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Slow Sand Filters for Rural Water Supplies in Developing Countries

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ABSTRACT

The National Environmental Engineering Research Institute (NEERI), Nagpur, India in collaboration with the WHO International Reference Centre (WHO IRC) for Community Water Supply, the Hague, the Netherlands has been participating in a global research-cum-demonstration project on slow sand filtration for community water supplies in developing countries. In the first phase of the programme applied research was undertaken on important aspects that have a bearing on the performance of slow sand filters as well as cost of the system. Pilot scale experiments were conducted over a period of 30 months on the effect of different filtration rates, shading, intermittent operation high levels of organic pollution in raw water and builder grade sand on the performance of slow sand filters with a view to develop design criteria appropriate to local conditions. This paper discusses the salient findings of the study and outlines the approach for field demonstration programmes under the second phase.

Introduction

The recommendation of the United Nations Water Conference held at Mar del Plata, Argentina in March 1977 that the period 1981 to 1990 be designated as the ' International Drinking Water Supply and Sanitation Decade ' has been unanimously endorsed by the 30th World Health Assembly. While adopting this resolution which is an unequivocal minifestation of the universal concern for reaching this vital necessity for all by 1990, WHO has emphasized, among other things, the need for the development of alternative approaches and materials so as to suit the particular conditions of the country. This paper

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presents the salient features and findings of a research-cum-demonstration programme on slow sand filtration which has a great potential as an appropriate technique for treatment of surface waters for the rural communities of developing countries.

Global Water Supply Situation - an Over-view

A survey by WHO of the water supply situation in developing countries as of December 1970 and 1975 is summarised in Table 1.

TABLE 1 - Estimated Population Provided with Community Water Supply Service in the Developing Countries excluding China *

(Based on mid-decade survey in 1975)

	Population Served Adequately (house connection or reasonable access)				
	1970		1975		
	in millions	p.c. of population	in millions	p.c. of population	Increase in percentage
Urban	316	67	450	77	10
Rural	182	14	313	22	8
Total	498	29	763	38	9

By the end of 1970, 67 per cent of urban population and 14 per cent of rural population had a reasonable access to safe water supply. The data for 1975 which covered only 90 per cent of the population surveyed in 1970, show that an increase of 10 per cent and 8 per cent has been achieved in the urban and rural sectors respectively. Further; it is

* World Health Statistics Report, Vol. 29, No. 10, World Health Organization, Geneva

estimated that if the investment per annum upto 1990 remain at the level of 1971 to 1975, the proportion of the world's urban population with water supply may remain static at 77 per cent and the proportion of the rural population served may rise from 22 per cent to 38 per cent. A number of factors has contributed to this unsatisfactory progress.

Constraints to Progress

The greatest single limiting factor in the development of water supply in general and rural water supply programmes in particular has been inadequate financial inputs. In developing countries, priority has not been given in proportion to the need for this sector, due to the competing demands from other sectors on the limited resources. Lack of political will at national level, inadequate and inappropriate organisational and administrative set-up, lack of trained personnel at appropriate levels and inadequate community participation have all contributed to the slow progress in this vital sector.

Another important aspect in the provision of protected water supply is the prevailing differences between the urban and rural environment - cultural and socio-economic. The concept of commercialization of water supply as a self-supporting proposition, let alone a profitable one, has seldom gained acceptance in rural areas of developing countries. Hence, the approach and strategy to be adopted to rural water supply programmes have to be different from those for urban schemes. The multiple nature of rural projects calls for special techniques and it is a misconception to think that these small supplies are merely ' scaled down ' versions of urban installations, requiring less engineering skill and ingenuity. The exact opposite may often be the case.

Appropriate Technology

Rural water supply systems in developing countries have to be technologically sound, economically viable, environmentally compatible and socially acceptable. Modern technology offers a choice of treatment methods that can produce virtually any desired quality of product water from any source, the limiting factor being economical rather than technical. When groundwater of acceptable quality is available within a reasonable depth and distance from the community it remains to be the first choice. It is due to the reasons of simplicity and economy. However, there are numerous instances where groundwater is not available or even when available, poses problems of quality due to excessive fluorides, salinity, iron and managanese, etc.

In such cases one has to depend upon available surface sources which are invariably polluted and have to be treated for domestic supplies. The selection of the treatment system should meet the real needs of the population, be within the capabilities of the local community to implement, operate and maintain and suit the socio-cultural setting.

Slow Sand Filtration

Slow sand filtration, the earliest method of purification of public water supplies, continues to enjoy the reputation of being a reliable means of treating polluted surface waters. The technical advantages of the process such as its simplicity of design and operation and its ability to bring about a simultaneous improvement in physical, chemical and bacteriological quality of raw water go to make it an appropriate technique especially for small communities in developing countries. In each of its functions, it represents the nearest approach to the processes that occur in nature and perhaps because of this, it has unusual powers to suffer misuse without failure and a capacity for self-regeneration after such misuse.

It should also be recognised that slow sand filtration is not a panacea for all water treatment problems and that it has certain limitations. High inorganic turbidity in raw water causes rapid clogging of the filter surface necessitating cleaning at too frequent intervals. If turbidity exceeds 50 units (FTU) for long periods, pre-treatment by settling or simple rapid filtration may be necessary. In industrialised countries the large areas of land required for slow sand filters and the labour for the manual cleaning processes are serious disadvantages. However, these limitations do not apply to most of the developing countries.

Recent Efforts on Research and Development

Despite the fact that slow sand filters have been operating successfully for more than a century now, there are still certain aspects of their performance and operation which are not fully understood. Further, there appears to be a misconception among designers of water treatment that this method of purification is superceded by ether more modern techniques. The need for a better understanding of the potentialities of this simple process and its application especially for small communities of developing countries was recognised and accorded high priority by the collaborating institutions of the WHO International Reference Centre (WHO IRC) for Community Water Supply, the Hague (1973). On the basis of international collaboration, a programme of applied research and investigation has been developed to demonstrate the suitability and appropriateness of the process under local conditions and to promote its large scale application for treatment of drinking water. In the first phase of the project for which financial support has been made available by the Directorate for International Technical Assistance of the Netherlands Ministry of Foreign Affairs, six countries have been participating on collaborative basis while the international coordination of the various activities is undertaken by the WHO IRC, the Hague.

Contribution by NEERI

The National Environmental Engineering Research Institute (NEERI), Nagpur, India, one of the reference centres of WHO IRC for Community Water Supply, has been participating in this programme. In the first phase, applied research on pilot filters, field investigations on existing plants and literature studies were carried out so as to dev-lop design criteria appropriate to local conditions. The research content was so organised as to cover important aspects which have a direct bearing on either the performance of the process or on the cost of the system. Specifically, the performance of slow sand filters in relation to the following was investigated :

i) The quality of raw water with regard to turbidity, bacterial pollution, etc.

ii) The effect of higher filtration rates.

iii) The influence of shading.

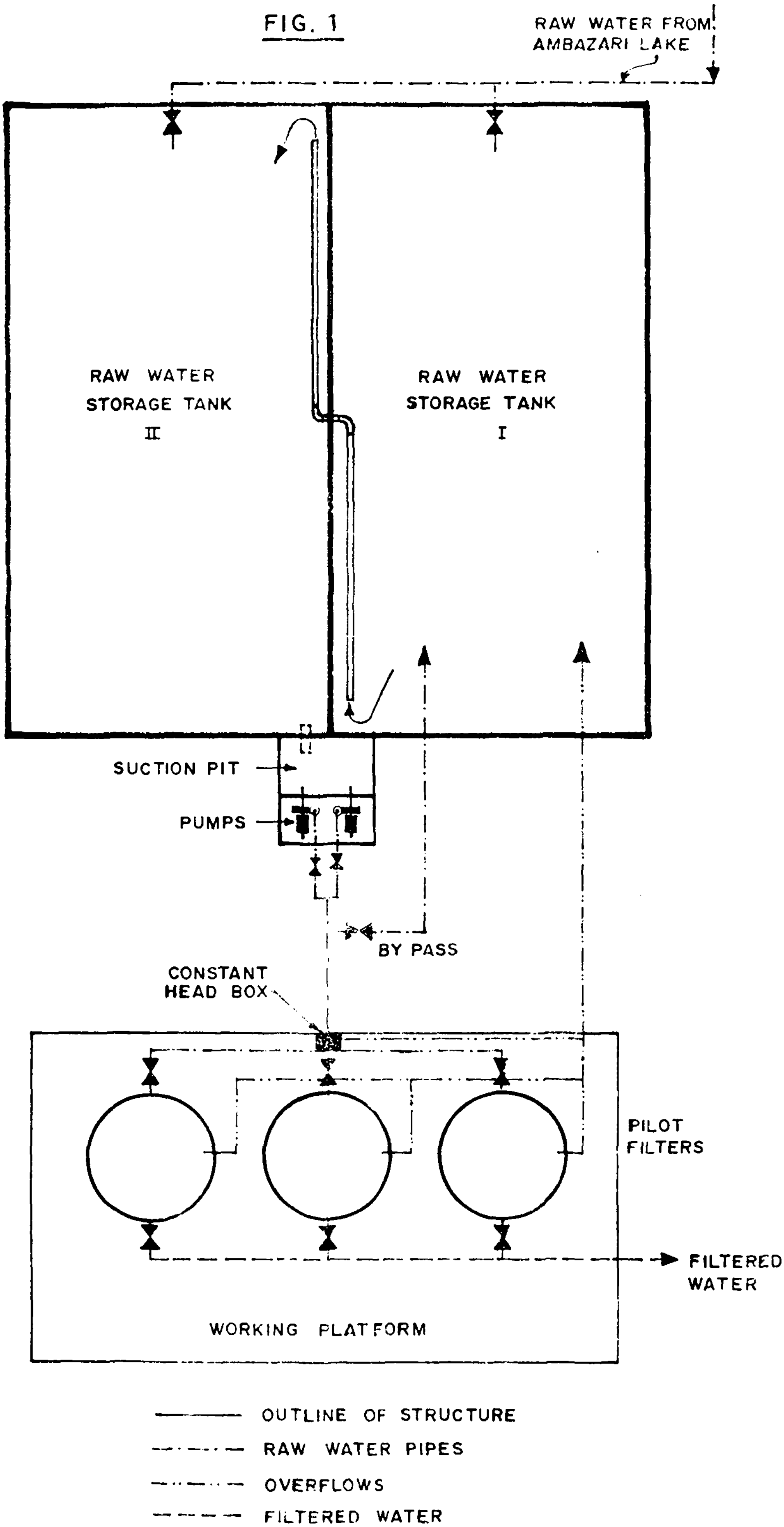
iv) The effect of intermittent operation.

v) The effect of high organic pollution in raw water.

vi) The use of builder grade sand.

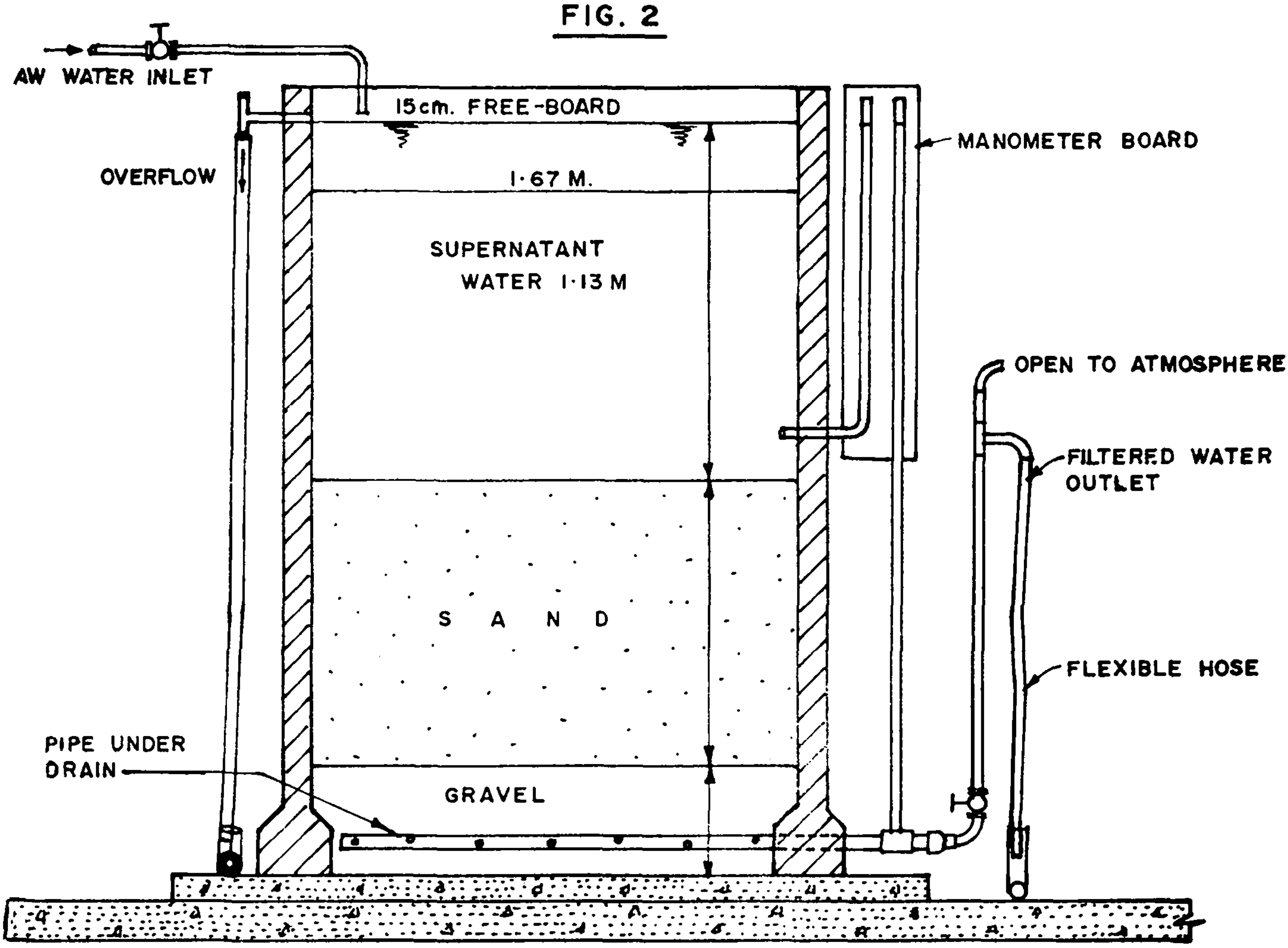
The investigations were carried out on three pilot filters 1.67 m dia and 2.5 m deep and provided with necessary accessories for desired operation and control. The pilot plant layout and filter details are shown in Figs. 1 and 2 respectively. All the experiments were conducted with raw water drawn from a lake so as to simulate field conditions. Samples of filtered water were collected daily and analysed for important parameters such as turbidity, dissolved oxygen, pH and bacteriological quality in addition to complete physico-chemical characteristics at regular intervals.

FIG. 1

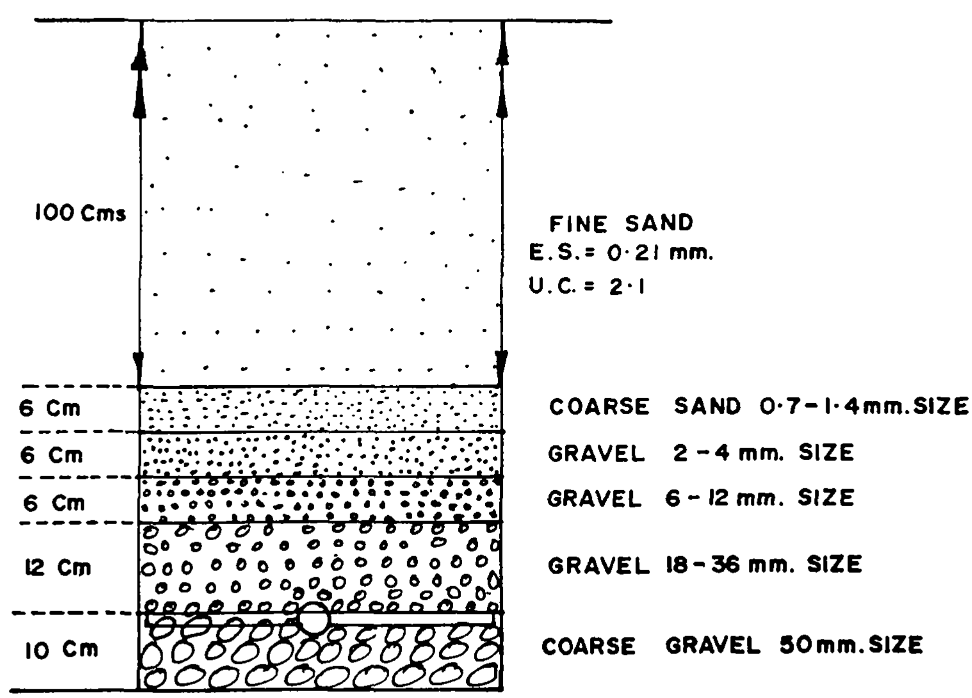


PILOT PLANT LAYOUT - SCHEMATIC

FIG. 2



FILTER SET UP



MEDIA DETAILS

Performance of Filters at Higher Filtration Rates

The performance of filters operated at 0.1, 0.2 and 0.3 m/hr rates of filtration is summarized in Table 2 and presented in Figs. 3 & 4.

The turbidity of raw water was generally below 5 FTU, except for a short period of 2 weeks when it increased to about 10 FTU. During the initial ripening period which lasted about 5 weeks, the turbidity of filtered waters was more than 1 FTU but below 2 FTU; later on it improved and remained below 1 FTU. It was observed that the filtrate turbidity seemed to follow an inverse trend with regard to rate of filtration. The filter operated at 0.3 m/hr always produced a filtrate of lowest turbidity while those operated at 0.2 m/hr and 0.1 m/hr gave filtered waters of higher turbidity but less than 1 unit.

The dissolved oxygen in the filtrate was found to be lower with lower rates of filtration. This can be explained by the fact that at lower rates of filtration the incoming water is retained for a longer period in the filter and therefore, a greater depletion of oxygen by the biological system. No perceptible difference in the chemical characteristics such as alkalinity, hardness, chlorides and sulphates of filtered waters was observed. However, considerable reduction in total iron was recorded due to filtration.

The organic pollution in raw water estimated as COD, varied from about 6 mg/l to 10 mg/l. Due to filtration, the average reduction in COD was 54.3, 53.1 and 50.4 per cent respectively at 0.1, 0.2 and 0.3 m/hr filtration rates. Statistical evaluation by analysis of variance has shown that there is no significant difference in COD removal with regard to rate of filtration. This is in support of the observation at the Amsterdam Water Works where three covered filters have been operated for a full year at different rates of 0.1, 0.25 and 0.45 m/hr without any marked difference in effluent quality. *

It was observed that the filters operated at 0.1 m/hr and 0.3 m/hr delivered water free from <u>E.coli</u> on 66 and 65 occasions respectively out of a total number of 71 samples tested. The filter operated at 0.2 m/hr gave a filtrate which was free from <u>E.coli</u> in 72 out of 76 observations. While this degree of bacteriological purity

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*Slow Sand Filtration - L. Huisman & W.E. Wood, WHO 1974, p. 44

TABLE 2 - Effect of Rate of Filtration - Summary of Filter Runs

Run No.	Rate of Filtration	Length of Run		Net Water Filtered
		Days	Hours	m^3
1	0.1 m/hr	27	3	141.19
2		52	9	254.14
3		37	6	180.57
1	0.2 m/hr	27	3	282.38
2		19	5	182.12
3		24	0	248.67
4		35	7	323.00
1	0.3 m/hr	13	6	204.89
2		27	6	388.77
3		4	6	49.91
4		7	5	110.33
5		11	6	176.00
6		30	4	408.47
7		8	22	139.22
8		7	0	106.83
9		8	0	122.58

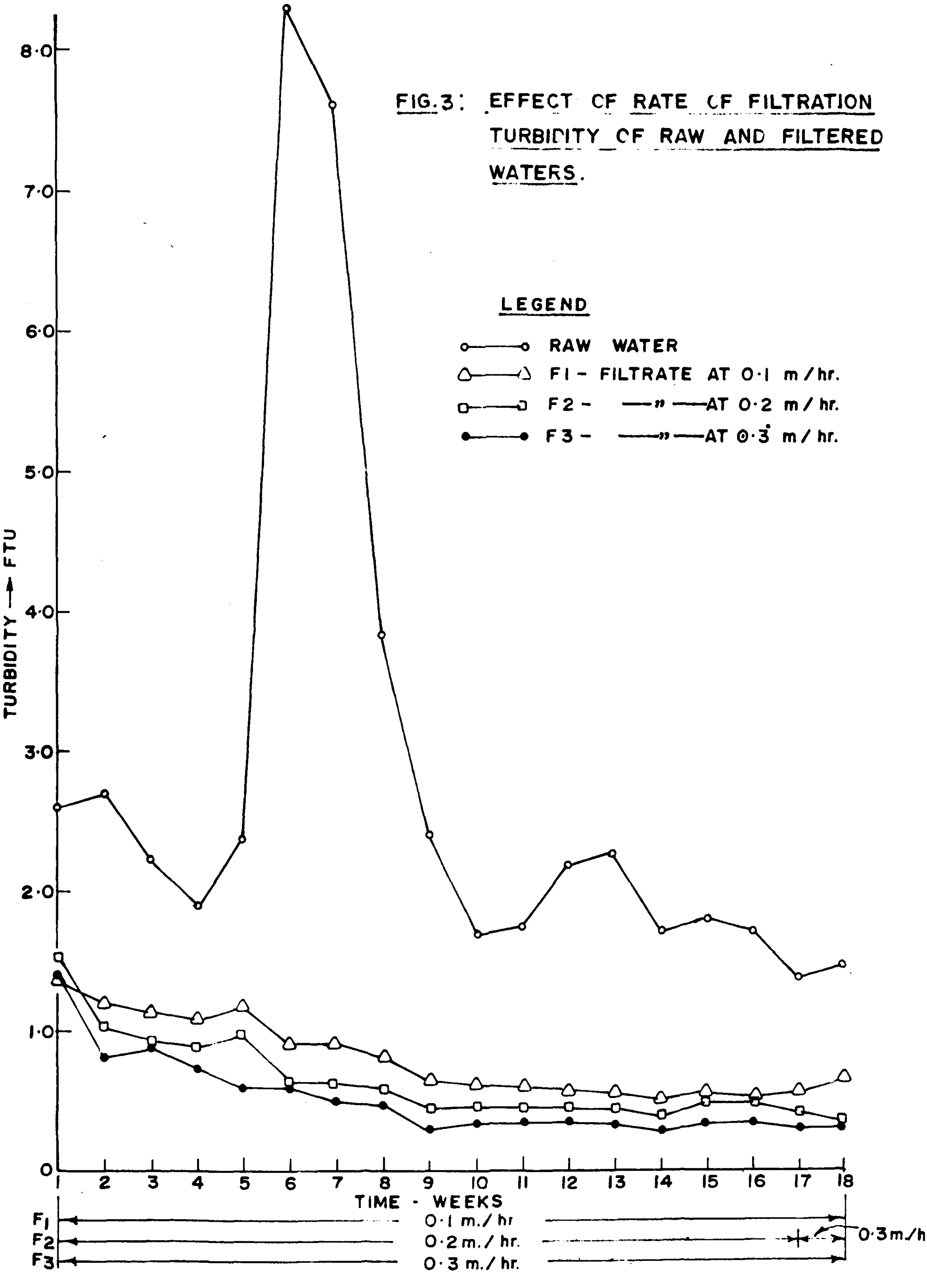
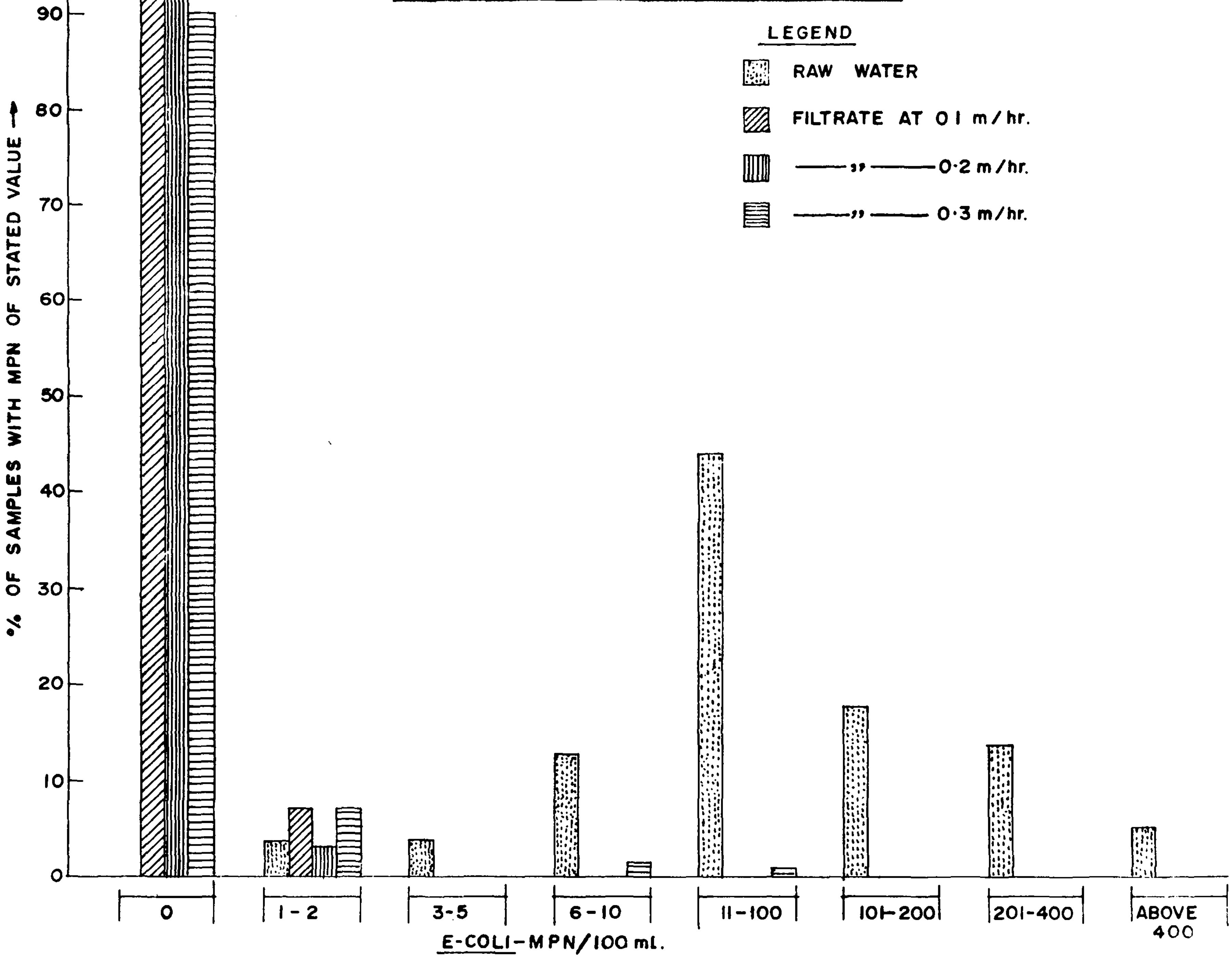


FIG.3: EFFECT OF RATE OF FILTRATION TURBIDITY OF RAW AND FILTERED WATERS.
LEGEND
RAW WATER
F1 - FILTRATE AT 0·1 m/hr.
F2 - " AT 0·2 m/hr.
F3 - " AT 0·3 m/hr.
TURBIDITY → FTU
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
TIME - WEEKS
F1 0·1 m./hr
F2 0·2 m./hr.
F3 0·3 m./hr.
0·3 m./h

FIG. 4. BACTERIOLOGICAL PERFORMANCE OF FILTERS AT DIFFERENT FILTRATION RATES.



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may be considered acceptable for rural supplies, as a safety precaution, terminal disinfection of filtered water is desirable.

The average length of run for the filters operated at 0.1, 0.2 and 0.3 m/hr was 45, 26 and 13 days respectively. Assuming a downtime of 4 days per cleaning operation, the corresponding filter output per year would be 806, 1510 and 2000 m^3/m^2 respectively. It is evident from the data that the output of a filter increases with increase in rate of filtration but follows a law of diminishing return. The results have clearly indicated that slow sand filters treating raw water of turbidity less than 10 FTU can produce a good quality filtrate at all the filtration rates of 0.1, 0.2 and 0.3 m/hr. The observations are of practical significance for the designer, in that the traditional filtration rate of 0.1 m/hr need not be held sacrosanct but higher rates could be used under favourable conditions of low raw water turbidity with the possible advantage of greater output and with no adverse effect on filtrate quality.

Observations on Effect of Shading

Surface waters containing essential nutrients like nitrates, phosphates and carbon dioxide provide favourable conditions for the growth and proliferation of algae especially in tropical areas. When these waters are treated by slow sand filters the algae can produce significant effects on the working of the filters. Whether these effects will be beneficial or harmful will depend upon the type of algae and a variety of other conditions. It was considered that some of the adverse effects of algae may be minimised by shading the filters to prevent sunlight from reaching them. The influence of shading on filter performance was, therefore, investigated with the following observations.

Shading of filters either partly or completely did not have any influence on the filtered water turbidity which remained below 0.5 FTU at both 0.1 and 0.2 m/hr filtration rates. Shaded filters produced a filtrate with a more or less uniform dissolved oxygen as measured at 7.00 AM and 3.00 PM, however, the completely shaded filters gave a filtrate with relatively higher D.O. than that obtained from the partly shaded filter. The trend in filtrate D.O. of the control filter was one of minimum in the morning and maximum in the afternoon hours. This can be attributed to the enhanced photosynthetic activity of algae during daytime followed by the respiration during night resulting in D.O. depletion. The limited data (Table 3) on algal counts observed from the filter

TABLE 3 - Effect of Shading - Quantitative Data on Phytoplankton from Filter Scrapings (Organisms per sq.cm)

Date	Completely shaded	Open to sky	Partly shaded
2.6.76	2125×10^2		2115×10^2
Dominant/ Sub-dominant	Cymbella/Navicula Denticula		Cymbella/Navicula Denticula
11.6.76		2828×10^3	
Dominant/ Sub-dominant		Cymbella/Navicula Denticula	

scrapings indicate a relatively low number in the shaded filters and these were predominantly diatoms. In the control filter, which was open to sky, there was a predominance of green algae. This may provide a possible explanation to the observation that there was no significant difference in the length of run. Similarly, there was no significant difference between the filters in the reduction of COD which ranged from 62 to 68 per cent. It was concluded that shading of filters helps reduce the algal activity in the filters but does not affect the filter performance.

