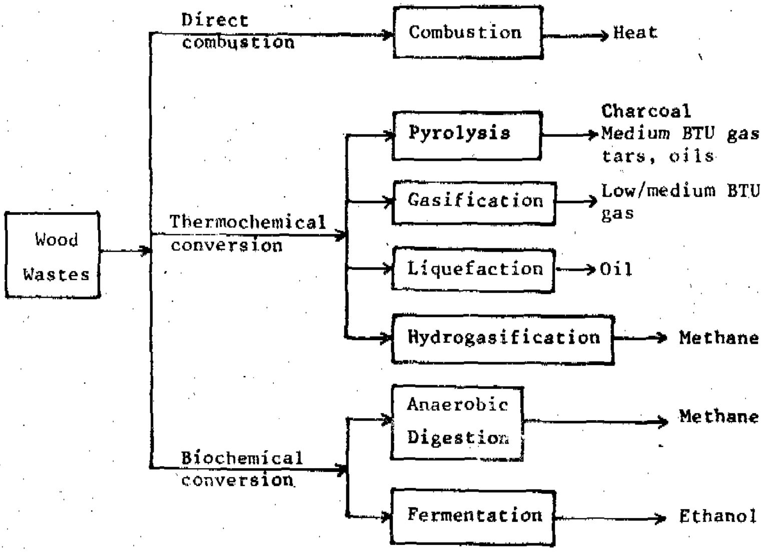

Fig. 1. Energy conversion of wood wastes

matter in the gas phase (> 873K) and char gasification (> 973K).

Complete char gasification with air introduces too much nitrogen in the product gas, thereby decreasing its heating value. An alternative approach would be to operate the reactor to produce fuel gas and charcoal. This is an economically attractive option provided that a suitable market can be found for the charcoal. For instance, it may be used in the manufacture of briquettes or activated carbon.

The process could be further improved if an activated carbon were produced directly in the reactor. This would require operation at the right temperature in order to promote partial gasification of the carbon (20–30%), thereby opening up the pore structure of the solid and increasing its surface area.

Such a scheme is used in the "Carbonization and Gasification Chamber" (CGC), designed and built by Carbotécnica (Lisbon)[2].

This unit has no internal moving parts; instead, it is positioned at such an angle that the solids slide down the reactor in countercurrent with the gas. A vibrating tray, fed by a conveyor belt, delivers the solids directly on top of the CGC. The speed of the conveyor controls the flow rate of solids. The average residence time of the solids in the CGC is 1-2 hours at temperatures of the order of 1073-1173K. The charcoal is extracted at the bottom after quenching by water injection. The energy needed to carry out the process is obtained by combustion of a portion of the gas inside the CGC. To to so, air is admitted through a register located at the bottom of the CGC above the level of solids. The amount of air admitted must be carefully controlled, otherwise the heating value of the gas produced will be very low.

The gas produced can be used as fuel in boilers or furnaces. Close coupled applications are most suitable, in order to take advantage of the sensible heat of the gas.

In this communication, we report our results on the pyrolysis of wood wastes such as sawdust to produce fuel gas and activated carbon.

EXPERIMENTAL

Dry sawdust with an average particle size of 0.63mm was used in the laboratorial experiments.

Thermograms were carried out in a CI Electronics MK 2B microbalance with a suitable flow attachment, electric furnace and a Stanton Redcroft linear temperature programmer, so that the sample weight changes associated with a linear increase in temperature were continously recorded.

Pyrolysis and gasification yields were determined in a tubular reactor: a silica tube was packed with about 8g of sawdust, a flow of nitrogen was established (4.5×10^{-4} mole/s) and the tube was inserted into an electric furnace.

The effluent from the reactor was passed through a cold trap to condense the volatile products and the gases were vented. Occasionally, samples of the gas were collected and analysed in a Varian 1400 gas chromatograph fitted with a Poropak Q column (1/8"; 3.7m long) and a thermal conductivity detector. Yields of liquids and solids were determined by weighing, yields of gases were calculated by difference.

Specific surface areas of the chars were determined from nitrogen adsorption data at 77K by the BET method.

True and apparent densities were determined by helium and mercury porosimetry, respectively.

RESULTS AND DISCUSSION

Pyrolysis

A thermogram of sawdust under nitrogen flow is shown in Fig.2.

It can be seen that most of the volatile matter is evolved in the temperature range from 520-550K. From the composition of pyrolytic gases shown in Fig.3, it can be concluded that high temperatures favour the production of CO and H_2 while low temperatures favour the production of CO_2 and CH_4.

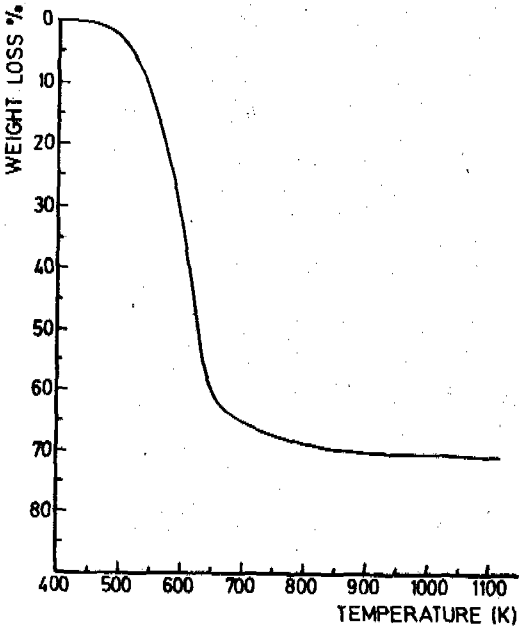

Fig. 2. Thermogram of sawdust under nitrogen flow (2.2×10^{-4} mole/s) Heating rate 10K/min.

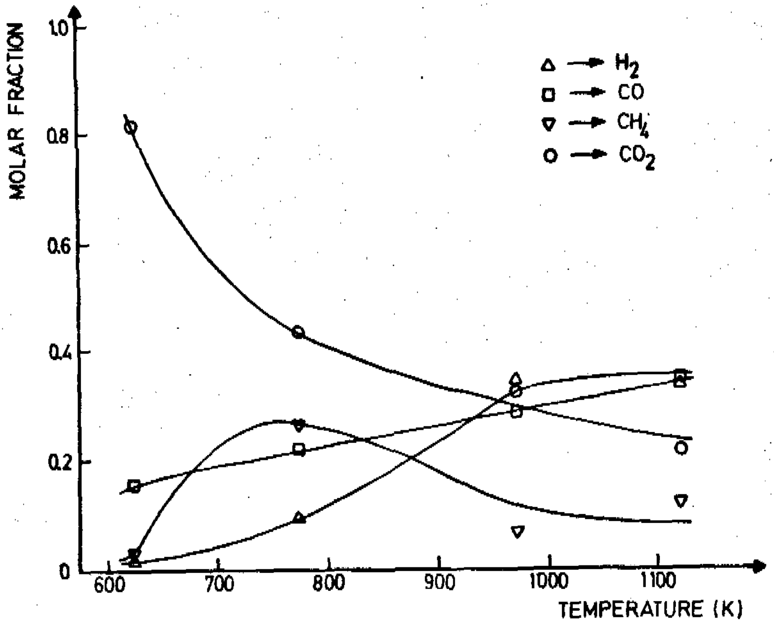

Fig. 3. **Composition** of pyrolytic gases.

In addition, the yields of char, gases and liquids were determined in the temperature range 673-1073K. It was observed that the yield of the liquid fraction goes through a maximum in the temperature range 773-873K. Operation at higher temperatures favours the production of gases at the expense of larger molecules due to the increasing importance of cracking reactions. Indeed, extrapolation shows that the liquid fraction will be negligible at temperatures higher than 1073K. This is an important finding, since the product gas is required free of tars to avoid condensation and fouling of downstream equipment.

The char obtained by pyrolysis for about 1 hour at 1123K has a surface area of $98m^2/g$; the char yield is 29% and the lower heating value of the pyrolysis gas produced is about 8.2×10^3 KJ/m^3.

Char gasification

The chars obtained by pyrolysis are suitable raw materials for activated carbon manufacture by parcial gasification. A detailed study was carried out in the laboratory, using CO_2 as the activation agent.

FIGUE1REDO

It was observed that the specific surface areas increase with increasing temperature up to 1098K (Fig. 4).

Gasification at higher temperatures occurs in the diffusional regime with no further activation[3].

The influence of the extent of activation upon the specific surface areas is represented in Fig. 5, showing that a plateau is reached after about 1 hour.

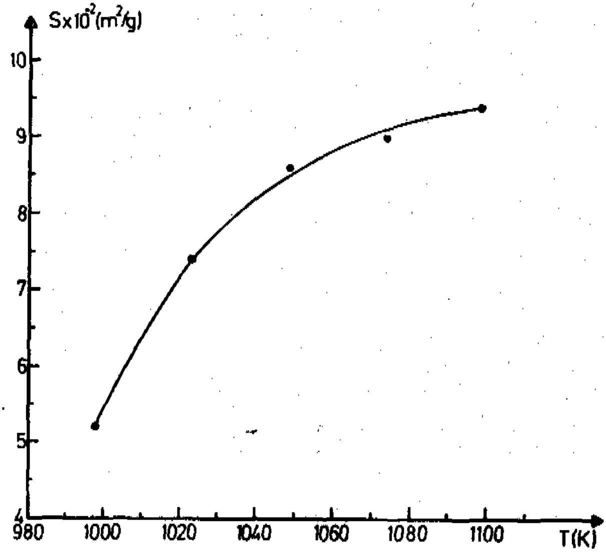

Fig. 4. Change in specific surface area (S) with gasification temperature (T).

Pyrolysis temperature	1123K
CO_2 flow	4.5×10^{-4} mole/s
Extent of activation	60 min

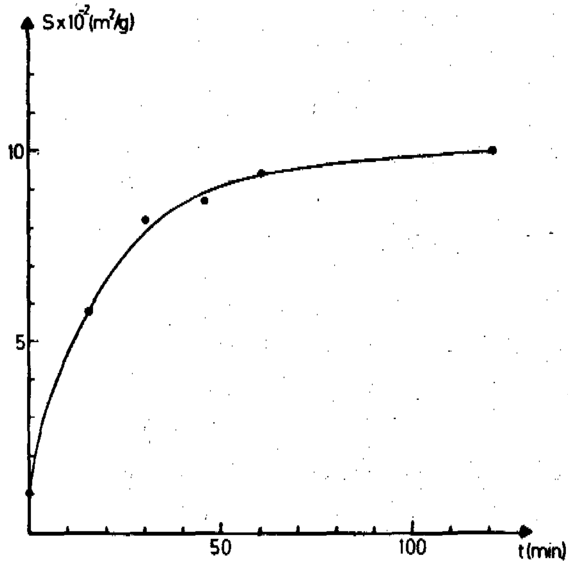

Fig. 5. Change in specific surface area (S) with the extent of activation (t)

Activation temperature	1098K
Pyrolysis temperature	1123K
CO_2 flow	4.5×10^{-4} mole/s

So, an activated carbon with a specific surface area of 940 m^2/g is obtained after carbonization at 1123K and gasification to a burnoff of 18% at 1098K for 1 hour.

The results of the present study show that activated carbons of high surface area may be obtained from wood wastes in a gasifier environment together with a combustible gas free of tars, provided that the temperature is conveniently chosen.

INDUSTRIAL EXPERIENCE

Results obtained in the industrial scale reactor (CGC) show that the heating value of the produced gas depends on the moisture of the raw material according to:

$$PCI = 6.8 \times 10^3 - 89H$$

where PCI - lower heating value KJ/m^3 dry gas STP
H - % moisture

In addition, samples of charcoal obtained in the CCC were characterized as show in Table 1 by determination of the true densities, ρ_r, and total pore volumes, V_p.

Table 1. Textural characterization

Material	ρ_r (g/cm^3)	V_p (cm^3/g)
Pine cones	1.61	0.516
Charcoal 95/40*	1.82	1.72
Charcoal 30/35*	1.90	1.66

*Charcoal x/y means that the insufflation of steam was y kg/hr and the production of charcoal was x kg/hr.

The results confirm that, during the operation of the CGC, the pore structure of the charcoal may be developed to such an extent that it may be used as an adsorbent.

Aknowledgements

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COST ESTIMATION OF DIFFERENT

AMBIENT WATER QUALITY PROTECTION POLICIES

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INTRODUCTION

Beneficial uses of ambient waters in a part of West Morava river basin are defined by Federal Regulations as: public water supply, fishery, irrigation and recreation. All ambient waters are classified and strict water quality criteria are set. But, due to rapidly increasing population migration towards river valleys, pollution loads were also considerably increased in recent years and water quality standards are in some places violated, wholly or partially (carbonaceous or /and nitrogenous BOD too high, low content of dissolved oxygen, too many coliforms in water, etc.).

This report presents an approach for solving serious ambient water quality deterioration in part of West Morava river basin with drainage area of 1250 sq. kilometers and total river length of 94 kilometers.

A mathematical model of water quality in West Morava, based upon the program STEKAR (Gherini and Summers, 1978), was made and calibrated. Different alternatives for waste water treatment (point sources only) were proposed - each one consisting of a set of prescribed degrees of waste water treatment for each point source (Filip and Obradović, 1984). The effects of alternative solutions were then analysed on the mathematical model for the low flow conditions.

CLASSIFICATION OF AMBIENT WATER QUALITY IN THE STUDY AREA

Ambient water quality classification is given in Table 1. Classes I, II-a and II-b respectively correspond to categories A_1,

A_2 and A_3 as defined by the Council of European Communities (Luxemburg, June 1965).

Table 1. Classification of Ambient Waters

River Class	Class Limiting Parameter	Criteria Value*	Water Use
I	Dissolved Oxygen	8	. Drinking Water Supply (Disinfection only)
	BOD_5	2	
	TDS	350	. Fishery
	Coliforms	200	. Recreation
II A	Dissolved Oxygen	6	. Drinking Water Supply (Conventional treatment)
	BOD_5	4	
	TDS	1000	. Fishery
	Coliforms	6000	. Recreation
II B	Dissolved Oxygen	5	. Substantially the same as for II A
	BOD_5	6	
	TDS	1000	
	Coliforms	6000	
III	Dissolved Oxygen	4	. Industrial Water Supply
	BOD_5	7	
	TDS	1500	
	Coliforms	10000	
IV	Dissolved Oxygen	0.5	. Out of use
	BOD_5	unlimited	
	Coliforms	unlimited	

* All values in mg/l. Coliforms in MPN/100 ml

VIOLATIONS OF AMBIENT WATER QUALITY STANDARDS IN THE STUDY AREA

Measurements of ambient water quality as well as point sources pollution emission in different river flow conditions were conducted for one-year period. These data were then used for Model calibration, i.e. determination of reaeration constants, decay rates and other constants.

The calibrated model was used for simulation of ambient water quality in low-flow conditions for cases:

- no waste water treatment,
- effects of different degrees of waste water treatment.

Violation of ambient water quality standards for pollution loads as measured in 1978/79 and predicted pollution loads in 1985 and 1990 are presented in Table 2.

Table 2. Extent of Ambient Water Quality Standards Violation

River	Total Length km	Length of River Reach where WQ are Violated km					
		BOD_5			Dissolved Oxygen		
		1978/79	1985	1990	1978/79	1985	1990
West Morava	61	61	61	61	0	0	0
Despotovica	15	0*	0*	0*	10	10	10
Dičina	12	9	9	9	9	9	9
Čemernica	6	6	6	6	6	6	6

* There is no limitation of BOD_5 concentration in Despotovica river – from the waste water inflows down to the Dičina river, due to its classification in IV Class.

DEFINITION OF AMBIENT WATER QUALITY PROTECTION POLICIES

The step-wise ambient water quality improvement is accepted as a policy, so the costs will be more easily met.

Ambient water quality goals are listed in the Table 3., given as maximum permissible concentration (MPC). Complete removal of floating debris, grease and oil as well as substantial removal of coliforms are anticipated. Implementation of the third degree of protection ensures the class of stream prescribed by Regulations. Water quality of this stream is wholly protected. If the fourth degree of protection is introduced, some of river reaches may attain a higher class.

Table 3. Ambient Water Quality Improvement Goals

Degree of Protection	Prevention of MPC Violation				Improvement of Stream Category
	Toxic Materials and Coliforms	Dissolved Oxygen	Suspended Solids	BOD_5	
First	+				
Second	+	+			
Third	+	+	+	+	
Fourth	+	+	+	+	+

BENEFITS OF THE IMPLEMENTATION OF CERTAIN DEGREES OF PROTECTION

The benefits to be gained from this step-wise protection of deteriorated ambient water quality are as follows:

First Degree of Protection

Benefits of applied first degree of protection are:

- water may be used for watering of cattle and irrigation;
- WQ in downstream reaches will be improved, with a corresponding benefit to local users;
- aquatic population is protected;
- aesthetic appearance of the stream and environment will be improved;
- better situation in water supply system located further, downstream, either in the case of direct intake, or in the case of infiltration basins/ground water aquifer use.

Second Degree of Protection

Benefits of applied second degree of protection are:

- all positive effects of the first degree are included plus the following benefits:
  . further improvement of water quality for all uses;
  . prevention of septic conditions in some river reaches;
  . better self-purification characteristics of the stream;
  . full protection of aquatic life;
  . possibility of using the river for recreation.

Third Degree of Protection

Benefits of applied third degree of protection are:

- all positive effects of the both previous degrees of protection are included plus the following benefits:

  . return of the stream in its class as prescribed by Regulations;

  . guaranteed possibility of using river for water supply of towns and industry with usual treatment only;

  . better organoleptic characteristics of water;

  . reduction of water quality deterioration in distribution network.

Fourth Degree of Protection

Benefits of applied fourth degree of protection are:

- all positive effects of all three previous degrees of protection are included plus the following benefits:

  . improvement of water quality in river Despotovica, from Gornji Milanovac to Dičina, enough to raise it to a higher class. Water quality in Dičina, Čemernica and West Morava will be than better to such a degree that reclassification of these rivers will be achieved.