Effect of Intermittent Operation

In developing countries, for reasons of economy in operation and maintenance, small water works serving upto a few thousand population are designed to operate for a part of the day only. Studies were carried out in order to assess the effect of such intermittent operation on the filtered water quality and the practical implications on the design and operation of filter system.

During the initial part of this study, one of the three pilot filters was run continuously as a control and the other two intermittently for 10 hours a day from 7 AM to 5 PM. At the end of the working cycle (10 hours), the outlet valves of the intermittently operated filters were closed and raw water inflow cut off. The full depth of supernatant was left in stagnant condition till the filter operation was resumed next morning. Daily samples of filtrate were collected soon after starting the filters following overnight stagnation and tested for bacteriological quality, turbidity, pH and dissolved oxygen. Periodic observations on the diurnal variation in D.O. of filtered waters were also made.

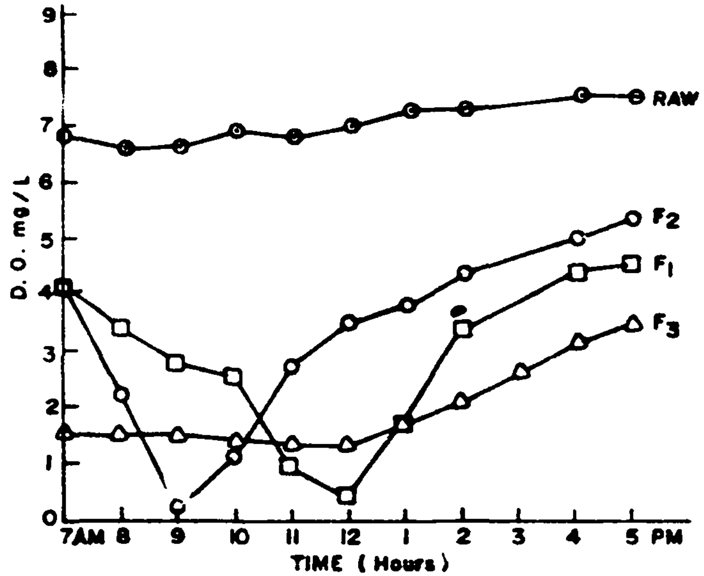
The turbidity of raw water was below 5 FTU for a period of about 10 weeks and later, due to monsoon, increased to a maximum of about 24 FTU. Irrespective of this variation in raw water turbidity, the filtrate from all the filters had turbidity values below 1 FTU. Similarly, the efficiency of COD removal and the bacteriological quality of filtrates from the control and test filters were quite comparable. A perusal of the diurnal variation in the D.O. of filtrate (Fig. 5) from the intermittently operated filters indicated that the time of occurrence of minimum D.O. coincides more or less with the time at which the layer of water in contact with the schmutzdecke passes out as filtrate. This observation was suggestive of a possible deterioration in the bacteriological quality also of the filtrate due to intermittent operation. Hence, further studies were conducted to confirm this hypothesis.

For these studies a more intensive and elaborate sampling programme was followed and the observations were restricted to only one filter at a time. The test filter was operated continuously without interruption for 5-7 days in the beginning of the run and subsequently switched over to intermittent cycle of 8 hours (9 AM to 5 PM) followed by stagnation for 16 hours. Hourly samples of filtrate were collected daily and tested for bacteriological quality.

The results of bacteriological tests (Table 4) clearly show that when the filter is run continuously without interruption, a filtrate of consistently satisfactory quality is obtained. However, when switched over to intermittent operation, a definite deterioration in bacterial quality is observed. The impairment does not occur soon after starting the filter, but after a period of time which appears to vary with the rate of filtration and the depth of filter sand used. Interestingly enough, the filter tends to recover gradually and gives a filtrate of satisfactory quality at the end of the operation cycle.

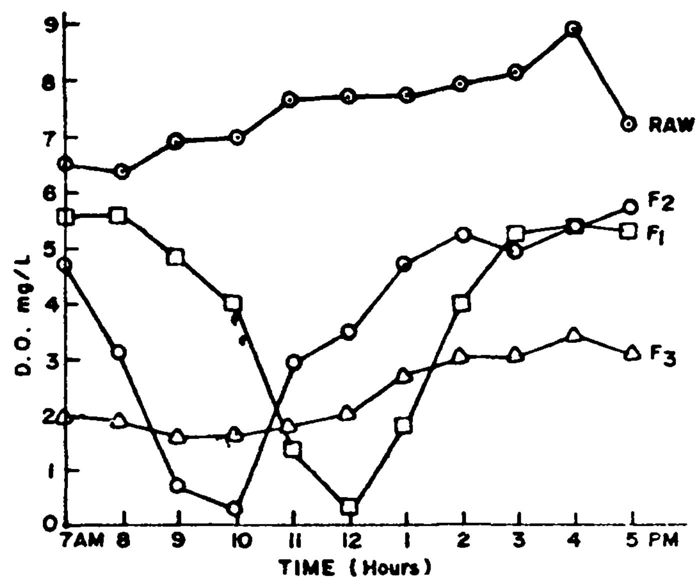
While intermittent operation of filters may lead to economy in operation and maintenance, the cost of filter

FIG. 5



DIURNAL VARIATION IN D. O. OF RAW AND FILTERED WATERS.

LEGEND – F1 – INTERMITTENT OPERATION – 0·1 m/hr.
F2 – INTERMITTENT OPERATION – 0·2 m/hr.
F3 – INTERMITTENT OPERATION – 0·1 m/hr.



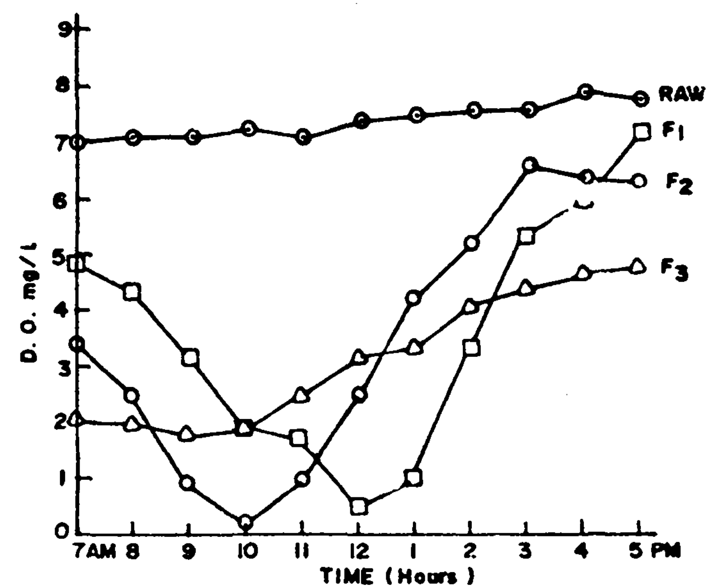


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TABLE 4 - Bacteriological Performance of Filters under Continuous and Intermittent Operation

Rate of Filtration : 0.1 m/hr

E.S. of Sand : 0.25 mm U.C. : 2.92 Depth of Sand : 57 cm

	E.coli Count/100 ml									
	Raw water	Filtrate collected at								
Time Days	9 AM	9 AM	10	11	12	1 PM	2	3	4	5
		Continuous Operation								
1	920	0	0	0	0	0	0	0	0	0
2	33	0	0	0	0	0	0	0	0	0
3	240	0	0	0	0	0	0	0	0	0
4	33	0	0	0	0	0	0	0	0	0
5	79	0	0	0	0	0	0	0	0	0
6	33	0	0	0	0	0	0	0	0	0
7	1600	0	0	0	0	2	0	0	0	0
8	79	0	0	0	2	2	0	0	2	-
		Intermittent Operation (9 AM - 5 PM)								
9	49	0	0	240+	240+	49	5	2	2	-
10	78	0	0	49	33	49	7	0	7	-
11	49	0	0	49	49	23	2	2	2	-
12	240	0	0	49	49	7	5	0	2	-
13	33	0	0	33	17	7	4	0	2	-
14	33	0	0	17	79	8	0	2	0	0
15	46	0	0	17	4	2	0	0	2	0
		Continuous Operation								
16	17	0	0	2	0	0	0	0	0	-
17		0	0	0	0	0	0	0	0	-
18	8	0	0	0	0	0	0	0	0	-
19	17	0	0	0	0	0	2	0	0	-
20	33	0	0	0	0	0	0	0	0	-
		Intermittent Operation with Declining Rate								
21	46	0	0	0	0	0	0	0	0	0
22	130	0	0	0	0	0	0	0	0	0
23	49	0	0	0	0	0	0	0	0	0
24	49	0	0	0	0	0	0	0	0	0
25	130	0	0	0	0	0	0	0	0	0

construction will increase due to increased filter area requirement and also poses, as described above, the danger of an impairment in the bacteriological quality of filtered water. In order to explore the possible alternate methods of operation for field practice, the filter run was continued with a modification in operation. At the end of 8 hours (9 AM - 5 PM) operation, raw water inflow to the filter was cut off but filtration was continued with a falling supernatant till next morning when supply of raw water was resumed. The sampling schedule remained the same and the data on bacteriological quality are given in Table 4. It is evident from the results that the alternative method of running a slow sand filter with a falling supernatant water level does not lead to any significant impairment of filtrate quality.

This alternative, while producing a filtrate comparable to that obtained under continuous constant-rate operation, however, poses difficulties in the design and operation of raw water pumps and the associated pre-treatment facilities where provided. Further, in the declining-rate method of operation, depending upon the rate of filtration and the time interval between successive raw water pumping, a stagnant condition may result due to complete draining of the supernatant especially in the initial stages of the run when the head loss is minimum. Therefore, a satisfactory solution which would eliminate this contingency and also result in a design with minimum filter area would be to provide for an uninterrupted operation of the filter. Even with restricted raw water pumping hours, this can be achieved by the provision of a separate storage tank of appropriate capacity which will feed by gravity raw water to the filter during nob-pumping hours (Fig. 6) so as to ensure round the clock operation of the filters.

Performance of Slow Sand Filters Treating Highly Polluted Water

In order to obtain information on the effects of high levels of organic and bacterial pollution in raw water on filter performance, experiments were conducted with lake water contaminated by sewage. When sewage was added to the shallow raw water storage tanks, they started functioning as stabilization ponds. This was evident from the observations that the raw water gradually turned green due to intense algal growth and the increase in coliform count in raw water was not commensurate with the quantity of sewage added - phenomena typical of oxidation ponds.

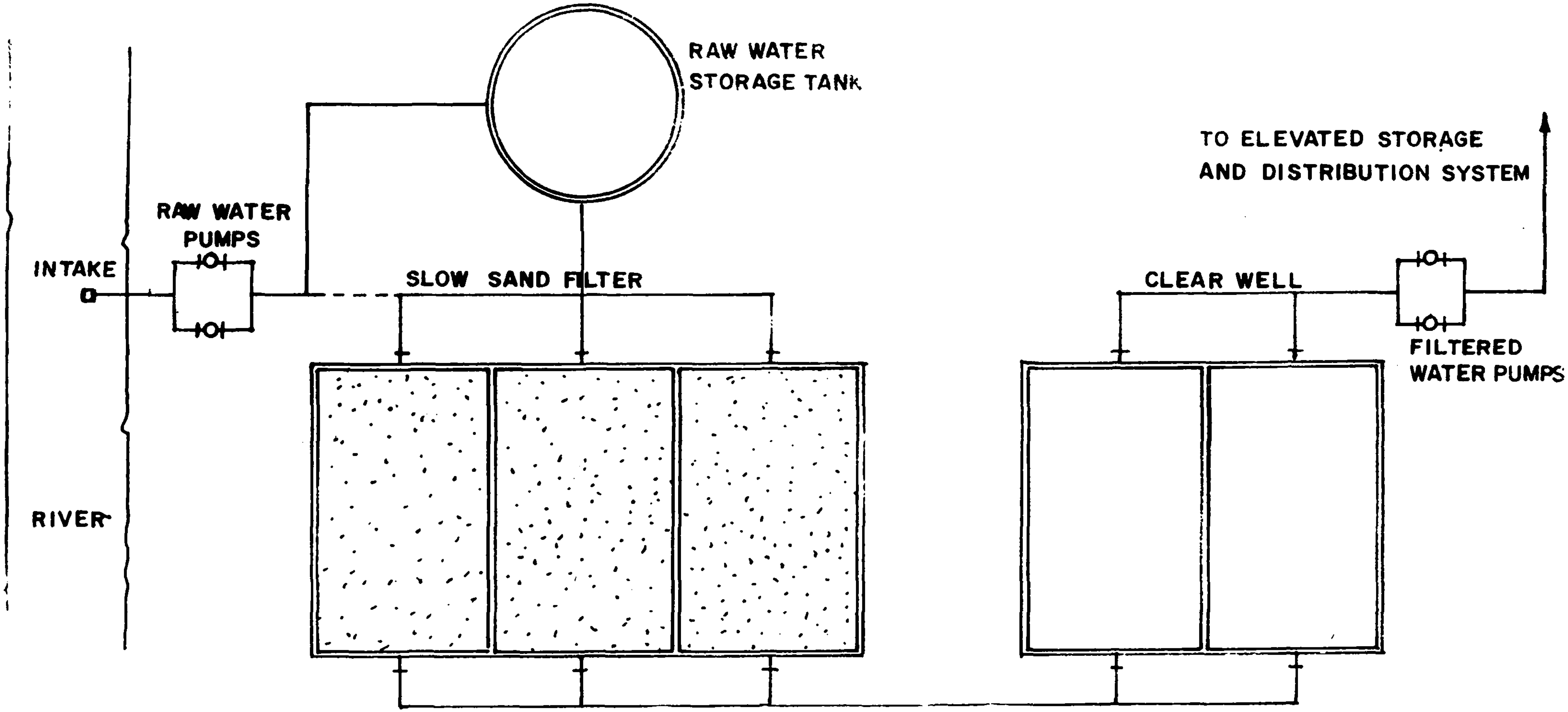

FIG.6: SCHEMATIC PLAN FOR A SLOW SAND FILTER FOR CONTINUOUS OPERATION

The chemical analysis of polluted raw water indicated that the COD values were increasing with daily addition of sewage and when it reached a value of 20-25 mg/l (equivalent to 6-8 mg/l BOD) the filter started giving out algae in the effluent. When sewage addition was discontinued the filters recovered gradually and gave algae free filtrate.

Filters treating sewage contaminated raw water produced a filtrate of unsatisfactory bacteriological quality when operated at both 0.1 m/hr and 0.2 m/hr. It was observed that the formation of Schmutzdecke was not satisfactory and the bed infested with Chironomus larvae. It is known that these larvae are capable of disturbing the top active layer and even wriggling through the bed. The presence of these larvae in large numbers may be one of the reasons for the poor bacteriological performance of the filter.

Slow sand filters gave a satisfactory performance when treating raw waters with normal levels of organic pollution upto about 10 mg/l as COD and coliform concentration upto 1,000 - 2,000 MPN/100 ml. However, when sewage was added to raw water as in the present studies, the filters produced a filtrate of unsatisfactory bacteriological quality. When the pollution level exceeded about 20 mg/l as COD algae were observed in the filtrate in large numbers. Under these conditions suitable additional treatment may have to be considered.

Slow Sand Filters with Builder Grade Sand

Slow sand filters require a large volume of filter medium which is usually sand. Experience has shown that the cost of sand may constitute a sizeable fraction of the total cost of filter installation. While due care needs to be excercised in the specification and choice of sand for rapid filters, the relatively heavy expense of careful grading can be avoided for slow sand filters. Under many situations it may be possible to use locally available material with no adverse effect on filter performance. This would help bring down the cost of sand considerably. When the cost of construction of a slow sand filter is reduced and made economical, the system has a greater chance of application for rural communities. The performance of slow sand filters with builder grade sand was evaluated. Builder grade sand as defined in the present study is river sand subjected to a minimum of screening to remove coarse and fine material as practised in building construction. Three pilot filters, each with a different grading of sand, were used for the experiments and the salient observations are discussed below.

Turbidity observations for raw water and filtrates expressed as weekly averages for the period of study are shown in Fig. 7. The raw water was clear with a low

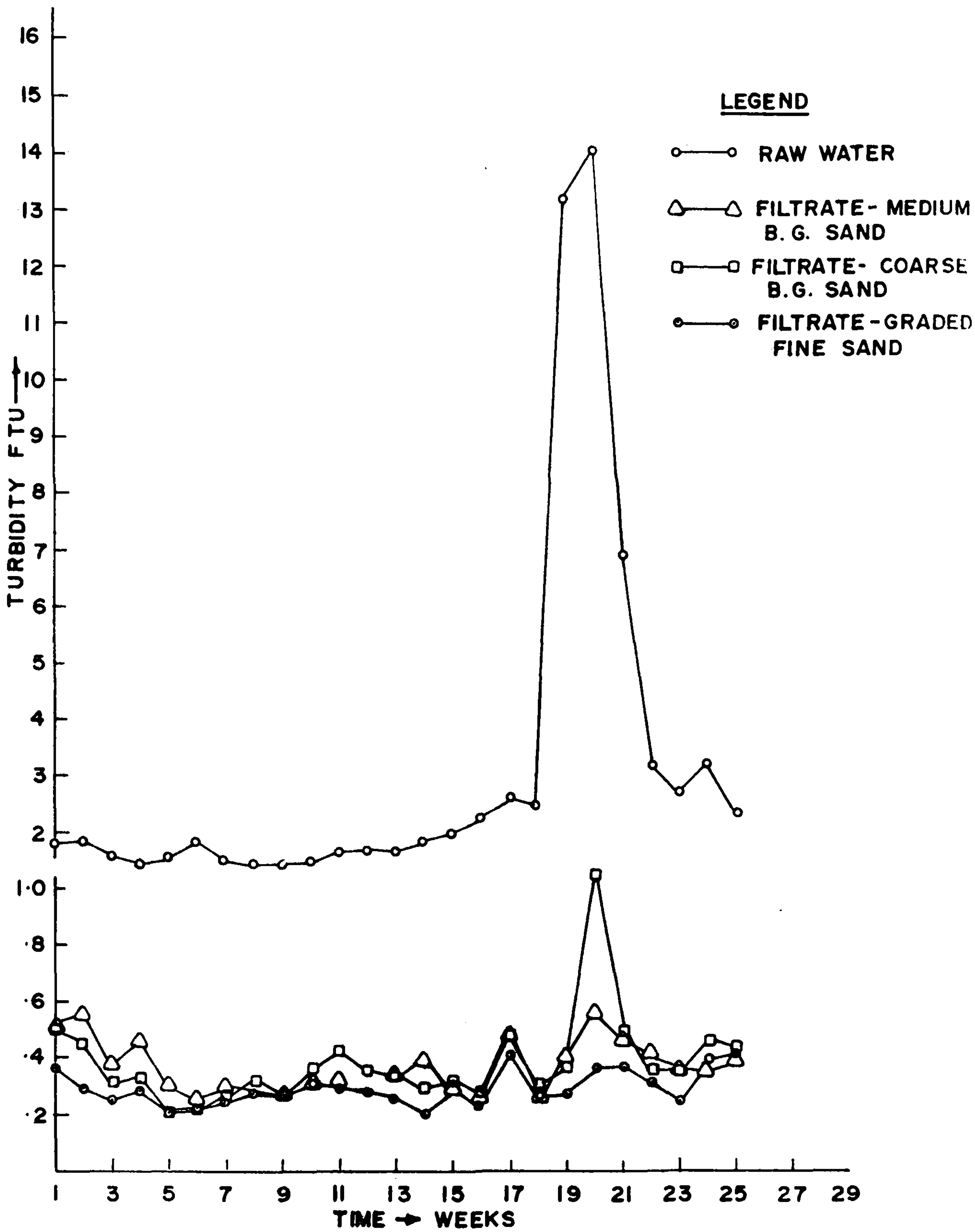

FIG. 7 : EXPERIMENTS ON BUILDER GRADE SAND. VARIATION IN RAW & FILTERED WATER TURBIDITY.

turbidity (less than 3 FTU) for a major part of the study except for about 2 weeks when it exceeded 10 FTU but remained below 15 FTU. It may be seen from the results that the filtrate turbidity from all the filters was always well below 1 FTU irrespective of the variation in raw water turbidity.

The organic pollution in raw water expressed as COD varied from about 6-13 mg/l, with an average value of 8.2 mg/l. The average reduction in COD after filtration through graded fine sand with an E.S. of 0.21 mm and U.C. 2.1 was 74.3 per cent. The other two filters in which medium (E.S. 0.25 mm and U.C. 2.92) and coarse (E.S. 0.32 mm, U.C. 2.59) builder grade sands were used, gave a COD reduction of 63,57 and 67.16 per cent respectively. Statistical evaluation of the performance of filters with respect to reduction in COD revealed that the filter with graded fine sand was more efficient than those with builder grade sands. However, the difference between the filters using medium and coarse builder grade sands was not significant.

The bacteriological results showed that more than 89 per cent of the filtered water samples from the filters with graded fine sand and medium builder grade sand were free from E. coli. The filter with coarse builder grade sand, however, produced a filtrate free from E.coli only in 66 per cent of the samples. Statistical analysis of bacteriological data using the test for proportions, has revealed that graded fine sand and medium builder grade sand are equally efficient in removal of E.coli. Coarse builder grade sand, however, appears to be less efficient.

The length of run for any particular filter varied considerably in spite of no significant change in raw water quality. As expected, builder grade sands gave longer runs than graded fine sand. Considered in the order of increasing grain size, the average length of run at 0.1 m/hr filtration rate was 28, 35 and 38 days respectively. The corresponding length of run at 0.2 m/hr was 6, 8 and 18 days respectively. The depth of penetration of impurities increases with the rate of filtration, and the size of sand grain. This implies that where coarser sand is used or higher filtration rate is adopted, it may be necessary to scrape a deeper (about 3 cm) layer of top sand during filter cleaning. The deeper penetration of impurities when coarse sand is used is also confirmed by the presence of greater number of phytoplankton in the lower layers of sand bed. Builder grade sands with E.S. upto about 0.3 mm and U.C. below 3 give satisfactory performance and economy in cost of filter construction and maintenance.

Demonstration at Village Level

The first phase of the programme directed towards applied research and critical analysis of the performance of slow sand filters under different conditions of operation has resulted in the selection and development of a filter system that can produce a filtrate of acceptable physico-chemical and bacteriological quality. Engineering details of a number of slow sand filter installations in use in the various States of India were reviewed. Some of the common problems experienced in the operation and maintenance of such units were looked into carefully and suitable modifications evolved. Arising out of these, guidelines for design and construction of small slow sand filter installations have been formulated.

As a follow up of the first phase, the guidelines arrived at are to be further tested under actual field conditions. For this purpose, four village demonstration plants (VDPs) in India, one each in the States of Andhra Pradesh, Haryana, Maharashtra and Tamil Nadu are being constructed. The salient features of the demonstration plants are summarised in Table 5. In the selection of villages for demonstration purposes, careful attention has been given to the population size, the actual needs of the village, the source of raw water, the socio-economic and cultural background of the community and its willingness to participate. The main elements of this programme are continued applied research and investigations, transfer and exchange of know-how and experiences and the demonstration of the appropriateness of the system for large scale implementation.

An important feature of this demonstration project is the integrated, multi-disciplinary and collaborative approach among research workers, field engineers, government agencies and policy makers at local, national and international levels which may lead to an improvement of national infrastructure in the field of water supply and sanitation. Another essential element of the programme is the orientation to local circumstances and constraints. Optimal use of local resources in terms of know-how, experiences, manpower materials and finance will be encouraged and promoted. A-part from the engineering and technical aspects, community participation, health education, training, dissemination and exchange of information and experience constitute the essential ingredients of the demonstration programme.

TABLE 5 - Slow Sand Demonstration Plants at Village Level in India

Salient Features

Description	Plant I	Plant II	Plant III	Plant IV
State	Andhra Pradesh	Haryana	Maharashtra	Tamil Nadu
Village	Pothunuru	Abubshahar (Group of villages)	Borujwara	Kamayagoundanpatti
Population				
Present	5443 persons	8719 persons	672 persons	8500 persons
Projected	8200 "	12695 "	1300 "	10,000 "
Design per capita water supply	45 lpd	45 lpd	70 lpd	45 lpd
Plant capacity	23 m^3/hr	24 m^3/hr	5.75 m^3/hr	18.75 m^3/hr
Raw water source	Irrigation canal	Irrigation canal	River Kolar	River Suruliar
Pre-treatment	Storage	Storage	Infiltration Gallery	Plain sedimentation + horizontal pre-filtration
Slow sand filters	3 Nos. each 12.5 m x 6.5 m	3 Nos. each 10 m dia.	2 Nos. each 5.0 m x 3.5 m	2 Nos. each 12 m dia
Distribution	Standposts	Standposts	Standposts	Standposts + house connections
Estimated cost (Indian Rs)	3,68,000/-	16,68,000/-	2,00,000	4,10,000/-

Conclusions

The broad conclusions that can be drawn from the first phase of the study are :

1 Slow sand filters treating surface waters of turbidity upto 30 FTU produce a good quality filtrate with a turbidity less than 1 FTU at filtration rates of 0.1, 0.2 and 0.3 m/hr.

2 Dissolved oxygen in filtered water is higher with higher rates of filtration.

3 Under varying conditions of filter operation, more than 85 per cent of the filtrate samples are free from E.coli.

4 In tropical conditions, shading of slow sand filters helps retard the development and proliferation of algae but does not influence the length of run.

5 Intermittent operation of slow sand filters produces a filtrate of unsatisfactory bacteriological quality. However, the deterioration is insignificant if continuous filtration is ensured even with a falling supernatant.

6 High levels of organic and bacterial pollution in raw water upsets the filter performance and leads to deterioration of filtrate quality. However, the filters recover when the pollution load is reduced.

7 Slow sand filters with builder grade sand produce a filter ed water of satisfactory quality.

ACKNOWLEDGEMENT

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Paper 1d

Experiences on Slow Sand Filtration Programme in Thailand

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ABSTRACT

The slow sand filtration system has been introduced in the Community Potable Water Supply Project in Thailand since 1966. The system has proved to be appropriate to the local conditions especially from technical view point with little problem of maintenance. The experiences gained revealed that the unavailability of mechanical spare parts has been obstacle to the continuity of water supply service. The water bill collection by water meters is as appropriate since it is fair and equitable. The survey of two selected plants at Kranuan and Ubolratna communities showed that the water supply can be operated successfully with its own revenue if it is well managed. If the distribution system has been improved, the more revenue would certainly be obtained. At present, the slow sand filtration system has not been constructed as much as it should be eventhough the operation is simple; this is because of the limitation of the construction cost and the availability of the good raw water quality.

EXPERIENCES ON SLOW SAND FILTRATION PROGRAMME IN THAILAND

1. Present status of slow sand filtration water supply in Thailand

The Royal Thai Government has developed the Community Potable Water Supply Project since 1966. The Project activity is responsible by the Rural Water Supply Division, Department of Health, to assist the community size of 500 - 5,000 people. By last December 1978, about 580 systems have been constructed serving some 1,400 villages with a total population of approximately 1,673,000. The type of treatment employed varies according to the quality of raw water source. The water is treated by chemical coagulation, sedimentation and rapid sand filtration in majority of the surface water systems. Deep well water is another source of water used. The treatment of deep well water involves simple chlorination to complicated systems of aeration followed by rapid or slow sand filtration process. In all instances, the treated water are subjected to chlorination before it is supplied to consumers through the piped systems. Though the slow sand filtration system has more advantages in its simplicity of operation and maintenance than rapid sand filtration system, there are still many factors that influence the choice of the slow sand filtration system. For example, the turbidity of the raw water before filter is conventionally limited to below 30 mg/l, and the high initial construction cost of the slow sand filter. As the results, at present only about 5% of the total number of the existing water supply systems in Thailand employing the slow sand filtration system.

The use of slow sand filter for water treatment in Thailand is rather limited due to the reasons mentioned above until recently. At present the International Reference Centre of the Netherlands (IRC) has sponsored the Slow Sand Filtration Research Projects in Thailand through the Rural Water Supply Division, Department of Health through which three plants are being selected for assistance as demonstration projects. It is thus, therefore, advantageous to review the performance of the existing slow sand filtration system under operation so that some comparison and experiences can be gained from them.

2. The Study of Kranuan Slow Sand Filtration System

The slow sand filter plant at Kranuan, locates in Khon Kaen province about 500 kms. northeast of Bangkok was constructed in 1971. It is designed to serve 9,600 people with the capacity of 50 m^3 per hour. (See Table 1 for the summary of the plant construction operation and maintenance). The water source of this plant is pumped from a reservoir with a capacity of approximately 1.5 million m^3 and locates about 8 kms. away from the treatment plant. The water is pumped into a holding pond with the holding capacity of approximately 20,000 m^3, thus giving the detention period of more than 3 months before flowing into the slow sand filter unit by gravity. The flow of the water into the filter is regulated by the adjustment of a sluice gate at its inlet. Under the present operation set up, the loading on the filter is approximately 0.05 $m^3/m^2/hr$. Since the raw water is of quite good quality, very ideal for slow sand filter operation, (See Table 2 : Typical Kranuan Raw Water Quality). Therefore it has been found that the operation and maintenance has not become a problem. Each filter is being used alternately at one month interval before being cut-off for cleaning. The cleaning is done by draining off the water from the filter and sand on top layer of the filter is scraped off for approximately 1". The cleaning of the filter is carried out by one of the plant operators and it takes about 2-3 days to complete the work. After cleaning and replacing the sand, the filter is then allowed to stand idle for a period of almost one month before it is again put back in operation. Since it is found that the raw water from the reservoir is quite clear and of excellent quality, the water is then allowed to by-pass the holding pond and thus discharged directly on the filters. The summary of the system performance is tabulated in Table 1.

3. The Study of Ubolratna Slow Sand Filtration System

Another slow sand filter is located at Ubolratna village, located at about 50 kms. from the province centre, also in Khon Kaen Province. The raw water source has been from Ubolratna Dam reservoir. The water is pumped to the treatment system which is located on a hill top. The water after passing through the slow sand filter flows into a storage clear well which also acts as an eleavated tank since it is also on the hill. Thus no pump is required for the distribution system. As a result, the cost and problem of operation and maintenance are much reduced. Various details information on the system operation and maintenance are summarized in Table 1.

Table 1 : Summary of the Survey Results on Plant Construction, Operation and Maintenance of the Two Slow Sand Filtration System at Kranuan and Ubolratna Village, Khon Kaen, Thailand.

Description	Kranuan Water Supply System	Ubolratna Water Supply System
1. Raw Water Source		
1.1 Type	Nong Yai reservoir	Ubolratna Dam reservoir
1.2 Capacity	$1.5 \times 10^6 m^3$	$> 100 \times 10^6 m^3$
1.3 Physical water quality	turbid for 4 months (between 50 - 100 mg/1, Jackson Turbidity Unit)	turbid for 3 month (between 50 - 100 mg/1, Jackson Turbidity Unit)
2. Water Treatment Process		
2.1 Holding pond	one pond, size $93 \times 75 m^2$	no
2.2 Slow sand filter	2 units	2 units
2.3 Filter shape	rectangular	circular
2.4 Filter area (each)	$27 \times 42 m^2$	13 m.dia.
2.5 Filter side slope	1 : 2, slope with concrete lining	vertical concrete wall
2.6 Filter inlet	at one end, by gravity, regulated by sluice gate	at centre, by pumping and sluice gate
2.7 Inlet control to filter	sluice gate	control pumping rate
2.8 Filter capacity (each)	50 cu.m/hr.	20 cu.m/hr.
3. Filter construction		
3.1 Gravel bed size:(from bottom, total depth of gravel 40 cm.	size 10-75 mm., 20 cm. deep	size 25-60 mm., 20cm. deep
	size 10-25 mm., 10 cm. deep	size 10-25 mm.,10cm.deep
	size 5-10 mm., 10 cm. deep	size 5-10 mm., 10mm.deep
3.2 Depth of sand	size 0.25-0.35 mm.,100cm.deep	size 0.25-0.35 mm., 100 cm. deep
3.3 Water level maintained above sand bed during operation	80 - 100 cm.	80 - 120 cm.
3.4 Sand uniformity coefficient	2 - 3	2 - 3

Description	Kranuan Water Supply System	Ubolratna Water Supply System
3.5 Water level control regulation	over flow	over flow
3.6 Free board	60 cm.	40 cm.
3.7 Total filter wall depth	300 cm.	320 cm.
3.8 Filter capacity (each)	50 cu.m./hr.	20 cu.m./hr.
3.9 Applied filtration rate	0.05 m^3/m^2/hr.	0.15 m^3/m^2/hr.
4. <u>Storage System</u>		
4.1 Clear well capacity	160 m^3	100 m^3
4.2 Elevated tank cap.	100 m^3	using clear well as elevated tank
4.3 Finished water supply head	18 m.	40 m.
4.4 Volume of water consumed	400 m^3/day	70 m^3/day
5. <u>Plant Operation</u>		
5.1 Raw water pump	8 hrs.	5 - 8 hrs.
5.2 Pumping period for elevated tank	8 hrs	not required, using gravity flow
5.3 Filter using	one at a time, alternate use at one month interval	one at a time, alternate use at two-week interval
5.4 Sand cleaning	once/month	twice/month
5.5 Hours of supply to consumers	24 hrs.	24 hrs.
5.6 Type of water meter used	Asahi (฿ 350. U.S.$17.5)	Ashitokai (฿180,U.S.$9)
5.7 Peak hours	7 am. - 9 am. 5 pm. - 7 pm.	7 am.- 9 am. 5 pm. - 7 pm.
6. <u>Operator Supervision & Training</u>		
6.1 Supervision	under District Committee	under District Committee
6.2 Number of operators employed, trained under the Dept. of Health	2	2
6.3 Water supply refresher course attendance	1	-
6.4 Operator's salary(each)	฿ 1,450/month (US.$ 72.5/month)	฿ 900/month(US.$45/month)

Description	Kranuan Water Supply System	Ubolratna Water Supply System
7. Sand Filter Cleaning Operation		
7.1 Cleaning	once/month	twice/month
7.2 Time required for cleaning(using one plant operator)	2 - 3 days	2 - 3 days
7.3 Depth of sand removed	½" - 1"	½" - 1"
7.4 Sand replacement	5 m^3 at a time	-
7.5 Sand cost	฿ 500/bed(US.$25/bed)	-
7.6 Sand recleaning unit	not available	available
8. Pumping System		
8.1 Raw water intake pump	one pump of diesel engine, 60 H.P. with delivery cap. 50 m^3/hr.	two pumps of diesel engine cap. with 20 H.P. each, and delivery cap. 20 m^3/hr.
8.2 Pumps for elevated tank	two pumps of electric motor of 15 H.P. with delivery cap. 40-60 m^3/hr.	not required
9. Piping System		
9.1 Intake suction pipe	G.S. pipe 4" Ø	G.S. pipe 4" Ø
9.2 Raw water delivery to slow sand filter	AC pipe 8"(with 8 air release valves)	G.S. pipe 4" Ø (with one air release valve)
9.3 Main distribution pipe to consumers	AC pipe(approx. 12 kms. long)	AC pipe(approx. 5 kms.long)
9.4 Public tap	none	none
9.5 Village fire hydrant stand	yes	yes
10. Water Revenue		
10.1 Water rate	฿3/m^3(US.$ 0.15/m^3)	฿ 3/m^3(US.$ 0.15/m^3)
10.2 Water rate for school	฿ 2/m^3(US.$ 0.10/m^3)	First 10 m^3 free of charge, then ฿ 2/m^3(US.$ 0.1/m^3) thereafter.
10.3 Water rate for hospital	฿ 2/m^3(US.$ 0.1/m^3)	฿ 3/m^3(US.$ 0.1/m^3)

Description	Kranuan Water Supply System	Ubolratna Water Supply System
10.4 Institutions which obtain water, free of charge	1. Equipment Centre of ARD 30 m^3/day 2. Border-Patrol Police 20 m^3/day 3. Cleaning District Market 10 m^3/day	1. Police Station 10 m^3/month 2. Health Centre 10 m^3/month 3. District Office 10 m^3/month 4. Temples 10 m^3/month
10.5 Average total revenue	฿ 25,000/month(US.$ 1,250/month)	฿ 5,500/month(US.$ 275/month)
11. <u>Expenses</u>		
11.1 Salary for 2 operators	฿ 2,900/month(US.$ 145/month)	฿ 1,800/month(US.$ 90/month)
11.2 Fuel & electricity	฿ 5,060/month(US.$ 253/month)	฿ 1,360/month(US.$ 68/month)
11.3 Chemicals	฿ 900/month(US.$ 45/month)	฿ 500/month(US.$ 25/month)
11.4 Sand cost	฿ 500/month(US.$ 25/month)	Not available
11.5 Repair & maintenance costs	฿ 100/month(US.$ 5/month)	฿ 600/month(US.$ 30/month)
11.6 Total expenses	฿ 9,460/month(US.$ 473/month)	฿ 4,260/month(US.$ 213/month)
12. <u>Accounting Balance</u>	฿ 15,540/month profit (US.$ 777/month)	฿ 1,240/month profit (US.$ 62/month)
13. <u>Population Served</u>		
13.1 Total number of houses within the village	1,910	1,190
13.2 Number of houses within the reach of the Water Main Distribution at present	1,000	600
13.3 Total number of population	9,563	5,960
13.4 Village institution - school - hospital	 1 1 - 30 beds hospital	 1 None

Description	Kranuan Water Supply System	Ubolratna Water Supply System
13.5 Total number and percentage of houses connected to water system	440 (44%)	199 (33%)
13.6 Total number and percentage of population served	2,200 (44%)	995 (33%)
13.7 Rate of increasing of house applied for connection per month	10 house/month	5 - 10 house/month
14. Water Consumption		
14.1 Water consumption per day	400 m^3	70 m^3
14.2 Average per capita consumption (litre/capita/day)	136 lpcd	68 lpcd
15. Water Production		
15.1 Amount of water produced	400 m^3/day	70 m^3/day
15.2 Amount distributed, free of charge	100 m^3/day	2 m^3/day
15.3 Amount of water with charge	300 m^3/day	68 m^3/day
15.4 Water-production cost per cubic meter	฿ 1.05/m^3(US.$ 0.05/m^3)	฿ 2.08/m^3(US.$ 0.1/m^3)
16. Construction		
16.1 Operation commencing	Year : 1971	Year : October 1978
16.2 Construction cost	1,180,000 (US.$ 59,000)	1,560,000 (US.$ 78,000)
16.3 Central Gov't contribution(as percentage of total construction cost)	500,000 (42%) (US.$ 25,000)	904,000 (58%) (US.$ 45,200)
16.4 Community contribution (as percentage of total cost)	680,000 (58%) (US.$ 34,000)	656,000 (42%) (US.$ 32,800)
16.5 Average cost of private house connection (charge to the home owner)	฿ 800 - 1,200 (US.$ 40 - 60)	฿ 600 - 800 (US.$ 30 - 40)

Description	Kranuan Water Supply System	Ubolratna Water Supply System
17. Maintenance		
17.1 Tools for pipe & engine repair	2 sets	2 sets
17.2 Within the house	self - repair	self - repair
17.3 Outside the house	by operator	by operator

Table 2 : Typical Kranuan Water Quality

Characteristics	Raw water quality	Finished water quality
pH	8.6	8.05
colour	5	5
turbidity	25-50	4.2
total solids	69.2	67.9
hardness	53.5	53.4
alkalinity m.o.	123.4	127.2
dissolved oxygen	8.1	5.6
residual chlorine	none	0.12
coliform,MPN/100 ml	122.3	nil

Table 3 : Results of Water Analysis of Ubolratna Water Supply

(collection, January 1979)

characteristics	raw water	filtered water
ph	7.0	6.9
Colour, Pt-Co scale	10	5.0
Turbidity, SiO_2 scale	65	22
Suspended solids	193	122
Alhalinity, PP	nil	nil
Alhalinity, mo	72	62
Hardness (as $CaCO_3$)	64	62
Calcium (as Ca)	12	19
Magnesium (as Mg)	3.4	3.4
Iron (as Fe)	1.4	0.54
Manganese (as Mn)	nil	nil
Copper (as Cu)	0.12	0.10
Chromium (as Cr)	0.03	0.02
Sulphate (as SO_4)	-	8
Chloride	3	1
Nitrate (as N)	0.40	0.12
BOD	4.9	-
COD	3.6	-
Total phosphate (as P)	0.20	-

4. Experiences gained from the study

From the results of the study of these two slow sand filtration system, the following observation can be made:-

1. It can be said that the slow sand filtration system have proved to be very suitable for these two rural villages since there arise very little operation and maintenance problems. This observation is also in agreement with other recommendations of WHO and elsewhere (provided that the raw water if of relatively good quality).

2. It is felt that the slow sand filter loading rate at Kranuan as applied present (0.05 $m^3/m^2/hr.$) is rather low which, as a result, the filter area is over designed and not fully utilized. The area of only one filter would be more than sufficient at Kranuan. At Ubolratna, the filtration rate is about three times higher than at Kranuan (0.15 $m^3/m^2/hr.$), which results in filter cleaning approximately once every two weeks. One of the problem which arises with the application of low filtration rate is the algal growth. But the problem is not quite yet serious at present. It is therefore suggested that a loading rate of 0.20 $m^3/m^2/hr.$ which would result in cleaning once every week could be recommended and employed in these cases. Some major problems which often arise at present are the lack of spare parts for pumps and chlorinators. The use of electric motor pump instead of diesel engine pump is being considered since from our experiences the problem of repair and maintenance on electric pump is much less.

3. It has proved that the major breakdown of the system operation is prevented with the use of slow sand filters in comparison with other rapid sand filter system with chemical treatment which we are experiencing at present in Thailand.

4. With such reliable treatment system, the consumers are quite confident with the water supply and the collection of the water bills has proved to be of no problem. At other villages which use other type of filtration frequent disruption has been a major problem to the revenue collection from the consumers. Thus it has showed that the slow sand filtration systems have proved to be self-maintained, simple to operate and can be operated with some profit. The cost of production is between US.$0.05-0.1

per cubic meter is relatively quite low.

5. At present only about 44% of the houses within the not-far distance from the main distribution system at Kranuan and about 33% of the same at Ubolratna are connected, mainly due to our limited budget allotted for the distribution system. Many more customers could be obtained, had more main distribution lines been laid. Attempts have been made in our future design to correct this condition, i.e., reduction of the treatment costs with the increase in the budget for the distribution lines.

6. As we have requested each house to pay for the cost of its private house connection including house meter at a cost of US.$ 30 - 60 per house, this cost is considered to be quite high and becomes prohibitive to many houses to apply for the connection. We still try to solve this obstacle either by more government subsidy and by obtaining revolving fund from the Government for the implementation installment scheme.

7. During the period of rainy season, the quality of the filtered water sometime become turbid and not considered satisfactory. This is, however, for a period of a few days during which the raw water quality is very turbid. More research work and study will be carried out to correct this condition.

8. Post chlorination of the treated water before pumping to the elevated tank fcr distribution has become a problem due to the frequent breakdown and clogging of the chlorinator unit.

9. It is felt that the installation of a master meter at the head of the distribution line is necessary to account for the water produced, loss and leakage. However, its cost has become quite prohibitive for its installation.

5. Conclusion and Recommendation

The investigation has shown that the water supply management of both selected plants can be operated on a self-sustained basis. The operators have not faced with the problem of collecting water bills. Most of the householders are willing to pay for water with metering system, based on the actual quantity used since that is fair and equitable. The income also covers the regular payment of operator salary, chemicals, fuel and miscellaneous costs. Relatively good and reliable services of the systems have been attained through the community committee participation and responsibility.

The Rural Water Supply Division still has a duty to supervise their operation. The improvement of service by expansion of the distribution area are being considered. As the number of consumers increase the water supply revenue will subsequently increase. Thus the other health projects can also be introduced into their communities.

Eventhough the slow sand filter systems have been proved to be operated quite successfully at these two communities and at a few more villages in Thailand, its construction cost and the areas required in many cases is still quite prohibitive eventhough its operation and maintenance has been proved to be relatively simple. Besides, from the technical view point, the availability of good raw water quality such as these two cases is still very limited. Most surface water sources in Thailand usually from river and streams are still quite turbid. Thus it is unavoidable in most cases to use the turbid water as the source of raw water for the system. As it is usually recommended that the turbidity should be removed to a certain minimum extent (normally below 50 mg/l) so that its turbidity will not affect with the slow sand filter operation. In Thailand we have found that in many instances the water turbidity has been found to be on the increase as the results of heavy deforestation of the water shed area. Research works are underway to solve the problem of applying high turbidity to the slow sand filter. The use of pre-horizontal flow filtration unit is recommended by the Asian Institute of Technology.

At present the World Health Orgainzation International Reference Centre, the Netherlands has sponsored the study and construction of three slow sand filtration systems for rural villages in the Central Part of Thailand. These systems will serve as demonstration projects as well as a case study of the suitability of slow sand filtration for the local condition in Thailand. The information and data obtained will be evaluated on the basis of its suitability and effectiveness. One must always realize, however that the complexity of the water supply programme does not lie only with the technical problems, which it has proved times and again, but the difficulty depends very largely on non-technical aspects, mainly the socio-economic conditions, motivation and willingness of the community to accept the system and to feel that it is their need that we have constructed the system for them to meet their needs and not to meet our requirement.

6. Acknowledgement

This paper reported herein is part of the programme on "The Study of Slow Sand Filtration in Thailand" which is under the auspices of the Department of Health,the Royal Thai Government Ministry of Public Health, Thailand, and the World Health Organization and the International Reference Centre, the Netherlands. The assistance cooperation and guidance of Ir. P. Kerkhoven,Ir. E.L.P. Hessing and Dr. J.M.G. Van Damme, advisors and manager of the International Reference Centre, are gratefully appreciated.

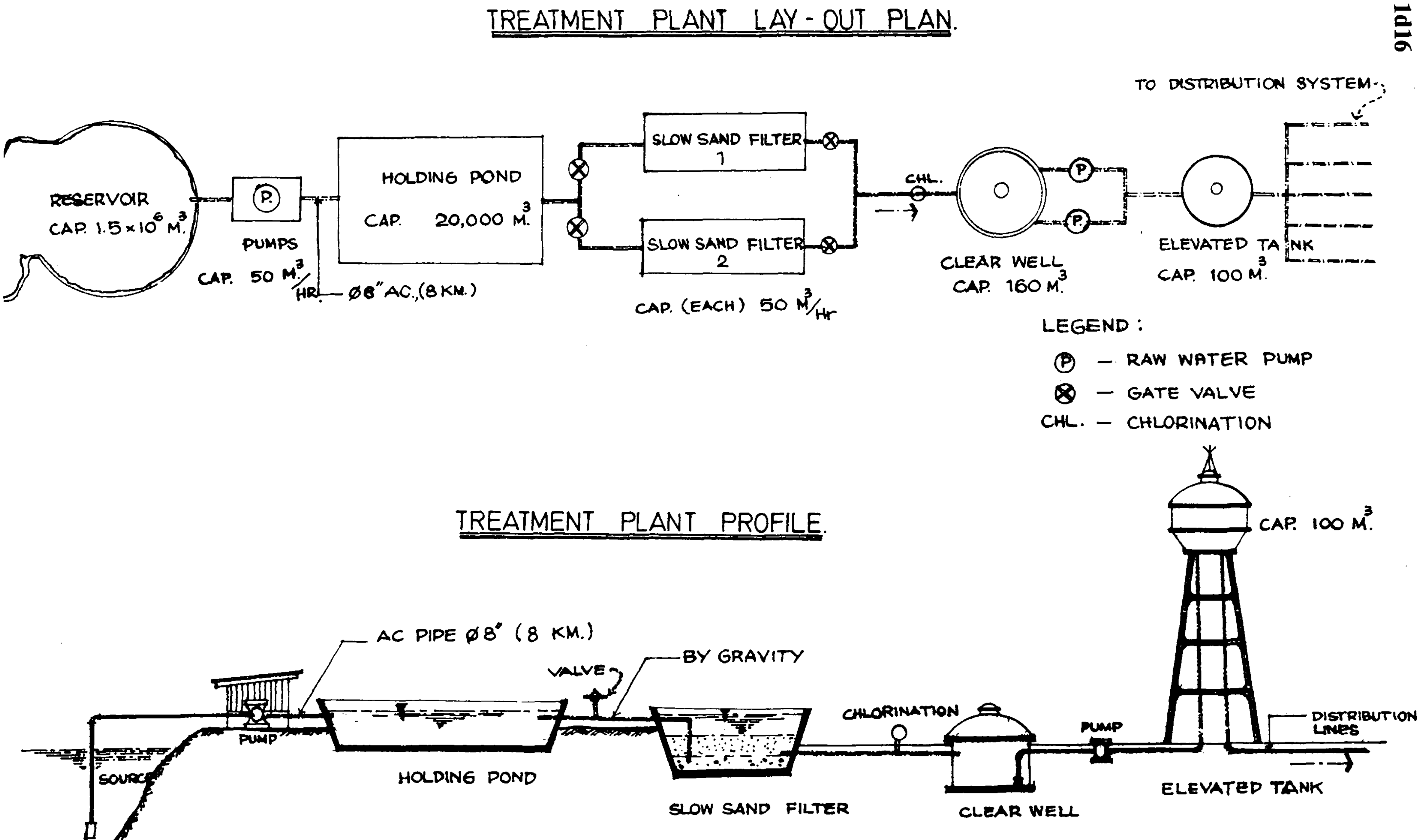
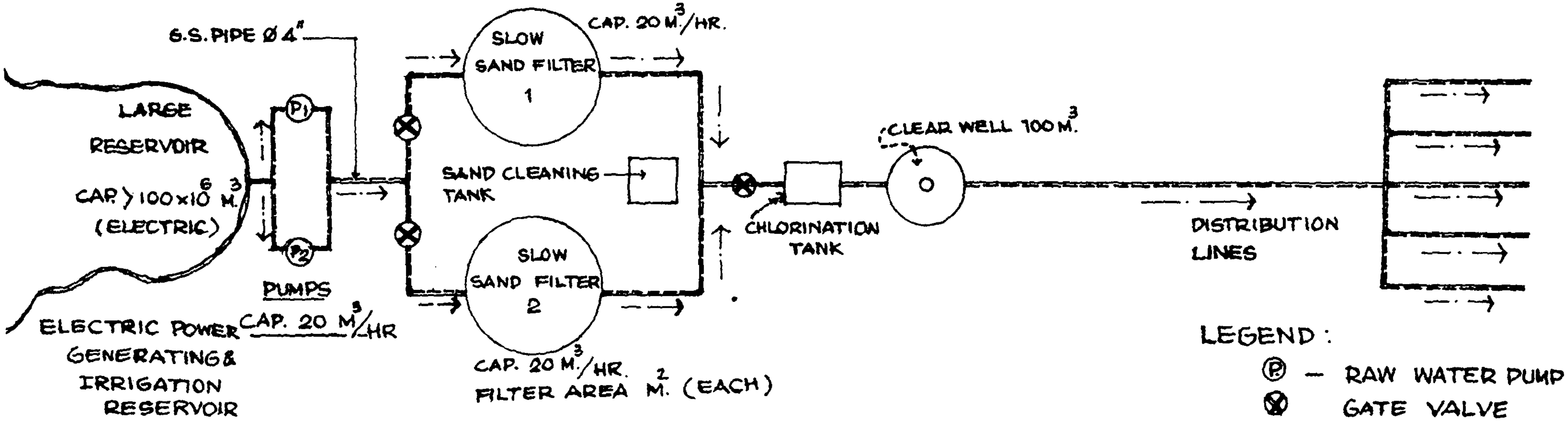


FIG 1 : SCHEMATIC DIAGRAM OF SLOW SAND FILTRATION SYSTEM AT AMPHOE KRANUAN CHANGWAT KHONKAEN

TREATMENT PLANT LAY-OUT PLAN.



TREATMENT PLANT PROFILE

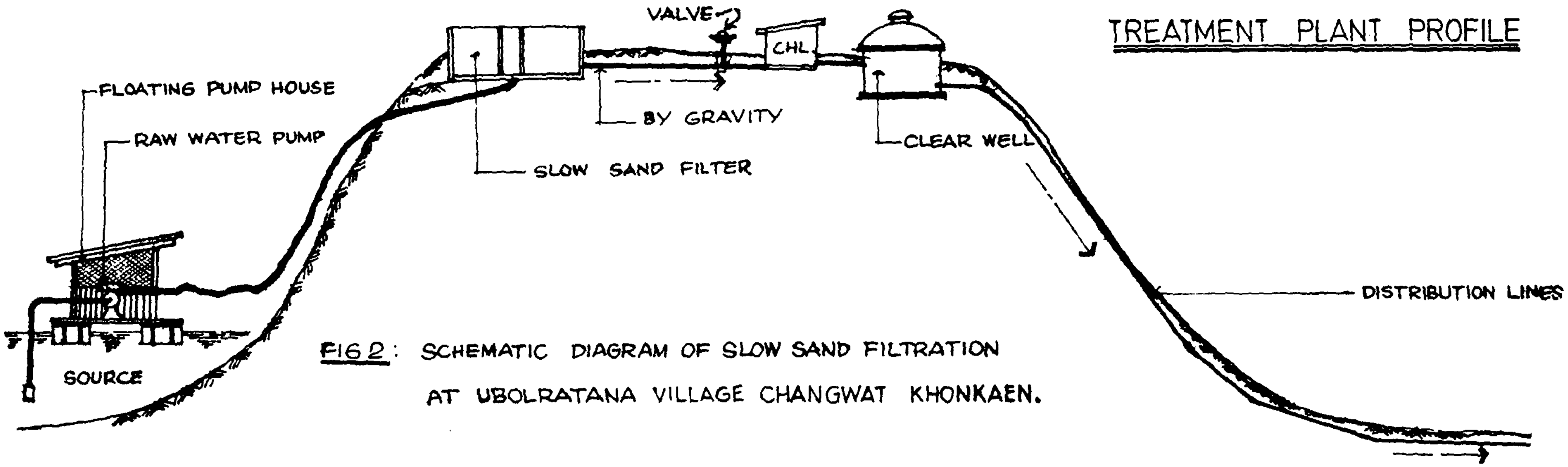


FIG 2: SCHEMATIC DIAGRAM OF SLOW SAND FILTRATION AT UBOLRATANA VILLAGE CHANGWAT KHONKAEN.

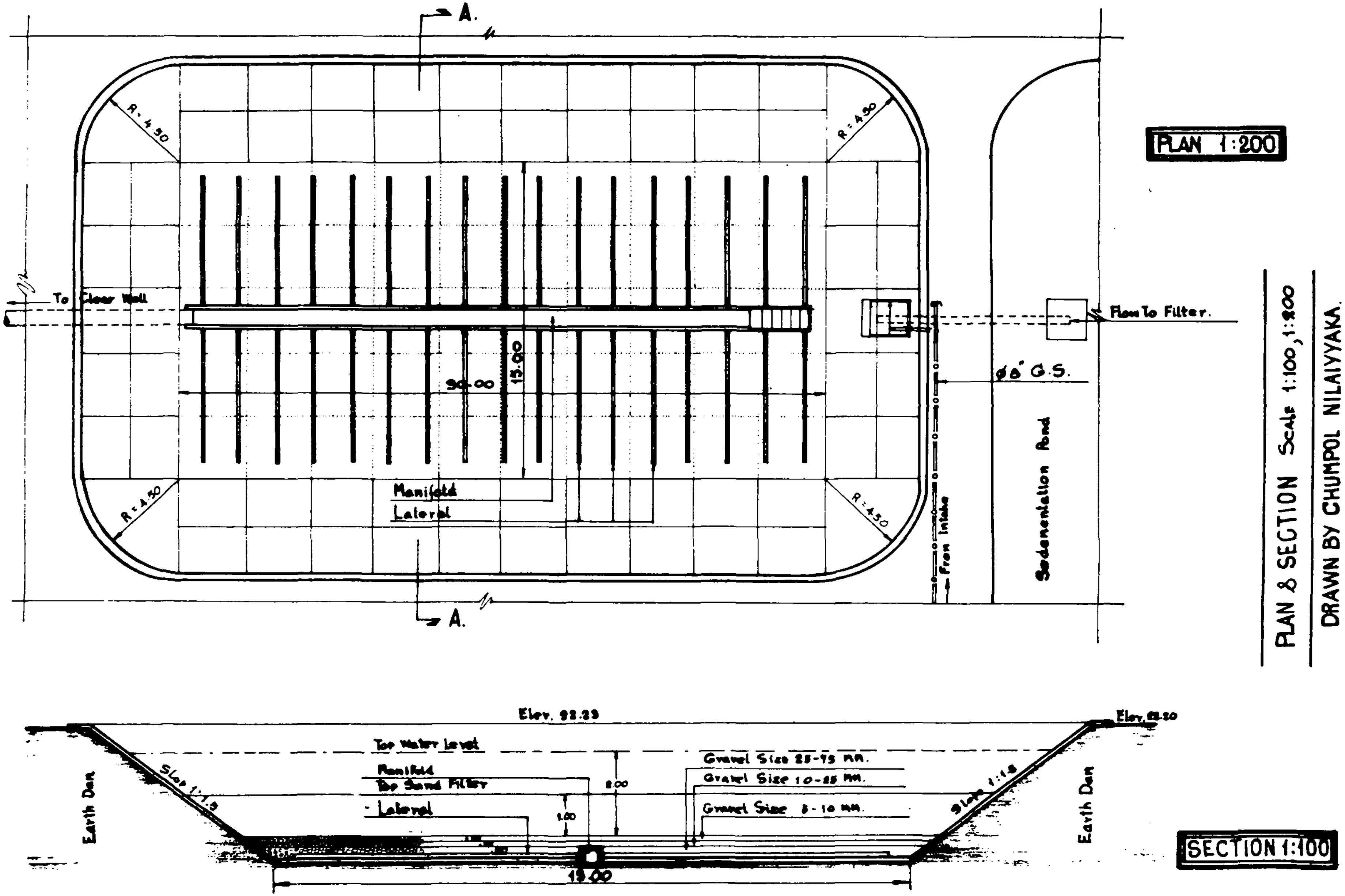
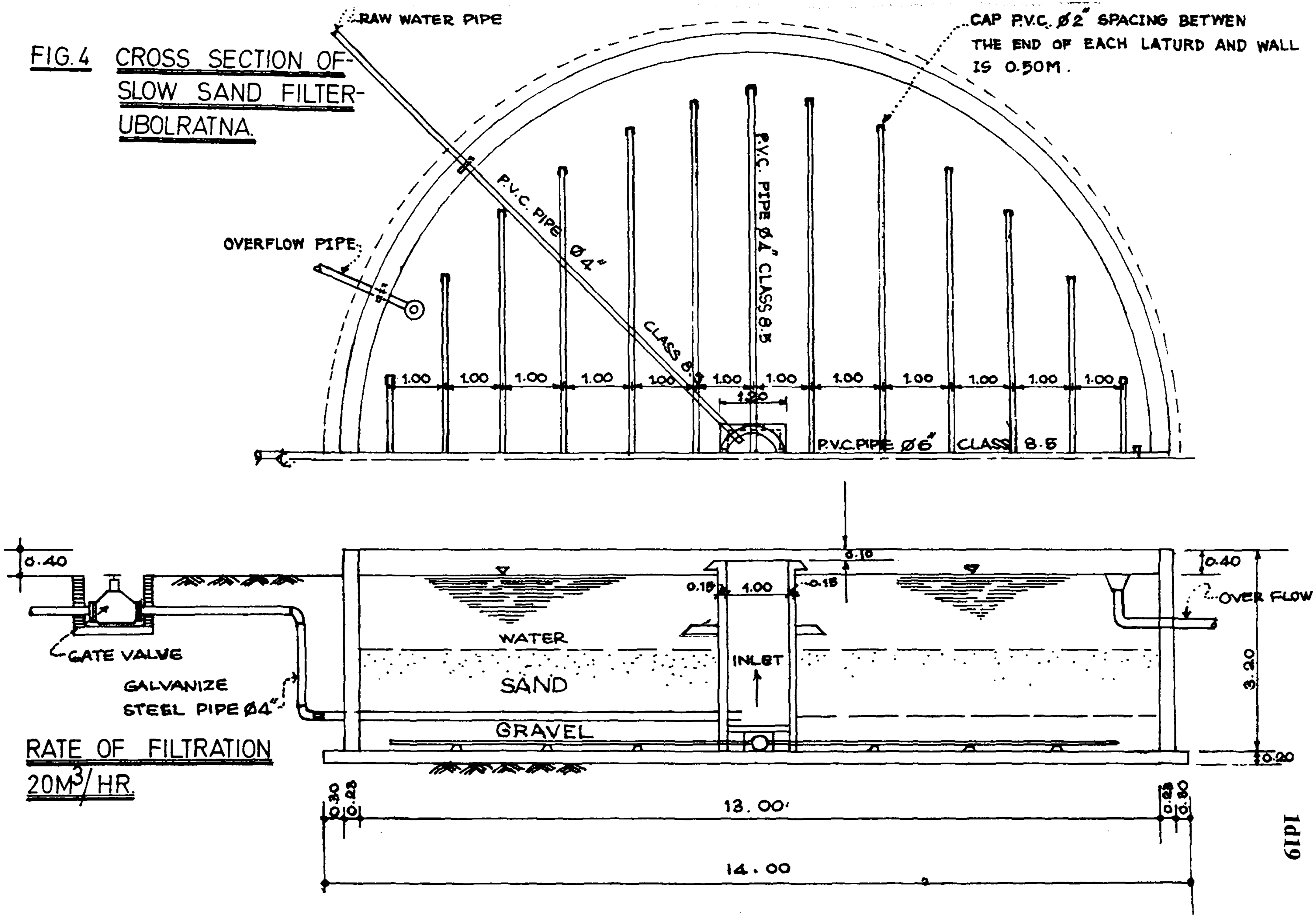


FIG. 3 SLOW SAND FILTER, KRANUAN.