NECESSARY DEGREE OF WASTE LOADS REDUCTION AND COST ESTIMATION

A desired degree of protection can be achieved only by applying the definite level of waste water treatment. Standardized waste water treatment plants for towns nave been supposed and unit costs calculated. These plants can be upgraded and enlarged if such a necessity arises later. For industrial wastes that are not compatible with municipal ones, separate physico-chemical treatments or pretreatments are foreseen. Several alternatives with different degree of waste water treatment have been simulated on a computer (Filip, Obradović, 1984), and feasible solutions for ambient water quality protection in the region were elaborated.

Investment costs were based on 1980 prices level. Annual costs consist of annuities for civil works based on 13.6 percent of investment, annuities for equipment based on 16.2 percent of equipment costs as well as operational and maintenance costs.

Necessary degree of waste loads treatment as well as investment and annual costs for 1985 and 1990 pollution are presented in Table 4 and Table 5, respectively.

Table 4. Necessary Degree of Treatment and Costs of Protection for 1985 Pollution

Degree of Protection	Pollution Source	Treatment Level	Treatment Costs (10^6 din.) Investment Costs	Annual Costs
First Degree of Protection	Čačak II	P	98.81	20.98
	Industry	FH	18.79	4.42
	Paper Mill	FH	15.30	4.46
	Trbušani	FH	10.89	3.94
	G. Milanovac	P	85.40	20.28
	T o t a l:		229.19	54.08
Second Degree of Protection	Čačak II	S	166.29	37.42
	Industry	FH	18.79	4.42
	Paper Mill	FH	15.30	4.46
	Trbušani	FH	10.89	3.94
	G. Milanovac	P	85.40	20.28
	T o t a l:		296.67	69.87
Third Degree of Protection	Čačak II	S	166.29	37.42
	Industry	FH	18.79	4.42
	Paper Mill	FH	15.30	4.46
	Trbušani	FH	10.89	3.94
	G. Milanovac	S	121.41	31.90
	T o t a l:		332.63	82.19
Fourth Degree of Protection	Čačak II	S	166.29	37.42
	Industry	FH	18.79	4.42
	Paper Mill	FH	15.30	4.46
	Trbušani	FH	10.89	3.94
	G. Milanovac	T	157.16	41.74
	T o t a l:		368.43	91.98

P : Primary Treatment (BOD_5 Reduction 30 percent, SS Reduction 60 percent).

S : Secondary Treatment (BOD_5 Reduction 85 percent, SS Reduction 85 percent).

T : Tertiary Treatment (BOD_5 Reduction 96 percent, SS Reduction 96 percent).

FH: Physico-Chemical Treatment of Industrial Waste Waters.

Table 5. **Necessary Degree of Treatment and Costs of Protection for 1990 Pollution**

Degree of Protection	Pollution Source	Treatment Level	Treatment Costs (10^6 din.) Investment Costs	Annual Costs
First Degree of Protection	Čačak II	P	111.47	24.10
	Industry	FH	21.67	5.20
	Paper Mill	FH	20.40	5.79
	Trbušani	FH	27.28	5.21
	G. Milanovac	P	97.96	22.62
	T o t a l:		278.78	62.92
Second Degree of Protection	Čačak II	S	195.49	44.41
	Industry	FH	21.67	5.20
	Paper Mill	FH	20.40	5.79
	Trbušani	FH	27.28	5.21
	G. Milanovac	S	145.97	38.34
	T o t a l:		410.81	98.95
Third Degree of Protection	Čačak II	T	254.14	57.73
	Industry	FH	21.67	5.20
	Paper Mill	FH	20.40	5.79
	Trbušani	FH	27.28	5.21
	G. Milanovac	S	145.97	38.34
	T o t a l:		469.46	112.27
Fourth Degree of Protection	Čačak II	T	254.14	57.73
	Industry	FH	21.67	5.20
	Paper Mill	FH	20.40	5.79
	Trbušani	T	35.46	6.78
	G. Milanovac	T	189.76	49.84
	T o t a l:		521.43	125.34

P : Primary Treatment (BOD_5 Reduction 30 percent, SS Reduction 60 percent).
S : Secondary Treatment (BOD_5 Reduction 85 percent, SS Reduction 85 percent).
T : Tertiary Treatment (BOD_5 Reduction 96 percent, SS Reduction 96 percent).
FH: Physico-Chemical Treatment of Industrial Waste Waters.

Cost estimation for protection measures for 1990 pollution are based on assumption that no actions are taken before 1990.

SUMMARY AND CONCLUSIONS

The mathematical model describing the ambient water quality in West Morava watershed are used for evaluating different water quality protection policies. For anticipated degrees of ambient water quality protection necessary decrease of pollution emission for 1985 and 1990 is evaluated and costs are estimated.

ACKONOWLEDGEMENTS

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REVERSE OSMOSIS PROPERTIES OF CELLULOSE ACETATE COAL MEMBRANES

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INTRODUCTION

The preparation and properties of cellulose acetate membranes have been investigated from many workers. Such membranes are well known and commercially available. Even though the cellulose acetate membranes enjoys the better status in comparation with other membranes, further hopes and expections were to get a membranes with good and reliable characteristics. These characteristics (product rate and solute separation) are achieved by different types of casting solutions[1,2] or different materials, respectively additives.[3,4,5]

In literature are the data for uses a sulphonated Coal, Saito[6], lignite and brown Coal, Tominage at al,[7] and low carbonating Coal "crushed lignite", Tatsuyama at al,[8] for removing a heavy metals from solutions and wastewaters, but lack of data for uses a Coal for preparation of reverse osmosis membranes.

S.Gashi and N.Daci[9,10] used Kosova's lignite as additive for preparation of asymmetric reverse osmosis membranes.

In previous papers reverse osmosis properties of cellulose acetate Coal membranes have been introduced. In these studies were described casting conditions and effect of coal on preparation of such membranes. It was pointed out that these membranes showed good properties respectively the same characteristics (product rate and solute separation) in comparation with those of cellulose acetate under same conditions.The advantages of such membranes showed enough promise to justify the farther research.

This work is the next step toward preparation of cellulose acetate-coal membranes of solute composition cellulose acetate-coal (1:1.5),acetone,dioxane,magnesium perchlorate and water.As we showed above the primary materials for preparation of these membranes were cellulose acetate and coal.For such reason,and because the higher amount of coal is used for its preparation,the membranes are named "Cellulose Acetate-Coal membranes". The casting solution composition cellulose acetate-coal of mass ratio (1:1.5) has been to modify the characteristics of these membranes.

Reverse osmosis preparation and properties of these membranes were the basic aim of this work.

EXPERIMENTAL

Materials

Eastman cellulose acetate E-398-3 with degree of acetilation 39.8% and Kosova basen coal were used as primary materials in this work.

Coal preparation

The Kosova basen Coal was treated with boiled water with stirring.The residual coal after filtering was dried at 105°C to constant weight,grounded and fractionated.The fractions of o.24 meschis then were used. The elemental analysis and functional groups of lignite used are given in literature[1o].

Membrane preparation

Casting solution composition of cellulose acetate,and reagent grade acetone,dioxane,magnesium perchlorate, water and Coal were employed.The film casting details in present study are given in table 1.

Tablel.Film casting details

Casting solution composition,mass%	
Cellolose acetate (E-398-3)	10
Coal	15
Acetone	42.o6
Dioxane	19.23
Magnesium perchlorate	1.45
Water	12.25

Temperature of casting solution:24°C
Temperature of casting atmosphere:24°C
Casting atmosphere:ambient air(rel.humidity 6o%)
Solvent evaporation period:zero min.
Gelation medium:ice cold water
Film shrinkage temperature 88°C

The membrane were cast in a glass plate at zero period of solvent evaporation.After being cast,the membranes were allowed to remain in gelation bath one hour,and were heat treated to desired temperature,which controlled to within ± 1/2 °C for 1o minutes.Membranes were shrunk at the same temperature,ie 88°C in which we got the near same surface pore structures and hence the slighty different solute separation at present operating conditions.The thickness of asymmetric reverse osmosis membranes was ~ 0.082 mm.

Reverse osmosis experiments

Reverse osmosis experiments were done employing the standard reverse osmosis apparatus[12] and usual experimental procedure.These experiments were carried out at $17.63x10^5$Pa using feed solution containing 0.00685M of sodium chloride.The behaviour of membranes with another inorganic salts and aquoeus solution of phenols of feed concentration of 0.0022M were also studied. Before the reverse osmosis experiment each film was subjected to a pure water pressure treatment for one hour at $20.01x10^5$Pa.

All experiments were of the short run type and performed at temperature of 25°C.A feed flow rate of $450dm^3$/min. was used giving a mass transfer coefficient $k=45x10^{-4}$cm/sec on the high pressure side of the membrane as calculated by the Kimura-Sourirajan analysis of experimental reverse osmosis data[13]. A constant k was kept constant in all experiments.

For all salt concentrations,a conductivity bridge was used for analysis.

In each experiment the solute separation,f,defined as

$$f = \frac{\text{solute conc.in feed mol/dm}^3 - \text{sol.conc.in product mol/dm}^3}{\text{solute conc. in feed mol/dm}^3}$$

the product rate,Pr,in gram per hour, and pure water permeation rate,PWP,in gram per hour per given area of film surface 13.52 cm^2 were determined.The concentration of phenols are determined by bensenquinoline method.[11]

RESULTS AND DISCUSSION

Cellulose Acetate-Coal membranes were characterised in terms of pure water permeability constant A, solute transport parameter, $D_{AM}/K\delta$. The product rate and solute separation obtainable with a membrane so specified is a functions of the mass transfer coefficient, k, on the high pressure side of the membrane. The values of these parameters for aquoeus solution of sodium chloride are presented in table 2.

Table 2. Membrane Specification Data

Film no.	$A\times10^{-5}$ mol H_2O / cm^2 sec Pa	$D_{AM}/K\delta \times10^{-4}$ cm/sec	Feed conc, 0.00685M NaCl $k=45\times10^{-4}$ cm/sec	
			sol.sep.%	prod.rate g/h
1	6.12	51.95	69.54	88.66
2	4.74	47.00	68.46	69.52
3	4.9	57.51	64.36	71.41
4	5.08	63.39	62.85	75.05
5	7.37	125.86	51.18	108.64
6	8.34	146.26	48.7	121.9

The data given in table 2 on the values of A and $D_{AM}/K\delta$ for sodium chloride at 17.63×10^{5} Pa specify the membranes used in the present studies.

As expected the values of solute transport parameter $D_{aM}/K\delta$ increase with decreases in solute separation and with an increase in product rate. The membrane pore size represented by $D_{AM}/K\delta$ from 51.95×10^{-4} cm/sec to 146.26×10^{-4} cm/sec showed high productivity of membranes used at low operating pressure.

Two types a presentation of data $D_{AM}/K\delta$ vs. A, and product rate solute separation could be taken in consideration to show difference in properties of these membranes and their behaviour in comparation with those reported erlier[10]. For the sake of clarity we can write down membranes as follows: 1. Cellulose Acetate ; 2. Cellulose Acetate-Coal (1:1) ; and 3. Cellulose Acetate-Coal membranes (1:1.5).

The data of solute transport parameter $D_{AM}/K\delta$,vs. pure water permeability constant, for 1,2,3 types of membranes are shown in fig1.

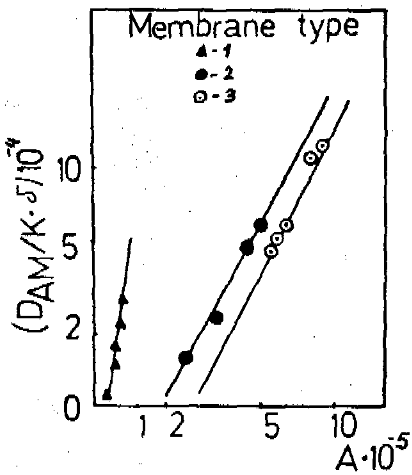

Fig.1. Specification of membranes at 17.63×10^{5} Pa

The data of solute transport parameter, $D_{am}/K\delta$,vs. pure water permeability constant, shows that characteristic lines of membranes 3 are located to the right of lines for membranes 1 and 2, which indicates that membranes 3 posses better properties, ie. bigger number of pores in surface layer according to Kunst at al[2].

From the membrane properties(product rate and solute separation) fig.2. it should be pointed out that for reference system of aqueous solution of sodium chloride and other monovalent salts these membranes shows slight imprpvement in performances.The optimum performance of membranes was defined as the maximum product rate at a specific degree of salt rejection which was chosen arbitrarily at 7o % for NaCl in this study.The order of selectivity is the same in three types of membranes, respectively threevalent and twovalent salts separates better than monovalent salts.

Membranes of such properties are used for determination of reverse osmosis characteristics of following inorganic salts:$NaCl-H_2O$,$NaF-H_2O$,$NaNO_3-H_2O$,$Na_3PO_4-H_2O$,$CuSO_4-H_2O$,$MnSO_4-H_2O$,$CdSO_4-H_2O$,$ZnSO_4-H_2O$,$MgSO_4-H_2O$,and aqueous solution of phenols.The product rate and solute separation of mentioned salts with membranes [illegible] are also shown in fig 2.

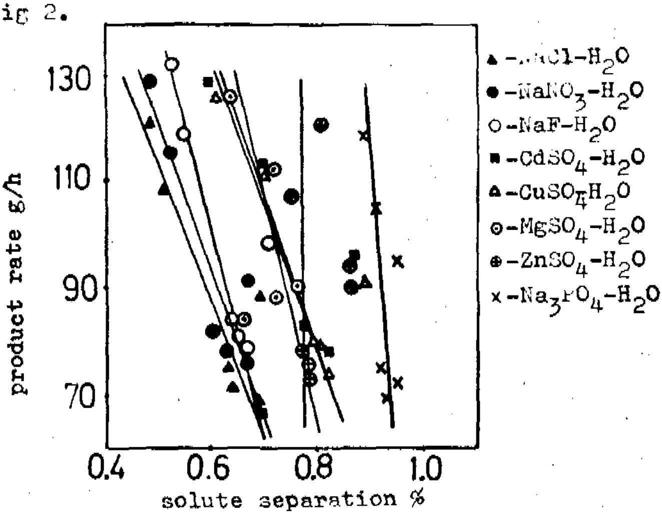

Fig 2.Solute separation and product rate of inorganic salts

It is evident that characteristics (relative selectivity and esspecially a product rate) of membranes 3 are superior for three and two valent salts in comparation with previous membranes[10]. For same films the product rate is two to three times more. As we idicated previosly[10] Coal affects in characteristics of membranes. Now, it could be concluded that icreasing a content of coal imprøved considerably performances of membranes as we shows above.

These membranes are tested also with o.oo22M aqueous solution of phenols.

The data of separation and product rate of phenols are shown in table 3.

Table 3. Solute separation and product rate of phenols by membrane 3.

Film no	solut.sep.%	product rate g/h
1	89.8	85.53
2	77.33	62.57
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Data from table 3 shows that solute separation of phenols is up to 93% with higher product rate. These membranes looks to be also iteresting for separation of organic substances, which needs further investigation. By the end we can conclude that these membranes have following advantages:

Coal was treated only with boiled water, ie low cost of membranes.

Membranes are made under normal conditions,respectively evaporation rate was zero minutes.
Membranes showed much better flux in comparation with Cellulose acetate membranes in low operating pressure ie. very productive membranes.
Membranes can be used for treatment of similar system and waste waters.
Membranes can be used also for separation of aqueous solutions of organic substances.

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CHARACTERIZATION AND TREATMENT OF

SWINE EFFLUENTS IN PORTUGAL

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1 - INTRODUCTION

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- High pollutant load
- Diversity of the installations size
- Great dispersion through the country
- Very disordered growth

Even though it will be difficult to make a precise inventory and to determine the exact impact that they have in the quality of the national inland waters, it is possible, using some officiai data, to present the following map. In this map, it is presented for each district, the swine population, as well as the number of installations working as closed cicle. In a general way, the pollution produced in Portugal by the several sectors of activity; domestic, industrial and cattle breeding are expressed in terms of equivalent

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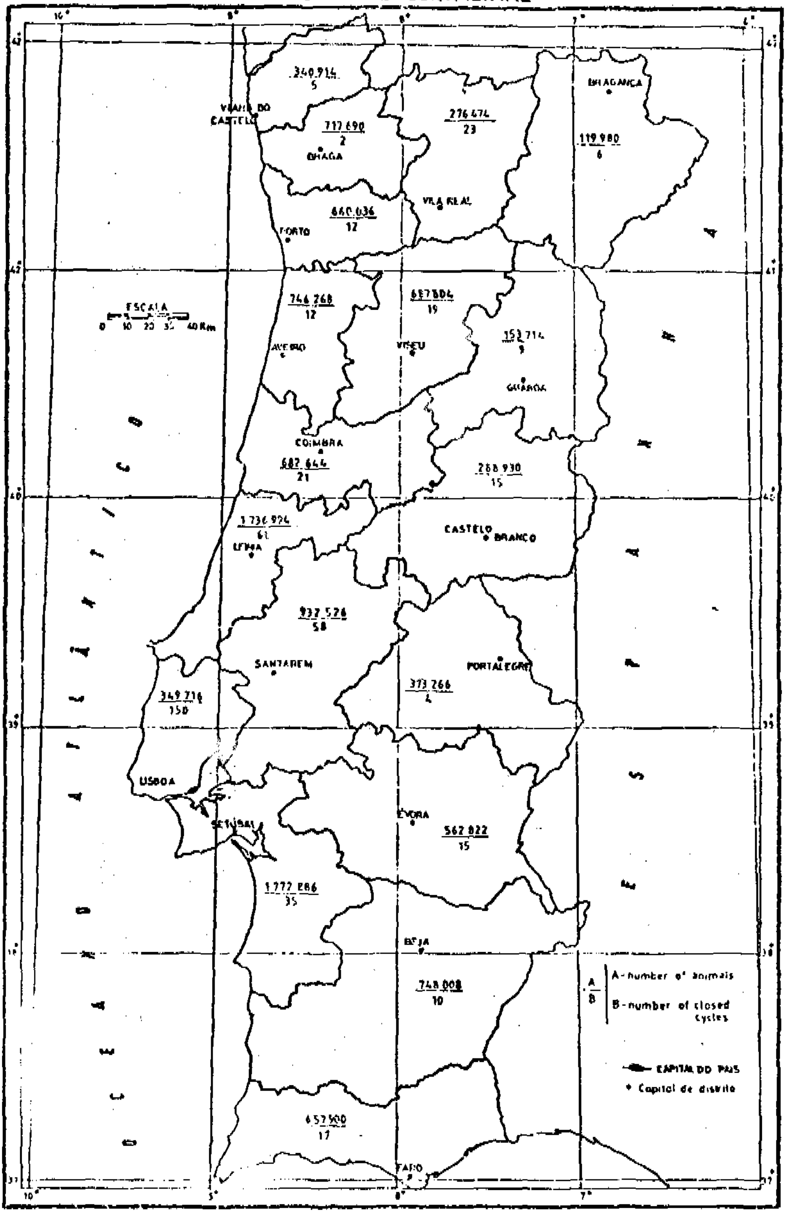
PORTUGAL CONTINENTAL



habitants as follow:

Domestic Pollution	9.291.519 (eq.-hab.)
Industrial Pollution	20.849.226 (eq.-hab.)
Cattle Breeding Pollution	14.917.440 (eq.-hab.)
Total	45.058.185 (eq.-hab.)