1d18

FIG. 4 CROSS SECTION OF SLOW SAND FILTER-UBOLRATNA.



RATE OF FILTRATION 20M³/HR.

Paper 2c

Simplifying Design Criteria for Community Water Supply Systems

by Martin Von Kaenel, Motor Columbus Consulting Engineers, Baden, Switzerland

1. INTRODUCTION.

The decade of 1980 to 1990 has been named the "International Water Supply and Sanitation Decade" and a target has been set to serve all the population with a safe water supply by the end of this period.

The World Bank and the World Health Organization are getting together to develop a world wide strategy to implement necessary actions. In developing countries, water supply is being recognised lately as a social rather than only an economic issue. Accordingly political attention and national funds are directed to this task. Also foreign aid is eagerly pouring towards this field.

Altogether these are rather positive prerogatives, for the achievement of this formidable target. But when you come down to the execution of an actual project in any of the countries where this would be most needed, the outlook is not so bright any more. All those countries have an almost complete lack of technical personnel required for the planning, implementation and maintenance of any such project. The few local consulting engineers are fully engaged in other, possibly more profitable and less complex tasks, as e.g. housing and transportation. The reliance on foreign consultants may be an answer for metropolitan water supply systems, serving a population of hundreds of thousandsor even millions. But the bulk of the world's population lives in rural areas or cities of a few thousand or ten thousand inhabitants. It is these people which have been most neglected until now and which are meant to be reached in the coming water decade. Here the escape to foreign consultancy cannot provide an answer.

On the other hand, education and training of local engineers, who would once be capable of planning all the necessary facilities based on present design criteria, would take more than the next ten years. It therefore seems that the implementation of the "Water Decade Programme" will never start, because it will never be designed.

2. SCIENTIFIC DESIGN.

What is this technology, or more specifically this scientific design theory, that is so difficult to teach and get applied in developing countries?

Over the last one hundred and fifty years, western technology has evolved from craftsmanship based upon practical experience and tradition to an interdisciplinary science. Any engineering problem today is approached with the tools of an exact science.

Problems must be quantified and expressed in a formula and its parameters before they can be handled at all. To do so, each task is broken down into parts and for each such part a mathematical model is created, which then can be solved, whenever possible on a computer.

Below some examples of parameters used in the design of water supply systems are listed.

- Population and population growth
- Population distribution and areal density
- Specific average water use for various groups of consumers
- Peak hour demand ratio and daily variation
- Maximum day ratio and yearly variation
- Ratio of leakages and unaccounted for uses.

This to name only a few of the most basic ones. Each one of the above figures, now is the subject of endless discussions at conferences and in publications at all levels. They vary with time, social conditions, standard of living, climate etc. Textbooks, usually written in a highly civilized country, only give a sensible range for each parameter. Sensible, that is, for the conditions prevailing in the respective country of origin of the book.

Finally it is left to the man in the field, say a technician of the public work department of a small town in central Java, to understand all those parameters, to interpret the local conditions, to decide on respective values, and finally to assemble all the bits and pieces to dimension the diameter of his distribution pipeline.

The question of appropriate technology arises not only when discussing remote control but also in techniques of design.

3. SIMPLIFYING DESIGN CRITERIA.

Before discussing ways of simplifying design criteria for water supply schemes, one should be aware of one important difference between the water supply field and other fields of engineering. If one element of a steel structure is wrongly dimensioned, it might cause the collapse of the whole construction. A railway bridge is constructed for a set load, which will occur the moment it is taken into operation. In water supply engineering, however, there is a time element involved, i.e. the design period. No water supply scheme will run at its full capacity when taken into operation and seldom is the installed capacity intended to be sufficient for times ever after. Applied to design criteria this means, that a slight error in design of capacity, resulting from simplified criteria, will at the most add or deduct a few years from the intended design period. The crucial point of design criteria for water supply in developing countries is not their scientific exactitude but their applicability, their appropriateness.

3.1 MANUALS.

One of the most common ways to support the "man in the field" are manuals. Most of the developed countries have their national manuals, to name only the "American Waterworks Association Manuals" or the "Design Criteria for Waterworks Facilities" issued by the Japanese Waterworks Association. Unfortunately such manuals do not exist there where they would be most needed, i.e. in developing countries. Here, outright recipe books in the language of the respective country would be one of the basic necessities to boost water production in smaller towns, semi rural and rural areas. An idea as to what extent of simplification such recipes could possibly go, is given later in the form of an example.

3.2 STANDARDS.

A further necessary help to engineers and water enterprise managers are standards for materials, dimensions and entire products. In the design phase, standards allow to be much more precise in specifications and are the necessary tool for an evaluation of procurement bids. Many developing countries are reluctant to introduce one standard because of the fact that they rely on bilateral soft loan money for their projects. It is not in spite of this, but just because of this fact, that standards are of importance to developing countries. This is not so evident in the design phase of a project, but unfortunately only too evident in the following maintenance phase. According to our experience, a good deal of the difficulties in maintenance stems from the diversity of material installed over the last forty years. Every new project is bound to bring in still another type of material. To investigate the positive long term effect of standardization on the local water related industries, cannot be the chore of this paper, but is a subject also worthy of consideration.

3.3 STANDARD FACILITIES.

The next logical step after manuals and standards is to create a collection of standard design for whole functional elements within a water supply scheme. This could start with such basic things as e.g. house connection design and water meter installations. It could proceed to typical design of whole elevated reservoirs, pumping stations, etc. Co-operation with the respective local industries in such developments would lead to a much higher degree of self reliance. Finally all those elements could be assembled to ready made projects, allowing for very short project design periods and accurate cost estimations. The backfeed of experience made in a number of such projects would be more direct, allowing to arrive at a reasonably high, if necessarily narrow, degree of technical sophistication. The advantages in management, maintenance, operation and training are obvious.

4. DIMENSIONING OF DISTRIBUTION LINES.

After this excursion later into the general possibilities of supporting the engineer in his design problems, we should like to sketch out a practical example of simplified, appropriate design criteria.

One of the ever occurring problems is the design of distribution lines be this for a new network, an extension or a replacement of old lines. Generally distribution lines are designed at community level by the Local water enterprise technicians with little or no support from outside: A typical case for the necessity of appropriate design criteria.

Let us consider the following regional characteristics:-

- A typical town of up to half a million inhabitants in South East Asia has almost no two or more storied buildings.
- The family incomes of different social groups vary widely.
- Population density is strongly related to income levels.
- The same applies to per capita water consumption.

The last two of these characteristics are quantified in the table below for fully developed areas of a typical town in Central Java:-

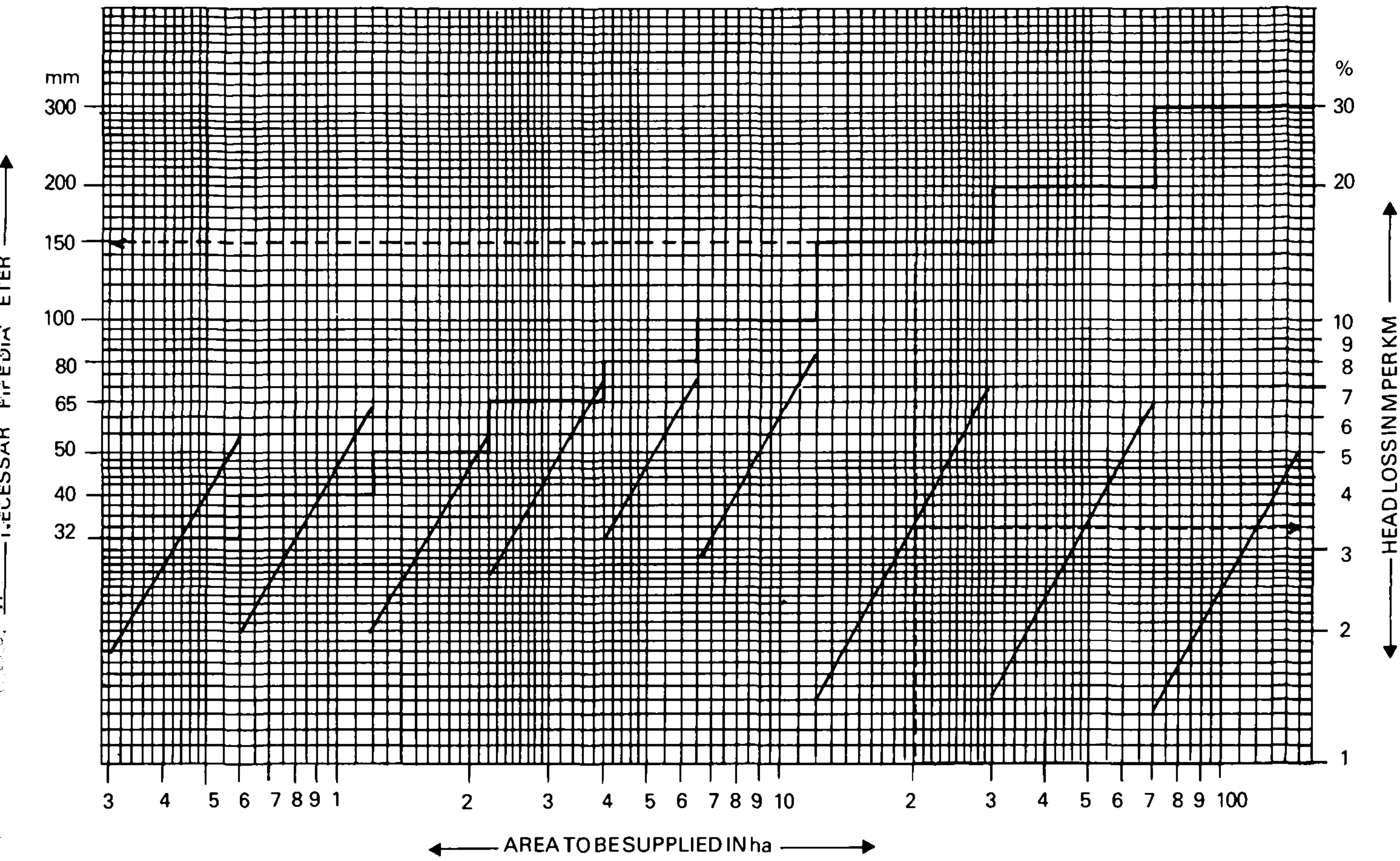
INCOME AREAS	Pop.Density	Per Capita Consumption	Per ha Consumption
	c/ha	l/cd	m^3/ha d
High income residential (multiple tap installation)	100	250	25
Medium income residential (multiple tap installation)	140	180	25
Lower income areas (single tap, patio connection)	200	125	25
Very low income areas public stand pipes within 50 m. range	500	50	25

The significant trend apparent is, that for fully developed areas the consumption per unit area is constant. A very convenient fact, when we think about the fast changes in social level that are possible in such town areas. Calculating with a peak hour demand of 0.58 l/sec/ha, it then is possible to express necessary pipe diameters in function of the area to be supplied, and a table like the one given on Page 5 becomes the only necessary tool for our technician to dimension his distribution system.

To supply an area of 20 ha a pipe diameter of 150 mm would be needed and a pressure loss of 3.4 m per km would have to expected. Please observe that graph is only valid for a specific region and is meant as a qualitative example only.

5. CONCLUSION.

This paper has dicussed the presently used design criteria for water supply schemes and compared the required technical know-how needed for its application, with the engineering resources available in developing countries. It came to the conclusion that a new approach in design criteria for those countries is necessary if the target set by the International Water decade is not to be only an illusion. It was recommended to prepare national design manuals in local languages based on an appropriate level of technology. The significance of standards was stressed and standard design facilities were proposed as a means to improve and fasten the feedback of technical experience. The possibility of adapting and simplifying traditional design criteria, was shown on the example of dimensioning distribution lines.



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Paper 3e

Innovations in Water Technology In India

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SUMMARY OF PAPER

India has to cater to the increasing demands of clean and potable water for its huge population living in its cities and villages and for its growing industries. The vastness of the problem and inadequate finances add to the complexity of the situation. At the same time, there is dearth of trained personnel and facilities to handle sophistcated equipment and processes particularly in the rural areas.

To meet this situation, Indian engineers have recently been engaged in evolving processes, methods and devices, which are cheap, simple and reliable. Experimentation on these has yielded encouraging results. Reliance is now being placed on non traditional materials, locally available and hitherto unused.

Two such materials are the crushed cocoanut shell as filter media and a permeable matrix formed from inert matter which has vast applications.

Treatment plants built with gravel based prefilters, settlers and the patented crushed cocoanut shell as media for filter have been installed in a few places in the state of Maharashtra, nearabout Bombay, mainly to supply water to small communities and groups of villages. These have been functioning satisfactorily for the past few years, which has encouraged the designer to build similar plants in other places. This has lead to increased loadings a substantial saving in capital costs and space, besides reducing reliance on skilled operation and maintenance.

Similarly, in Tamil Nadu, improvements have been made on the traditional methods of tapping ground water, slow sand filters and rapid sand filtration. In case of collector wells, faster and easier methods of well construction have been evolved. The underdrains for slow as well as rapid sand filters have been modified to increase effectiveness. The varied use of the permeable material has resulted in reduction in costs and improved performance. The principle of the permeable capsule has been employed in other situations such as prevention of sand blows and in chemical dosing devices. Other advantages in these developments are elimination of gravel and reduction in the shell volume of the rapid sand filters and higher loadings. Some of these are patented..

These are only some examples of the new activities in the field of water technology now in progress in India. Except in some extra - ordinary situations, the entire know how and equipment for water procurement and treatment in India is indigenously available thus doing away with reliance on other countries.

Further developments are underway which are likely to improve upon the existing design parameters and help reduce costs. India looks to these with expectation and confidence.

INTRODUCTION

In the past three decades, since India attained Independence, strenuous efforts are being made, to improve the standards of living of its citizens. One important outcome of this is the fact that greater attention is now being paid to the problem of supplying clean and potable water to the millions of people living in towns and villages. Rapid industrialisation has also led to an increase in the demand for process water and water for its housing facilities. The problem of water supply, however is not an easy matter because of its magnitude on the one hand and limited financial resources on the other. The situation is further aggravated by the tremendous increase in the population every year. Paucity of trained personnel and lack of facilities to handle sophisticated and expensive equipment has compelled technologists in India to evolve systems and devices which are simple and easy to operate.

All this calls for a technology which is indigenous and less expensive. Several activities have progressed in this regard and as a result, some new processes and devices have been developed in India. Some of them are directly applicable and have actually been incorporated in urban and rural water supply schemes succesfully in the past few years. Some of these have been patended and are being commercially exploited in India and abroad. Some of these constitute an improvement over the existing designs and construction procedures. Consequently, there is a big saving in capital costs and construction expenses in many cases, followed by better performance of the plants. In this paper, the details of a few of these are presented.

IMPROVEMENTS IN DESIGN AND CONSTRUCTION OF RAPID SAND FILTERS

The old concept of rapid sand filtration has undergone a change on the western countries, with the use of multiple media filters, incorporating use of materials such as anthracite. The benefits of this are

1. increase in the filtration rate
2. reduction in the loss of head required for the back wash and
3. minimising or elimination of the gravel layer.

In India, considerable work has been carried out in this direction.

i) Multimedia filters

Non-avialability of anthracite in India has compelled engineers to look out for alternative materials., such as bituminous coal etc. A notable achievement in this direction is the use of crushed cocoanut shell in a number of filtration plants in the state of Maharashtra. Mr. Kardile of the Maharashtra Engineering Research Institute, Nasik, has a patent for the use of this material as a filter media after considerable research. He has designed the above mentioned units primarily to meet the needs of small towns and villages.

In the first case at Ramtek, Maharashtra[1],Mr. Kardile has designed a simplified plant for a small township to treat 2.4mld of water. In this plant, in place of the conventional coagulation, flocculation and sedimentation units, an upflow grannular media bed is used as a prefilter. This is principally designed to hande water of low turbidity. The bed consists of (Fig 1) graded gravel 10 to 25 mm size. The loading rate is 6750 litres per square meter per hour. The filtration unit consists of a 450 mm layer of 1.5 mm size crushed cocoanut shell over layers of gravel and sand. The designed rate of flow is 6570 lit/sq.m/hour.

The plant which was commissioned in 1974 has been performing very well. In the prefilter, the turbidity of the effluent has always been less than 25 ppm even when the raw turbidity ranged from 100 to 500. Addition of alum was necessary only when the turbidity exceeded 20 ppm. A high reduction in the MPN count was also noticed. The filters, during studies were tried with 50% higher rate without any deterioration in the water quality. Filter runs of 88 hours on an average were obtained. At times of low turbidity, a run of 200 hours was obtained. The consumption of water for back wash was only about 0.85% of the filtered water in the case of one of the beds.

A modified and improved version of the above plant has been installed by Mr. Kardile at Varangaon, Maharashtra[2] (Fig 2) to treat 4.2 mld of water for a group of villages. In this case, a downward flow gravel bed acts only as a flocculator unit. The media consists of a 2.5 meter layer of gravel of size 60 to 25 mm from bottom to top, supported on flat M.S. mesh.A sloped bottom enables collection of sludge at the bottom for disposal. The flocculated water is then passed through a square shaped settling tank containing a set of PVC tubes 0.6 m high each 50 x 50 mm square. The surface loading is 6600 litres/sq.m/hour. and the detention period is 30 minutes.

The filter bed consists of multimedia as in the earlier case above, viz., crushed cocoanut shell and sand. The under drainage system consists of m.s. manifold with PVC laterals. The filter operates on the declining rate control system. As against the plant at Ramtek, this plant is designed to handle higher turbidities rising to almost to 4000 ppm during the rainy season.

The total cost of the plant is about Rs. 0.4 million as against the an estimate of about Rs. 0.8 million for a conventional treatment plant with flash mixers, flocculators and sedimentation units, and pressure filter. The space required for the plant is about 30% of that required for a conventional plant.

While the performance of the flocculator is satisfactory, it has actually helped an increase in the loading rate on the settling tank leading to a reduction in the detention period from the conventional 2½ hours to just 30 minutes. In the case of filters, it has been possible to increase the loading from the designed 6,600 litres/sq.m./hour to 10,000.

Mr. Kardile is now busy modifying some of the existing plants by incorporating the above features to increase their capacities. The results are awaited with interest.

ii) Underdrainage System

The system commonly adopted in India consists of a manifold with asbestos pipe laterals. In some cases pre-cast RCC false bottom filter blocks have been adopted.

A recent development in this regard is a special filter block patented by one of the authors[3] (Fg.3). This is a perforated stool of cement concrete which is precast. The top of the stool has a slab with openings of 25 mm dia. The top portion of the slab is recessed as shown in the sketch and this is filled up with a layer of permeable material. The legs of the stool provide the support and clearance for the passage of the filtered water and the backwash water. The blocks are placed adjacent to each other and the joints between them are sealed off with mortar after anchoring with reinforcement steel. With this arrangement, the permeable area is about 70%.

With the use of this block, it will not be necessary to have the gravel media. The stool supports 7.5 cm layer of coarse sand followed by a 60 cm layer of filter sand. Thus the depth of the media reduced to 67.5 cm as against the conventional 75 cm.

The stool is being used on an experimental basis at the Kilapuk Water Works Madras since April 1977 and its performance is comparable to that of the conventional filter. The loading is almost 100 lpm/m2. The average turbidity is about 2 ppm. It has been established by pilot studies that in this system, the loss of head is much less. The principal advantages of this filter block are:

1. elimination of gravel
2. reduction in the depth of the filter shell
3. reduction in energy required for filter cleansing.

SLOW SAND FILTERS

i. Underdrains

In the conventional slow sand filters, the underdrains are usually of brick or perforated burnt clay pipes. Recently a patented 'permeable capsule' has been used as an alternative on an experimental basis. This has been developed by one of the authors. The underdrain consists of an UPVC grid with terminal capsules made of permeable material. The capsules 63 mm dia x 100 mm long are placed at the rate of one per square metre of filter area. Here again, gravel is dispensed with. The filter is being improved with the provision of arrangements for continuous scraping of the filter surface.

ii. Package Slow Sand Filters

A package slow sand filter has been designed by T. Damodara Rao for small communities. This unit essentially consists of a steel tank with two chambers. The larger chamber which includes the entire bottom constitutes the filter while the smaller chamber acts as a reservoir for the filtered water[4] (Fig 4). The filter contains the conventional media. The filtered water is collected by a grid of UPVC pipes with permeable capsules referred to above. The filtered water rises into the reservoir through a connecting pipe and is stored there. A tap is attached to the reservoir so that the consumer can draw water directly from it. This is a compact unit which can be place above village wells and the water pumped into the unit. One such unit has been in successful use in a village near Madras for the past two years.

iii. Iron Removal Plants

The above package plant has been modified (fig.4) by the addition of an aeration unit above the package plant. This was primarily designed for a situation where the iron content in the water was excessive. The iron rich water is sprayed over a layer of charcoal or coke and the water then trickles down on the filter. This unit has been performing well for over an year now. A commercial firm has obtained the marketing rights for such units in India and abroad. These units can be used either with powered pumps or with a hand pump where power is not available.

Yet another modification of this plant is the provision for the addition of alum or lime for the removal of flourides. This unit is now being field tested.

GROUND WATER SUPPLY

Tapping of ground water is one the common problems in water supply schemes in India. The methods generally adopted in this regard are collector wells and infiltration galleries.

Collector wells usually have perforated steel pipes driven into an acquifer. These calls for special equipment and skill.

In a collector well near Madras, UPVC laterals were laid in trenches and connected to a central collection well. These laterals were fitted with capsules of permeable materials as above. Coarse sand was packed around the laterals for easy infiltration of the water into the capsules[5] (Fig. 5).

It is common knowledge that when slots are made in pipes of materials such as PVC, the pipe looses much of its structural strength. This situation has been overcome in the present case by the provision of the capsules in the pipes. With the provision of sand packs, there is no need for 'development' normally necessary for a collector well. This method of constructing a collector well was developed to face an emergency in an year when there was a drought on account of the failure of rains. The simplicity, economy, ease and speed of construction make this an acceptable method particularly for rural areas. It will be also possible to use the same principle for using laterals of greater length.

The permeable material has also been used in an experiment near a city close to the sea to tap sweet water floating over saline water. The permeable layer in conjunction with a gravel bed has been adopted as shown in the sketch (Fig 6). Similar arrangements are being tried in the state of Tamil Nadu to tap water from river beds by having a series of laterals embedded in the river bed.

PRESSURE RELEASE VALVES

Another interesting application of the permeable capsule is its use to prevent sand blows commonly encountered when placing pressure release valves in floors of settling tanks. In a particular case, where the sub-soil water level was very high and where the floor slab was not designed to resist the pressure therefrom, pressure release valves had to be provided to automatically operate whenever the pressure occured. During the installation of these valves, due to sandy nature of the soil blows occured creating large crevices beneath the floors. Permeable capsules referred to above were installed (Fig.7) beneath the valves and since then there has been no movement of sand for the past three years.

CHEMICAL DOSING DEVICES

One of the difficult aspects of water supply for the rural areas in India is the operation and maintenance of the facilities including chemical dosing devices. Therefore, cheaper and simpler systems are needed. One such is the double - pot chlorinator developed by the National Environmental Engineering Research Institute, Nagpur. This is double chamber and from which a disinfectant such as bleaching powder is allowed to dissolve and diffuse into water bodies such as wells, slowly over a long period. The pot is left immersed in water for this purpose. One of the authors, referred to earlier, has improved upon this and patented a new diffuser. This consists of a single chamber, the top of which is filled with exfoliated vermiculate to hold the chemical. This is supported on a layer of the permeable material, mentioned earlier. This device is immersed in water as before. Water which enters the pot from the top dissolves the chemical. This solution slowly trickles down through the permeable layer through a set of openings at the bottom into the water. The advantage of this device is that the full available volume of the chamber is used to fill the chemical being dosed, which is not the case with the former.

CONCLUSION

The cases mentioned are only a few of the many new developments taking place in India to improve the water technology for meet the increasing demands needs of water over the entire country. This has helped in elevating the level of water engineering. These include new concepts of design and construction such as declining rate filters, elimination of rate controllers etc. The country can proudly look forward to the problems in future without having to turn to the more advanced countries for help. It is a matter of great satisfaction that now, that except where specific needs demand, the entire range of equipment required for water treatment in India is manufactured in the country itself.