The two fundamental types of cattle breeding pollution are due to

Bovines	8.890.654 (eq.-hab.)*
Swines	6.026.786 (eq.-hab.)

So, the swine breeding installation are responsible for about 13,4% of the pollution produced in Portugal. Even though the disper tion of the installations all over the country, it is in the district of Setubal, Leiria, Santarém, Évora and Beja that their concentration is higher.

With the present publication, we intend, using specialized thecnical bibliography and some data already existent in our country, to make a characterization as precise as possible of the swine breeding effluents in Portugal and suggest some possible treatments. It will be also mentioned the more important phases of this breeding process and present the results of some analyses not only of the global effluent but also of the sectorial effluents, carriyed on some portuguese installations.

2 - GENERAL DATA OF SWINE BREEDING INSTALLATIONS

2.1. - Types of Installations and Sections

Even though the great diversity in size of the swine installations, they can be divided in two big categories:

*Small impact in the inland waters because most of the animals are in pasturing.

- Closed cycle installations
- Fattening installations

In the closed cycle installations, there are fundamentaly five sections:

- Boars section: The boar is installed in an individual division, due to its agressived characteristics and near the installations of the reprodutive sows. Each boar weights generally between 250-270 Kg.
- Gestation section: the sows in gestation are in individual divisions or in groups. The gestation period is about 90 days and the sows weight is generally between 170-180 Kg.
- Nursery section: in this section, the mother sow and the shoats cohabit in individual divisions till the shoats weight is about 5 to 6 Kg.
- Fattening section: in this zone the animals are in groups and in general, the area per animal varies between 0,8-1,2m^2.

2.2. - Types of Stabling

As far as stabling type is concerned, there are mainly three types:

- Concret pavement with straw bed
- Concret pavement without straw bed
- Stabling on slotted floors

The first type is not usual in Portugal and is used only in some very small installations. In this case, most of the liquid waste and the total of the solids stay on the straw, carrying the effluent only part of the urine and the washing waters. In the other two types, the effluents carry all the lees and urines together with the washing waters, having these a weekly or daily periodicity. The pollution caused by this two types of stabling is much higher than the straw bed stabling.

3 - BASES TO DEFINE THE TREATMENT PROCESS

As far as treatment process is concerned, its choose must be based on the following aspects:

- Characteristics of the residual waters
- Destination of the final effluent
- Thechnical means avaiable

In order to can estimate the average characteristics of the residual waters, it is necessary to take into account the following aspects:

- Type of stabling
- Average weight of the animals presents
- Type of feed
- Water consumption (washing and drinking waters)
- Use of periodic desinfections

The average weight of the animals depend on sex, age ... As far as type of feed is concerned, when the animals are fed with milk serum, the ammount of urines is higher than if the feed is based on cereals. In general, the daily waste production, expressed in Kg/day is more or less 7,5-8% of the animals weight. The volume of water used, depends on several factors such as: type of feedlots, type of feed and animals age. The total water consumption is due to drinking and washing waters.

In Portugal, and based on some informations obtained, the majority of the swine breeding installations make daily washings with a range of 1 to 9 l/pig.day. In average, the drinking water consumption is about 5 to 9 l/pig.day.

Table 1. Amount of Lees and Urines Accordingly the Animal Weight

	Feed based on cereals					
	30 Kg	50 Kg	80 Kg	Pregnant sows		Sucking sows
				150 Kg	200 Kg	250 Kg
Lees (Kg/day)	0,53	0,62	1,27	0,63	0,93	2,14
Urines (1/day)	1,90	2,20	3,50	6,30	8,60	3,70

Table 2. Amount of Urines Depending the Type of Feed

	Type of feed	
	Serum	Cereals
Urines (1/day)	8 - 15	3 - 4

Table 3. Dringing Water Consumption Accordingly the Animal Weight

Animal	Weight (Kg)	Water Consumption
Shoats	6	0,1 1/day
	9	1,0 1/day
	20	2,2 1/day
	20 - 50	2,2 - 3,5 1/day
Pigs	50 - 100	2 - 31/Kg dry food
Boars	-	12-15 1/day
Pregnant sows	-	8-12 1/day
Sucking sows	-	10 1/day + 1,5 1/ /shoat

In Portugal, are often considered as average characteristics of he swine wastes, the following values, expressed in g/Kg animal weight.day.

Waste amount	74,00
Total solids	8,90
Total volatile solids	5,40
BOD_5	3,10
COD	6,40
Nitrogen (NH_4^+)	0,24
Total nitrogen	0,51
Phosphorus (P_2O_5)	0,42
Potassium (K_2O)	0,40

In the case of a pig of 60 Kg (average weight of an animal in a closed cycle), the daily amounts will be as follow:

Waste amount	4,44 Kg
Total solids	534 g
Total volatile solids	324 g
BOD_5	186 g
COD	384 g
Nitrogen (NH_4^+)	14,4 g
Total nitrogen	30,6 g
Phosphorus (P_2O_5)	25,2 g
Potassium (K_2O)	24,2 g

In a general way, the estimation of the number of animals present in a feedlot is based on the number of sows considering that for each sow there are 8,5 animals. Based on the values presented, there is a charge of 534g of total solids per animal and per day, with a 60,7% of volatile solids. These values are so 9 times higher than those to the domestic sewages. In average, we will have a COD/$/BOD_5$=2,065, what shows that these effluents can easily, he treated by a byological process, if inhibiting compounds will not be present (antibiotics or desinfectants).

Considering a water consumption of 15 l/animal.day we will have the following average characteristics of the residual waters:

Total solids	35,6 g/l
Total volatile solids	21,6 g/l
BOD_5	12.400 mg/l
COD	25.600 mg/l
Nitrogen (NH_4^+)	960 mg/l
Total nitrogen	2040 mg/l
Phosphorus (P_2O_5)	1680 mg/l
Potassium (K_2O)	1600 mg/l

4 - RESULTS OF ANALYSIS FROM CLOSED CYCLE INSTALLATIONS IN PORTUGAL

Table 4. Swine Breeding in Rio Maior

Section	Date	pH	BOD5 (O_2mg/l)	COD (O_2mg/l)	COD/BOD_5
Fattening	7.10.83	7,0	14400	28512	1,98
Shoat fattening	7.10.83	7,2	3500	9505	2,72
Nursery	7.10.83	7,3	7867	22750	2,89
Gestation	7.10.83	7,3	8200	24480	2,99

Table 5. Swine Breeding in Montijo - Final Effluent

Total suspended solids (mg/l)	12.800
BOD_5 (O_2 - mg/l)	11.950
COD (O_2 mg/l)	22.785
COD/BO_5	1,91

Note: Results of composed samples during 12 hours with a periodicity of 5 minutes and proporcional to the flow.

Table 6. Swine Breeding in Leiria

Section	Date	Total suspended solids (mg/l)	BOD5 (O_2mg/l)	COD (O2mg/l)	COD/BOD_5
Fattening	15.06.83	21.168	13.200	25.920	1,96
	12.09.83	16.546	8.285	25.650	3,13
	10.10.83	17.860	14.400	28.512	2,00
Shoat Fattening	15.06.83	9.740	12.500	25.020	2,04
	12.09.83	11.788	6.200	11.230	1,81
	10.10.83	11.440	4.100	9.504	2,32
Nursery	15.06.83	7.992	6.350	12.840	2,04
	12,09.83	7.046	9.850	25.920	2,63
	10.10.83	11.020	5.867	22.752	3,85
Gestation	15.06.83	16.644	8.720	20.735	2,38
	12.09.83	10.460	11.200	24.480	2,19

Table 7. Resume of the Results

Parameter	Fattening	Shoat Fattening	Nursery	Gestation	Final Effluent
pH	7,0	7,2	7,3	7,3	7,2
TSS (mg/l)	16546-21168	9740-11788	7046-11020	10460-16644	12800
BOD5 (O_2mg/l)	13200-14400	3500-6200	5867-9850	8200 - 11200	11950
COD (O_2mg/l)	25512-28512	9504-25020	12840-25920	20725-24480	22785
COD/BOD5	1,96-3,13	1,81-2,72	2,04-3,85	2,19-2,99	1,91

5. TYPE OF TREATMENT TO BE CHOOSEN

To choose the type of treatment, three important aspects have to be considered:

- which is the final destination of the effluent
- whenever possible must be given priority to the low energetic cost processes.
- a good maintenance and control of the treatment plant must be assured.

Considering the favorable climatic conditions of Portugal, the lack of legislation and means to assure sophisticated maintenances, and the fact that the majority of the swine breeding installations are very small, it is vital to full explore the possibility of the low energetic cost types of treatment.

When the irrigation is possible, it is essential to know the soil propreties as well as the plants necessities. The equilibrium between the nutrients supplied and used by the plants must be achieved. As far as irrigation is concerned, can be said that is general $1m^3$ of swine breeding effluents contains:

2,0 Kg of Nitrogen
1,68 Kg of Phosphorus
1,60 Kg of Potassium

The irrigation is usually made by the use of a deposit pulled by a tractor, by sectors and in a rotativity way. It is necessary to have a tank with a minimum retention time of 30 days. To avoid bad odoures it is recomended to have a aerated capacity of about 5 - 8g (O_2)/animal.hour. To feedlots with more than 500 animals, it is useful to make a screening using the solids as manure and only after to storage the effluent. In the case of small feedlots, less than 500 animals, and when the final destination is only the soil infiltration, must be used a septic tank with a volume of 0,3 m^3/animal corresponding a retention time of about 10 to 30 days, depending on the periodicity of the washings. The septic tank must be followed by infiltration drains.

Table 8. *Volumes of Effluent to Achieve the Crop Necessities in Terms of Nutrients*

Nutrient / Crop	Volume of effluents (m^3/ha)				
	Wheat	Corn	Potato	Permanent Pasture	Temporary Pasture
Nitrogen	65	50	75	300*	190
Phosphorus	30	24	50	95*	95
Potassium	[illegible]	39	131	213*	144

* with 1:1 dilution to avoid excess of Nitrogen that can damage the plant.

If no one of the solutions refered can be adopted, the final destination will be the discharge to a superficial water. In this case, three possibilities are suggested:

a) Screening, anaerobic pond, facultative pond and maturation pond
b) Screening, anaerobic pond, aerated pond and settling pond
c) Oxidation ditch

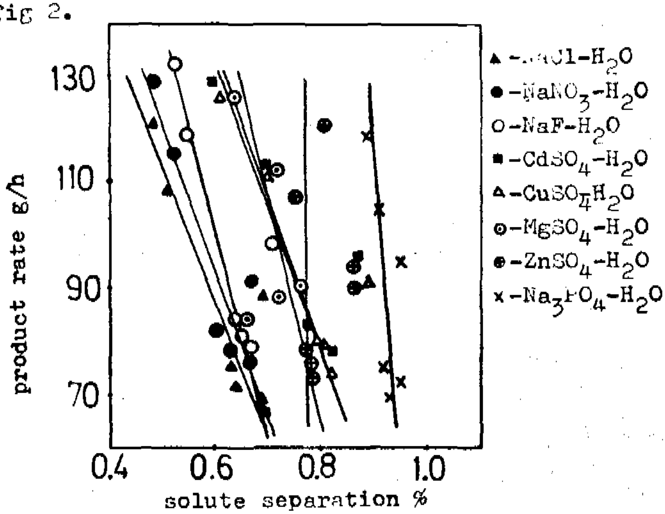
Always that enough land is avaiable, the solution a) is the cheapest one. However, if the installation will have more than 1000 animals, the two others solutions b) and c) are more viable. It is suggested the oxidation ditch and not the activated sludge process because the necessary brushes are already made in Portugal and so, the initial investment is much lower. However, the maintenance expences, mainly due to the energy consumption, are relatively high.

Table 9. Comparation between the Processes in Terms of Depuration, Efficiency, Retention Times Needed and Energy Consumption

Process	Depuration efficiency		Retention times and volumes	Energy Consumption	Final destination of the effluent
	BOD5	TSS			
Storage tank	0	0	Over 30 days	40 W/hour/ /animal.day	irrigation
Screening + Storage tank	15-20%	20-60%	Over 30 days	60W hour/ /animal.day	irrigation
Septic tank + + Infiltration drains	50-60%	60-80%	$0,30m^3$/ /animal	0	Soil infiltration
Anaerobic pond + Facultative pond + Maturation pond	95-99%	85-95%	Anaerob.pond 30(20-50)d Facult.pond 20(15-40)d Maturat.pond 30(10-40)d.	0	Discharge to a superficial water
Anaerobic pond + Aerated pond + Setting pond	95-99%	85-95%	Anaerob.pond 30(20-50)d. Facult.pond 8(7-10)days Setting pond 4(3-6)days	90W hour/ /animal.day	Discharge to a superficial water
Oxidation ditch	95-99%	95-99%	0,4-0,8 m^3/ /animal	160W hour/ /animal. .day	Discharge to a superfic. water

From the membrane properties(product rate and solute separation) fig.2. it should be pointed out that for reference system of aqueous solution of sodium chloride and other monovalent salts these membranes shows slight imprpvement in performances.The optimum performance of membranes was defined as the maximum product rate at a specific degree of salt rejection which was chosen arbitrarily at 7o % for NaCl in this study.The order of selectivity is the same in three types of membranes, respectively threevalent and twovalent salts separates better than monovalent salts.

Membranes of such properties are used for determination of reverse osmosis characteristics of following inorganic salts:$NaCl-H_2O$,$NaF-H_2O$,$NaNO_3-H_2O$,$Na_3PO_4-H_2O$,$CuSO_4-H_2O$,$MnSO_4-H_2O$,$CdSO_4-H_2O$,$ZnSO_4-H_2O$,$MgSO_4-H_2O$,and aqueous solution of phenols.The product rate and solute separation of mentioned salts with membranes are also shown in fig 2.



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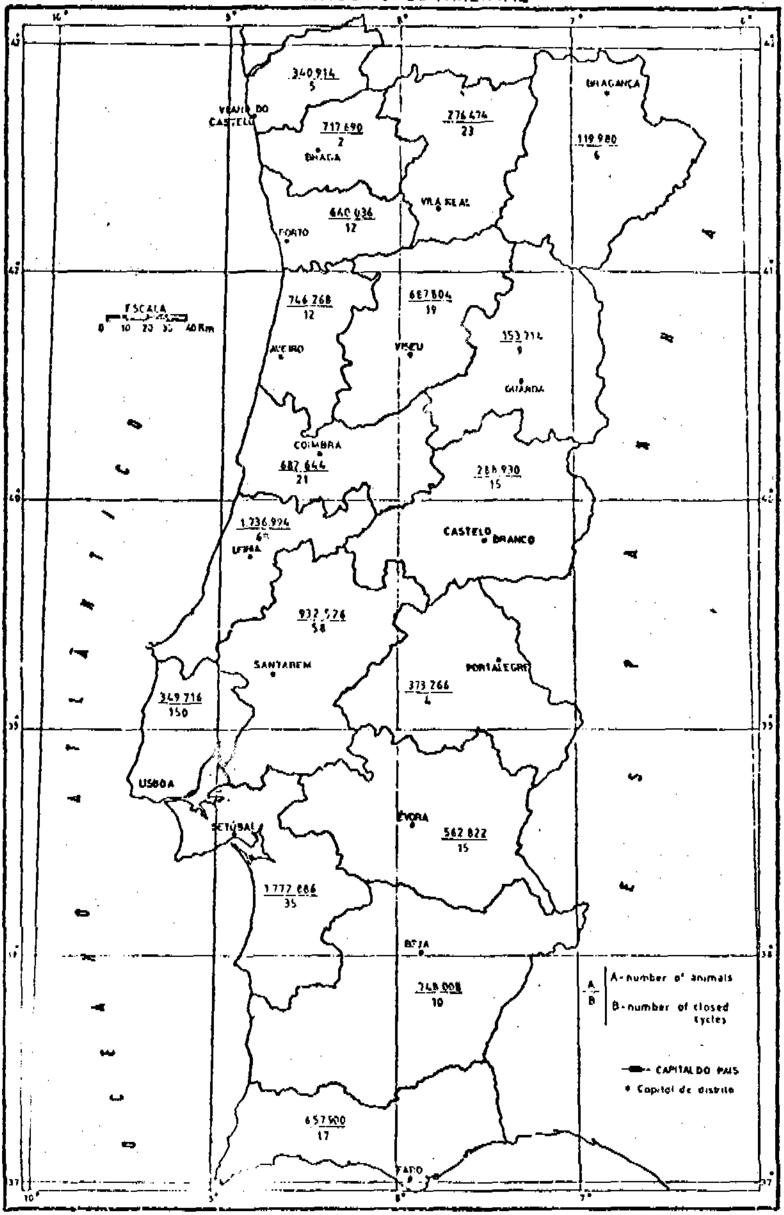

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	30 Kg	50 Kg	80 Kg	Pregnant sows		Sucking sows
				150 Kg	200 Kg	250 Kg
Lees (Kg/day)	0,53	0,62	1,27	0,63	0,93	2,14
Urines (l/day)	1,90	2,20	3,50	6,30	8,60	3,70

Table 2. Amount of Urines Depending the Type of Feed

	Type of feed	
	Serum	Cereals
Urines (l/day)	8 - 15	3 - 4

Table 3. Dringing Water Consumption Accordingly the Animal Weight

Animal	Weight (Kg)	Water Consumption
Shoats	6	0,1 l/day
	9	1,0 l/day
	20	2,2 l/day
	20 - 50	2,2 - 3,5 l/day
Pigs	50 - 100	2 - 3l/Kg dry food
Boars	-	12-15 l/day
Pregnant sows	-	8-12 l/day
Sucking sows	-	10 l/day + 1,5 l/ /shoat

In Portugal, are often considered as average characteristics of he swine wastes, the following values, expressed in g/Kg animal weight.day.

Waste amount	74,00
Total solids	8,90
Total volatile solids	5,40
BOD_5	3,10
COD	6,40
Nitrogen (NH_4^+)	0,24
Total nitrogen	0,51
Phosphorus (P_2O_5)	0,42
Potassium (K_2O)	0,40

In the case of a pig of 60 Kg (average weight of an animal in a closed cycle), the daily amounts will be as follow:

Waste amount	4,44 Kg
Total solids	534 g
Total volatile solids	324 g
BOD_5	186 g
COD	384 g
Nitrogen (NH_4^+)	14,4 g
Total nitrogen	30,6 g
Phosphorus (P_2O_5)	25,2 g
Potassium (K_2O)	24,2 g

In a general way, the estimation of the number of animals present in a feedlot is based on the number of sows considering that for each sow there are 8,5 animals. Based on the values presented, there is a charge of 534g of total solids per animal and per day, with a 60,7% of volatile solids. These values are so 9 times higher than those to the domestic sewages. In average, we will have a COD/BOD_5=2,065, what shows that these effluents can easily, he treated by a byological process, if inhibiting compounds will not be present (antibiotics or desinfectants).

Considering a water consumption of 15 l/animal.day we will have the following average characteristics of the residual waters:

Total solids	35,6 g/l
Total volatile solids	21,6 g/l
BOD_5	12.400 mg/l
COD	25.600 mg/l
Nitrogen (NH_4^+)	960 mg/l
Total nitrogen	2040 mg/l
Phosphorus (P_2O_5)	1680 mg/l
Potassium (K_2O)	1600 mg/l

4 - RESULTS OF ANALYSIS FROM CLOSED CYCLE INSTALLATIONS IN PORTUGAL

Table 4. Swine Breeding in Rio Maior

Section	Date	pH	BOD5 (O_2mg/l)	COD (O_2mg/l)	COD/BOD_5
Fattening	7.10.83	7,0	14400	28512	1,98
Shoat fattening	7.10.83	7,2	3500	9505	2,72
Nursery	7.10.83	7,3	7867	22750	2,89
Gestation	7.10.83	7,3	8200	24480	2,99

Table 5. Swine Breeding in Montijo - Final Effluent

Total suspended solids (mg/l)	12.800
BOD_5 (O_2 - mg/l)	11.950
COD (O_2 mg/l)	22.785
COD/BO_5	1,91

Note: Results of composed samples during 12 hours with a periodicity of 5 minutes and proporcional to the flow.

Table 6. Swine Breeding in Leiria

Section	Date	Total suspended solids (mg/l)	BOD5 (O_2mg/l)	COD (O2mg/l)	COD/BOD_5
Fattening	15.06.83	21.168	13.200	25.920	1,96
	12.09.83	16.546	8.285	25.650	3,13
	10.10.83	17.860	14.400	28.512	2,00
Shoat Fattening	15.06.83	9.740	12.500	25.020	2,04
	12.09.83	11.788	6.200	11.230	1,81
	10.10.83	11.440	4.100	9.504	2,32
Nursery	15.06.83	7.992	6.350	12.840	2,04
	12.09.83	7.046	9.850	25.920	2,63
	10.10.83	11.020	5.867	22.752	3,85
Gestation	15.06.83	16.644	8.720	20.735	2,38
	12.09.83	10.460	11.200	24.480	2,19

Table 7. Resume of the Results

Parameter	Fattening	Shoat Fattening	Nursery	Gestation	Final Effluent
pH	7,0	7,2	7,3	7,3	7,2
TSS (mg/l)	16546-21168	9740-11788	7046-11020	10460-16644	12800
BOD5 (O_2mg/l)	13200-14400	3500-6200	5867-9850	8200 -11200	11950
COD (O_2mg/l)	25512-28512	9504-25020	12840-25920	20725-24480	22785
COD/BOD5	1,96-3,13	1,81-2,72	2,04-3,85	2,19-2,99	1,91

5. TYPE OF TREATMENT TO BE CHOOSEN

To choose the type of treatment, three important aspects have to be considered:

- which is the final destination of the effluent
- whenever possible must be given priority to the low energetic cost processes.
- a good maintenance and control of the treatment plant must be assured.

Considering the favorable climatic conditions of Portugal, the lack of legislation and means to assure sophisticated maintenances, and the fact that the majority of the swine breeding installations are very small, it is vital to full explore the possibility of the low energetic cost types of treatment.

When the irrigation is possible, it is essential to know the soil proprieties as well as the plants necessities. The equilibrium between the nutrients supplied and used by the plants must be achieved. As far as irrigation is concerned, can be said that is general $1m^3$ of swine breeding effluents contains:

2,0 Kg of Nitrogen
1,68 Kg of Phosphorus
1,60 Kg of Potassium

The irrigation is usually made by the use of a deposit pulled by a tractor, by sectors and in a rotativity way. It is necessary to have a tank with a minimum retention time of 30 days. To avoid bad odoures it is recomended to have a aerated capacity of about 5 - 8g (O_2)/animal.hour. To feedlots with more than 500 animals, it is useful to make a screening using the solids as manure and only after to storage the effluent. In the case of small feedlots, less than 500 animals, and when the final destination is only the soil infiltration, must be used a septic tank with a volume of 0,3 m^3/animal corresponding a retention time of about 10 to 30 days, depending on the periodicity of the washings. The septic tank must be followed by infiltration drains.

Table 8. Volumes of Effluent to Achieve the Crop Necessities in Terms of Nutrients

Nutrient / Crop	Wheat	Corn	Potato	Permanent Pasture	Temporary Pasture
	Volume of effluents (m^3/ha)				
Nitrogen	65	50	75	300*	190
Phosphorus	39	24	50	95*	95
Potassium	[illegible]	19	131	213*	144

* with 1:1 dilution to avoid excess of Nitrogen that can damage the plant.

If no one of the solutions refered can be adopted, the final destination will be the discharge to a superficial water. In this case, three possibilities are suggested:

a) Screening, anaerobic pond, facultative pond and maturation pond

b) Screening, anaerobic pond, aerated pond and settling pond

c) Oxidation ditch

Always that enough land is avaiable, the solution a) is the cheapest one. However, if the installation will have more than 1000 animals, the two others solutions b) and c) are more viable. It is suggested the oxidation ditch and not the activated sludge process because the necessary brushes are already made in Portugal and so, the initial investment is much lower. However, the maintenance expences, mainly due to the energy consumption, are relatively high.

Table 9. Comparation between the Processes in Terms of Depuration, Efficiency, Retention Times Needed and Energy Consumption

Process	Depuration efficiency		Retention times and volumes	Energy Consumption	Final destination of the effluent
	BOD5	TSS			
Storage tank	0	0	Over 30 days	40 W/hour/ /animal.day	irrigation
Screening + Storage tank	15-20%	20-60%	Over 30 days	60W hour/ /animal.day	irrigation
Septic tank + + Infiltration drains	50-60%	60-80%	0,30m^3/ /animal	0	Soil infiltration
Anaerobic pond + Facultative pond + Maturation pond	95-99%	85-95%	Anaerob.pond 30(20-50)d Facult.pond 20(15-40)d Maturat.pond 30(10-40)d.	0	Discharge to a superficial water
Anaerobic pond + Aerated pond + Setting pond	95-99%	85-95%	Anaerob.pond 30(20-50)d. Facult.pond 8(7-10)days Setting pond 4(3-6)days	90W hour/ /animal.day	Discharge to a superficial water
Oxidation ditch	95-99%	95-[illegible]%	0,4-0,8 m^3/ /animal	160W hour/ /animal. .day	Discharge to a superfic. water

6. CONCLUSIONS

Due to the great diversity in dimension, type and dispersion, and the high organic load produced, the swine breeding installations are responsable for one of the more important hydric pollution problems in Portugal.

In view of the lack of thecnical and financial supports to the implementation of the maintenance and control of sophisticated treatment plants and the favorable climatic conditions, the more realistic solution to this problem, will have to consider the low energetic cost processes. So, it is suggested, whenever possible, the use of treatments based on stabilization ponds.

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SELECTED INDUSTRIAL WASTEWATER

POLLUTION PROBLEMS IN EAST-AFRICA

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INTRODUCTION

Industrialization is one of the key factors in the process of development. This is very important in developing countries where most commodities and manufactured goods are imported. A lot of foreign currency is spent on the import of products which could be produced within the country.

Any new industrial process cannot ever fully utilize the raw materials. Every kind of manufacturing will also produce wastes. Especially the environmental nuisances of industrial wastewater discharges can not be overemphasized. The location of wastewater treatment plant and industry should be considered also in the light of discharge and [illegible] points. Adequate dilution ratio must be obtained also during the dry seasons. If water resources are not adequately protected against pollution, this may cause health hazards down-stream or at least severe deterioration in the water quality.

Mostly development programmes are planned and carried out in [illegible] so that emphasis has been given to water supply and wastewater disposal has been postponed. This is evident with limited resources, but the final system is not the desired one.

Often the establishment of a new industry [illegible] and even political interests. At the same time [illegible] lation is not [illegible] or is neglected and therefore [illegible] contribute to water resources protection.

ECONOMIC STRUCTURE AND SITUATION IN KENYA AND ZAMBIA

Kenya

The growth of the economy in Kenya over the period 1964-81 was at an average annual rate of 5,2 %. The average population growth rate has been 3,6 % for the whole period. However, World Development Report (1982) gives a World Bank forecast of 4,1 % for Kenya's population growth in 1980-2000. This growth rate estimate is the second highest in the world.

The Kenyan economy is based on agriculture mainly privately owned. During the period 1964-81 the annual agricultural growth of Gross Domestic Production (GDP) was 3,7 % as an average and the industrial growth was 7,2 %.

Being one of the most industrialized country in East-Africa, Kenya's industrial portion of GDP is only about 10 %. In 1981 the three major foreign exchange commodity earners of the country were petroleum products, coffee and tea. The foreign exchange earnings from tourism have increased steadily up to KSh 2 400 million in 1982 corresponding a value of one third of the total industrial portion of GDP.

According to the Development Plan for the period 1984 to 1988 the projected GDP in industries will increase with 33 % up to KSh 10 000 million. The most important sub-sectors enumerated in succession according to their value in GDP are metal and engineering industries, food industries and chemical sub-sector. The highest projected rise in 1983-1988 is within the leather industries with nearly 60 % increase. The textile sub-sector comes next with an estimated rise of 42 % the other sectors remaining between 25 and 40 %.

In spite of the relatively small portion of industry in the economy of Kenya water pollution problems have risen since late fifty's. For instance the Nairobi river can contain up to 60 % sewage effluent during the dry weather and is therefore highly polluted.

Zambia

The total population of Zambia was 5,8 million in 1978 out of which about 40 % was living in urban areas. Nowadays the urban population is growing faster than the population as a whole. The average annual growth rate was 3,1 % in 1980.

The industrial production was 39 % of the GDP in 1980. At the same time the production in agriculture was only 15 %. The main exported items were copper (91 %), zinc (2,5 %) and cobolt (2 %). The value of exports decreased 20 % in 1982 mainly because of the world market prices for copper and cobolt decreased of the order of 20 %. The industries and mining activities are concentrated on the Copperbelt and the vicinity of Lusaka. The most remarkable industries are food and beverage, chemical, metal and textile industry.

In 1980 a half of the population was in working age (15 – 64 years) out of which 11 % worked in industry, 67 % in agriculture and 22 % in services. The average annual growth rate of labour force is estimated to be 3 % during the next 20 years.

The industrial sector has been regarded as a source of employment and income generation. However, uncontrolled urbanization brings wider environmental problems and greater needs for services, especially housing, water supply and sanitation.

WASTEWATERS OF LEATHER INDUSTRY IN KENYA

Leather Industry in Kenya

The raw hide and skin exports represent some 25 % of Kenyan exports of crude materials. In 1981 Kenyan exports of leather were about KSh 2 million which was about 10 % of Kenyan exports of manufactured goods. During the last few years about 2 million hides and 6 million skins have been available. This estimate includes the unrecorded imports from neighbouring countries.

In 1981 there were 7 major tanneries operating in Kenya. Of the total hides only about 20 % are prosessed to finished product state.

Typical process for African dry hides for corrected grain upper leather contains the following stages:

- soak
- lime
- delime and tan
- retan/dye
- finish to requirement.

Water consumption varies quite much but it can be estimated that a typical hide of 5,5 kg dry weight may consume 650 l of water during the processing to the crust state. The major sources of pollutants are the constituents of the raw hide, the chemicals employed and miscellaneous pollutants from machine working and other sanitary activities. In addition to the effluents produced tanneries produce large volumes of solid wastes.

For reducing discharges it is possible to use in-plant measures like reducing water usage, curring by sun dry instead of using salt, improving lime/sulphide dehairing, pickle and chrome tan.

Case Studies of Some Tanneries

For this case study three different Kenyan tanneries were chosen.

First tannery

The first tannery is of small size with daily production of 200 dried cattle and [illegible] 000 dried sheep and goat skins. The total water consumption has been estimated to be about 100 m^3/d. The liming and soaking liquors and the rinsing wastewaters are collected and treated separately from tannage liquors.

The liming and soaking liquors go through sulphide stripping tank (by air) before entering an oxidation ditch with a retention period of 24 hours. The wastewaters are then clarified in a sedimentation basin from which they are used directly for irrigation. Sludge is pumped to drying beds and the dried sludge is used as land fertilizer.

The tanning liquors are led into a holding tank with a retention period of 24 hours, pH is raised to about 9 by adding lime. Chromium hydroxide is then precipitated and chromium sludge dried. Tannage liquors are pre-used for two times before chromium precipitation. Recovery of the chromium from the dried sludge has been studied.

The effluent quality based on six samples of the effluent were: BOD_5 [illegible]00 mg O_2/l, total suspended solids 120 mg/l and chromium 0,6 mg/l. The highest values were two to three times as much. Conductivity of effluent ranged from 4 000 - 10 000 μS/cm. The suitability of the effluent for irrigation except the most tolerant plants is questionable. However, irrigation can be used as a effective means of wastewater disposal. The operation of the wastewater treatment plant was not effective and some improvements and changes had been made and several were still under consideration. Anyhow chromium removal system was very innovative and seemed to be working quite well.

Second tannery

The second tannery is of medium size and it processes 5 000 dried sheep and goat skins a day. The total water consumption is about 600 m^3/d. The wastewaters are pretreated before discharging into the municipal sewerage system.

Beam house liquors together with rinsing waters are passed through sulphide stripping chamber where air is added. The liquor is taken to an oxidation tank for 24 hours. Thereafter the liquor passes into a clarification tank after which it joins the wastewaters from the tannage. This combined sewage is pumped into the municipal sewerage.

Pickling and tanning liquors are screened and led to a sedimentation tank for 24 hours. Facility for raising pH exists but is rarely used. The effluent joins the beam house effluent before pumping into the municipal sewer. Chromium sludge is removed.

According to seven grab samples the pH ranged from 6,8 to 8,5; BOD_5 from 650 to 920 mg O_2/l, chromium content from 1,3 to 40 mg/l. These values are too high and should not be acceptable for discharge into the municipal sewer. The improvement of the operation of the wastewater treatment plant would be very important.

Third tannery

The annual production of the third tannery is about 300 tons of raw hide and 185 tons of raw skins. The water consumption for industrial use is about 650 m^3/day. The water for social use is taken from the municipal network.

Tanning and beam house liquors are treated separately. Beam house liquors from the old tannery are conveyed to two oxidation lagoons where they are combined with beam house liquors from the new tannery. After the period of 12 hours they are pumped to two other aerated lagoons for a total period of 12 hours. Finally the wastewaters are clarified for one more 12 hours before they are discharged into a river.

The chromium liquors are separated but the pH is not raised and therefore the precipitation of chromium is quite slow.

The lowest BOD_5 value observed was 450 mg O_2/l and the lowest SS value was 120 mg/l. The chromium values were from 1,3 up to 35 mg/l. The effluent guidelines were exceeded by far.

The minimum daily dry weather flow of 14 years in the recipient river was about 0,5 m^3/s and the tannery's discharge was 0,01 – 0,02 m^3/s. The dilution is therefore about 25 times. This may not be enough because of poor operation of the treatment plant and because the river upstream is already quite highly polluted by coffee factory wastes and non-point pollution.

Conclusion

The survey showed that none of the three tanneries could meet their effluent guidelines. However , it must be noted that these guidelines mostly originate from foreign sources and proper effluent guidelines for Kenyan conditions should be developed. This effort should take into account the hydrological, climatic, tehnological, economic and sociological situations prevailing in the country.

The charges of discharging the wastewaters to municipal sewers should be based also on the strength of the effluent instead of pure hydraulic loading. This would motivate the operation of pretreatment plants. The importance of skilled manpower for operation of the plant cannot ever be overemphasized. In-plant measures for reducing discharges should also be emphasized. This would save the processing costs in the manufacture as well as wastewater treatment costs. Reuse of chemicals i.e. chromium should be further developed as well as possibilities of utilization of local resources (solar energy for drying etc.) in the waste treatment should be studied.

A MULTI-INDUSTRIAL URBAN CENTRE

Background of the Survey

This study deals with some of the basic water pollution problems in an urban centre in Zambia. Industrial activities and inhabitants are concentrated on upstream areas, where as the raw water source, an impoundment, lies downstream.