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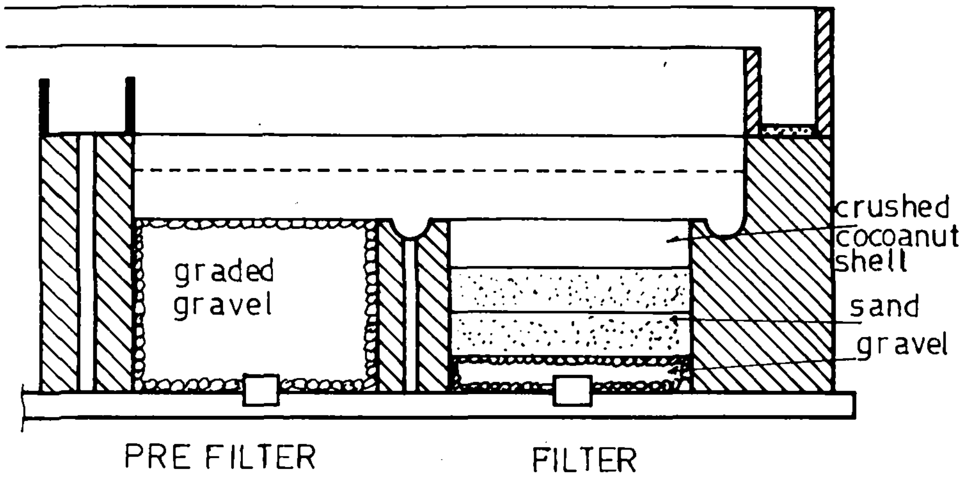
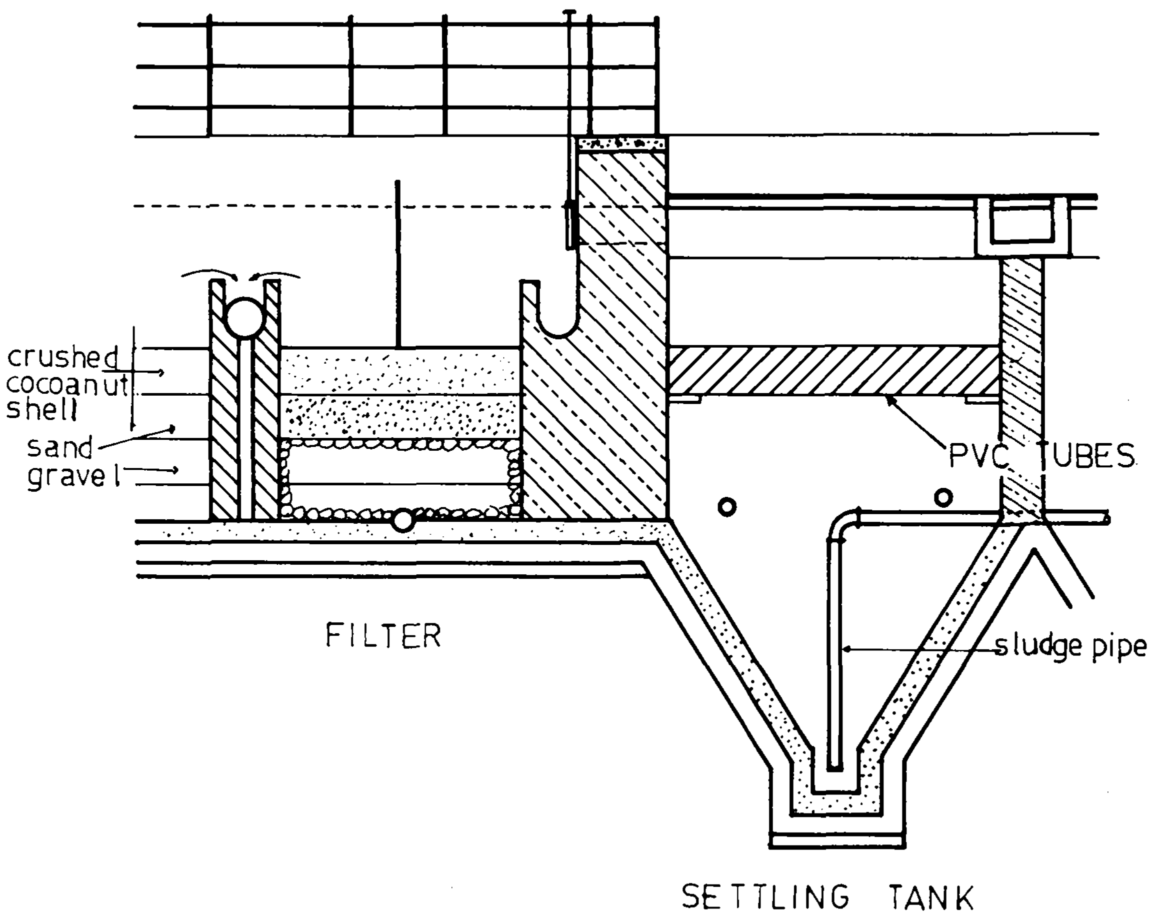


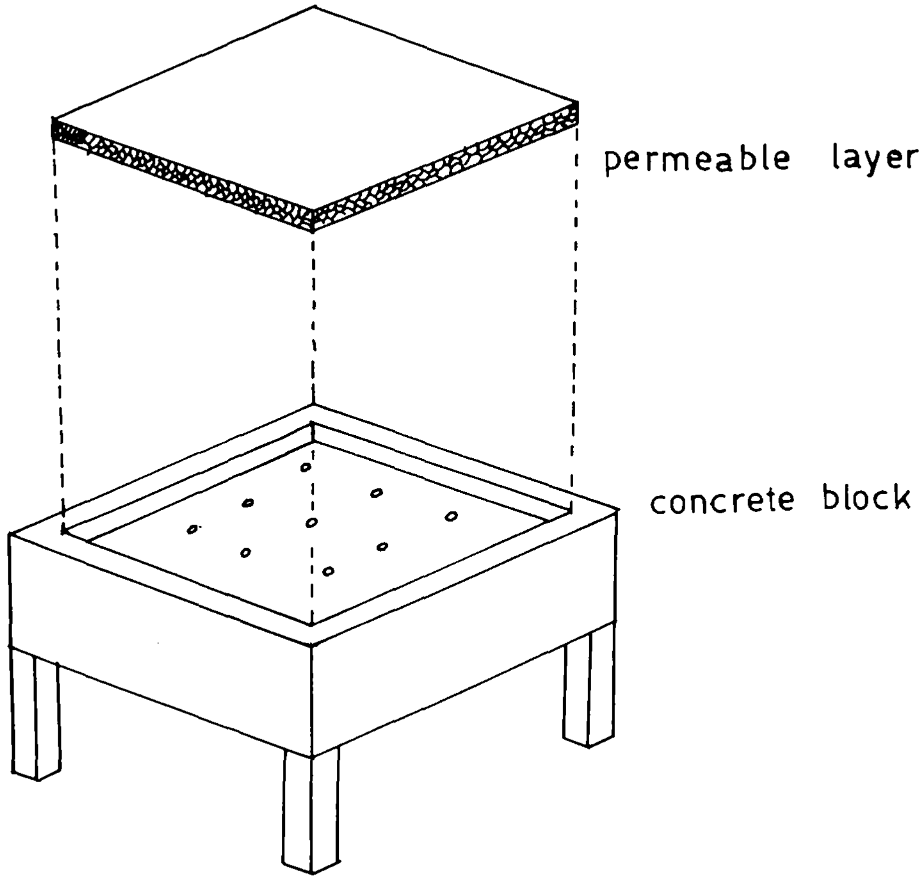
TREATMENT PLANT AT RAMTEK

FIG. NO. 1

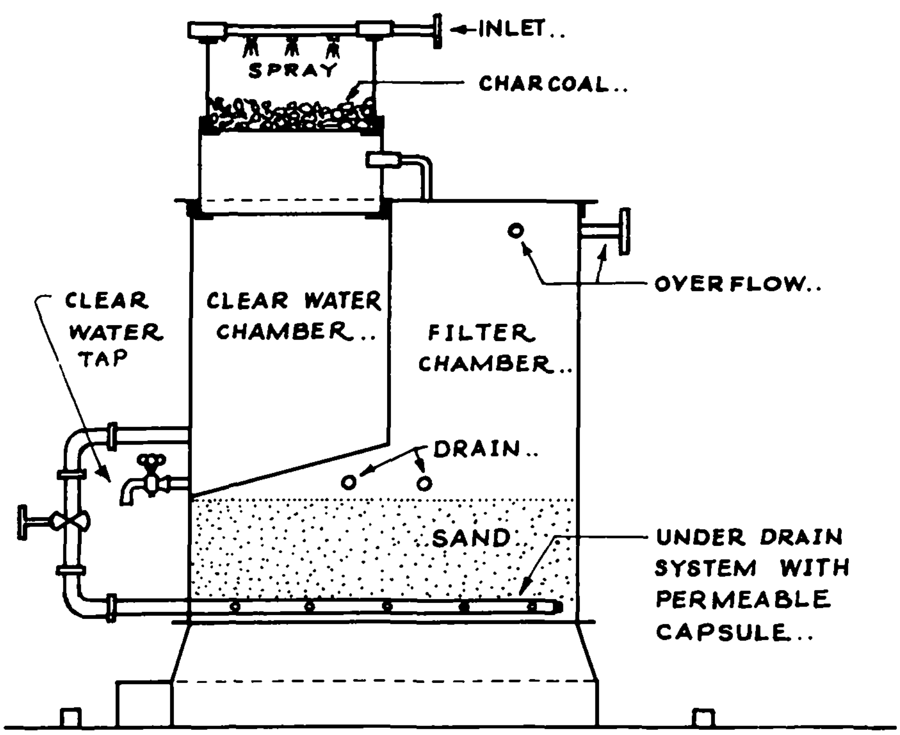


WATER TREATMENT PLANT AT VARANGAON

FIG. NO. 2

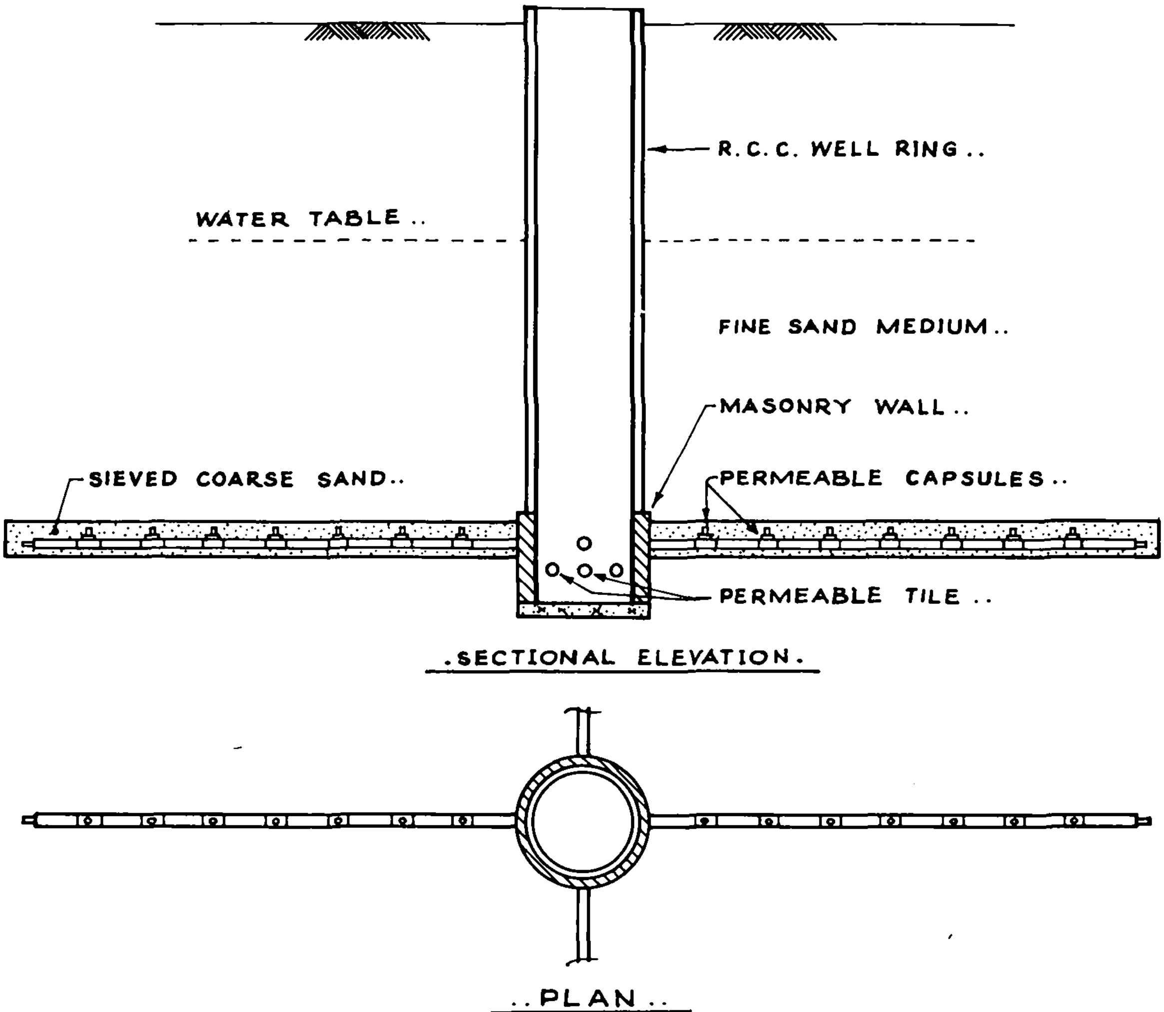


PERMEABLE FILTER BLOCK
FIG. NO. 3



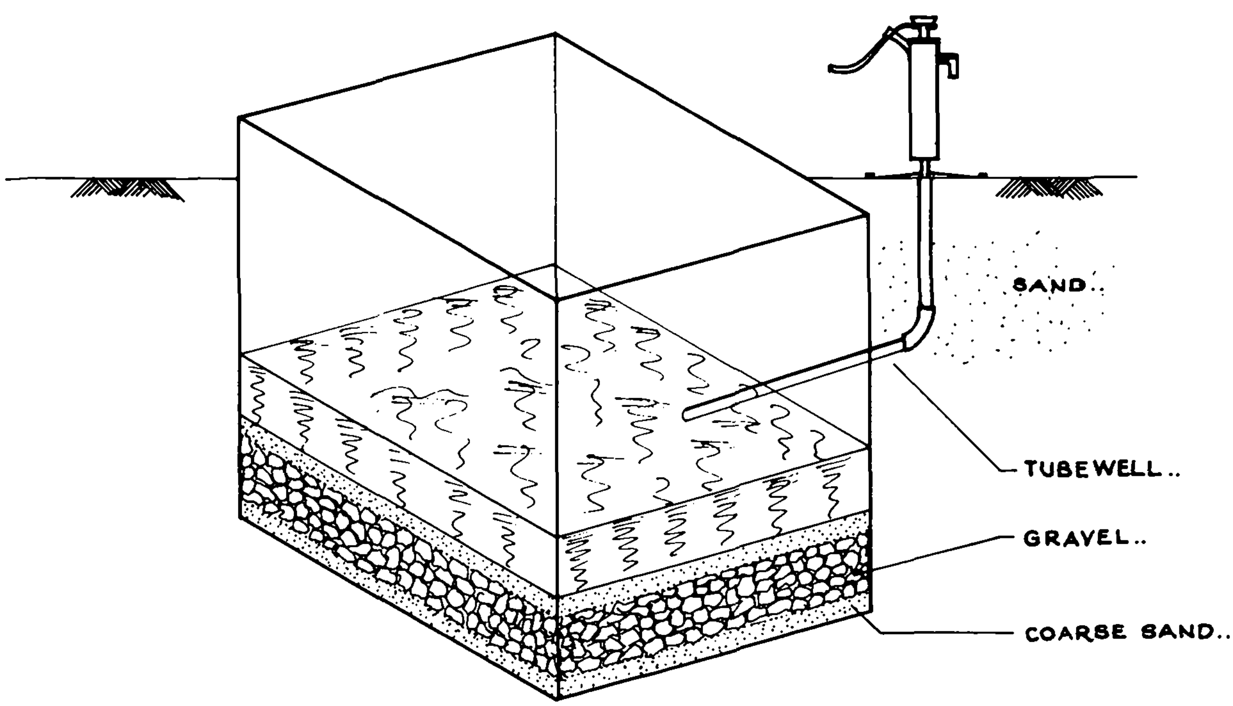
PACKAGE FILTRATION PANT

FIG. NO. 4



WELL WITH INFILTRATION LATERALS (NOT TO SCALE)..

FIG. NO. 5



GRAVEL BLOCK TUBEWELL

FIG. NO. 6

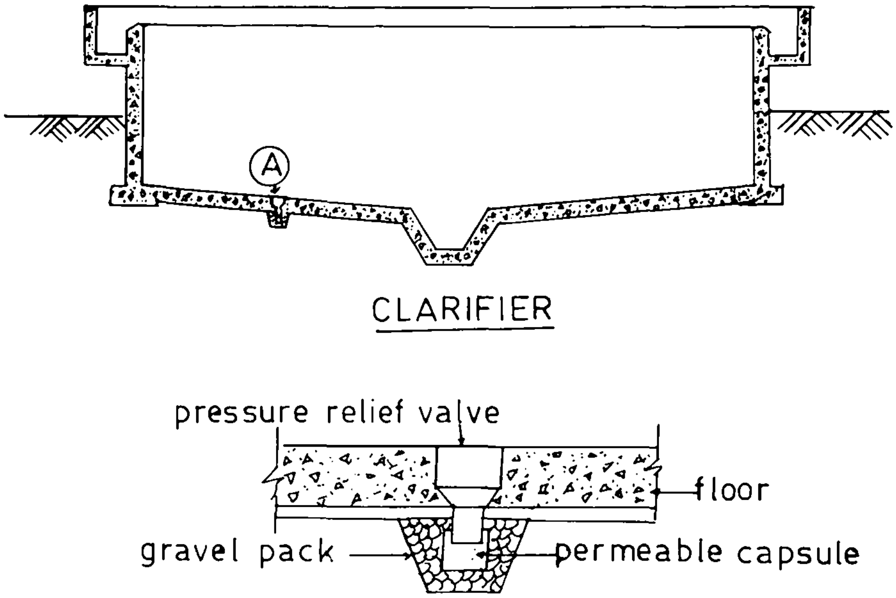

A
CLARIFIER
pressure relief valve
floor
gravel pack
permeable capsule
DETAIL 'A'

FIG. NO. 7

Paper 4e

Water Supply Finance and the World Bank

by Arthur E. Bruestle
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SUMMARY

The World Bank provides technical and financial assistance for great variety of projects of its member countries, ranging from agriculture to population, industry and public utilities. Criteria it employs in evaluating public utility projects generally and water supply projects specifically have the objectives of ensuring that projects are economic and meet prescribed health and social objectives. The Bank assists its borrowers in building institutions capable of planning and operating water supply systems and mobilizing financial resources. It also assists in the training of staff and seeks to ensure that water utilities become financially viable and managerially autonomous.

Introduction

1. The World Bank made its first loan for water supply in the early 1960's. Recent years have seen a sharp increase in water supply lending and the number of operations now number from 10 to 15 per year, with loan amounts ranging from 10 to 100 million U.S. dollars. Borrowing countries are throughout the world: Africa, Asia, Latin America and Europe.

Objectives

2. The Bank's objectives in lending for water supply are to:

(a) assist governments in providing basic infrastructure at least cost;

(b) ensure access to public services to all segments of society, particularly lower income groups;

(c) build institutions capable of planning and implementing national programs, including mobilizing through adequate pricing policies, the funds necessary for physical development and the training of staff;

(d) establish financial viability of implementing agencies so they may cover operation, maintenance and depreciation costs and contribute to future investments.

Fulfilling Objectives

3. The physical components of projects submitted to the Bank for financing are given a thorough technical review to ensure that they represent the least cost method of fulfilling demand. The review covers subjects such as demand analysis, geology and hydrology. Engineering designs are reviewed for the choice of technology with the view of minimizing capital and operating costs, and to ensure that the capacities of the components, such as source works,

treatment and distribution, are appropriately matched. At the time of the review the project's capacity to serve industry, commercial and domestic - including low income - consumers, is established. Often Bank staff assist governments in the early stages of planning and participate in the planning process.

4. The Bank tries to ensure that the beneficiaries of its loans have a reasonable measure of autonomy, control costs and are financially viable. Specifically it looks for:

(a) competent management, and preferably a separation between a board of directors responsible for policy and a management charged with its execution;

(b) financial independence, in the sense that the entity is adequately capitalized, empowered to manage its own funds, can make adequate provision for depreciation of assets and occasional adversity or cost overruns, and is able to formulate appropriate investment plans and pricing policies;

(c) the power to set wages and salaries at competitive levels to attract and retain competent staff, and the authority to engage, dismiss and discipline staff;

(d) a separate accounting system, on an accrual basis, capable of making available quickly and reliably the data needed for effective management;

(e) the legislative backing to deal with consumers who default in payment or violate regulations; and

(f) primary responsibility for the procurement of goods and services required.

5. Some of these objectives have proved easier to attain than others. Governments are often jealous of their right to set salary scales for everyone in the public sector, and government powers of general surveillance often have a tendency to increase rather than decrease, especially when financial difficulties arise or when, for example, tariffs become a pawn of politics. Thus the Bank may have to allow a sufficient time for the objectives listed above to be achieved; in some countries, the move towards full autonomy of the borrower may have to take place over several successive lending operations.

6. Because of the monopolistic character of most water supply beneficiaries, and the fact that their output is normally regarded as a necessity, it is particularly important to ensure that efforts are made to achieve efficient operations and to control costs. The Bank contributes to this objective by reviewing the beneficiaries's operations and procedures and recommending that appropriate changes be made either as a precondition of the loan, or, where the required measures are expected to take some time, during the project construction period, or over a longer period which may encompass a series of loans. This may involve actions in a number of areas:

(a) Accounting and Budgeting

Where a satisfactory accounting and budgeting system, able to provide sufficient information for financial management, does not exist, the Bank requires that the deficiencies be remedied.

(b) Audit

The Bank requires an annual independent audit, and the setting up of satisfactory systems of internal controls where internal financial controls are absent or inadequate.

(c) Management and Staffing

Common problems in all sectors have been the acute shortage of experienced and competent staff, and inadequate training facilities to alleviate this shortage. Thus the Bank has to examine the borrower's level of staffing and training requirements. The problem of overstaffing at lower levels often exists in juxtaposition with the more serious problem of shortages of experienced and competent middle and upper-level staff. Where competent managers cannot readily be found within a country, the Bank is prepared to finance full-time foreign personnel, who, in addition to helping existing managers in day-to-day operations, are also able to train staff in modern management techniques. In some cases, reorganization is required. For example, scarce skilled manpower may be used to the best advantage when a single unit is given responsibility for planning, construction and operation on a national scale.

(d) Other Factors Affecting Costs

Experience shows that it is also prudent to review other elements affecting capital and operating costs. For example, it may be necessary to ensure satisfactory procurement procedures for items financed from the borrower's own funds. Inventory control may be weak in some instances. Operating and maintenance practices may be poor, partly reflecting the inadequate training of staff. There may be excessive losses of revenue owing to leakage or theft; inadequate billing and collection procedures are a problem with which many enterprises have had to contend.

7. Loans for water supply are usually made to revenue-earning entities which are financially independent and which are expected to achieve appropriate financial targets and objectives. With few exceptions, these are public sector entities. Many of the entities have a high demand for capital because of the intrinsic capital-intensiveness of their facilities and of the need to catch up with past underinvestment and/or to expand rapidly (doubling or more of capacity every five to ten years) to meet future demand. Given the difficulties faced by many borrowing countries in mobilizing public savings, especially in times of inflation, the absence of capital markets, and the competing demands for available resources by non-revenue-earning sectors, the Bank requires that the borrower's revenues cover all operating costs and debt service as well as a reasonable part of the investment programs, usually varying between 20% and 60%. The contribution to investment depends upon the circumstances of each case, including such factors as the stage of development of the beneficiay, the availability and adequacy of external capital sources, the size of the investment program in relation to existing facilities, and the terms of past and prospective borrowings. One of the most significant factors in judging the adequacy of the financial performance is the rate of return earned on invested capital, which serves as a measure of the extent of cost recovery from the beneficiaries of the services provided (see para. 15).

8. The Bank usually stipulates that revenues be raised to the required level primarily through direct user prices. This is fairly widely accepted among Bank borrowers, although newer entities may have short-term difficulties in generating sufficient funds. To ensure efficient allocation of resources, tariffs should, in principle, be related to the incremental opportunity costs of expanding output or service. But there are theoretical and practical difficulties in applying such a principle, particularly when there are large indivisible investments and conflicting social goals. Consequently, the Bank has tried simply to ensure that the average levels of tariffs or prices are adequate to meet specified financial goals.

9. Most water utilities face a number of problems in setting tariffs related to the incremantal opportunity cost of expanding output. First, since a minimum amount of water is needed to sustain life and health irrespective of income levels, charges for water can unduly burden the lowest income groups, and thus there has been a reluctance to recover water costs wholly through prices. Second, water supply investments often have to be "lumpy" since it is usually economic to provide facilities capable of meeting anticipated demand in a community for ten years or more; therefore the relationship of user charges to incremental costs has, in practice, to be approximate, and, where appropriate, averaged over some future period. Third, the general health benefits to the environment of the project area through the provision of safe water imply that some form of cross-subsidy may be appropriate. (Para 11.)

10. Another operational problem mainly related to the water supply sector is the failure of some borrowers to control losses and to collect all the revenue for services rendered. There are three main aspects to this problem: physical losses, improper billings, and poor collections. Many water supply undertakings cannot obtain payment for as much as half the water which they produce because of leakages or inability to meter or control consumption. In such cases the Bank may require special studies to analyze the costs and benefits of metering systems or theft and leakage prevention, and follow-up by inclusion of corrective measures in future loans. The Bank also reviews a borrower's performance on billings and collections to ensure that steps are being taken to bill the consumer properly and to collect the revenue promptly. In most cases such steps must be taken before a loan is made or within a reasonable period thereafter.

11. Once the principle of an adequate level of tariffs and charges is established, and inefficiencies in the revenue collection system have been remedied, it is possible to focus attention on the structure of tariffs. This requires that charges roughly reflect the cost of supply so that excessive consumption and waste is discouraged. It is a complex matter: for example, there are difficult analytical questions involved in designing an appropriate system of charges which vary with the time of day or season of the year in order to shift usage from peak (high cost) to off-

peak (low cost) periods. Similarly, there are problems involved in apportioning fairly the costs of service among different classes of consumers. Pricing services purely according to their actual cost may exclude many people from access to service. To overcome this it may be necessary to design tariffs which have a "social" or "lifeline" component to ensure that a basic minimum service is available virtually to all. In such situations, to maintain financial viability a cross-subsidy from higher income consumers or a government subsidy may be necessary.

Criteria of Financial Performance

12. In preparing a specific lending operation, the Bank and the borrower agree on precise criteria for minimum financial performance, not only for the purpose of achieving the broad objectives stated above, but also to assure the continued solvency and financial viability of the borrower and to assure the implementation of the financing plan for the Bank project. The careful formulation of these performance criteria is as much in the interest of the borrowing entity as of the government as guarantor, or the Bank as lender. The Bank recognizes, however, that the application of these criteria may have to be reviewed from time to time to ensure their continuing appropriateness when policies evolve and external events impinge on the operations of the borrowing entities.

13. Among the various tests, usually expressed in the form of covenants agreed to by the borrower, but sometimes agreed informally between the Bank and the borrower in a "plan of action," two tests have developed into standard requirements for practically all loans in these sectors; one aims at maintaining a specific minimum level of earnings throughout the life of the loan (Revenue Covenant), and the other establishes warning signals to prevent the borrower from entering at any given time into commitments which might endanger his solvency, and obliges him to consult with the Bank when these signals are triggered (Debt Limitation Covenant).

Revenue Covenants

14. While there are several types of revenue covenants which might be used, historically the Bank has usually employed two types of covenants for water supply and sanitation projects. These are based on:

(a) a rate of return on investment (net operating income after taxes as percentage of net fixed assets in operation plus, in some cases, adequate working capital); or

(b) a contribution to expansion (internally generated funds after operating expenses and debt service as a percentage of capital expenditures).

15. The *rate of return* concept has been by far the most commonly used basis for a revenue covenant. This is because (i) it is a standard measure of financial performance, (ii) it reflects generally accepted principles of costing of utility services, (iii) it provides an effective means (assuming proper revaluation of assets) of compensating for the effects of inflation, (iv) it mirrors concepts of tariff regulation which have been used in many parts of the world, and (v) it is an accurate and objective test. Specific minimum rates of return and of depreciation (preferably straightline) are normally agreed upon. These rates are determined after the Bank has satisfied itself that fixed assets are adequately valued and that suitable arrangements exist for allowing assets to be revalued to compensate for inflation and to ensure that net income and depreciation charges are maintained at the appropriate level in constant terms. Indeed, in countries which are experiencing high inflation, the use of a revenue covenant of this type is practical only if periodic revaluation of assets for rate-making purposes is provided for.

16. In addition to serving as a measure of the adequacy of revenues compared to the cost of capital, the revenue covenant based on the rate of return aims at providing internal cash generation for the specific purposes and requirements of the undertaking. The factors determining the actual level of funds required should be analyzed during the Bank's appraisal of the project. They include the existing capitalization of the enterprise, its debt service and any dividend requirements, the incidence of taxation, economic and social considerations such as consumers ability to pay, the expected growth rate for the services, the prospective investment pattern and the availability of other capital funds. This emphasis on the cash aspects of the rate of return is normally broadly consistent with the parallel objective of having tariffs or fees include an adequate charge for the cost of capital invested in the enterprise; however, in a situation with little, or concessionary, debt or a low rate of expansion of the utility cash requirements, the rate of return might be unacceptably low. Internal cash generation by itself rarely covers all the costs of expansion and is usually supplemented by the infusion of loan or equity capital.

17. Borrowing countries, reluctant to implement unpopular tariff increases, have often considered a government subsidy as a substitute. The Bank, however, has not accepted this except where the subsidy is given to compensate for losses sustained by the utility in undertaking social programs, e.g., water supply projects designed to meet basic needs of the poor. The Bank has held that it would not be right for the general budget to subsidize service to those consumers who belong to a comparatively affluent group of the population.

18. The alternative revenue covenant which deals directly with internal cash generation and *contribution to expansion* (and is sometimes called a cash generation covenant) (i) is more responsive to changes in the size of the investment program arising from inflation or other reasons, (ii) is a direct test of net cash generation, and (iii) is easily understood by borrowers and governments particularly in terms of the financing plan for the immediate investment program. However, a cash generation

covenant in itself cannot be relied upon as a guide to the adequacy of an entity's earnings for cost recovery purposes. Furthermore, because annual investments are often "lumpy," the cash requirement under this covenant tends to vary greatly from year to year; it is therefore necessary to calculate or estimate sliding averages of investment over periods of several years, and this leads to monitoring difficulties. Even when a cash generation covenant is used, the rate of return implied under the covenant is estimated and borrowers operating under inflationary conditions are asked to revalue their assets regularly; this enables an assessment of real earnings to be made, which in turn helps in determining the appropriate level of internal cash generation.

19. The debt limiation covenant is intended to prevent the borrower from entering into debt obligations which would cause future debt service to become excessive and endanger the borrower's financial viability. Such a covenant places a limit on the amount entities may borrow without Bank agreement and may also prevent an entity from entering into debt obligations having unsuitable terms and conditions. Some examples of such debt are: loans with relatively short maturities compared to the life of the assets financed by such debt, borrowings at very high interest rates, and debts having balloon payments without provisions for accumulating the funds for ultimate repayment.

Economic Justification

20. There are three main stages in considering the economic justification of projects in the water supply sector. The first is to make as thorough a study as is feasible of the market demand for the service, reflecting expected economic developments and the effects on demand of alternative pricing policies for the services in question.

21. The second step is to investigate whether the project is the least costly means of meeting the anticipated level of demand: for example, is the proposed water supply development optimal from the point of view of balance between source development and reduction in system leakage, choice of treatment process, and phasing and sizing of transmission and distribution mains? The determination of the least cost alternative usually involves the comparison of different time steams of capital and operating costs by an appropriate discounting technique. It also usually requires "shadow pricing" of costs where prices of inputs, labor or foreign exchange do not reflect the real economic costs.

22. The third step is to test whether the project is worth executing, by determining that the benefits of the project to the economy as a whole exceed its economic costs. In practice, this calculation is difficult for two reasons. First, most of the data available for the benefit calculation normally come from the financial accounts of the utility, which do not reflect the full benefits to the economy such as health benefits. The second difficulty arises from the fact that where the project consists of selected parts of an expansion program, it may not be possible to attribute the benefits deriving from these separate parts.