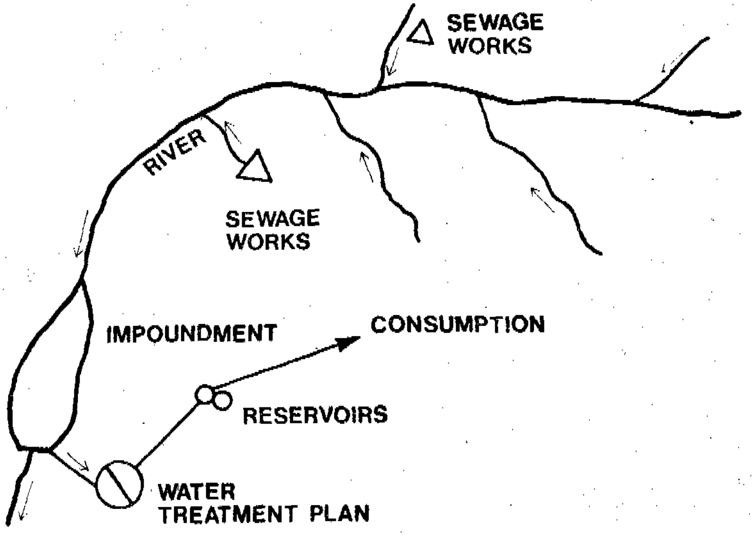

Figure 1. A schematic map of the surveyed area.

The industrial centre consist of wide range of industrial and commercial activities ranging from refineries to carpentry workshops. The biggest plants are a paper mill, two breweries, sugar refinery, two soap and detergent factories and a chemical factory.

Urban development and industrial expansion have been encouraged in the area without introducing water pollution control measures, until quite recently. Partly this is understandable because of shortage of manpower and finance to monitor discharges. Also the knowledge of legislative, administrative and technical procedures to control water pollution has been lacking.

The reasons for this survey were bad tastes and odours in the city water supply system, which caused a lot of complaints by consumers. The main reason was found to be the deterioration of the raw water source, especially during the dry season. This led to a pioneering research of municipal and industrial discharges to the water course.

Discharges

Municipal wastewaters are treated in two treatment plants with a combined capacity of 16 000 m^3/d. The treatment process includes primary clarifiers, trickling filters and secondary clarifiers. The [illegible]fluent is discharged directly to the stream. At the moment the [illegible]atment plants are overloaded by 30 % of design flows. The monthly [illegible]ver[illegible] BOD_5 values of the influent were 150 - 280 mg O_2/l. Respec[illegible]iv ly the average BOD_5 values of the effluent were 25 - 45 mg O_2/l, [illegible]ich [illegible] [illegible]lightly higher than the target value set by the City [illegible]il, 20 [illegible] O_2/l. The removal of BOD_5 was 80 - 90 %. Thus the discharged BOD_5 loading from wastewater treatment plants was in the range of 400 - 720 kg/d.

The average concentration of phosphates analyzed in August 1983 - January 1984 was 10,6 mg/l in the influent and 8,1 mg/l in the effluent. The removal was about 20 % on average and the daily discharge of phosphates to the stream was 130 kg/d.

The total wastewater discharge of the industries was 4 700 m^3/d. Only the paper mill includes a treatment plant for its wastewaters before discharging to the stream (precipitation by aluminium sulphate).

The studied industries and some of the analyzed parameters of their wastewaters are shown in the table below.

GATHUO

INDUSTRY	Wastewater discharge (m^3/d)	BOD_5 mg/l	BOD_5 kg/d	BOD_5 %	P mg/l	P kg/d	P %
Brewery I	1 200	500	600	14	9,0	10,8	39
Brewery II	120	4 600	550	13	20,5	2,3	8
Sugar refinery	600	2 040	1 220	29	9,5	5,7	20
Soap and detergent factory I*	530	560	300	7	5,0	2,7	10
Soap and detergent factory II	65	960	60	2	8,0	0,5	2
Paper mill*	2 080	650	1 350	32	2,5	5,2	19
Chemical factory	95	1 220	120	3	6,0	0,6	2
Total	4 690		4 200	100		27,8	100

* Samples were taken after the wastewater treatment plant.

The total BOD_5 loading from the industry was about 4 200 kg/d. The highest BOD_5 loading (32 %) came still from the paper mill, despite of the installed treatment facilities. However, the treatment plant has reduced about 50 % of the BOD_5 load of the paper mill, which means also a remarkable reduction (30 %) in the total industrial BOD_5 discharged into the stream. Another fairly large organic pollution source was the sugar refinery.

The total phosphorus load from the industries was 28 kg/d and the major phosphorus load came from the Brewery I (about 40 %).

Considering the discharges as a whole, about 90 % of the organic load as BOD_5 was discharged by the industries and 10 % by municipal wastewater treatment plant. Over 80 % of the phosphorus loading came from the wastewater treatment plants and less than 20 % from the studied industry. The agricultural runoff has not been included. Anyhow this can be fairly high especially in the beginning of rainy season.

Recipient Water Course

The stream with the smaller tributary streams was under heavy pollution from the industries and from the wastewater treatment plants. During the study very high decomposition of organic matter was found in the streams. This was detected in low dissolved oxygen values, the lowest monthly average was only 1 mg/l (temperature 26°C -28°C). The annual average dissolved oxygen values in the stream in 1976-81 have been 1 - 4 mg/l (26 - 28°C). According to measurement the dissolved oxygen values did not recover until in the impoundment, but however almost anaerobic conditions remain in the deepest points.

The impoundment is a 6 km long, man-made, eutrophic lake with a capacity of $15 \times 10^6\ m^3$. The deepest points are less than 10 m and during dry season only a few metres. Eutrofication dominates the aquatic life of the lake, because of high nutrient levels in the water. In November 1983 - January 1984 the analyzed concentrations of PO_4 were 8 - 22 mg/l and those of NO_3 8 - 13 mg/l. The studied period was very dry, which meant a minimal dilution.

During the dry season the lake was covered almost entirely by floating weed (Salvinia Molesta). In places where sun light could penetrate into the water, huge algae blooming occured. Result was typical of trophical waters - so called supersaturation. The dissolved oxygen values rose up to 15 mg/l at 27°C. Generally the upper layers of water were rich in oxygen, 7 - 15 mg/l, but the bottom layers contained only 0,6 - 3 mg O_2/l (temperatures 24 - 28°C).

What to do ?

First of all, a more comprehensive research of the discharges and the characteristics of the recipient water course is necessary. After that the main trouble causing factors can be recognized and removed.

In order to reduce the growth of algae and weed in the impoundment the level of nutrients should be decreased. Agricultural run-off should be studied further. Continuous monitoring of discharges of industry and municipal wastewater treatment plants should be implemented in order to have more reliable quality and quantity analyses of discharges. Also flow measurement must be included and, of course, the flows in different streams should be measured in order to get dilution ratios.

The capacity of the wastewater treatment plants could be increased by expanding the plants. The phosphorus removal by precipitation could be considered. The priority of the sewer network renovation should be studied and rehabilitation part by part could be started. This reduces the portion of infiltrated water and storm water into sewage and decreases the hydraulic load of the wastewater treatment plants.

The treatment possibilities of some of the industrial wastewaters should be studied. The industries can have their own wastewater treatment plants or then have a combined treatment with municipal wastewaters or some kind of combination of these.

Last but not least, the implementation of pollution control by legislation and co-operation between industries and water authorities could safeguard the water resources.

The removal of the bottom sludge by flushing can improve the water quality (reduce phosphorus and anaerobic zones) in the impoundment. At the moment the flush-out is clogged by sediment which should be removed. Some appropriate remedies can be tried also. For example by improving the self-purification capacity of the streams a lower organic load into the impoundment could be achieved.

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CONSIDERATIONS IN DEVELOPING MASTER PLAN ALTERNATIVES FOR ESIA

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ABSTRACT

The objective of the present study was to develop and evaluate the Master Plan alternatives for the collection, treatment, and disposal/reuse of sanitary and industrial wastewaters in the Enlarged Shuaiba Industrial Area (ESIA) of Kuwait. The ESIA, which is the largest industrial area in Kuwait, consists of the relatively well developed Shuaiba Industrial Area (SIA) and the less developed Mina Abdullah Industrial Area (MAIA).

The least cost collection alternatives were combined with the corresponding treatment options to determine the minimum cost Master Plan. Minimum Cost sequences of treatment processes which can provide the required water quality for marine disposal, irrigation, or boiler feed reuse were determined using a simulation model known as SWAT. The least cost Master Plan was associated with the collection of combined wastewater in SIA and MAIA, and providing the treatment separately in each area. Cost benefit analysis showed that the reuse of treated effluent in irrigation is the most economically attractive option.

ACKNOWLEDGEMENT

This [illegible]stigation was co-funded and jointly performed by Shuaiba A[illegible]urhority (SAA) and Kuwait Institute for Scientific Research ([illegible]R).

INTRODUCTION AND STUDY OBJECTIVES

One of the major challenges to industrialization and development projects is how to undertake them while protecting the quality of the environment for safe and enjoyable living. In many countries, new industrial projects are planned and influenced from the earliest stages by environmental protection issues. In other words, environmental evaluation has become the third dimension in project feasibility studies, in addition to technical and economic considerations. To incorporate environmental evaluation properly, several alternatives must be available for the major features of the proposed industrial development. With the availability of alternatives, the most environmentally sound system within the acceptable technical and economic feasibilities can be selected.

The Enlarged Shuaiba Industrial Area (ESIA) is the largest and most important industrial complex in Kuwait. ESIA includes Shuaiba Industrial Area (SIA) accommodating the national industries of petroleum, petrochemicals, power generation, and desalination plants; and Mina Abdullah Industrial Area (MAIA) assigned for such light industries as building materials, construction, and paper manufacturing.

The ESIA is located about 50 km south of Kuwait city on the coastal stretch of the Arabian Gulf between Mina Ahmadi and Mina Abdullah. The SIA is a relatively well developed industrial region covering an area of about 1100 hectares. The topography of the area is characterized by a general inclination from about 40 ms elevation above mean sea level at the western border to about 5 ms elevation at the eastern shoreline. The MAIA is located south-west of SIA and occupies an area of about 1300 hectares, out of which only about 25% is developed by light industrial activities and the remaining area is assigned for future extension and development of similar industrial activities. The ground elevation in MAIA varies from 75 ms at its west above the mean sea level to 25 ms towards the east.

Two wastewater collection systems are servicing the SIA. The first is the sanitary wastewater collection system which currently disposes of untreated wastes into the Gulf. The second is the stormwater collection system that also collects industrial effluents after various degrees of pre-treatment and similarly disposes of these wastes ultimately to the Gulf. The projected average flow in SIA for sanitary and industrial wastewater for the year 2010 were estimated to be about 20 and 230 l/sec, respectively. These figures were obtained based on flow monitoring programme and information on future developments.

At present time, there is no collection network in MAIA for any of the generated wastewater streams. However, local disposal systems are established to serve the specific needs of each industry. The projected average flow in MAIA for sanitary and industrial wastewater for the year 2010 were estimated to be about 50 and 100 l/sec, respectively based on the following assumptions:

1. Labour force is 40 persons/hectare.

2. Average Sanitary flow rate is taken as 80 l/person/day.

3. Average Industrial flow rate is taken as 7.5 m^3/hectare/day.

The primary objective of this study was to develop and evaluate Master Plan alternatives for the collection systems of sanitary and industrial wastewaters within ESIA, and the corresponding treatment and disposal/reuse options. Needless to mention that evaluation of Master Plan alternatives should be made according to its technical feasibility, cost effectiveness, environmental impact, and resource conservation acceptability.

The Master Plan alternatives were to consider the following two potential situations:

1. Including the wastewater flow from a major industry *Kuwait National Petroleum Company* (KNPC refinaries) which generates an estimated average industrial flow of about 95 l/sec by the year 2010.

2. Excluding the wastewater flow from KNPC assuming that this large industry will develop its own system of collection, treatment and disposal/reuse of its wastewater.

DISPOSAL/REUSE OPTIONS

Treatment of wastewater depends primarily on the subsequent disposal/reuse option as well as the quantity and quality of wastewater. The cost of treatment is a function of the quantity, and influent and desired effluent quality of wastewater. Within this frame the disposal/reuse options determine the degree of the required treatment processes to achieve the specified effluent quality standards.

In the ESIA the possible disposal/reuse options were confined to the following:

1. Marine discharge.

2. Reuse for landscape irrigation or low quality industrial process water.

3. Reuse as boiler feed water (make-up water).

4. Joining an existing treatment system.

To serve the purpose of the cost estimates for the treatment of wastewater long term water quality objective standards were developed for the first three disposal/reuse options, see Table 1. The fourth option rests on the fact that SAA has contributed a significant capital cost towards the Ministry of Public Works (MPW) in order that the latter accepts sanitary wastewater from ESIA at the existing treatment plant provided for the Kuwait Village Sanitary Scheme (KVSS) at Reqqa, some 25 km from the ESIA. However, the connecting points to the gravity collection system of the KVSS is approximately 6 km distance from the center of the ESIA as shown in Fig. 1.

Table 1. Long Term Water Quality Objective Standards for Different Disposal/Reuse Options

Principal Pollutants	Discharge to sea, mg/l	Land Scape Irrigation mg/l	Boiler Feed mg/l
Chemical Oxygen Demand	200.0	150.0	10.0
Total Suspended Solids	30.0	15.0	5.0
Total Keldahl Nitrogen	30.0	20.0	2.0
Total Nitrogen	125.0	40.0	4.0
Ammonia	10.0	10.0	1.0
Oil	10.0	5.0	0.1
Hydrogen Sulphide	2.5	0.1	0.0
Chromium	0.3	0.3	0.1

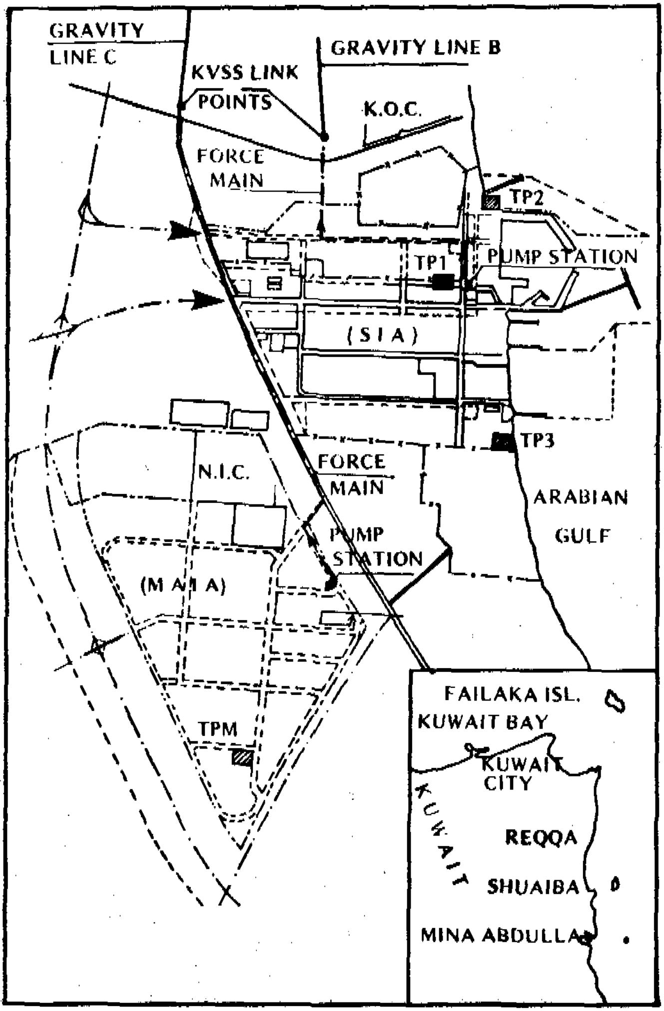

Fig. 1: Location of treatment plant proposed sites and KVSS connecting points.

Experimental results (Nesaratnam, S. and Ghobrial, F., 1984) indicated that the industrial waste arising from SIA are amenable to (most economic) biological treatment in admixture with one tenth or more by volume of sanitary wastes. Fortuitously, this is about the ratio which will prevail for the SIA when the area is fully developed. However, the separate collection and treatment of each of the sanitary and industrial wastewaters had to be considered in the scope of the present study to serve the fourth disposal/reuse option.

TREATMENT PLANT LOCATIONS

The location of the treatment plant influences the cost of the collection system and to certain extent the cost of treatment and disposal works. Three different locations for the treatment plant within SIA and one location within MAIA have been suggested by the SAA and therefore considered in the study. Table 2 describes these locations and Fig. 1 shows them.

Table 2. Possible Treatment Plant Locations in the ESIA

Treatment Plant Reference	Location	Remarks
TP1	SIA	This location is central to SIA only
TP2	SIA	On reclaimed land, within the harbour area
TP3	SIA	This location is central to both the SIA and MAIA
TPM	MAIA	At this location the plant will only receive wastes from MAIA.

The location of the treatment plant close to the cooling water intake (TP2) shall be on reclaimed land which will add an extra cost to the treatment works in comparison with the other locations. This location has the advantage of [illegible] available land space within ESIA borders for allocating [illegible] rtant industrial plants or the extension of existing ones. [illegible] the location (TP1) is central for SIA it is relatively [illegible] MAIA. However, (TP3) is central for both SIA and MAIA. [illegible] nals have been kept in mind in developing collection syst[illegible] atives.

TYPE OF COLLECTION SYSTEMS

The collection systems alternatives were [illegible] to serve both the disposal/reuse options and the different [illegible] plant locations. Moreover, two sets of alternatives were [illegible] to consider in one the inclusion of the wastewater flow from KNPC and in the other the exclusion of it. Accordingly three type of collection systems were investigated.

1. Separate sanitary
2. Separate industrial
3. Combined

The separate sanitary collection system for SIA and MAIA served the purpose of connecting the sanitary wastewater to the KVSS. The separate industrial collection system was a must either in SIA or in MAIA where sanitary wastes are separately collected to connect the KVSS. In this case the separate industrial collection system served SIA and MAIA to divert their industrial wastes to the three locations of the treatment plants in SIA. The combined system served the purpose of treating both sanitary and industrial wastes from SIA in any of the treatment plant locations of SIA together with or without the combined wastes from MAIA. It also served the purpose of treating combined wastes from MAIA in the treatment plant located in MAIA namely (TPM).

The collection system in every case was consisting of gravity collection network, pump station, and force main. In developing the collection system alternatives for SIA the existing sanitary wastewater collection network was considered and checked for its hydraulic capacity and reinforcements were made as necessary to meet future developments and extensions.

SELECTION OF THE FEASIBLE AND LEAST COST TREATMENT PROCESSES SEQUENCE

Two technically feasible sequences of treatment processes were used in this investigation. The first treatment sequence was developed primarily for the purpose of treating high strength wastewater of the SIA at any of the three treatment location sites in the SIA. This sequence is shown schematically in Fig. 2. The second treatment sequence was developed for the treatment of the less concentrated wastewater generated in MAIA at the treatment plant located in MAIA.*

Analysis of the industrial wastewater in both SIA and MAIA and the sanitary wastewater to determine their general characteristics was the first step in developing the adequate treatment process sequences. Given the influent quality characteristics, the minimum cost sequence of treatment processes is determined in two stages. The first identifies the feasible sequences of treatment processes whose efficiences in removing pollutants are adequate to provide the desired effluent quality levels. Then, total costs of these identified treatment sequence are estimated and the least-cost sequence is selected.

The total cost of the treatment included the capital cost of the units and equipment, land and civil works as well as the annual operating and maintenance (O&M) costs for wastewater and sludge treatment over the life time of the treatment facility. A computer software package was used to perform the cost analysis.

A modified computer programme for the simulation of Wastewater Treatment (SWAT) model was used in selecting the feasible and least cost option within the given sequence of treatment processes in view of the requested effluent quality standards. This model was developed (Macal, 1978) and several enhancements and adaptations were performed on this model (Kotob and Farah, 1984) before using it in the present study.

Briefly the SWAT simulation model enumerates all possible sequences of treatment processes which can be linked together. Sequences which meet the treatment standards are costed over the planning horizon of the treatment facility. The SWAT costs are simulated annually and discounted over the planning horizon. The least cost sequence which meets the treatment standards for a specific option of disposal/reuse is then selected. The main data input to this programme were as follows:

* The scheme of MAIA is similar to that shown in Fig. 2 with the exclusion of the oil separation units, the pH control unit, the cooling unit and the chemical addition for the biological treatment.

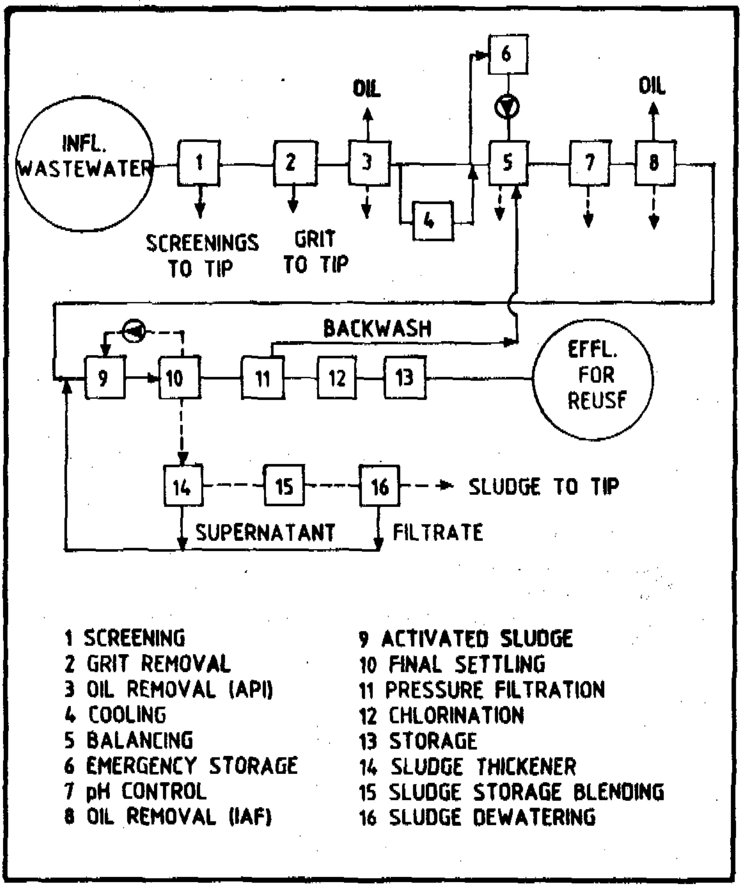

Fig. 2: Schematic of the proposed process sequence of the central wastewater treatment facility.

1. The projected characteristics of the influent wastewater.

2. The projected peak flow rate reaching the treatment plant.

3. The effluent quality standards as given in Table 1.

For each of the two main treatment sequences the removal ratio in each of the treatment units was given for the various water quality parameters. Moreover, the unit cost functions related to Kuwait Market were developed separately and used as part of the programme.

DEVELOPMENT OF MASTER PLAN ALTERNATIVES

A number of Master Plan alternatives were identified for the collection, treatment and disposal/reuse of wastewater within the ESIA. In developing the Master Plan alternatives the following points were taken into account are:

1. The possible location of the wastewater treatment plant and the type of wastewater to be treated.

2. The type of wastewater collection system required.

3. Whether the flows from KNPC are included or not, therefore, each alternative Master Plan was effectively considered twice-once with the KNPC wastewater flows excluded and once with them included.

A summary of the technical data for the various developed Master Plan alternatives are given in Table 3.

COST MINIMIZATION OF MASTER PLAN

The cost of the Master Plan alternatives was estimated in two successive steps. The first determined the total cost of each collection alternative. The second minimized the overall cost of collection and treatment for each option of wastewater disposal/reuse option, hence identifying the minimum cost master plan. These costs are the sum of the total present worth of operating and maintenance costs discounted at 10% over a planning horizon of twenty five years and the total capital cost. Master Plan cost estimates were presented for two phases of implementation. The initial phase covers the needs of the first 15 years while the ultimate phase includes projected needs during the last ten years of the planning horizon.

Table 3. Data Related to Master Plan Alternatives

Alternative	Disposal or Treatment Location	Collection System	
		Type	Location
D-1	KVSS	S	SIA[a]
D-2	KVSS	S	SIA
E-1	TP1	I	SIA
E-2	TP2	I	SIA
E-3	TP3	I	SIA
F-1	TP1	I	SIA[a]
F-2	TP2	I	SIA[a]
G-1	TP1	I	SIA[a]
G-2	TP2	I	SIA[a]
A-1	TP1	C	SIA
A-2	TP2	C	SIA
A-3	TP3	C	SIA
B-1	TP1	C	SIA[a]
B-2	TP2	C	SIA[a]
C-1	TP1	C	SIA[a]
C-2	TP2	C	SIA[a]
H-1	IVSS	S	MAIA
I-1	TP1	I	MAIA
I-2	TP2	I	MAIA
I-3	TP3	I	MAIA
K-1	TP1	C	MAIA
K-2	TP2	C	MAIA
K-3	TP3	C	MAIA
L-1	KVSS	C	MAIA
M-1	TPM	C	MAIA

Notes

a = Flow from KNPC is included.

TP1, TP2 and TP3 = Treatment plant locations in SIA.

TPM = Treatment plant located in Mina Abd [illegible] Industrial Area.

S, I, and C = Sanitary, Industrial and Co[illegible] Wastewater, respectively.

COLLECTION ALTERNATIVES COSTING

The capital, operating and maintenance costs of collection alternatives were determined based on the estimated unit costs of the proposed type of pipes for use as gravity sewer and the corresponding appurtenances, pumping stations, and force mains. Four main options for the combination of the sanitary and industrial wastewater collection systems in SIA and MAIA were investigated twice, once including and once excluding KNPC flow. Costs of all the collection alternatives combinations within each option were estimated. The least cost alternative combination for each option was then identified. Table 4 presents a summary of the least cost collection alternatives combinations related to the four main options for each of the two cases of including and excluding KNPC flow.

COLLECTION/TREATMENT COST MINIMIZATION

The minimum cost treatment alternatives corresponding to the collection alternatives combinations, listed in Table 4, were identified for the three disposal/reuse options. SWAT model was used to determine treatment costs. KVSS alternatives costs were estimated, according to the fees of the Ministry of Public Works per m3 of wastewater as KD. 250 capital cost and daily operation charge of KD. 0.050, respectively. Total cost of Master Plan alternatives was determined as the sum of the least cost collection alternative and the corresponding treatment cost. The least cost Master Plan alternatives for the various disposal/reuse options are identified in Table 5 for both cases of including and excluding KNPC flow.

Table 4. Least Costly Alternatives for Collecting Sanitary and Industrial Wastewater

Strategy and option	Alternatives combination	Cost (thousand KD)
Excluding KNPC-Mina Abdulla		
1	(D-2)+(H-1)+(E-3)+(I-3)	6 920
2	(A-1)+(M-1)	4 240
3	(A-1)+(H-1)+(I-1)	6 550
4	(E-1)+(D-2)+(M-1)	4 840
Including KNPC-Mina Abdulla		
1	(D-1)+(H-1)+(G-1)+(I-1)	7 320
2	(B-1)+(M-1)	4 730
3	(B-1)+(H-1)+(I-1)	7 030
4	(M-1)+(D-1)+(F-1)	5 310

Table 5 indicates that option 2 is the least cost Master Plan. This option consists of the combined collection of sanitary and industrial wastewater for individual treatment in SIA and MAIA respectively.

Excluding KNPC

Results presented in Table 5 indicate that if KNPC flow is excluded the least costs are associated with Master Plan-Option 2 and it varies from MKD 24.6 for marine discharge up to MKD 43.6 for boiler feed reuse.

Including KNPC

Including the flow of KNPC the costs increased as expected but least costs are still associated with option 2 and varied from MKD 31.5 for marine discharge, to MKD 58.6 for boiler feed reuse.

Cost estimates were also made for the several alternative combinations associated with alternative (L-1) where combined wastewater from MAIA are treated in the KVSS. To consider alternative (L-1) for further implementation negotiation should be initiated with the Ministry of Public Works (MPW) to get their permission to accept the characteristics of the combined wastewater from MAIA in the Treatment plant of KVSS. The results indicated that the least cost Master Plan Option is associated with the combination (L-1) + (A-1) if KNPC is excluded and (L-1) + (B-1) if KNPC is included. The estimated cost of this Master Plan Option is approximately MKD 23.5 and MKD 30.5 excluding and including KNPC flow, respectively, for marine discharge; and MKD 26 and MKD 33 for irrigation.

COST BENEFIT-ANALYSIS OF WATER DISPOSAL/REUSE OPTIONS

In order to select the most attractive end-use for the treated wastewater the cost effectiveness and benefits of each use was investigated. Table 6 presents the cost effectiveness and benefit analysis for each of the end-uses in both cases of including and excluding KNPC flow. In Table 6 the average ultimate flow was used to calculate the average unit cost.

Wastewater reuse for boiler feed requires that it possesses the same technical characteristics as desalinated water. The actual unit cost of desalinated water supplied by the Ministry of Electricity and Water (MEW) in Kuwait is 0.647 KD/m^3. Irrigation water is lower in quality than the desalinated water and accordingly cheaper. The actual unit cost of irrigation water, also provided by MEW is 0.337 KD/m^3. Irrigation water is lower

Table 5. Estimated Costs of Collection and Treatment Alternatives for Various End Uses, Excluding and Including Flows from KNPC-Mina Abdulla

End use	Option	Costs (thousand KD)					
		Excluding KNPC-Mina Abdulla			Including KNPC-Mina Abdulla		
		Collection	Treatment	Total	Collection	Treatment	Total
Marine discharge	1	6 920	20 100	27 000	7 320	25 600	32 900
	2	4 240	20 300	24 600[a]	4 730	26 700	31 500[a]
	3	6 550	19 400	26 000	7 030	24 900	31 900
	4	4 840	20 300	25 200	5 310	26 990	32 300
Irrigation	1	6 920	26 400	33 300	7 320	31 200	38 500
	2	4 240	22 800	27 100[a]	4 730	29 400	34 100[a]
	3	6 550	22 500	29 000	7 030	27 400	34 400
	4	4 840	25 200	30 000	5 310	29 800	35 100
Boiler feed	1	6 920	39 800	46 700	7 320	52 100	59 400
	2	4 240	39 400	43 600[a]	4 730	53 900	58 600[a]
	3	6 550	39 200	45 800	7 030	53 300	60 400
	4	4 840	38 700	43 600[a]	5 310	54 000	59 300

[a] Least cost option for this end use and strategy.

Table 6. Cost-Benefit Analysis of Water End Uses, Excluding and Including KNPC

Description	Excluding KNPC	Including KNPC
Flow rate (m^3/day)	25662	33882
Marine Discharge		
Unit cost of treatment (KD/M^3)	0.229	0.238
Irrigation		
Actual unit cost (KD/m^3)	0.337	0.337
Incremental treatment unit cost[a] (KD/m^3)	0.03	0.024
Benifit: cost ratio[b]	11.2	14.0
Boiler Feed		
Actual unit cost (KD/m^3)	0.647	0.647
Incremental treatment unit cost[a] (KD/m^3)	0.224	0.242
Benefit: cost ratio[b]	2.89	2.67

a The incremental unit cost above unit cost for marine discharge.

b This is the ratio between actual cost and incremental treatment unit cost.

in quality than the desalinated water and accordingly cheaper. The actual unit cost of irrigation water, also provided by MEW is 0.337 KD/m^3.

According to Table 6 the unit cost of treating the wastewater to reach the minimum quality characteristics for marine discharge is 0.229 KD/m^3 and 0.238 KD/m^3 for the two cases of excluding and including KNPC respectively. In order to make use of the treated water in irrigation the additional unit cost expenditure is 0.030 KD/m^3 and 0.024 KD/m^3 excluding and including KNPC, respectively, which is more than 10% increase over the marine discharge unit cost. On the other hand the incremental unit cost for boiler feed reuse is more than 90% higher than the marine discharge unit cost.

From the above analysis it can be seen that there is saving in reusing treated wastewater for either irrigation or boiler feed. However, the benefit, as measured by the cost benefit ratio given in Table 6, is much more viable for reuse in irrigation than for boiler feed. This benefit is greater when flow from KNPC is considered.

Therefore, water reuse for irrigation is considered beneficial and cost effective, in particularly for those master plan alternatives including the flow from KNPC. In a country like Kuwait the option of reusing water for irrigation adds more benefit of conserving and prolonging the life of the scarce groundwater resources which are the conventional source for irrigation water. This makes the irrigation option the most attractive for implementation.

DISCUSSION AND CONCLUSIONS

The results of this study indicate that the separation of the sanitary and industrial wastewater would not only increase the cost of collection network but would also reduce the dilution available and possibly decrease the treatability of the industrial wastewater. It has been demonstrated that the existing sanitary wastewater collection system in the SIA has sufficient capacity to handle the combined sanitary and industrial flows in the first phase of development, providing the wastes from KNPC are excluded.

Toward ultimate development the combined collection system is still considerably more cost effective than separate systems. Cost analysis indicated that the location of the treatment plant (TP2) is not an economic proposition as both the cost of the corresponding collection system and the land reclamation required will exceed that for other locations.

The least cost Master Plan was found to be associated with the collection of combined wastewater from the SIA for treatment in (TP1) and the collection of combined wastewater from MAIA for treatment in (TPM). In fact, the minimum cost Master Plan corresponds to the least cost collection alternative and the cost of the Master Plan increased by about 25% if the flow from KNPC is included.

Whilst the SAA has made a capital cost contribution to the MPW to allow sanitary wastewater from ESIA to be connected to the KVSS system, the additional capital costs required for separate collection of the sanitary and industrial waste reduced the cost effectiveness of this alternative. The cost of this solution was found 13% and 22% higher than the least cost Master Plan with and without the flow from KNPC, respectively.

Kuwait has been able to develop alternative sources of slightly brackish water to serve the needs of landscaping vegetation including private gardens within the urban area. In addition all sanitary wastewater has been directed after treatment to extending the existing agricultural forestry schemes. Increasingly in Kuwait, in common with other developing Middle East countries, policies are towards greater efficiency in waste reuse and economic utilization of resources.

Investigations of the cost effectiveness of treating the wastewater to meet the required effluent quality standards for the different disposal/reuse options revealed that the unit cost of treatment for reuse in irrigation is only about 10% more than for marine discharge. However, the unit cost of treatment for reuse as boiler make-up waste is 90% higher than for marine discharge. In addition to the high costs of such a sophisticated treatment system, its reliability of performance is not yet considered adequate for being a critical part of a vital industry such as electricity generation and water desalination. Therefore, the treatment of wastewater for reuse in irrigation seems to be the most economically attractive option. Wastewater reuse in irrigation also presents a major conservation factor for underground water in a country like Kuwait where water resources are scarce.

If better use is to be made of the investment in KVSS, negotiations should be held with the authorities of the MPW to explore the possibility of accepting combined flows of both sanitary and pretreated industrial wastes from MAIA into the village scheme. This would result in about 5% cost saving over the selected Master Plan for the same water end use. The accuracy of the cost estimates cannot be taken as more than 5%-10% which means that the cost for the two options are effectively the same and the choice between the two must take into account the following technical features:

* Operational and maintenance difficulties associated with the long rising main required for discharging combined wastes from MAIA to KVSS linking point

* The loss of potential for reuse within the [illegible] of new flows discharged to KVSS.

* The greater flexibility inherent in t[illegible] of a treatment plant within the MAI[illegible] expansion and coping with any changes in [illegible] characteristics.

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Technological, Economic, and Environmental Policies in Resource Recovery: the example of wastewater irrigation

by Charles G. Gunnerson

During 1976 to 1978, The World Bank conducted research on appropriate technology for water supply and sanitation in developing countries. The technological, financial, and economic findings of that project are being implemented in a number of World Bank and United Nations Development Programme rural and urban projects in Africa, Latin America, and Asia. The findings revealed a need for research and development in integrated resource recovery (waste recycling) which was undertaken in 1981 with UNDP collaboration. The research findings are being synthesized, and scheduled for publication in 1984 and 1985.

The research has revealed that there is increasing recognition in both developing and industrial countries of the need for technical and economic efficiency in allocation and utilization of resources. Collection and processing of solid waste materials for reuse provides employment for an estimated 1 to 2 percent of populations in developing country cities. Permanent or seasonal disposal of an estimated 80 percent of the sewage from these cities is to irrigation.