23. In most cases it will not be possible to quantify the economic benefits by consumers in excess of the amounts they actually pay and therefore the estimation of the social value of the project is precluded. It is normally possible, however, to calculate an incremental financial return, based on revenues from additional sales attributable to the project. When adjusted appropriately for transfer payments, such as taxes and subsidies, and the shadow prices of labor, capital and foreign exchange are taken into account, this usually represents at least a minimum estimate of the economic rate of return. If high enough it suggests that the project is economically justified, even though this will not usually be the determining factor. A low return may simply indicate that tariffs are too low, rather than that the project is not justified.

Conclusion

24. The World Bank's is a non-profit multinational organization. It is directed by representatives of the member countries and has a multinational staff. It seeks to assist its members in their efforts to promote better lives for all their people. It recognizes that the provision of potable water in adequate quantity is important for a better life. It assists member countries to provide water by providing financial and technical assistance. In so doing it asks that important social, economic, technical, financial and managerial criteria be met. But it recongizes that these criteria may sometimes be difficult to achieve and is therefore prepared to be flexible in its arrangements with borrowing countries.

Paper 4f

Water Supply Financing Under the Viability Concept— The Philippine Experience

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SUMMARY

Water Utilities in provincial urban centers outside the Greater Manila area had heretofore been the responsibility of local governments headed by elective officials. Their operations were heavily subsidized by general taxation and were characterized by very low water rates, the absence of long range planning, inefficiency and the deterioration of physical facilities and service. To rationalize and improve water supply services therefore, the Philippine Government created the Local Water Utilities Administration (LWUA) and established procedures for the creation of independent and self-reliant organizations called Water Districts at the local level. LWUA's equity is provided by the Philippine Government and this is augmented by funds which LWUA borrows from lending institutions. LWUA in turn lends its money to Water Districts for capital development. It also provides engineering, regulatory, institutional development and training services to said districts. Both LWUA and the districts are expected to be viable.

To enhance the viability of the Districts, LWUA designed a Commercial Practices System for their guidance. This includes a Chart of Accounts that envisions effective managerial control through the utilization of subordinate organizational units as responsibility centers, thus allowing decisions to be made at the lower operating levels where there is full awareness of facts and operating conditions. The installation of the system as well as the training of the personnel involved is part of the institutional development and training services that LWUA provides to the districts. LWUA also disseminates periodic water supply industry averages that can be used as operating standards.

Even while the administrative capability of the District is being developed, it must look into its pricing policy and structure since this is perhaps the most significant factor in determining its viability. Raising water rates to realistic levels requires an effective strategy that should consider:

1. The difference between what the average household is "able to pay" for monthly water bills and that which it is "willing to pay";

2. The estimated cost of development to be financed out of loans

3. The projected number of service connections; and

4. The projected yearly cash requirements of the District. After the completion of a District's capital development program, debt service usually constitutes about 50% to 70% of this.

Since LWUA is both the lender and the advisor, it designs a debt service schedule that fits the particular needs of the district and assists it in the development and implementation of the rate strategy. In preparing the schedule of projected rates itself, every attempt is made to avoid abrupt increases and erratic fluctuations. Consequently the peaks and troughs in cash requirements are evened out by providing a surplus in periods when cash requirements are low, so that such surplus can cover deficits in periods when cash requirements are high.

PROBLEMS:

1. Implementation of Rate Strategy

The difference between what households are "able to pay" and what they are "willing to pay" for water service normally indicates the magnitude of this problem and the amount of selling effort required in a particular District. The necessary persuasive effort is therefore brought to bear on the community. Where this fails to win acceptance for the increased rates or when such rates are beyond the average household's "ability to pay", then a re-evaluation of the engineering design is undertaken to bring down the cost (and debt service) for the Project without a proportionate loss of projected revenue. If the lower projected rates resulting from changes in plans are still unacceptable to the community, then the Project is deferred for a future date when, hopefully, a change in attitudes will have taken place. Where acceptance is secured however, then an appraisal of the District's administrative capability is made. If this is satisfactory, the project is bidded and subsequently goes into the construction stage. Within the realm of institutional development however lies many problems. Some of these are discussed here.

2. The District's Policy Makers

These are appointed by the head of the local government concerned from a list of nominees submitted by civic groups representing different sectors in the community. Since they are appointed by a local politician, some of them often allow political considerations to influence their vote on important matters affecting the District's viability. This often has harmful effects because some policies that are needed to enhance viability are politically unpalatable.

Another problem peculiar to some policy makers is their interference in purely management affairs. This not only erodes the authority of the General Manager, but it also disrupts operations since they often make suggestions or issue directives without an adequate knowledge of facts and operating conditions.

3. The General Manager and Supervisors

Here the critical element is managerial and supervisory capability. The specific deficiencies of some District managers and supervisors are:

a. The failure to delegate Authority

This results not only in a work overload on the part of the manager or supervisor concerned, but it also delays critical decisions that could have been made by lower level staff.

b. Rigidity in Leadership Styles

This is the inability to flex into the style that is most effective for particular situations, thus resulting in ineffective leadership and poor work group performance.

c. The tendency to be "soft" or tenderminded

This is the inability to make "hard" and sometimes unpopular decisions that are necessary. This is specially true in the management of people.

d. Poor Public Relations

This is the inability of some managers or supervisors to create or assist in creating a favorable public image for the District. In some ways, it also refers to the failure of some managers to influence the thinking of opinion leaders and decision makers external to the organization.

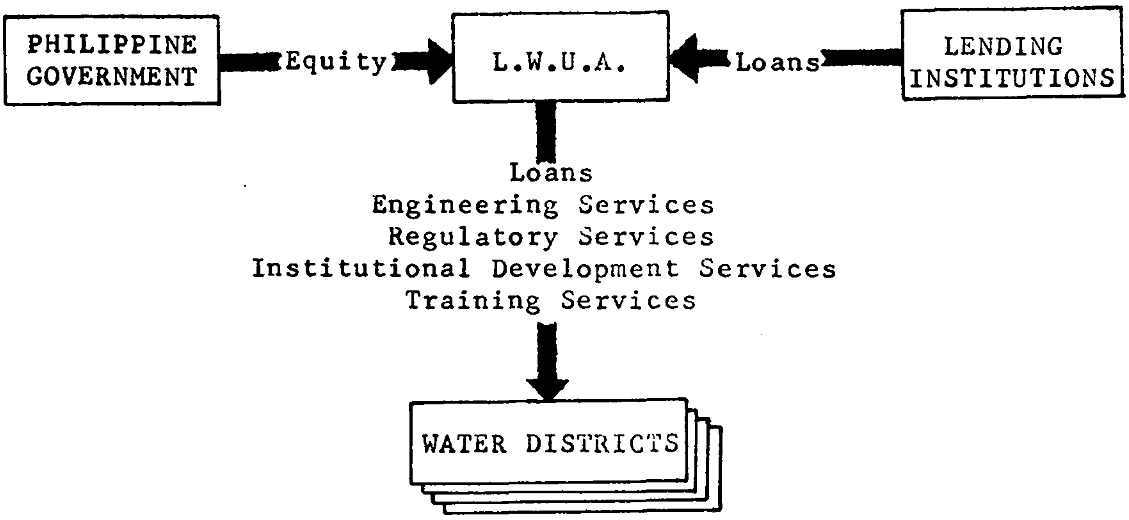
We are still working on many of the foregoing problems and hopefully the participants at this conference will contribute suggestions for their solution.

This discussion will focus on Water Utilities in provincial urban centers outside the Greater Manila Area.

BACKGROUND

Prior to the establishment of the present institutional framework for water supply development and operations, most of these water utilities were operated by local governments headed by elective officials. Since such officials were elected for a four year term of office, there was no real incentive for long range planning. The need to be popular often prevented the raising of water rates to realistic levels and in some cases even obstructed the effective collection of water bills. Since revenues from water supply services were grossly inadequate for operations, these utilities were therefore heavily subsidized by general taxation thus causing inequities in the allocation of burdens. Limited resources on the part of local governments also caused these utilities to deteriorate as well as to become inadequate for the requirements of the present population.

To rationalize and improve water supply services therefore, the Philippine Government created the Local Water Utilities Administration (LWUA) and established procedures for the creation of independent and self-reliant organizations called Water Districts at the local level. While LWUA is primarily a lending institution, it does provide engineering, regulatory, institutional development and training services to Water Districts. The Philippine Government provides the equity for LWUA by subscribing to its shares of stock and LWUA augments these funds by borrowing from lending institutions. LWUA in turn lends this money to Water Districts at an interest rate of 9% per year. This interest rate is expected to cover all of LWUA's costs, including expected bad debts and the anticipated loss in purchasing power of its equity brought about by inflation. A basic objective therefore is to make both LWUA and the Water Districts viable. The overall relationships are shown on the following Chart:



On the part of each Water District, revenues are expected to cover all its costs including debt service plus provision for reasonable reserves.

PROJECT SELECTION

After a planning survey of 100 provincial urban centers in 1975-76, a priority listing of areas for development was developed, using the following criteria:

A. NEED

1. Rate of incidence of water borne diseases.
2. Availability of water to users.

B. INVESTMENT EFFECTIVITY

1. No. of persons benefited per ₱1,000 - (U.S. $133) of investment.
2. Economic development potential.

C. INVESTMENT RISK

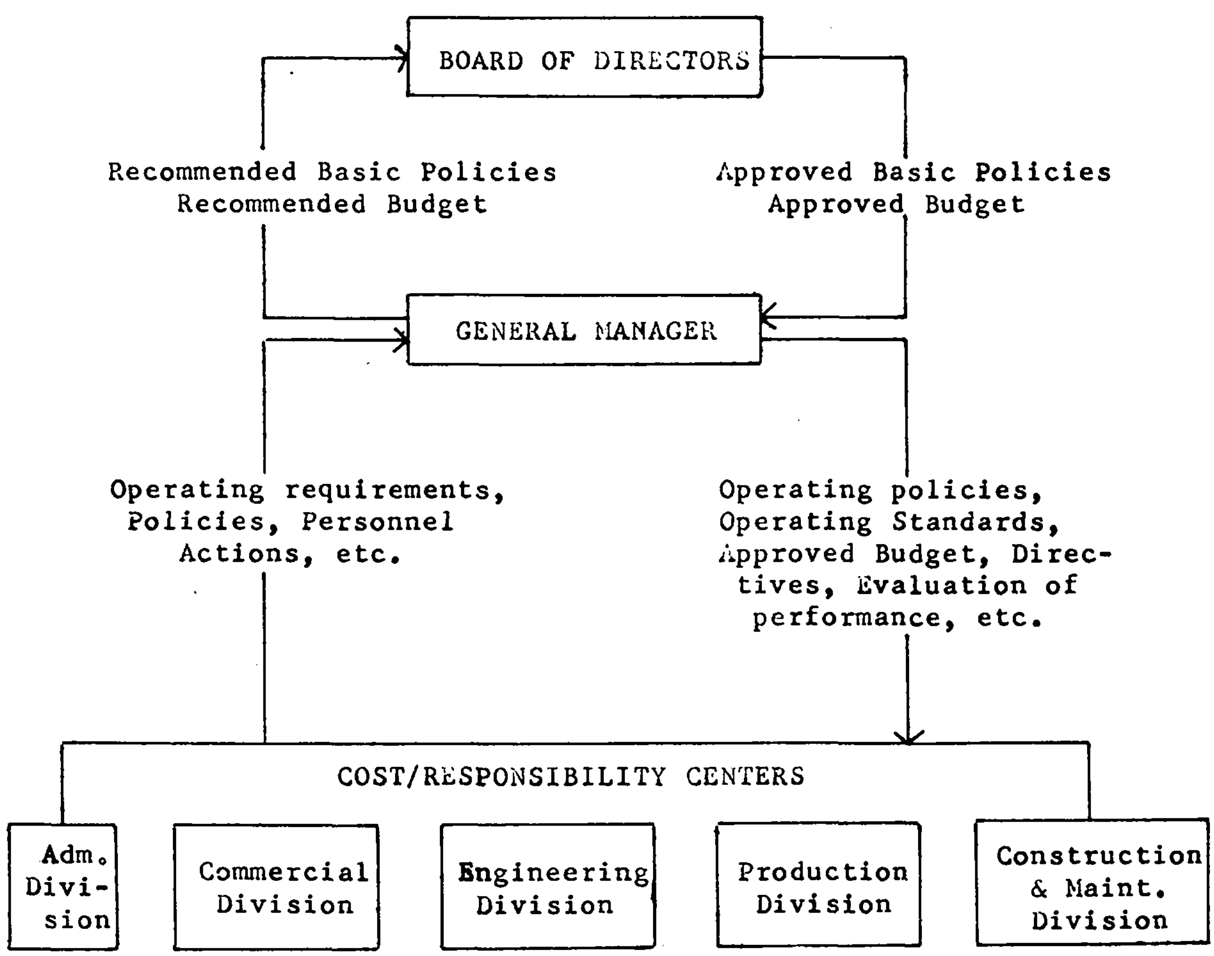
1. Average income/household.
2. Ratio of income of municipality or city to the estimated cost of development.
3. Projected operational costs.
4. Attitude of beneficiaries.

Priority areas were then encouraged to form Water Districts, then passed through successive stages of feasibility study, detailed engineering design and construction.

WATER DISTRICT OPERATIONS

From the time it is formed until after the start up of its new physical facilities, the District receives training and institutional development services from LWUA. Training services are provided through formal programs ranging in variety from a seminar for policy makers to a training program in meter repair, while institutional development services are implemented through tutorial or counselling services provided by LWUA's Management Advisory Teams to Water District managers and supervisors. While institutional development services are provided free of charge, training services are paid for by the Districts through seminar or training fees. On the other hand, the cost of feasibility studies, engineering design and construction are funded out of the loan which the District must pay over a thirty year période.

To further enhance the viability of the Districts, LWUA designed a Commercial Practices System for the guidance of the Districts. This includes procedures for billing and collection, purchasing and inventory control and accounting and budgeting. The Chart of Accounts included in the system envisions effective managerial control through the utilization of subordinate organizational units as cost or responsibility centers, thus allowing decisions to be made at the lower operating levels where there is full awareness of facts and operating conditions. The following chart shows how the Districts are expected to operate:



Hopefully, this operational concept will enhance the creativity of lower level supervisors and motivate them to extract maximum efficiency from their respective organizational units. For its part, LWUA provides assistance, not only in installing and operationalizing the concept but also by disseminating periodic water supply industry averages that can be used as operating standards.

WATER RATES

Perhaps the level of water rates of a District is the most significant factor in determining its viability. For this reason, LWUA puts in a lot of effort in helping Water District develop an effective rate strategy. As previously stated, all our Water Districts start out with rates that are way below realistic levels. Many of them charge a flat rate of ₱5.00 (U.S. $.67) per connection per month at the time the District is formed since this is the rate that the local government used to charge the consumer. Even assuming a low consumption (and wastage) of 20 cubic meters per connection, such rate would result in a very low charge of ₱.25 (U.S. $.03)/$M^3$. To increase such rate to say ₱1.50 (U.S. $.20)/$M^3$ after the completion of construction of new facilities therefore presents problems that often appear insurmountable. The solution of course is a detailed and well planned strategy not only for scheduling periodic increases but also for winning acceptance for such increases.

In developing a Water Rate Strategy, consideration is given to the following factors:

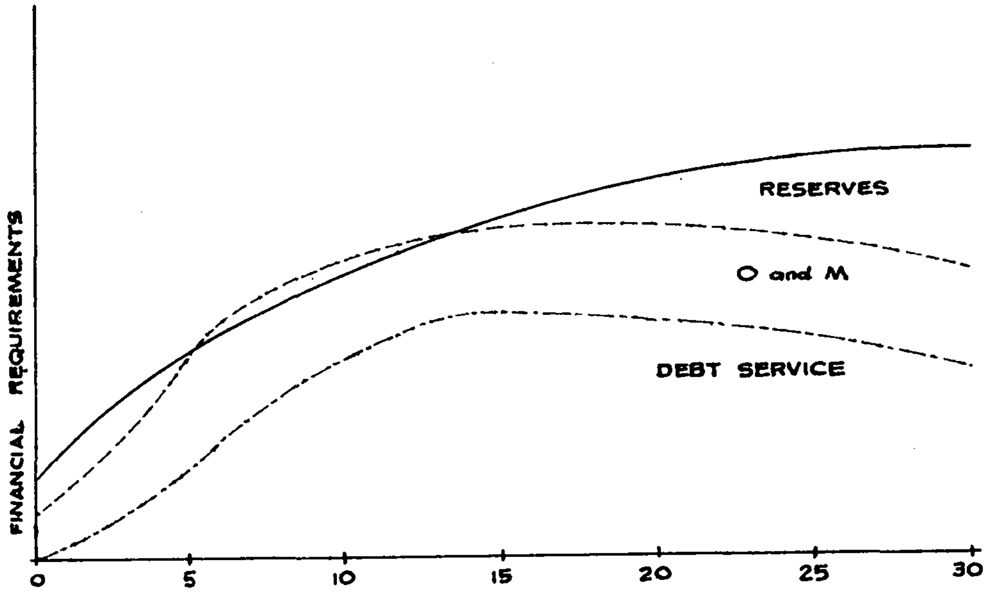
a. The "ability to pay" of the average household within the expected service area. This is estimated by a survey of the gross income of a number of households in the area, using a sample size that provides a maximum allowable error of 3% to 5% at a confidence interval of 95%. The weighted average of the gross incomes in the sample multiplied by 5% is the amount that the average household can afford to pay for domestic water service. The 5% figure was derived from previous studies which indicated that low income households pay as much as 6% of their gross income for water while high income groups pay as much as 3%. Since there are more households in the low income category, we settled for 5%;

b. The amount that the average household within the service area is "willing to pay" for each cubic meter of water. This is also a weighted average of the answers (figures) given by the respondents, using the sample size discussed in (a). This amount is multiplied by the average consumption of water per month and since the product obtained is usually lower than the estimated monthly amount that the average household is able to pay for water service, the difference is often used to measure the intensity of convincing (or selling) effort required in the District concerned. Our experience in this regard indicates that in most water districts, the amount that the average household is "willing to pay" as monthly water bills is about 45% of what they are "able to pay;"

c. The estimated cost of development (expansion and/or improvement) to be financed out of loans;

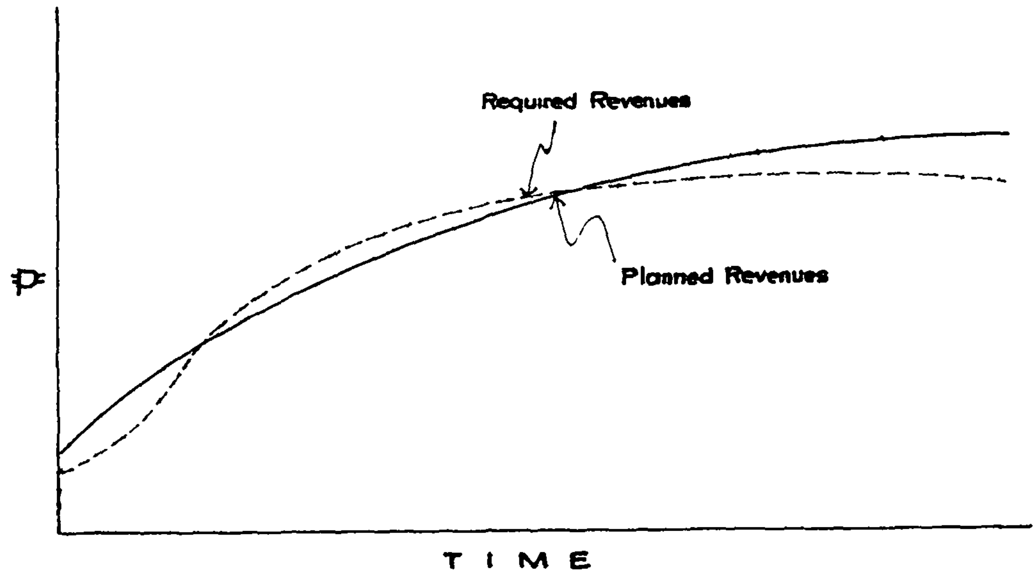
d. The estimated number of connections (or concessionaires) broken down on a yearly basis and stratified by size of connection and customer classification; and

e. The cash requirements of the District broken down on a yearly basis and stratified by general categories, namely, operation and maintenance, debt service and reserves. Since debt service after the completion of construction usually makes up about 50% to 70% of the District's cash requirements, LWUA as the lender works closely with each District in designing a debt service schedule that fits the particular needs of each District. This is also true to a lesser degree insofar as the reserve requirements, contained in the loan covenants, are concerned. For some "marginal" districts, reserve requirements have even been waived and interest due partly capitalized during the engineering design and construction stages, the primary purpose being to give the District sufficient time to tap the market as well as avoid abrupt increases in water rates. For most of the Districts however the expected financial picture is as shown on following Chart:



As indicated above, the debt service schedule embodied in the loan covenants does not follow the conventional straight line amortization method. Instead, it utilizes a series of capital recovery factors that reaches its highest value in the fourteenth year when the market contemplated in the engineering design will have been fully tapped. Beyond this point, it is expected that much of the effort will be concentrated in building up reserves for subsequent improvement or expansion of physical facilities. Of course, there is nothing sacred about the capital recovery factors. As a matter of fact, they can be adjusted to suit the particular needs of each District.

In preparing the schedule of projected rates itself, every attempt is made to avoid abrupt increases and erratic fluctuations. Consequently the peaks and troughs in cash requirements are smoothened out by providing a surplus in periods when cash requirements are low, so that such surplus can cover deficits in periods when cash requirements are high. This of course is standard financial planning for utilities and its effects on the District's cash flows are shown on the following Chart:



PROBLEMS

1. Implementation of Rate Strategy

The initial problem in rate strategy implementation comes when the projected water rates exceed the amount that consumers are "willing to pay" but is below that which they are "able to pay". This problem usually arises during the first five years of the District's life. To solve this problem, a sustained amount of convincing (or selling) effort is brought to bear on the consuming public, not only to sell the necessity for the improvements and corresponding rates but also to convince all those within the service area to connect to the water supply system. This persuasive effort utilizes all the behavioral theories known to the Water District and LWUA. For instance, we know that group pressure is a very strong element in influencing the behavior of individuals and for this reason, our selling campaign is initially focused on the more receptive elements of the community so that they as a group can bring pressure to bear on the dissenters. This is complemented by a sustained effort to ferret out illegal (or unauthorized) connections since we have discovered that the small number of registered connections in a District is usually attributable to the existence of a large number of unauthorized connections. This accomplishes a double purpose. It assures the registered concessionaires and the general public that everyone who draws water from the District's facilities is carrying his fair share of the burden and it increases the number of registered connections, thus improving the financial position of the District and enhances the possibility of a reduction in the projected water rates. Physical as well as moral persuasion is thus brought to bear on the dissenting elements of the consuming public. Where this fails to win acceptance for the projected rates and in cases where the projected rates themselves are beyond the "ability to pay" of the average household, then a re-evaluation of the engineering design for the project is undertaken. The result of this could include one or a combination of the following:

a. a scaling down of the project by deferring or deleting installation of non-productive, less urgent support facilities, e.g., Administration Building; or

b. the postponement of the laying of pipeline in sparsely populated areas where the expected marginal revenue accruing to the district will be less than marginal cost; or

c. a lowering of design standards including residual pressures at distribution pipelines during peak hours.

After the process of re-evaluation is completed, a revision of the projected water rates and financial forecast is made for the project. LWUA and the Water District then goes back to the community for a dialogue where the changes in the engineering design as well as its implications on the quality and extent of the service are explained together with the reduced water rates. If acceptance still cannot be obtained, then the Project is deferred for a future date when, hopefully, a change in attitudes will have taken place. Where acceptance is obtained however, a resolution accepting the Project and Schedule of Water Rates for the District is signed by the Mayor and a majority of the local legislative body and neighborhood and civic leaders in behalf of their respective constituents. This document describes the Project and specifies the water rates that will be in effect beginning on certain specified dates in the future. Of course the foregoing is a painstaking process but it does establish an agreement or commitment on the part of the community to support the Project. As a matter of policy, it is always a condition precedent before the start of the major investment (for construction) since it is always more difficult to negotiate on rates (or water tariffs) once construction contracts have been signed and even more so, when construction projects have already been completed. After all, the value of a service is always greater before it is rendered than after.

Once the foregoing commitment from the community is secured. an appraisal of the District's administrative capability is made by LWUA. If they get a satisfactory rating on specified development indicators, the project is bidded and subsequently goes into construction. Within the realm of institutional development however lies many of the District's problems. Some of these are discussed in this paper.

2. The District's Policy Makers

The Board of Directors is the policy making body of the District. Directors are nominated by civic groups representing different sectors in the community. The initial set of Directors are appointed from among the nominees by the chief executive officer of the locality concerned with the concurrence of the local legislative body. Subsequent appointments are made from among the nominees submitted by pertinent community sectors without the participation of the local legislature. Of the five initial directors, two are appointed for a term of two years, two for four years and one for six years. Subsequent appointments are all made for a six year term.

Since appointments are made by local politicians, some of these Directors often have a political orientation, thus defeating one of the purposes behind the water district concept --- that of insulating the utility from political influences. There have been instances where important policy decisions have been heavily influenced by political considerations. This of course affects the District's viability since some policies that are needed to enhance viability are often politically unpalatable. The most obvious example of this is of course the increase in water rates, but sometimes, it is not merely the fact of raising the rates but also the distribution or allocation of the burden. Individuals or groups with strong political leverage sometimes exert pressures on the Board through politicians to restructure the rates in a manner that eases the burdens on them or their establishments. Political pressures also intrude into the area of disconnection policy and sometimes a District's effort to enforce collection of delinquent accounts by disconnection of service is often frustrated by individual or collective efforts of Directors acting under political pressure. Perhaps the most harmful effect of political pressure is reflected in some District's personnel policies and actions. The presence of unqualified and incompetent political proteges in the District's staff sometimes causes a breakdown in morale that negates all the institutional development efforts that have been brought to bear on such District.

Another problem peculiar to policy makers is the case of the Director who interferes in purely management affairs. Sometimes he does have good intentions, but even in these cases, the effect of such interventions on the District's operations is dysfunctional since there tends to be an erosion of the General Manager's authority and he as well as lower level officials are not motivated to think for themselves. Even worse is the fact that despite his good intentions, the intruding Director usually does not have adequate knowledge of facts and operating conditions so that his suggestions (which are often taken as directives) are faulty and at best causes a loss of time spent in explaining to him why the actions of District staff should be different from or contrary to his suggestions.

LWUA's seminars for policy makers have sessions that are intended to delineate the functions of the directors, emphasize their basic role as policy makers and show the dysfunctional effects of the abovementioned actuations of some directors. Unfortunately, it is easier to impart knowledge than to change attitudes and so we have observed that some directors continue to exhibit dysfunctional behavior even after attending these seminars. Lately, a law has also been passed allowing LWUA to appoint any of its staff to sit on the board of directors of any district to which it has extended a loan. This will probably improve the situation insofar as matters discussed in the board sessions are concerned, although there is always the possibility that the LWUA man will be outvoted in important policy decisions. This also does not solve the problem of intervention in purely management or operational matters indulged in by some directors since the LWUA man will probably be in the District only for a few days at a time, to attend board sessions, provide advisory services and monitor district operations. This problem has not been completely solved therefore and hopefully we can provoke the participants of this conference into contributing suggestions for the solution of this problem.

3. The General Manager and Supervisors

In Districts where the general manager and supervisory staff are competent, many of the internal problems common to organizations can be easily solved. Where these people are not capable, then the

District is usually a disaster. In big Districts where capable specialists at lower levels are usually available, managerial competence is the critical factor that spells success or failure. In smaller Districts with limited staff the need for managerial competence becomes less pressing. The following are deficiencies of some district managers and supervisors:

a. The failure to delegate Authority

This results in the manager or supervisor being overloaded with work. This type prides himself in being "hard-working" and true enough, he runs everything and he runs everywhere. The misfortune is that while he works very hard, he gets very little work done. We have tried to solve this particular problem by training programs replete with lectures and case studies. It is interesting to note that some managers and supervisors who have consistently failed to delegate authority come out of our training programs with a full knowledge that he should delegate authority. He can discuss the concepts and their application to cases very well during classroom sessions but once he gets back to his District he reverts back to his old routines. In other cases, he even tells his lower staff to plan their operations and make the appropriate operating decisions --- but then a few days later he usurps the very authority that he has delegated, thus leaving the subordinate with nothing to decide. At the moment, we are looking into some kind of sensitivity training that hopefully will make our managers and supervisors react instinctively along desirable behavioral patterns, but this is definitely one problem where we need all the help that we can get at this conference.

b. Rigidity in Leadership Styles

In many respects, this is similar to the failure to delegate authority. The manager or supervisor concerned knows the appropriate leadership styles that are effective for specific situations. He can discuss and apply this to case problems at training sessions, but in the actual work situation he often continues his dictatorial tendencies even when dealing with professionals or higher level staff or conversely, --- he sometimes sticks to his relationship orientation even when dealing with menial rank and file workers. The result of course is ineffective leadership in getting the work done. Depending on the effectiveness of sensitivity training in the delegation problem, we will look into its applicability in correcting this particular deficiency.

c. The Tendency to be "Soft" or Tenderminded

Some managers or supervisors in certain Water Districts are simply unable to terminate the employment of people whom they know are incompetent. This is sometimes true even in cases where some employees have committed serious offenses that are punishable by dismissal from office. The remedy usually resorted to is to transfer the employee to another line of work where he may not be needed or where he is not familiar with the work to be performed. The end result is that the offender or incompetent employee is nothing but a burden on the District's financial resources. An even worse repercussion is the effect of the manager's action on the integrity and morale of the other employees of the District because once these employees feel that they can get by without working or that offenses are being tolerated, there is a tendency for such employees to indulge in wrongful or dysfunctional behavior. Quite frankly, the only solution that I can see for this deficiency is to change the manager or supervisor concerned. Unfortunately, it is only the Board of Directors that has the power to change the General Manager and in some cases, they too are soft and tenderminded. While there is a covenant in our Loan Contract that LWUA is to be consulted before the General Manager is appointed or made permanent, there is nothing in such Loan Covenants that provides remedies for deficiencies of a manager who has been issued a permanent appointment.

d. Deficiencies in External or Public Relations

Public Relations has lately been an important aspect in the operations of Water Districts in the Philippines. It has significant linkages with the success or failure of the other programs or activities of the District, specially that concerned with the raising of water rates and the prompt collection of water bills. It is an important job for the general manager and the chairman and members of the board of directors of the District because they serve as the "front men" for the organization. It is also an equally important aspect of the job of every district employee, specially those who have direct dealings with the consumers. It has been our experience that people with a background in sales or marketing are specially adept at public relations. The misfortune is that there are not many of these in the Districts. While we have many managers who can run fairly efficient internal operations, most of them turn out to be deficient when it comes to influencing their public or people over whom they have no direct authority. Let me just dwell briefly on this "influencing function" of a district manager because it has important implications even in the internal operations of the District. This refers to the responsibility of the manager to make his thinking felt within and outside his organization. It applies to how well he understands the needs of the district and succeeds in making his own thinking understood in a way that influences the thinking of people within and outside the organization.

Perhaps the more critical aspect of this function is that which refers to the responsibility of influencing the thinking of opinion leaders and decision makers external to the organization. If a manager cannot influence or convince, an otherwise efficient district often faces the specter of operating in an antagonistic environment and its chances of survival as a viable institution is considerably reduced. Some of these managers shrug off their inability to "sell" increased water rates or other district programs by referring to their publics as "non-controllable" entities over whose reactions they cannot be held accountable. We feel however that these entities are not really "non-controllable" in the absolute sense but rather that the manager concerned has not been really effective in his influencing job. It is my personal opinion that a real dedication to the mastery of the job of influencing is required of any manager who wants to progress very far. It demands observations and determination, an insight into the motivations and prejudices of the people sought to be influenced, a thorough understanding of the idea that the manager wants to "sell" and an honest belief in the validity of the idea itself. It uses communication as a basic tool. This is the ability to express oneself through different media --- precisely, concisely and to the point. But it also requires making oneself understood and understanding others, listening as well as talking, and selling to others one's ideas or a reasonable facsimile thereof. It is admittedly tough and this is why we are trying to put together a training program specifically for this aspect of the manager's job.

Perhaps another segment of the public relations job of the district manager is that which concerns the building of a favorable image for the water district. Our experience is that an image of professional competence, humility, fairness and efficiency on the part of the District's organization significantly helps to win public support for the water district and its programs. Perhaps this merely confirms the concept that "when people like you and trust you, they will believe you and support you" or in marketing that "the image of the manufacturer or the brand is half of the battle in selling the product."

A good image for the Water District is therefore a primary objective of the public relations campaign. Unfortunately it is not a thing that can be developed overnight. It is usually a long and painstaking process and a careless remark, a haughty attitude or any wrong move on the part of District employees can often undo what has been built up by weeks or months of painstaking effort. We have therefore advised the District to indoctrinate their employees on a number of things. Among these are:

1. Avoid gruff and careless remarks or jokes. Sometimes there is a very thin line between a joke and an insult.

2. Try not to project the image of an elite organization. This is specially significant because Water District salary levels are usually higher than those of local government. We know this is good motivation and is a source of pride for District employees but if they flaunt this in the community, they are bound to be resented.

3. Rehabilitate and repaint dirty and dilapidated vehicles, offices and facilities. These unsightly conditions give a bad image because people think that if these are dirty, the water supplied cannot be very different and if these are dilapidated,

the Water District as an organization cannot be very different either.

4. Remain cool when explaining things to a customer. Keep smiling and always remember to be courteous. You are running a business and in business the customer is always right.

We have derived a lot of satisfaction in seeing a number of our Water Districts develop as a viable institutions. A few of them have already accumulated sizeable reserves. We hope we can maintain this momentum as we move into the smaller communities in the years to come.

Paper 5c

Human Resource Development: The LWUA (Philippines) Experience

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INTRODUCTION

To fully appreciate the effects of training in the Philippines, as it applies to the supply of potable water, one must examine and understand the situation as it did exist. The situation hereafter described was typical for the provincial cities through the very early 1970's.

Actual construction of most of the existing transmission and distribution systems was completed in the late 1930's. Consequently, these physical systems were designed and constructed to serve significantly smaller populations and areas than those existing in the early 1970's. Additions and extensions to the systems called for by the growing demands for the service had been made with little or no consideration for the niceties of judicious planning. System maintenance had been inadequate at best, and non-existant at worst.

As a result, only about 20% of the population within the service area actually received service from the system. Those fortunate enough to receive service generally had to contend with very poor pressure and intermittent service. Seldom was the water available round-the-clock, and often was available for as few as one or two hours per day.

The systems were under the local or provincial governments and suffered from the evils of political whims and caprices. The water departments were a part of the spoils system and each change of political party in the elections signaled a change in personnel staffing. Many managers owed their position to their political affiliations rather than to their technical and managerial skills. The systems were overstaffed with underqualified and untrained personnel.

Revenues were inadequate to cover operations and maintenance. It was politically expedient to charge very low water tariffs and to cover the deficits from general funds. It is no wonder funds were not available for expansion and modernization since most systems could not even generate adequate funds to meet operating expenses.

There are, of course, exceptions where cities had a water system operated and managed by qualified professionals, providing adequate supply of potable water, and generating sufficient revenues. The sad fact is such water systems were in the very small minority. The majority of the systems under local government control provided inadequate services to a small percentage of the population while operating at a loss.

This situation was to change drastically when in 1973 Presidential Decree 198 was enacted. This was the enabling legislation for the formation of the Local Water Utilities Administration and the adoption of the Water District concept. This legislation signaled the dawning of a new era of water supply management in the Philippine provincial cities.

Presidential Decree 198 called for the formation of a national agency charged with the responsibility to control and co-ordinate the program of improvements in the water supplies for the provincial cities. The operating units, to be known as water districts, would be responsible for the actual operation and maintenance of the individual systems. and would operate on a financially self-supporting basis.

The Local Water Utilities Administration, or in short LWUA, was formed primarily as a lending institution with the added functions of providing technical, operating and skills training assistance. At the same time LWUA would perform monitoring of district compliance with established standards.

Loans were secured from international lending institutions. These loans were guaranteed by the national government and are relent to the various water districts through LWUA.

Loans are made at concessionary terms specifically for the improvement of the water supply systems based on comprehensive feasibility studies. These loans are not applicable to operating costs but rather are strictly for capital improvements. The basic tenets of each loan are that the district should be self sufficient, by economically viable, and repay the loan in full with interest.

Water Districts were and are being formed under the guidelines promulgated by Presidential Decree 198. Each local district is a semi-autonomous entity operating under the guidelines and policies of LWUA and its local Board of Directors.

The Board of Directors is composed of 5 local citizens nominated by various sectors of the community on the basis of experience, abilities, character, interest, and standing in the community. The Directors are responsible for setting the policies and insuring that management implement these policies. The Board is also the body which received the assets, records, and the physical system as turned over by the local or provincial government. As one of the conditions for turnover of the system most districts accepted the employees of the previously government administered water systems.

As indicated, most physical systems were in a poor operating condition having received little or no maintenance. Most systems were overstaffed with poorly trained or underqualified personnel. Service was limited in both quality and quantity. Revenues were inadequate and further appropriations from the government were stopped once the Water District was formed. This was the situation prior to and at the time of the formation of LWUA and the Water Districts.

IDENTIFICATION OF GOALS, OBSTACLES AND APPROACHES

The visionaries who were the leaders and initial staff members of LWUA agreed that the concepts of improving the water supply in the provincial cities and operating them on a self reliant basis were both worthwhile and achievable. Similar programs have been attempted and have met with varying levels of success in other areas.

In order to avoid the mistakes of the past and insure a high degree of success, these pioneering leaders analyzed the situation they faced. Such analysis identified the goals, the major obstacles, and the means available to overcome these obstacles.

Obstacles were numerous and were both tangible and intangible. Physical source and distribution systems were inadequate and in poor condition. Funds for both operation and capital improvements were woefully inadequate. Water system personnel were poorly trained and motivated. The members of the Board of Directors and managers of newly organized Water Districts did not fully understand and appreciate their duties and responsiblities. Technical and operating expertise were lacking. Finally, LWUA and District personnel and the general public had to be educated and oriented to appreciate, accept and implement these new concepts.

These various obstacles could be grouped into four major categories, namely; limited funds, lack of technical expertise, institutional inadequacy, and lack of trained personnel.

Recognizing that there is no such thing as instant success and instant expertise, LWUA formulated a deliberate program. The program was designed to solve all of these problems but always on a scale commensurate with the resources available. The approach was to maximize impact through related and interdependent improvements. No single obstacle was to be overcome while others were left untouched. Rather, all obstacles were to be approached and tackled simultaneously.

LWUA defined institutional development as a high priority effort. Prior programs have ultimately failed due to the absence of a vital and viable institution to continually administer to the program. LWUA elected to seek assistance and hired James M. Montgomery, Consulting Engineers, Inc. to act as institutional advisors.

This was not to be a normal consultance arrangement. James M. Montgomery did provide specific technical expertise and did undertake specific tasks. Additionally, they became the conduit for the transfer of technology and a major resource for the development of human resources.

In every category, the main tool used to overcome the obstacle was the development of human resources. This was the most significant decision and to this day the development of human resources remains of paramount importance.

LWUA made two early decisions, which in retrospect, have proven to be significant. First, LWUA determined that their long range interest would best be served by attracting intelligent and motivated employees. Age and experience were given no more importance than desires and abilities.

Second, LWUA committed itself to the extensive training of its employees and to the refinement of the new concepts it seeks to implement and propagate. A specific training division was established, staffed, and charged with formulating relevant training programs. Furthermore, all personnel in LWUA regardless of assignment, were considered as resource persons. This feeling has persisted and today LWUA remains committed to utilizing all personnel as sources in training and developing human resources.

So many of the steps and approaches taken were concurrent that it is almost impossible to identify them chronologically. It appears more proper for the purposes of this paper to enumerate those development activities and then briefly discuss their effects in overcoming the obstacles.

TRAINING PROGRAMS AND APPROACHES

The training approaches have included formal and informal programs, seminar sessions centralized in Manila and given in district offices throughout the Philippines, speakers with large groups and one-on-one training. Some programs are given on a regularly scheduled basis and others only as the needs warrant.

Grants and loans have been provided for LWUA employees to avail of courses at major learning centers. These are post-graduate courses. Some courses have led to advanced degrees while others have been merely to expand areas of expertise. Most of these advanced study courses have taken place in the Philippines but some have been for foreign study.

These men and women, so trained, are now occupying responsible positions. They are utilizing their acquired knowledged to further improve the abilities of LWUA to perform its multiple tasks. The experiences and knowledge gained is being passed on to their subordinates and co-workers, thus benefitting many from one individual learning experience. Further, through actual job experience these individuals are growing increasingly prepared to assume the expanded roles of leadership and greater responsibilities which they will undoubtedly be given.

Each time a loan is negotiated for major improvements, a portion of the proceeds are designated for training. These funds have been used to provide practical training for personnel from LWUA and the various Water Districts. Much of this training has been abroad in the larger and more advanced systems.

Trainees have gone out to the most advanced and sophisticated systems in Asia, Europe and the United States. The emphasis has always been on practical applications whether concerned with design, operation or maintenance. The entire spectrum of water utility functions has been considered in formulating such training travel itineraries.

Chairmen of Water District Boards of Directors have been sent to learn how similar Boards of the more advanced systems function. Engineers have gone out to learn differing design approaches and operational procedures. Commercial chiefs have studies the various commercial practices. Operations personnel have learned the various operational techniques and have even attended short courses at waterworks operator schools. Every aspect has been studied with the objective of learning and understanding the best of each system. These are then brought back, adapted and used in developing better systems in the Philippines.

Still within the formal aspect of training, an impressive array of seminars has been developed. These seminars are all designed for the development of the human resources. Appendix A is attached showing the listing of these seminars, attendee numbers, and man-hours of training involved. In summary, during the period from September 1973 through December 1978, a total of 82 programs have been conducted involving some 2,351 participants and almost 142,000 man-hours of formal training.

The early programs were formulated in response to the basic training needs. With the introduction of new concepts and organizations the early emphasis was on the policy makers and the managers. Training was deemed mandatory for the leaders before the training of subordinates could be undertaken.

As progress became a reality, the tone of the seminars changed. More emphasis was placed on training of specific categories of personnel. As the training and experience levels rose so did the complexity of the training until now when we are able to train in such sophisticated areas as water rates structuring, groundwater, public relations programs, financial management, and project development.

THE LWUA TRAINING CENTER

The culmination of LWUA's initial training efforts will come in 1979 with the completion of its training center. A very real problem to date has been the lack, or the inadequacy of facilities for conducting effective practical training. This has been particularly true in the areas where "hands-on" experience is so vital.

Appendix B shows a schematic layout of the training center, now under construction and scheduled to be completed by mid-1979. While every aspect has been considered, the planning and deliberations which went into the design of the training center are not all apparent in the layout.

The training center will have a functioning production well, chlorination system and elevated storage tank on-site for a self contained water system. Both pump and well tests can be run under conditions which will be encountered in the field. The effects of changing pump settings will be realistically and quickly shown. Operating situations and maintenance can be readily simulated and experienced.

In the piping area the trainees will have an opportunity to actually tap various types of pipes. Different types of valveswill be available for operating and maintenance experience under field conditions.

Also not shown on the schematic diagram is the small scale working model of a complete water system. This will be used to demonstrate visually the hydraulics involved in a major system incorporating pumping, storage, transmission, and distribution. This model is designed to reproduce a normal 24 hour cycle in just one hour. Thus daily variations can be shown during an hour while an entire weekly cycle can be shown in a single working day.

In anticipation of the completion of this training center, LWUA has begun a training course for the prospective trainors who will staff it. Although it is planned that resource persons from the academic, manufacturing, and industry will be assisting, the major portion of the trainors will come from the LWUA staff.

These trainors have experience both in the field and in training. They are reviewing and preparing training material and references on some 30 different phases of utility operations and maintenance. An integral part of the trainors' training is the preparation of course work and lesson plans.

LWUA has designed an operators' certification program consisting of four grades. The training center and the courses to be given will be a factor in the certification of operators level of competence. Combined with actual field operational experience, an increasing number of courses must be successfully completed by operators to attain higher grades of certification.

Considering that existing training needs are being met, and continually aware of the growing complexity of problems caused by advanced development and rising human expectations, LWUA is now looking to the future. As water systems are improved, the quality of life improved, and a greater percentage of the population made aware of the benefits of sound sanitary practices, there will come increasing pressures to address the wastewater problem.

Since LWUA is charged with the development of water and wastewater systems for the provincial cities, it must be prepared. A sewerage division has been formed and staffed. This division is now embarked on a combined training and fact finding program.

The program includes a total of four months study on the nature, collection, treatment and disposal of wastewater. Three major cities have been selected for pilot study under this program. The sewerage group will perform pre-feasibility studies on these cities. The main objectives are to a) identify the problem b) enumerate the alternative approaches and c) define the economic, culture, technical and sociological aspects of the various alternates.

In this manner, LWUA has already planned for and has begun the training for its future involvement in the wastewater field.

THE SANITARY ENGINEERING AND PLANT INSPECTORS TRAINING

Several of the programs have been specifically designed to respond to unusual training needs of LWUA. Two examples are the sanitary engineering and the plan inspector courses.

The situation that LWUA is experiencing is one of having a large number of young engineers employed and many more applying for employment. Their disciplines cover the engineering spectrum with the exception of practical sanitary engineering. Few possessing this background are to be found. The decision was made that it would be more profitable and realistic for LWUA to train their own personnel than enter into the extremely competitive market for the few available, which would still not satisfy LWUA's needs.

A sixteen week course was designed for graduate engineers. The entire range of sanitary engineering was included with emphasis on the practical applications. Such an accelerated course was possible since the participants were relatively new graduate engineers with some work experience and therefore did not require extensive schooling in engineering fundamentals.

Each department within LWUA was invited to nominate engineers who had displayed above average interest, ability, and work performance. Other governmental agencies were likewise invited to send selected representatives for this training. The best of the nominees were chosen and completed the course.

The coursework was given during the employees' regularly scheduled workhours. An integral part of the course was the assignment of homework and the testing. Unannounced quizzes were given along with regular tests and a major mid-term and final exams. Grades were assigned and academic standings were published.

It is worthy of note that the graduation ceremonies reflected the interest and important of this training. The ceremonies included a luncheon hosted by the General Manager and the Department Managers. Included in the program were the presentation of certificates of successful completion, a validictory address, and the award of reference books to the top three students. Such are the motivating techniques which help to keep the interest high towards training.

Two classes were successfully "graduated" from the sanitary engineering course. The results have already proven the value of such training. Many good employees were converted into even more valuable employees, LWUA now has the experience and lesson plans to repeat the courses as required. Finally, the real benefits were realized not by additional hiring but by developing the existing human resources.

The same pattern was duplicated in the plant inspectors course The water districts were purchasing large quantities of goods produced in the Philippines, principally in the Manila area. In order to assure the quality of these products, LWUA organized a quality control section to inspect plants and products.

Again, rather than attempt to hire the woefully small number of qualified personnel available, the decision was to upgrade, via training, existing LWUA personnel. It was an opportunity for employees to improve their position and adhered to the LWUA principles of training and advancement from within the organization.

The training was a combination of classroom sessions and on-the-job assignments. Field trips were made to plant sites and the prospective inspectors were shown by experienced instructors what to look for and how to make the actual physical inspections.

The approaches of this course differed slightly, but the interest and efforts were no less intense. The graduate inspectors also received a luncheon and certificates of completion.

In both of these courses LWUA utilized the services and expertise of foreign consultants. However, such services were for the expressed purpose of transferring technology and experience and for the further development of human resources. The use of foreign experts not only met the immediate need but concurrently developed the local resources to meet such needs in the future without assistance.

DISTRICT TRAINING AND INSTITUTIONAL DEVELOPMENT

An area that has required tremendous amounts of training has been the institutional development of water districts. This need was not fully recognized at the creation of LWUA, but rather was early defined by the LWUA as critical to the viability of the water district concept in the Philippines.

Initial efforts have evolved into what is considered today as an excellent training experience. This experience is benefitting LWUA personnel, district personnel, and the districts institutionally.

Orders of priority needs of the districts were identified as finances, people, systems, and operations. This is not to imply that improper operations would be ignored until last, but was merely a recognition that without adequate funds true progress was impossible. With adequate funds competent personnel could be acquired and trained. With funds and personnel, proper systems can be devised and maintained. Good operations will then become the acceptable norm rather than the rarity.

A series of guidelines are available for the use and information of the districts. Preparation and updating of these guidelines is a continuing effort. The topics range from proposed rules and regulations governing the operation of a typical water district, to preparation of water rates and accompanying cash flow projections, to a safety program, to water quality, criteria, and testing, to name but a few. These guidelines are not mandatory but are for information and adaptation to local conditions by each district.

Not included in the guidelines are such items as technical standards, commercial practices, construction inspection and management practices, or general operations and maintenance. These major items are all being treated in individual manuals.

LWUA has devised a standard accounting and commercial practices methodology. This was formalized in print in the Commercial Practices Manual. Adoption of this system is mandatory for all districts and has resulted in uniform accounting and financial procedures throughout the Philippines.

Commercial Practices System Teams have been formed and trained. Their primary function is to assist the districts in installing the systems and in training district personnel. It is not enough to have devised appropriate systems, there must be trained personnel to understand and apply such systems.

The technical standards were promulgated and published several years ago and are presently being reviewed and revised as needed, by the LWUA technical standards committee. The operations and maintenance manual is at the printers and is expected to be available soon. The construction inspection and management manual is undergoing final review before printing. The management manual is completed in draft form.

In viewing the operations of the water districts the LWUA determined that the districts would require much more assistance than originally contemplated. A position of district advisor was created to provide for this added service.

The advisors were charged with assisting the districts to attain satisfactory institutional development, financial viability, and sound operational practices for providing continuous potable water service.

Initially service was provided to five districts. This was soon increased to thirty districts as formation of districts accelerated and the results of advisory service were borne out. The concept was to again avail of foreign expertise and as always, to utilize such help in training the LWUA and District personnel.

Advisory Teams were formed consisting of one foreign and one LWUA counterpart. These advisory teams were assigned six to ten districts which they were to visit on a monthly basis. The teams travel and live together in the field. Such associations provide the opportunity to learn and appreciate the differing cultures within the team. More importantly it provides the opportunity to discuss in detail and in privacy the day's activities and actions, thus facilitating a great deal of one-on-one training during off hours.

The foreign advisors were all selected on the basis of utility management experience ranging from fifteen to thirty five years. All had been utility managers themselves. The LWUA advisors are all degree holders in various disciplines, had experience related to utilities or management and were selected on the basis of adaptability and maturity.

Visits are made on a monthly basis, normally only 2 or 3 days in duration. Longer or more frequent visits tended to involve the advisors in the district's routine daily activities. This is to be avoided since it not only generated less progress but also is directly counter to developing self sufficiency in the districts.

A listing of twenty eight development indicators was produced. This served as the guide for advisory services and also functioned as a rating checklist. Usage of these indicators serves as a means of quantifying the development of districts. Five levels of accomplishment were devised ranging from no action through full implementation with a full description of attainments required for each level. Each level was assigned a point value ranging from 0 to 6. At the end of the monthly rating, the points attained for each development level are added. This pure number has a maximum value of 168 (28 x 6).

The development indicator point total can be used as a pure number. Compared with previous numbers it will indicate additional development attained or identify a problem of regression. It is also a relative indicator of development levels in comparing districts. Comparisons can not be precise when based upon a pure number but obviously a district which has attained 150 development points is advanced when compared to a district which has attained only 50 development points.

When divided by the age of the district the development points become a rate of development. Initially rates of development are expected to be very high and six points per month is an average to low rate. As districts mature and develop it becomes increasingly difficult to maintain the rate and the rate gradually drops. A district which is able to consistently maintain a development rate between four and five is considered as developing satisfactorily.

The original twenty eight development indicators proved to be an effective tool in training and institutional development. Their use provided the means of quantifying development and quickly identify needs, progress, or regression. The results were so gratifying that a second group of twenty eight indicators was prepared. These Phase II indicators deal heavily with advanced operations, maintenance, and planning. The districts which accomplish the Phase II development will be able to stand proudly side by side with the most advanced utilities in the world.

The advisors are careful to course all recommendations and directives through the manager and his division chiefs. In no way is the authority or ability of the manager and his staff impugned.

All recommendations are in written form. They are discussed thoroughly with the manager and if he concurs he is asked to sign the recommendation indicating his agreement. Further he is requested to commit a date, which in his own opinion, is reasonable for accomplishing the recommendation. This is a subtle form of training in establishing priorities, following-up on assigned tasks, and in meeting one commitments.

There is a very real and strong correlation between the managers who consistantly meet their commitments and the districts which, by any reference scale, are considered to be the better districts. Better management will eventually produce better operations and better service.

The advisors are also careful to assist in the training of district personnel. They have the responsibility to define training needs and to recommend appropriate means of satisfying these needs. The advisors are likewise trainors themselves. Part of their function is to help in training district personnel to perform better. The advisors will not spend an hour running a pump test for a district but they will invest as much time as is required to train district personnel in running and interpreting pump tests.

The advisors' objectives are not so much to accomplish personnally as to help others learn to do for themselves.

The bulk of the training for the advisors has come from the one-on-one situation of working and traveling together. The finishing touches are applied in seminar course covering management concepts, basic utility accounting, communication skills, and even technical areas for non-engineers.

These types of training seminars are not included in the appendix of training seminars. They are but examples of numerous special training seminars given within departments for limited participants. They are given almost exclusively with the training resources available within each department.

To indicate the effectiveness of the advisory training, we have but to look at the results to date. This program was begun in the fall of 1976, just two and one quarter years ago. Initially there were four LWUA trainees and twenty five districts receiving advisory services.

As of 31 December 1978, LWUA has 8 independent advisors trained and capable of functioning without counterparts. There are 4 full counterparts and 3 trainees. Advisory service is now provided to some 70 districts and projections are the number will exceed 100 in 1979.

SUMMARY AND CONCLUSIONS

The situation appeared grim indeed at the birth of LWUA in late 1973. A new agency was being created and charged with responsibility for the improvement of water supply systems in the provincial cities of the Philippines.

Existing water supply systems had been installed during the 1930's. They had been subjected to the worst possible political evils and official neglect. Revenues were inadequate. Staffing was done under the spoils system. Most personnel were underqualified and almost all were inadequately trained. Through neglect, politics and lack of funds the systems were permitted to deteriorate. A small percentage of the population was receiving some hours of water service of dubious quality. There were the exceptions, but this describes the average system that LWUA had to work with.

The major obstacles were defined as insufficiency of funds, institutional inadequacy, lack of technical and operational expertise, and lack of trained personnel.

Originally funds were obtained from the national government and grants and loans from USAID. As the program grew, funds were also provided via loans from Danida, Asian Development Bank, and World Bank.

These loan commitments were used to provide long term loans at concessionary rates to the water districts. The funds were restricted to capital improvements to maximize the impact on expanding and improving the water service.

Increased operating funds were generated as a result of institutional development occuring in the staffing, financial, and commercial practices area.

Initially, the required expertise was acquired locally if possible. For needs that could not be immediately satisfied locally, the decision was to hire foreign expertise and simultaneously begin the training to develop in-house expertise.

The agreements with foreign consultants were specific in requiring training and technology transfers to be an integral portion of the services required. This procedure has been faithfully followed each time consultancy services have been required. The counterpart relationships have fostered improved understanding, have produced more lasting results, and have led to generally harmonious relations.

Institutional development has been attained, and continues to be a growing living endeavor. Institutional development is a continuing process since any living entity must plan, adapt and react in order to survive and prosper.

The development in LWUA has been self induoed. The institutional development within the districts has been induced through the innovation of advisory services and other training programs.

Training and developing the human resources have by far required the most effort and attention. Every aspect has thus far been addressed in a variety of ways. The approaches have been formal and informal, classroom situations and seminar type discussions, group and one-on-one experiences, and theoretical and practical. Each approach and experience has contributed in its own manner to the training efforts and results.

A training division has been formed and staffed within LWUA, The division formulates, coordinates and conducts training programs and seminars. Some twenty-three different programs are now being conducted by this division. To date 82 sessions of these programs have been completed benefitting directly the more than 2,300 attendees.

Numerous specialty training seminars have been given by the various departments in addition to the programs of the training division. Totals of such seminars and numbers of attendees are not compiled.

The fact that such seminars are frequently given underscores the LWUA commitment to training and development of human resources. It is also reflective of the concept that all the resources of LWUA are available and share in the training efforts.

The results to date show quite clearly that the investments in developing human resources are returning dividends.

In slightly more than five short years the following dividends have accrued:

LWUA has grown from an infant agency of 5 employees into a vital and viable force of over 400.

The number of Districts has grown from the original 5 to 83 with the formation of an additional 28 districts projected for 1979.

Total loans in excess of 857 million pesos have been committed for improvement and expansion of services in the districts. The collection efficiency on the loan principal as of 31 December 1978 is an excellent 74% (this is the more impressive since originally these same districts could not even meet operating expenses).

LWUA is now providing assistance to the districts on financial, management, public information, operation, legal, design, and construction matters. Help is available and provided on virtually every aspect of water utility operations.

Engineers from LWUA are now designing, preparing specifications, and functioning as resident engineers on the Interim Demonstration Program of improvements for 60 Districts. They have also developed the capability to conduct feasibility studies on their own.

Thirty four guidelines and five manuals have been prepared and are available, or will be shortly, for use by the Districts in training and operation.

Service quality has improved and operating costs reduced throughout the districts, as a result of improvements in the operation and maintenance efforts.

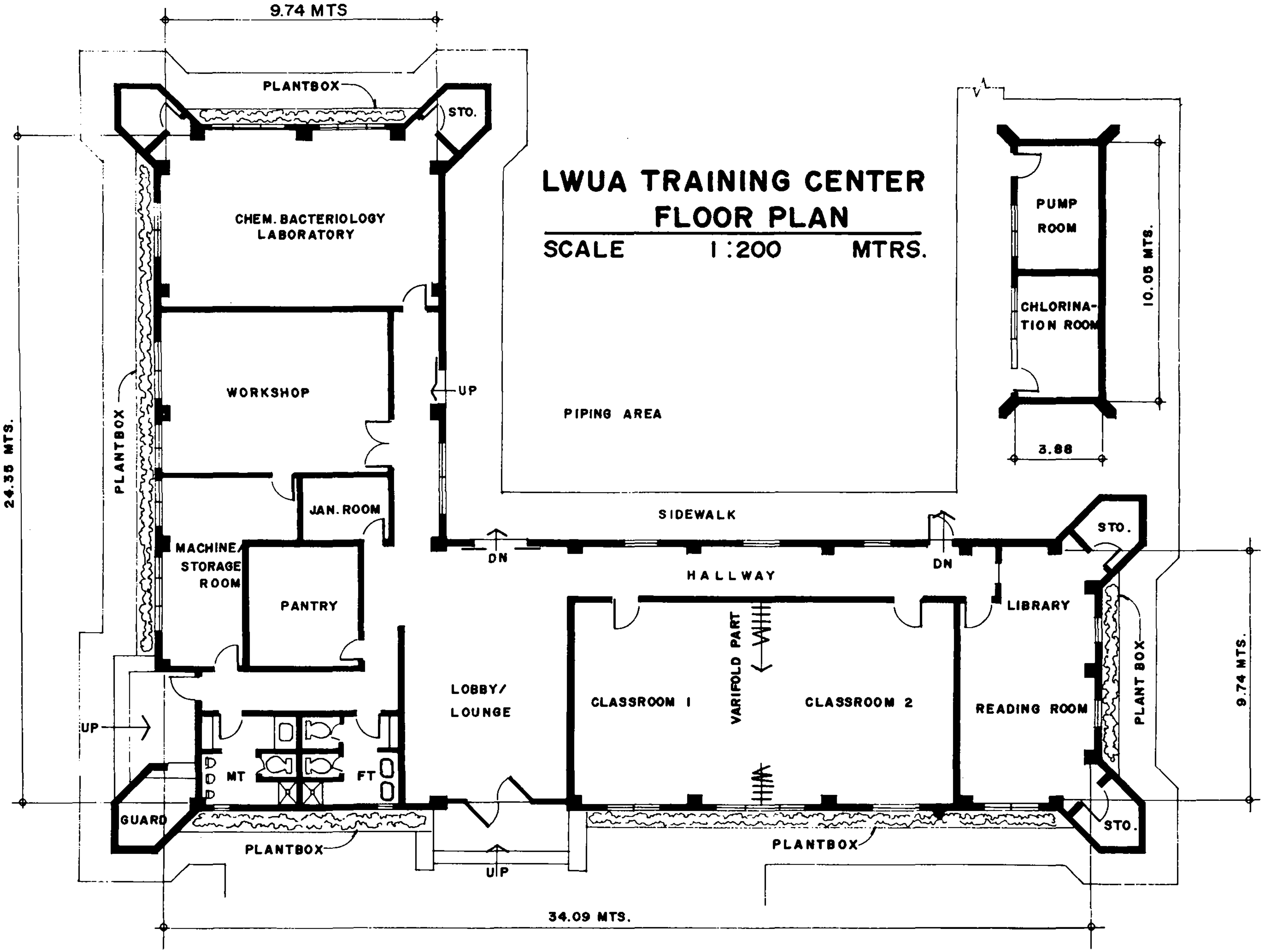
Construction has begun on what will be the finest and most modern training facility in the Philippines. Practical hands-on training will be available for the benefit of all.