Policy decisions common to resource recovery from either solid or liquid urban wastes concern technological, economic, and environmental issues and their priorities. Technological issues include user service levels, system resilience (robustness), comparative costing of upgradeable alternatives, sophistication of both hardware and software, and engineering fees based on services rather than on construction costs. Economic issues concern institutional change, full economic costing and cost recovery, rationalization of locally relevant elements of the underground economy, present and future self sufficiency in resources, and due regard for fact that most of the costs are rarely borne by the sectors that receive most of the benefits. Environmental issues concern ecological stability, resource allocation, public health, and risk (where zero-risk is a restatement of the thermodynamically impossible zero pollution discharge previously sought after by some industrial country policies).

In all cases, whether for wastewater or solid wastes recycling, technology selection and investment priorities can be based on cost-benefit ratios which have been shown follow a logistic curve.

ACTUAL SLUDGE PRODUCTION IN MUNICIPAL SECONDARY WASTEWATER TREATMENT PLANTS

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ABSTRACT

Treatment and disposal of sludge is usually the most difficult and expensive aspect of wastewater treatment. Proper design of sludge facilities requires careful estimation of sludge quantities to be handled. This paper presents actual sludge production data from 26 activated sludge plants evaluated in an attempt to provide a better basis for the design of sludge facilities.

The plants studied received normal pollutant (SS and BOD) loadings and showed good performance. Actual total sludge production coefficients found varied according to plant size. Values obtained differ from those typically used in design suggesting that empirical sludge production coefficients developed in well-performing facilities would provide a more realistic design basis. The mass of waste activated sludge solids produced per mass of BOD removed increased with F/M loading applied and a linear correlation was found. Values obtained were higher than cell yield coefficients based on process kinetics. Sludge generated at the plants studies has a high nutrient content and its good fertilizing value remains after anaerobic digestion.

INTRODUCTION

Wastewater treatment involves not only the treatment and renovation of the liquid but also the processing and disposal of the solids removed or generated during treatment of the liquid. Sludge may be defined as a mixture of the solids and associated liquid produced during the treatment of wastewater. Processing and disposal of sludge may account for up to 50% of the total cost of treating wastewater (Farrell, 1974).

Proper design of sludge facilities requires careful evaluation of sludge quantities produced at wastewater treatment plants. An engineer must be able to estimate the total quantity of sludge produced during treatment before the design of sludge processing and disposal facilities can be completed. Mathematical calculation of sludge quantities generated by each treatment process can be made based on process fundamentals (Benefield et al., 1975; Metcalf & Eddy, 1979). However, it will generally be necessary to assume sludge production rates based on "typical" values taking into account the probable nature of the wastewater, the capacity of the works, the type of wastewater treatment processes to be employed and likely seasonal variations.

This study was initiated in an effort to provide a better evaluation of sludge quantities based on actual sludge production data obtained from operating secondary wastewater treatment plants employing the conventional activated sludge process. The popularity of this type of treatment has increased to satisfy the need for a good quality effluent.

METHODOLOGY

Sludge production data were collected at 25 operating activated sludge plants in the province of Ontaío, Canada, through a survey of municipal wastewater treatment facilities. In addition, the main activated sludge plant in Kuwait was also surveyed. These plants ranged in capacity from about 500 to 200,000 m^3/d (cubic meter per day). All facilities treated primarily domestic wastewaters and encompassed primary and secondary (conventional activated sludge) treatment stages. Yearly sludge production data were obtained from these plants. Moreover, the monthly average data were available from the main plant in Kuwait to allow further evaluation.

It is commonly difficult to obtain a precise estimate of the mass of sludge solids generated at a particular wastewater treatment plant due to lack of representative samples for solids determination. Changes in the sludge inventory within the treatment process also contribute to this difficulty. However, such problems are overcomed by evaluating sludge production on a monthly or longer basis.

Attempts were made to relate sludge production with common operating parameters. Statistical correlations were examined in each case. Data from all plants studied were analyzed to formulate general relationships whereas detailed information from Kuwait's main plant was used to examine specific parameters.

RESULTS AND DISCUSSION

The results of this study involve wastewater characteristics, total sludge production, surplus activated sludge quantities, and sludge characteristics at the plants considered in the study.

Wastewater Characteristics

Average annual concentrations reported for raw wastewater suspended solids (SS) and five-day biochemical oxygen demand (BOD) are presented in Table 1 along with the per capita loading values of these principal contaminants. Ontario plants surveyed receive medium-strength wastewater whereas Kuwait's plant treats strong wastewater according to typical composition of raw domestic wastewater (Metcalf & Eddy, 1979). The high strength of Kuwait's wastewater is presumably due to the relatively low per capita wastewater flow and the established habits of community residents. Significant variations are reported in the SS concentration of Kuwait's raw wastewater caused primarily by frequent sand storms.

The unit waste SS and BOD loading factors presented in Table 1 lie within the normal range of 90-150 g SS/capita.d and 80-120 g BOD/capita.d reported from various municipalities (Metcalf & Eddy, 1979).

Total Sludge Production

The quantity and characteristics of sludge produced is related to the wastewater flow and characteristics, type of process, and degree of treatment. The two main sources of sludge generated at secondary (activated sludge) plants are suspended solids from the influent wastewater (raw primary sludge) and biological solids synthesized from BOD removed in the activated sludge process (waste activated sludge).

Information from treatment plants concerning the relative proportions of raw primary sludge and waste (excess) activated sludge was generally not available. Some plants combine both types of sludge before processing and disposal while others pump the excess

Table 1. Raw Wastewater Characteristics and Loading Factors

Parameter	Ontario	Kuwait
SS (mg/ℓ)[a]	212 ± 78	280 ± 121
BOD (mg/ℓ)[a]	190 ± 65	415 ± 74
Flow (ℓ/capita.d)[b]	485	273
SS (g/capita.d)[b]	105	80
BOD (g/capita.d)[b]	92	113

(a) mean ± standard deviation
(b) based on mean values

Table 2. Sludge Production Unit Values

Unit	Value
$m^3/10^3$ m^3 of waste treated	4.90
Kg TS/10^3 m^3 of waste treated	219
g TS/capita.d	95
g TS/g (SS + BOD) removed	0.83

activated sludge to the primary sedimentation tanks for co-settling with primary sludge. Consequently, total (primary plus waste activated) sludge production figures are considered in these analyses.

Table 2 presents average sludge volume generated based on wastewater volume treated and average sludge quantity (dry weight of solids) produced based on wastewater volume treated, population served, and pollutants (SS + BOD) removed. In Table 2, the average volume of sludge produced per volume of wastewater treated (about 0.5%) is typically reported (Benefield et al. 1975; Metcalf & Eddy, 1979) although a higher value 1% is usually assumed (U.S.EPA, 1974). Average sludge dry solids production values obtained differ from those design figures (Metcalf & Eddy, 1979),

An attempt was made to relate the yearly sludge quantity produced (dry total solids) from the plants of various sizes studied to the corresponding flow rates, population served, and SS + BOD removed reported at these plants. Figures 1 to 3 display the relationships obtained on a logarithmic scale, respectively. The line of best fit found in each case shows a good correlation. Table 3 gives the correlation coefficients and regression equations obtained. It can be noted from Figure 1 that as the plant size increased from 10^3 to 10^5 m^3/d the amount of dry solids produced per unit of flow decreased by about 35%.

Waste Activated Sludge

Although total sludge production is most important for practical application, excess activate sludge growth solids contribute significantly to total sludge production. Data were available from Kuwait's main plant to allow further evaluation of the waste activated sludge portion of the total sludge produced. The performance of the activated sludge process was examined using monthly operation data collected in the years 1975, 1980, and 1983, during which the plant passed through various stages of increasing hydraulic and organic loadings.

Activated sludge production and wasting requirements may vary both between plants and also within a single plant for different periods. It might be expected that sludge production could be predicted based on the organic loading factor, i.e. food-to-microorganism ratio (F/M), or other parameters that influence activated sludge process performance. Efforts were made to examine the effect of this factor, expressed as mass of BOD applied per day per mass of mixed liquor suspended solids in the activated sludge aeration tank ($Kg\ BOD_A/Kg\ MLSS.Day$). Figures 4 and 5 show respectively the dependency of BOD removal efficiency and sludge volume index (SVI), a measure of sludge settleability, on the organic loading factor. Consequently, this factor would most likely influence activated sludge production.

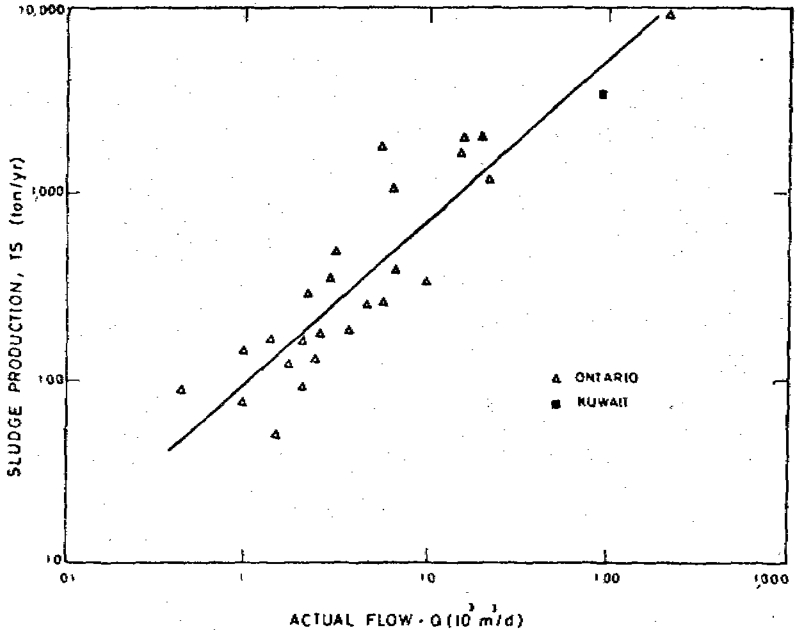

Fig.1. Relationship between sludge production and actual flow of wastewater treated.

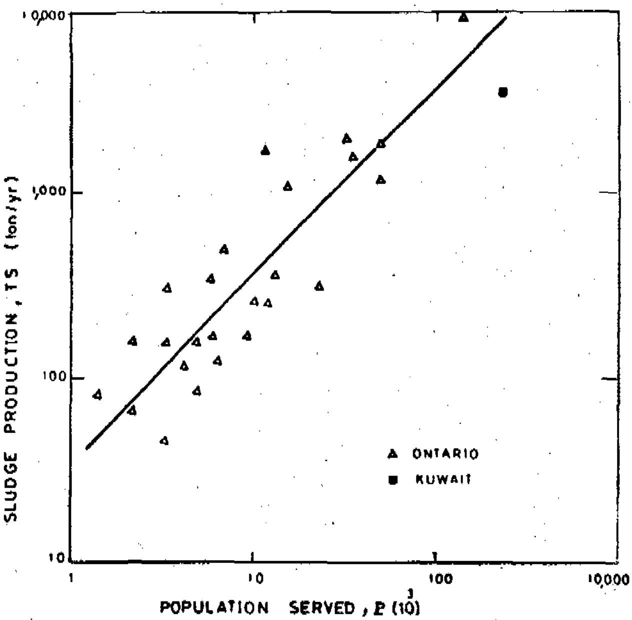

Fig.2. Relationship between sludge production and population served.

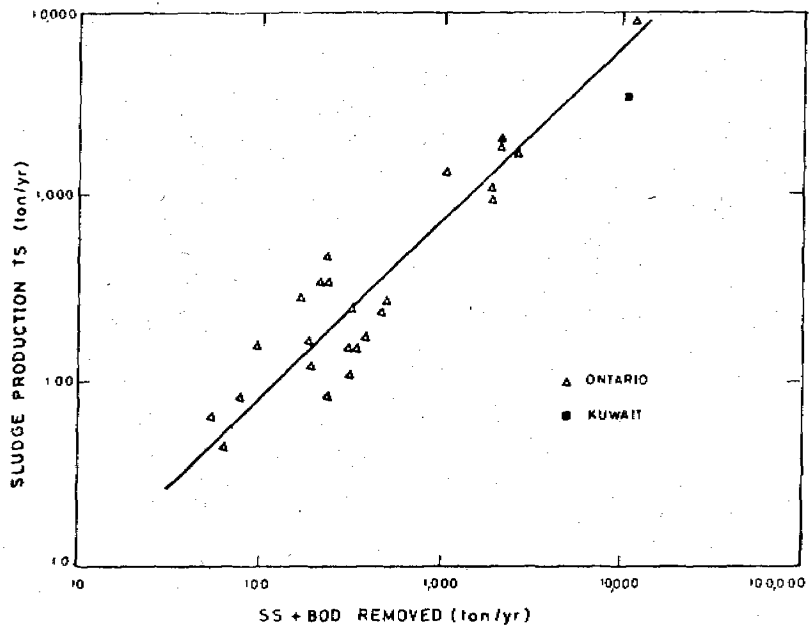

Fig.3. Relationship between sludge production and SS + BOD removed

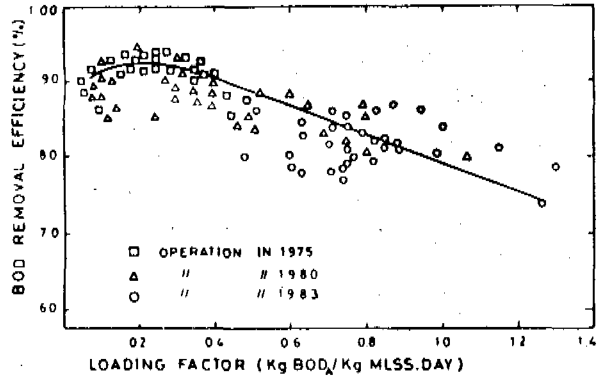

Fig.4. Effect of organic loading on BOD removal efficiency

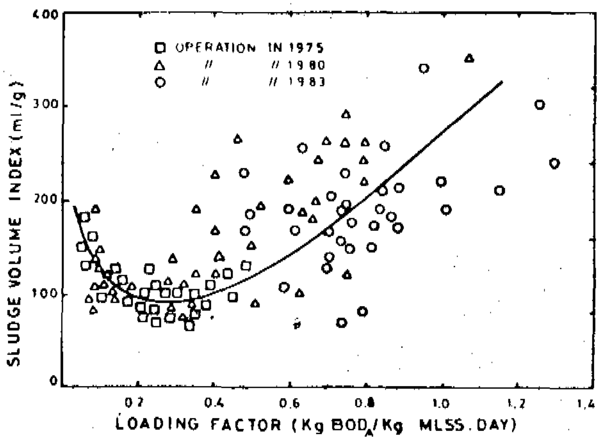

Fig.5. Effect of organic loading on sludge volume index

To compare activated sludge production at different plants, a common basis for documenting sludge generated is the mass of volatile suspended solids (VSS) produced per mass of BOD removed expressed as a coefficient (Kg VSS/Kg BOD_R). Volatile suspended solids is likely a better measure of sludge biomass than total suspended solids, although the later parameter is perhaps more commonly determined in practice. The mass of BOD removed was calculated using influent and effluent total BOD results of the activated sludge process. Activated sludge solids intentionally wasted were only used in claculating sludge production. In this study, the solids lost in the activated sludge system effluent were insignificant to contribute to total solids production. However, significant quantities of effluent solids, if present, may introduce an unnecessary variable into the evaluation.

The relationship between the loading factor (F/M ratio) and the sludge wasting coefficient is presented in Figure 6 for the loading range of the conventional activated sludge process. The least-squares line of best fit obtained shows a correlation coefficient, r, of 0.86 indicating a reasonably good linear correlation between these two parameters within the studied range of F/M loadings. However, the linear correlation obtained may not be valid for lower or higher F/M loadings indicative of different microbial growth phases. (Shultz et al., 1982).

The values obtained for the activated sludge wasting coefficient shown in Figure 6 are somewhat higher than a typical cell yield coefficient of 0.45 Kg VSS/Kg BOD_R or 0.65 Kg TSS/Kg BOD_R commonly used in system design based on process kinetics (Benedict et al., 1979; Shultz et al., 1982), knowing that the average volatile content of the sludge suspended solids observed in this study was 70%. Thus, cell yield coefficients that address only microbial solids growth should not be used as estimates of sludge production.

Sludge Characteristics

In order to design sludge treatment and disposal facilities properly, not only the quantities of sludge solids are required but also the characteristics of the sludge to be handled must be known. These characteristics vary depending on the origin of the solids and sludge. Some particular characteristics which are important in considering the fertilizer value of the sludge were studied using the data obtained from the surveyed plants. These plants practice the anaerobic digestion of sludge and the land disposal of digested sludge.

Table 4 summarizes the data obtained on sludge solids, nitrogen and phosphorus content which are important characteristics where the sludge is to be used as a soil conditioner. Data on

Table 3. Sludge Production Relationships

Relationship Obtained	Correlation Coefficient, r	Regression Equation[a]
Figure 1	+ 0.81	log Y = 0.881 logQ + 1.972
Figure 2	+ 0.82	log Y = 1.027 logP + 1.518
Figure 3	+ 0.94	log Y = 0.970 logX - 0.005

[a] Y = sludge produced in tonnes dry solids (TS) per year
Q = wastewater flow treated in thousand cu.m. per day
P = population served in thousands
X = SS + BOD removed in tonnes per year.

Table 4. Average Nutrient Characteristics of Total Sludge Produced at Secondary Activated Sludge Plants

Constituent	Untreated Sludge[a] (mg/ℓ)	Anaerobically Digested Sludge[a] (mg/ℓ)	Anaerobically Digested Sludge[b] (% of Dry wt.)
Total Solids (TS)	20,000±8,500	40,1000±18,200	100
Volatile Solids (VS)	13,000±2,300	20,500 ± 3,360	51
Total Kjeldahl Nitrogen (N)	2,400± 610	2,110 ± 495	5.16
Total Phosphorus (P)	1,000± 520	975 ± 603	2.38

[a] mean ± standard deviation

[b] based on mean values

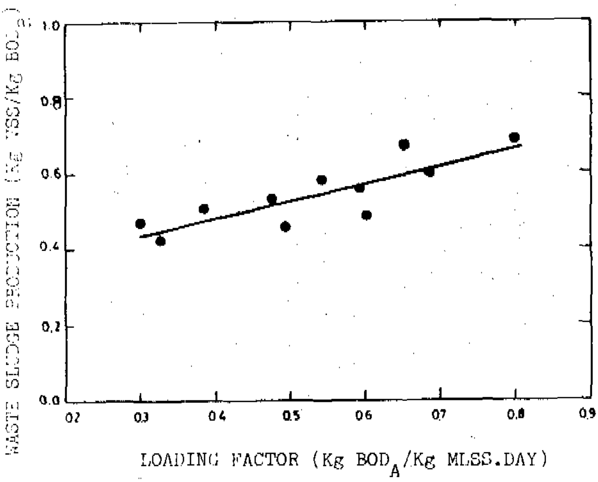

Fig. 6. Effect of Organic Loading on Sludge Production in the Activated Sludge System

heavy metals present in the sludge were scarce.

The data presented in Table 4 are comparable to those reported by Metcalf & Eddy (1979). In general, these data indicate a high nutrient content of the sludge. This quality was not greatly influenced by anaerobic digestion.

SUMMARY AND CONCLUSIONS

This paper has presented actual sludge production data from 26 well-performing activated sludge plants which were evaluated as to provide a better basis for the estimation of sludge production values used in the design of sludge facilities.

Analyses of wastewater characteristics have shown that the plants studied received normal pollutant (SS and BOD) loadings. However, total sludge production values obtained differ from those typically used in design. These values varied according to plant size. It has been found that the quantity of total sludge produced per pollutants (SS + BOD) removed is a more reliable parameter than the "per waste volume" or "per capita served" ratios often misused for design.

The mass of waste sludge generated per mass of BOD removed by the conventional activated sludge process increased with the increase in the F/M loading applied and a linear correlation was obtained. The actual waste sludge production coefficient (Kg VSS/Kg BOD_R) was higher than the cell yield coefficient typically used in design based on process kinetics.

Sludge production values are expected to vary according to local factors which should be decided case by case. Empirical sludge production coefficients developed in well-performing facilities provide a more realistic basis for design if good facility performance is to be achieved.

Sludge generated at the plants studied has a high nutrient content. The fertilizer value of the sludge was not greatly influenced by anaerobic digestion.

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CONTROL OF LIQUID EMISSIONS FROM THE PAPER CONVERSION INDUSTRY

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INTRODUCTION

The product of the paper machine is raw paper commonly called "dummy roll". The processing of this bulk output into finished products is termed "paper conversion". The basic differences in the various types of papers include durability flexibility, brightness, opacity, smoothness and printability are function of raw material selection and paper-making techniques.

The VARTA Paper Conversion Complex in Alexandria includes two plants. Plant I produces coated printing (one or two sides), coated bristol, index tag, fine packaging, special industrial paper, facial tissue and napkin, while plant II produces unbleached liner board, corrugating, folding carton, spinning cones for textile fibers and special packaging papers. The estimated annual water consumption of plants I and II are 3600 and 3500 cu. meters, respectively. The processing effluents are currently discharged through four separate outlets to the sanitary sewerage network.

SURVEY OF POLLUTION SOURCES AT VARTA

The preparation of printing cylinders in plant I involves photographing, etching and galvanization of the cylinders. In these operations, several chemicals are used including hydroqunione, sodium sulfite, potassium bromide, sodium thiosulfate, cyanoacetic acid, ethyl alcohol, ammonia, paraffin oil, potassium cyanide, silver nitrate and sulfuric acid. Most of the chemicals are used in dipping baths which are frequently enriched through addition of new chemicals. When the chemicals are exhaused or rendered unsuitable due to increase of concentration of impurities, they are directly disposed off to the sewerage network.

The dumping of chemicals is an intermittent process which depends to a great extent on operators judgement. Other operations at plant I include nylon printing (sodium tricyanide, sodium bromide, and sodium thiosulfate) and paper conversion processes (animal glue, China clay, Barium sulfate and printing inks). These operations are dry in nature and wastewaters are generated only during cleanup and equipment maintenance. Both effluents of plant I contain extremely high levels of chemical oxygen demand (COD) and biochemical oxygen demand (BOD). The suspended solids (SS) are high while oil and grease (O & G) are normal as shown in Table (1).

Major chemicals used in processing of corrugated and folding carton in plant II are sodium silicates, starch and animal glue (Eff.II-1) while effluent of the utilities and maintenance depatratments contain very high O & G content due to frequent dumping of lubricating oil in the sewers. High levels of pollutants in the processing effluents occur as a result of the low-volume water use for cleanup and maintenance and the direct dumping of chemicals and oils in the sewer system. Occasional testing indicated high sulfide level (5-10 mg/l) in effluents I-1, I-2 and II-1.

Egyptian emission standards for discharge of industrial wastes to public sewers limit O & G to 100 mg/l and sulfide to 1 mg/l. No maximum limit has been set for BOD, COD and SS (law 93/62).

BENCH-SCALE TREATABILITY STUDIES OF THE COMBINED EFFLUENT

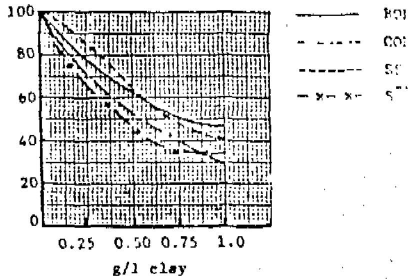
Although reducing the organic load of the wastewaters from this plant does not receive great attention as effluentis discharged to public sewers, it was felt that any proposed scheme for waste treatment should provide for adequate reduction of the BOD and COD. As shown in Figure (1) adsorption by natural clay (Aswan clay) is not highly effective for removal of BOD, COD and SS, specially when used in low doses of 250-500 mg/l. However, the clay is locally available and need not to be regenerated. The estimated O & M cost of the system is 30 cents/cu meter when applying a dose of 1000 mg/l clay in the adsorption process.

Direct aeration is highly effective for removal of the sulfides (S). Moderate removals of the BOD and COD were achieved upon extending the aeration period to 12-16 hours. Aeration has limited effect on removal of SS as shown in Figure (1). To improve the treatment efficiency, double media filtration (sand 0.45 mm with 5% powdered activated carbon and sand 0.45 mm) was applied to the aerated effluent. A significant improvement in the treatment efficiency was achieved by aeration for 12 hours followed by filtration. However, the estimated O & M costs of this system is 52 cents/cu meter.

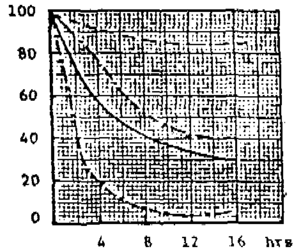
Table 1. CHARACTERISTICS OF WASTEWATER EFFLUENTS FROM VARTA PAPER CONVERSION COMPANY

		pH	Turb NTU	Sett. Solid ml/l	TS mg/l	SS mg/l	VS mg/l	Cl^- mg/l	Alk mg/l	Total Hardness	PO_4^{3-} mg/l	NO_3^- mg/l	O&G mg/l	Oxygen mg/l BOD	Oxygen mg/l COD
Plant I Eff. 1	$\bar{X}$		9.383	0.50	748	366	339	75	182	240	157	56	15	2128	3325
	SD	0.27	0.47	0.6	248	136	133	33	40	78	39	20	4.8	595	625
	R	6.5-7.3	8.7-10	0.1-1.2	523-980	210-561	200-520	50-140	120-240	120-340	90-200	30-80	10-20	1380-2950	2240-3700
Plant I Eff. 2	$\bar{X}$		44.5	0.16	1311	242	705	197	305	274	170	75	35	4206	7263
	SD	0.79	1.64	0.05	234	117	162	46	43	54	51	20	9	520	859
	R	5.5-7.1	42-47	0.1-0.2	1110-1720	160-450	513-954	150-260	250-380	200-340	100-230	50-110	29-56	[illegible]-5100	[illegible]-8200
Plant II Eff. 1	$\bar{X}$		6	0.43	652	183	335	98	208	225	135	90	57	2414	4258
	SD	0.4	0.6	0.17	103	17	126	37	24	21	18	20	14	354	186
	R	6.2-7.3	5.6-6.2	0.2-0.6	538-818	160-198	228-500	70-160	180-240	200-240	110-150	60-110	50-80	2100-2950	4000-4520
Plant II Eff. 2	$\bar{X}$		52.16	2.4	3981	2744	1597	705	290	390	198	158	2585	4453	8210
	SD	0.47	15.15	0.58	2033	1287	991	115	91	86	26	13	404	1372	1359
	R	6.8-7.4	30-68	1.8-3.2	1954-5480	954-3700	779-2784	560-830	140-410	330-560	160-200	140-170	2120-3100	3200-5920	6300-9400

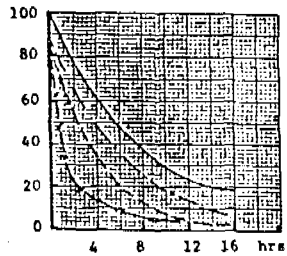
$\bar{X}$ = Average of seven observations.
SD = Standard Deviation.
R = Range



a) Effect of Adsorption by Clay on Removal of Pollutants.



b) Effect of Aeration on Removal of Pollutants.



c) Effect of Aeration-Filtration on Removal of Pollutants.

Figure (1) EFFECT OF TREATMENT ON THE COMBINED EFFLUENT OF VARTA PAPER CONVERSION PLANT.

In view of the existing emission limitations, it is not advisable to use clay adsorption due to its low treatment efficiency and aeration filtration due to the high O & M costs. A recommended treatment system should encompasses equalization and pH adjustment, sedimentation, aeration and clarification to achieve acceptable removals of solids and sulfides and partial reduction of the organic loading.

PROPOSED TREATMENT SYSTEM AT VARTA(1,2,3)

It is proposed to implement the pollution control program in two phases. Phase I should emphasize segregation of low-volume toxic effluents from the preparation of printing cylinders and nylon printing departments. The segregated wastes should be collected and treated in separate tanks as shown in Figure (2). The cyanic wastes can be treated with sodium bisulfite followed by 100 mg/l polymer coagulation. Conc acids should be neutralized while printing wastes may be treated by high coagulant dosage (1 g/l alum, 100 mg/l polymer). The detoxified effluents should be carefully monitored before ultimate discharge to the public sewers.

Phase II includes diversion of the existing four outlets to a common treatment system as shown in Figure (3). Dumping of O & G from the maintenance depatment should be ceased and grease trap must be installed for the effluent II-2 as a protective measure to insure removal of most of O & G before reaching the treatment system.

The proposed treatment of the combined effluent includes primary sedimentation, aeration and clarification as shown in Figure (4). Detailed system for treatment of VARTA effluent is depicted in Figure (5). The proposed system will meet the regulations for discharge of S^{--} and O & G, and will aid in reducing the organic load before discharge to public sewers.

CONCLUSIONS

A field study has been carried out at VARTA paper conversion plant to develop practical pollution abatement scheme to meet the emission limitation of industrial effluents to public sewers. All plant effluents are low-volume highly concentrated wastes since most processes are dry in nature with

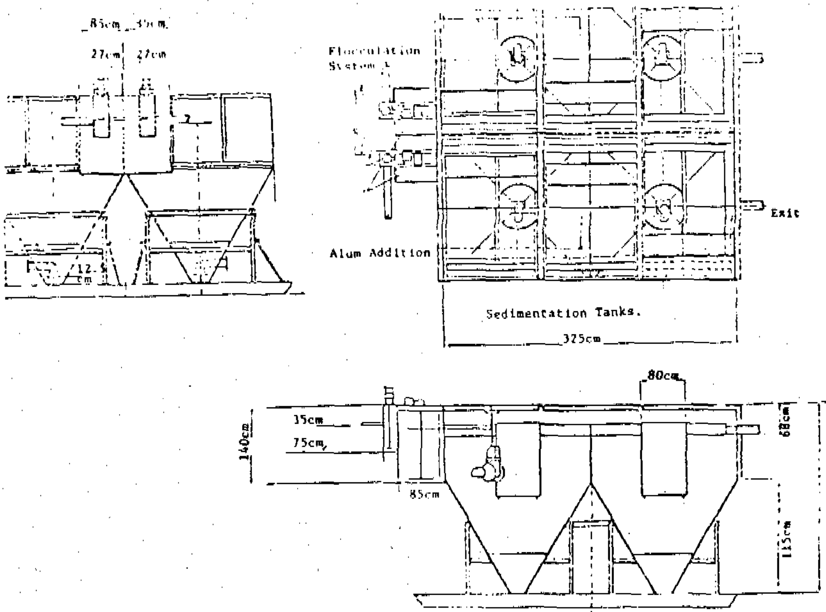


Fig. 2. DETAILS OF THE TREATMENT SYSTEM OF TOXIC WASTES

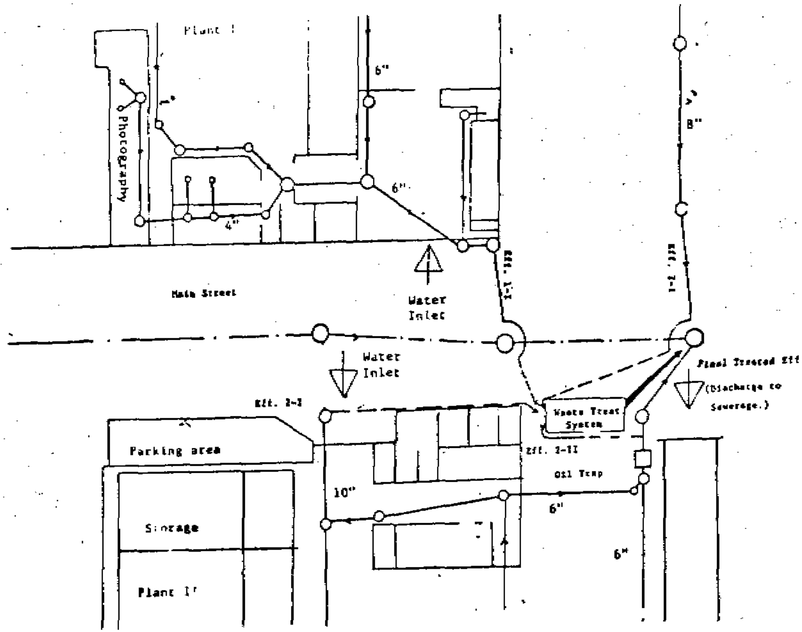


Fig. 3. SEGREGATION OF PROCESSING EFFLUENTS AT VARTA PLANT

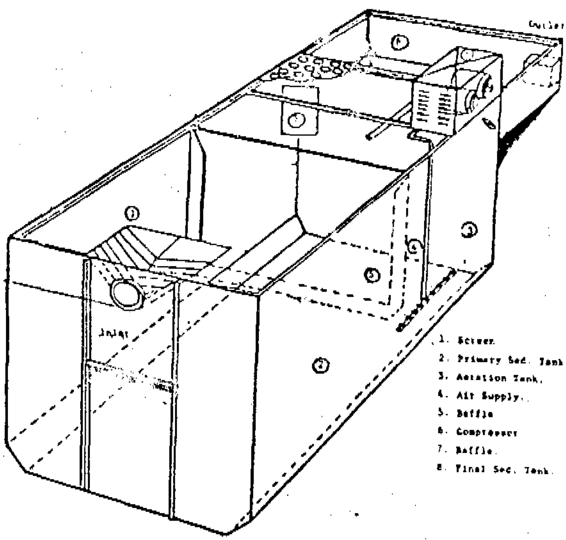


Fig. 4. LAYOUT OF TREMENT UNIT OF VARTA WASTEWATER

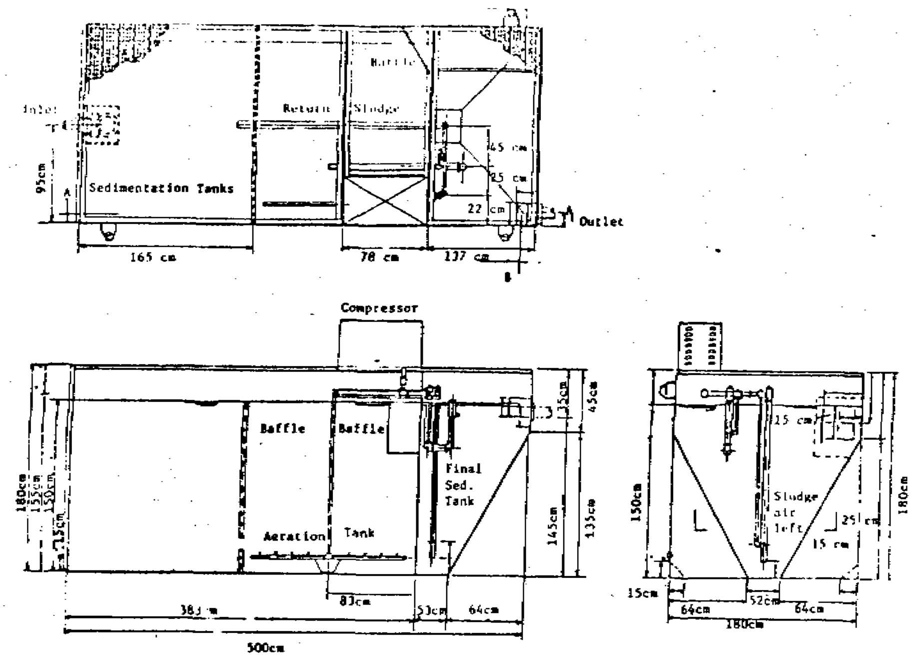


Fig. 5. TREATMENT SYSTEM FOR NON-TOXIC EFFLUENTS AT VARTA

the water use limited to cleanup and maintenance operations. The high loading is attributed to direct dumping of processing chemicals and [illegible] to the sewers. The proposed treatment scheme involves segregation and detoxification of hazardous chemicals used in some departments and diverting the rest of the processing effluents to a common treatment system which include sedimentation and aeration to remove solids, sulfides and portion of the organic constituents.

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