The investment in developing human resources has been heavy. In reviewing the dividends this investment has produced to date, it is obvious the return has been of value to the districts, the LWUA, and in fact the Philippines.

Annex A

TRAINING PROGRAMS CONDUCTED
AS OF 31 DECEMBER 1978

	Freq.	No. of Parti-cipants	No. of Man-Hours
Water District Personnel			
Policy-Makers	11	220	5,106
Management	6	134	6,656
Public Relations	1	40	960
Financial Management	2	52	2,184
Operations and Maintenance	3	90	5,050
On-the-Job Training	4	41	1,144
Orientation of Local Officials	2	58	621
Water Quality	1	14	448
Trainors Training	1	19	1,520
Construction Inspection	2	34	1,712
Well Drilling	1	19	532
Personnel Testing	1	25	450
Water Meter Repair	1	16	968
Water Rates Structuring	8	94	218
Technical Training Course	4	51	1,489
Groundwater Seminar	1	13	416
Project Development	2	74	4,448
Sub-Totals	51	994	40,182
In-House Training			
Cadetship	10	176	59,072
Sanitary Engineering	2	42	13,916
Staff Development	1	6	192
Plant Inspectors	1	10	5,760
Sub-Totals	14	234	78,940
Special Programs			
Pre-Construction	11	605	12,135
LWUA-WD Forum	6	518	10,715
Sub-Totals	17	1,123	22,850
GRAND TOTALS ---------------	82	2,351	141,972


LWUA TRAINING CENTER
FLOOR PLAN
SCALE 1:200 MTRS.
9.74 MTS
PLANTBOX
STO.
CHEM. BACTERIOLOGY LABORATORY
WORKSHOP
UP
JAN. ROOM
MACHINE/ STORAGE ROOM
PANTRY
LOBBY/ LOUNGE
MT
FT
GUARD
PLANTBOX
UP
24.35 MTS.
PLANTBOX
PIPING AREA
PUMP ROOM
CHLORINATION ROOM
10.05 MTS.
3.88
SIDEWALK
DN
HALLWAY
DN
STO.
LIBRARY
VARIFOLD PART
CLASSROOM 1
CLASSROOM 2
READING ROOM
PLANT BOX
9.74 MTS.
STO.
PLANTBOX
34.09 MTS.

Annex B

5c15

Annex C

DISTRICT DEVELOPMENT PROGRESS INDICATORS

Phase I Indicators

Utility Rules and Regulations
Billing and Collecting System
Ageing of Accounts
Collection Enforcement
Personnel Rules and Regulations
Organization Chart
Job Descriptions
Commercial Chief
Finance Officer
Administrative Chief
Production Chief
Construction and Maintenance Chief
General Accounting Systems
Chart of Accounts
Budget
Public Information
100% Metering
Bacteriological Testing
Chlorine Residual
Production Data
Machinery Tested
Customer Service System
10 Year Cash Flow Projection
Rate Strategy
Comprehensive Rate
Less Than 10% in Arrears
Bills Paid on Time Over 85%
Reports Submitted

Phase II Indicators

Illegal Connections
Unaccounted for Water
Economics
Materials Stock
Tools and Equipment
Meter Maintenance
Production Machinery
Equipment Maintenance
Valve and Hydrant Exercise
Mapping System
System Operation
System Maintenance
System Correction
System Pressure
Master Plan
24 Hour Pressure
Drinking Water Standards
Subdivision Policy
Safety Program
Training
System Growth
Dead Ends
Crew Efficiency
Standard Procedures
Records and Data
Continuing Property Records
Employee Incentive Plan
Balanced Staffing

Paper 5d

Training in the Water Supplies Department of Hong Kong

by WONG Kwok-lai
Government Water Engineer/Supply and Distribution,
Water Supplies Department, Hong Kong

Introduction

The Water Supplies Department in Hong Kong has a total staff establishment of about 4,000 of which about 180 are professional, 300 technical, 350 deal with accounts and clerical matters, the remainder being operational and works staff. There are more than 800,000 consumers and all of them are supplied through individual meters. Apart from a few large schemes, all new works are designed and supervised by the staff of the department, construction being carried out by contractors. The day-to-day operation is all carried out by the department's own staff which constitutes more than 60% of the total staff strength.

2. All the operational and works staff are educated and trained locally and few of them have previous experience in waterworks prior to joining the department. The staff comprises various disciplines and trades, namely, works supervisors, electrical and mechanical operators and fitters, filter station and laboratory staff, house service inspectors, meter readers, mainlayers and plumbers, miscellaneous artisans, waste detection gangs, turncocks and unskilled labourers. It is therefore apparent that a wide range of departmental training is required for this vast establishment of staff, but at the same time there are various problems which need to be overcome before such training can be adequately and effectively carried out.

Training provided for Staff

3. Because of the rapid expansion and growth of development in Hong Kong, much of the department's effort in the past years has been concentrated towards developing new water resources, constructing new works and providing water supplies in response to the rate of development. It has not been possible, therefore, to expand the training facilities to the level required to bring them in line with our needs. This is understandable, because a utility company often requires to respond preferentially to the more immediate needs and tends to defer the more long-term or less pressing issues. Unfortunately, training has fallen into the latter category and under these circumstances it has not been given adequate attention in the way of expansion to keep pace with other developments.

4. Currently, the department has a small Training Unit headed by a Training Officer at the inspectorate grade who is assisted by one assistant inspector. The Training Officer is responsible to a senior engineer, but the latter is only engaged part-time on training matters. The Training Unit is responsible for organising and co-ordinating activities, and the lectures and demonstrations are given by staff in the department who do not belong to the Training Unit. When necessary guest speakers are

invited from outside the department on matters such as Industrial Safety, Fire Prevention and the various functions of other Government departments.

5. Basically, the courses have been designed by engineers many years ago although the subject details are regularly reviewed so that they can be improved and updated in the light of the experience gained from the training sessions. Because of the vast expansion in the department, the existing courses are now seen to be inadequate and additional courses are considered to be necessary. In view of this, we are contemplating an increase in strength of the Training Unit and it is likely that a professional officer at a senior grade will be brought in shortly with a view to planning and organising facilities to a greater scale. This will enable our present training requirements to be examined more thoroughly and ensure that training is properly conducted.

6. The form of training currently provided in the department can be broadly classified in two categories, namely basic and in-service training. The basic training courses are mainly designed for new recruits who only have the requisite educational or academic qualifications but do not possess adequate previous working experience. These courses are required for grades such as house service inspectors, meter readers, and works supervisors who generally need a period of training before they are posted to their work. The in-service training is mainly refresher courses which are designed for the benefit of serving officers to give them an opportunity to review the knowledge and requirements essential to their jobs as well as to bring them up-to-date with new techniques or skills.

7. The details of courses currently conducted in the department are described below in order to give a cross-section of the level of training being provided :

(i) <u>Basic Course for House Service Inspectors</u>

This course is designed to train new recruits to work as House Service Inspectors. The basic qualifications for entry to the grade are the possession of a polytechnic diploma or equivalent and a school leaving certificate with passes in appropriate subjects.

The duration of the course is 5 weeks and the contents are :-

Waterworks administration, waterworks ordinance, water billing and computerisation, outline of the organisation of the department, equipment and materials of waterworks, building plans and plumbing diagrams, principles and methods of pipe sizing in buildings, water treatment and filtration plants, water quality control, water meter and metering, contamination and pollution of inside service, jointing of pipes, valves and fittings, waste detection and prevention of wastes.

(ii) Basic Course for Works Supervisors

This course is designed to train new recruits for site supervision of construction and pipelaying works. The basic qualifications for entry to the grade are the possession of a polytechnic diploma or equivalent and a school leaving certificate with passes in appropriate subjects.

The duration of the course is 2 weeks and the contents are :-

Outline of the organisation of the department, pipelaying techniques, trenching and backfilling, contract specifications and bills of quantities, estimates and measurement, surveying, concrete and supervision of concreting, method of construction of service reservoirs and other general waterworks installations, industrial safety.

(iii) Basic course for Meter Readers

The course is designed to train new recruits to carry out the duties of meter readers. The entry qualification is a school leaving certificate with passes in appropriate subject.

The duration of the course is 1 week and the contents are :-

Outline of the organisation of the department, mechanisms for different types of water meters, maintenance of water meters, separate metering and reading of meters, water charges, general principles of plumbing.

(iv) Refresher Courses

These courses are conducted for the benefit of serving officers. The main purpose is to provide opoortunities to them to review what they have learned in earlier training after a period of working experience and to keep pace with any new knowledge and skills to improve their technical ability. Serving officers are released on rotation where possible to attend these courses. Currently there are six such courses organised for the different aspects of waterworks. These are all short courses the duration of which is normally 1 week.

8. The Public Works Department runs an apprenticeship training scheme for the electrical and mechanical disciplines. This scheme has been in existence for many years for both technical and craft apprentices. The scheme provides opportunities for school graduates after completing Form V or even lower forms to receive training leading to subsequent employment as electrical or mechanical technicians, artisans or supervisors. Those who join at this level first receive an initial basic training of 6 months at the Government Apprentices Practice Workshops and thereafter those recruited for Waterworks are posted to the department where they undergo a further training of 3½ to 4 years. During this period, apart from the practical training obtained in the course of their work, they are also given part-time day release to attend courses at the polytechnic. Those who successfully pass the examinations at the end of the training period are accepted as works supervisors or technicians in the case of technical apprentices training and artisans in the case of craft apprentices training. Very good quality staff are often found amongst these groups of trainees and a number of them have advanced into the inspectorate grades after some years of service in the department.

9. All the foregoing courses are geared to the requirements of the operational and works staff at the level below the inspectorate grade. No special courses are conducted for the technical staff at the higher grades who are expected to have gained adequate working experience and on-the-job training by virtue of their relatively long period of service in the department. Those who join the department at these higher technical grades from outside are required to have prior waterworks or suitable experience acquired in other utility companies or engineering firms.

10. Besides training of the above nature which is designed to prepare staff for certain posts, opportunity is provided to train staff for operational purposes at some specific plants. For large stations, the operational staff are selected early enough for a proportion of them to be engaged in the supervision of the installation thus enabling them to become familiarised with the various facets of the plant so that they can train other operational staff when the plant is commissioned. In addition to this, in the case of plant for major installations, electrical and mechanical staff have been sent to the manufacturers to observe the manufacture and assembly of the pumps and motors and to learn the necessary techniques and skills for operation and maintenance.

11. At the professional level, there is a scheme within the Public Works Department for training engineering graduates in which the Water Supplies Department participates. Each year, a large number of graduates from the engineering department of the Hong Kong University are accepted as engineering apprentices with a view to subsequent employment

as Assistant Engineers and to prepare them for the membership examination of the various engineering Institutions. These graduates are given a period of 3 years of training during which they work in a different department each year so that at the end of the period they will have had experience in works of different natures. During the period of training, the graudates are closely supervised and guided by full professional engineers and are given every opportunity to undertake both design and site supervision to enable them to obtain experience which is as broad as possible. Those who perform satisfactorily are retained in the department at the end of the period and engaged as assistant engineers and after obtaining further experience in this grade they normally qualify for corporate membership of their institutions and advance to full professional engineer.

12. Professional staff at the management level are given opportunities to attend administrative courses conducted by the Government Training Division. The contents of these courses mainly concern aspects such as administration in Government departments, management objectives and managerial skills. Staff at this level are selected to receive such training to equip them for advancement to senior managerial posts. The department also sends professional staff abroad to U.K. to attend management courses and the staff selected for these courses are usually considered to have long-term potential for advancement to the directorate grade.

Problems in Implementation of Training

13. Endeavours to plan and conduct an effective training programme have highlighted a number of problems which have made implementation difficult,especially in the circumstances prevailing in Hong Kong.These problems, which are beginning to give rise to adverse effects, are briefly described below :-

(i) Because of the boom in the construction and building industries in Hong Kong, there is a great demand for engineering staff and Government is in competition with the private sector for their employment. Difficulty is therefore experienced in obtaining staff with a suitable background to receive training and this results in a lack of staff both in relation to quality and quantity.

(ii) Because of the rapid expansion of the department together with the difficulty in recruitment of staff from the private sector, it has been necessary to re-deploy serving staff to jobs for which they may not have received prior training. These officers can only gain their experience by on-the-job training and much more supervision is required until they have acquired the necessary experience in their new fields.

(iii) Because of the rapid expansion of the department, the staff are more than fully engaged and it is difficult to release them frequently enough to attend refresher courses. This limits their ability to make a greater contribution in the department.

(iv) Because of the lack of opportunity for the staff to receive a wide field of training, their knowledge is limited to specific aspects and this reduces the flexibility for transfer and replacement of staff within the department when the need arises. Also, staff in one section may not fully understand the function of staff in other sections, hence creating co-ordination difficulties.

13. The department is exploring alternatives to oversome the above problems by considering ways and means whereby more staff can be recruited or released for training. A probable solution appears to be the acceptance of people with lower qualifications to avoid competition with the private sector where, generally speaking, staff are sought who immediately do their job on employment and where there is less interest in obtaining less qualified trainees. The department can then provide more comprehensive training to fit such staff for subsequent employment in functional posts. Although this will involve a more extensive and a longer training programme, it will gradually increase the strength and quality of staff and provide greater scope for them to be released to attend refresher courses. Such a scheme has already been implemented in other engineering departments of Government and has proved to be a success.

Other Facets of Training

14. An efficient training programme must contain courses which are suitably designed to meet the requirements of the operational and works divisions. The strategy and curricula adopted must vary depending on circumstances and, as far as new recruits are concerned, the degree and extent of training required will be dictated by the calibre of the intake.

15. The efficiency of the operation of a department depends a great deal on co-ordination and co-operation amongst and between its various divisions. Thus, besides training on the technical aspects, courses should also include information on the working systems and procedures of the department in order to provide the necessary guidance to staff on these aspects. Perhaps of equal importance is for the course instructors to impress upon the trainees their individual responsibility to the community as members of a utility department.

16. In the case of refresher courses, the frequency of re-education must be decided with care and can best be determined by experience. Over-provision of training may result in unnecessary expenditure and waste of staff time thus adversely affecting the department's efficiency. The contents of the training courses must be reviewed and revised in the light of the prevailing needs. It is essential for the training section to maintain close contact with the works and operations divisions so that any changes in their requirements can be properly incorporated in the training programme. Most importantly, participants should be invited to give their comments at the close of the courses and arrangements should be made for feed back on the adequacy and suitability of the courses after participants have returned to their working posts for a period of time.

17. The economics of training are seldomly evaluated. Although the training involvement and the loss of working time due to release of staff for training can be costed fairly readily, the benefits of training due to increased efficiency are difficult to quantify in monetary terms. Therefore, the degree and extent of training needs to be carefully decided, but a very effective yardstick is the loss of efficiency which is apparent when training is inadequate. The issue is nevertheless rather subjective and while the need for training is clearly essential an optimum programme can only be formulated in the light of experience. In determining what is required it is probably better to err on the generous side because training costs usually comprise a very small proportion of the budget for the overall operation of a department and hence the cost consideration should not be crucial except in rather exceptional cases.

Conclusion

18. In conclusion, the Water Supplies Department in Hong Kong is currently providing staff training which is limited in extent and is primarily opened to the training of operational and works staff. Only limited training is provided to staff of high grades. The existing training programme is considered to be inadequate on account of the rapid expansion of the department. The development boom in Hong Kong over recent years has led to difficulties in staff recruitment both in quantity and quality. Consideration is being given to admitting recruits with lower qualifications and providing them with more basic and comprehensive training. The training unit must maintain close liaison with the operational and works divisions and constantly review training requirements. Efficiency of the department can usually be taken as a measure of the adequacy or otherwise of the training facilities. Training costs are usually insignificant in comparison to the other operational costs for a major utility and hence should not be a crucial consideration in the formulation of an effective training programme.

Paper 6d

Fresh Water Problems in the Netherlands and their Solutions

by W. A. G. Hoeting, Esmil International B.V.

INTRODUCTION.

The Netherlands are one of the countries in the world most abounding in water. About one-fifth of the total area of 38 000 square kilometres consists of water originating from precipitation. For technicians responsible for the water supply in arid territories it must be incredible to hear that nevertheless there are big problems with the fresh water supply in a country like the Netherlands. Before describing the present desalination technology in the Netherlands we will try to give an impression of the existing problems.

The Western part of the Netherlands and especially the coastal region along the North Sea in which the largest cities of the country, Rotterdam, Amsterdam and The Hague are situated, is by far the most industrialized part of it. This territory also having the greatest density of population it is evident that the demand for water for industrial as well as domestic purposes is highest there.

Until about 1955 the Northern part of this region in which Amsterdam and The Hague are located could draw its fresh water from the subsoil reservoirs found in the coastal dunes. Due to the post-war rapid expansion of industrial development this resource cannot meet the requirements any longer. It is for that reason that the high quality water from the dunes is being made up by infiltrating river Rhine water into the coastal dunes. This river has a basin of about 16 000 square kilometres in which vast industrial areas in Germany, France and Switzerland are situated with a population of approx. 40 million people. As up till now most of the industrial and domestic waste water is dumped into the river without any treatment it will be clear that by the time the water crosses the Dutch border it is heavily polluted with matter of organic as well as inorganic origin. (Vide Table 1).

The concentration of the pollutants is closely related to the fluctuating drainage of the river. In order to make this water suitable for consumption it is at present chemically treated by the Dutch Waterworks so that the major part of the organic matter is removed. However the inorganic matter, so the salt content of the water, is practically not affected by this chemical treatment.

In comparison with the other constituents of inorganic origin the chloride content of the river Rhine water is very high. To a great extent this is due to dumping of waste salts into the river by the potassium mines in Alsace (France). Consequently, the river water has a chloride content that, at low river, can be as high as 350 mg/l. Bearing in mind that the water supply authorities in the Netherlands are aiming at the delivery of water with a max. chloride content of 150 mg/l, preferably 100 mg/l, and that the salt content of the river Rhine will most unlikely decrease in the near future it is obvious that even in watery Holland it will be inevitable to desalinate in order to supply good quality water for domestic as well as for industrial and agricultural purposes.

Fig. 1 shows the chloride transport of the river Rhine in The Netherlands from 1870 till 1978.

DESALINATION PLANTS IN OPERATION IN THE NETHERLANDS.

At present three multi-stage flash type evaporator plants are operating in the Netherlands with a total capacity of about 70 000 cubic metres per day (more than 17 mgpd) over 150 small reverse osmosis units ranging from 5 to 100 cubic metres per day, with a total capacity of about 6 000 cubic metres per day (about 1 500 000 gpd) and one reverse osmosis unit with a capacity of 1 000 m^3 per day (about 250 000 gpd).

Two evaporators are producing process water, one with a capacity of 29 000 m^3/day (7 700 mgpd US) from seawater and the second one with a capacity of 32 400 m^3/day (8 600 mgpd US) from river Rhine water. The third evaporator is producing 3 000 m^3/day (0,8 mgpd US) of potable water from seawater at the touristic island of Texel, located about 3 miles North off the Dutch coast. The reverse osmosis plant with a capacity of about 1 000 m^3/day produces process water from tap water for a synthetic fibre industry.

Nearly all of the more than 150 small reverse osmosis plants are placed in the greenhouse area between the Hague and Rotterdam and in and around the famous flower district of Aalsmeer, a small community at about 10 miles South of Amsterdam. For vegetables, plants and flowers growing in greenhouses it is essential to have water with a low salt content available. Almost all glasshouse crops are salt sensitive and give reduced yields and minor quality products with an increased salinity of the irrigation water. Especially, sodiumchloride plays an important part in the salinization of greenhouse soils.

Depending on the type of crops the chloride content has to be as low as 50 ppm up to a maximum of 200 ppm. The greenhouse industry entirely depends on surface water and subsoil water as a consequence of the impossibility to use natural rainfall. The quality of the surface water is dependent on the quality of the river Rhine water which is used to replenish and clean the waterways in the west of the Netherlands. This implicates that during a considerable part of the year the salt content of the surface water is in fact too high to be used as irrigation water. Also the ground water in this part of the country is unsuitable for irrigation because of infiltration of seawater. The consequences of irrigation with water of too high a salt content are clearly shown in Figures 2 - 5.

The only practical possible alternative to improve the yield and the quality of the crops under the given circumstances is desalination of the available water. Of the existing desalting processes reverse osmosis has proved to be the most economical, suitable and reliable one. In Table 2 the performance data of four reverse osmosis units operating in the Westland greenhouse area are shown.

JUST WHAT IS REVERSE OSMOSIS?

Reverse osmosis is a scientific method of reversing nature's physical process where a dilute or lighter solution passes spontaneously through a semi-porous membrance into a more concentrated solution. In human beings fluids pass in and out through such membranes (cell tissues) by the phenomenon known as osmosis while plants absorb food and moisture from the soil in the same way.

When nature provides semi-permeable membranes to separate fluids of different concentrations, water tends to flow through the membrane from the more dilute into the more concentrated fluid. For example, fresh water will flow through an osmotic membrane to mix with a heavier brackish or seawater solution. As the water passes through the membrane, the pressure of the concentrated solution rises until equilibrium is reached, halting the flow through the membrane. The difference in pressure between the two solutions in this state of equilibrium is known as the system's osmotic pressure. Seawater has an osmotic pressure of approximately 26 bars (375 psi) while brackish waters have much lower osmotic pressures, for example water containing 1 000 ppm of salt has an osmotic pressure of about 1 bar (15 psi). Scientists have long realised that if the natural process of osmosis could be reversed - if water from concentrated solutions could be made to pass through selective membranes and emerge as pure water - many practical applications could be developed.

For example, salts could be removed from brackish or seawater and many waste waters could be reclaimed - by a basically simple method requiring only a relatively small amount of energy.

The basic reverse osmosis concept is simple - just apply sufficient pressure to the concentrated solution (above its osmotic pressure) and in reversing the flow through a semi-permeable membrane, filter out salts and other dissolved solids. But, before this could be done, in a manner acceptable for practical applications, a membrane had to be created - a membrane of synthetic material that would be highly permeable to water but an effective barrier against salts and other dissolved minerals. In addition, the membrane had to be durable, economically acceptable and capable of easy installation in a simple and compact system. That search has been successful and the reverse osmosis process has been operational for approx. 10 years now. Figure 6 shows the principle of osmosis and reverse osmosis.

TWO SYSTEMS.

Today reverse osmosis is applied by using two membrane configurations that are predominant from a technical and commercial point of view viz. the hollow fine fibre type and the spiral wound thin-film type. Of both figurations two types of modules are available, one to suit seawater desalination and one to desalt brackish water.

THE HOLLOW FINE FIBRE SYSTEM.

The hollow fine fibre configuration as developed by Du Pont de Nemours Co. Inc., Wilmington, Del., U.S.A. is by far the most applied system. In Du Pont's version of hollow fibre reverse osmosis the fibres of aromatic polyamide have an outside diameter of approx. 85 microns and an inside diameter of approx. 42 microns which is comparable with a human hair.

The hollow fibres 2 000 times enlarged are shown in Figure 7. Figure 8 shows how the hollow fibres are incorporated in a reverse osmosis module.

THE SPIRAL WOUND THIN-FILM SYSTEM.

Spiral wound modules are supplied by Fluid Systems Division of UOP Inc., San Diego, Cal., U.S.A. are based on thin-film polyamide or cellulose acetate membranes. Membrane thickness is ranging from 10-100 microns depending on its application. A cross-sectional drawing of the membrane is shown in Figure 9.

With the spiral wound thin-film design (see Figure 10) hundreds of square feet of membrane can be accommodated in one cubic foot of pressure tube volume.

BASIS OF A REVERSE OSMOSIS SYSTEM.

In its most simple form a reverse osmosis system consists of a pump to raise the feedwater to the required pressure, a permeator and a throttling valve in the concentrate (reject) outlet to control conversion (Figure 11). A five or ten microns cartridge filter is used upstream of the plant to protect the pump and the permeator from particulate solids (Figure 12). This filter is not suited to protect the permeator from small size suspended matter. If the turbidity of the raw water is too high a separate pretreatment (e.g. flocculation and filtration) shall have to be envisaged.

From the high pressure pump the feedwater flows to the feed inlet of the permeator. The pressure of the feedwater, being higher than its osmotic pressure, will force water containing about 10% of residual salts through the membranes to the permeator product outlet. Reject water will leave the permeator reject outlet virtually at the feed pressure.

Pressure drop from feed inlet to reject outlet will usually be only five to twenty psig. The reject water flowrate is controlled by a reject flow control valve.

The product: reject ratio depends on the raw water composition and is limited mainly by the solubility limits of $CaCO_3$ and $CaSO_4$. As in the reverse osmosis process the salts in the feedwater are concentrated as a ratio of 2 upon 50% and at a ratio of 4 upon 75% conversion, these solubility limits can be exceeded and thus precipitation on the membranes may occur. Pretreatment to prevent membrane scaling can be applied in four different ways, viz:

1. Reduction of conversion to avoid any excess of solubility limits.
2. Removal of the calcium ions by means of ion exchange softening.
3. Removal of bicarbonate ions by acidication.
4. Sequestration of the calcium ions e.g. by means of hexametaphosphate.

The alternative to be chosen mainly depends on economics. In the case of the greenhouses chemical dosing is considered to be too complicated and it is for that reason that all plants fed by brackish ground water in this industry and equipped with polyamide membranes are operated at a low conversion of around 25% without any chemical dosing.

The only disadvantage is that energy consumption at lower conversion is somewhat higher. As, except for the pumps, there are no moving parts in a reverse osmosis unit, this system can be continuously operated without any noteable maintenance.

DESALINATION PROSPECTS.

It is only in recent years that distillation has become the primary means for desalting seawater and highly brackish waters whereas ion exchange used to be the only means for the demineralization of slightly to moderately brackish waters.

Distillation however requires vast amounts of energy which are not always sufficiently available and/or are too expensive and for ion exchange large amounts of possibly hazardous chemicals are needed for regeneration of the resins. Reverse osmosis not only requires less energy and chemicals but is also easier to operate at less expense. These are the reasons why during the past years practically all ion exchange units that were installed in the Dutch greenhouses have been replaced by reverse osmosis units. The steady increase in installed reverse osmosis units in this industry since 1973 is shown in Figure 15. This graph clearly indicates that further increase may be expected.

Apart from the greenhouse industry quite a number of other industries in the Netherlands, especially in the food stuffs line and the chemical field are showing increasing interest in the application of the reverse osmosis process for the production of high quality process water. KIWA, the Netherlands Waterworks' Testing and Research Institute, started in 1966 a programme to investigate the role desalination can play in the production of potable water from the heavily polluted river Rhine water. Results of experiments carried out with the available desalination techniques, viz. electrodialysis, reverse osmosis and evaporation have clearly indicated that reverse osmosis is technically as well as economically the most suitable process to lower the salt content of pretreated brackish surface water. After this conclusion was made the research efforts of the Institute have been concentrated on the removal of organic and inorganic pollutants present in the river water that are the main cause of fouling of the reverse osmosis membranes. The results of this research being very promising, it has been decided that shortly a pilot reverse osmosis plant with a capacity of 10 m^3/h will be installed at the site of one of the Dutch Waterworks.

From the above it may be concluded that the key to future supply of fresh water from brackish water for domestic, process and to a less extent also for agricultural purposes is reverse osmosis. This of course not only applies to the Netherlands but is in general applicable wherever in the world brackish water has to be desalted.

ACKNOWLEDGEMENT.

The author wishes to thank Mr. J.C. Schippers of KIWA (the Netherlands Waterworks' Testing and Research Institute) and Mr. C. Sonneveld of the Glasshouse Crops Research and Experiment Station, Naaldwijk, for their valuable advice.

Table I

THE RHINE SUPPLIES, ON AN AVERAGE,

69 MILLIARD CUBIC METRES OF WATER PER YEAR.

IN 1976 THE RIVER ENTRAINED A.O.

THE FOLLOWING QUANTITIES OF POLLUTANTS

9.750.000	TONS OF	CHLORIDE.
720.000		NITRATE.
52.000		ORTHO-PHOSPHATE.
8.500		ZINC.
1.500		CHROMIUM.
1.200		LEAD.
930		COPPER.
250		ARSENIC.
20		MERCURY.

FURTHER, THE RIVER IS POLLUTED BY OIL, PHENOL, DETERGENTS, BIOCIDES AND NUMEROUS OTHER NOXIOUS SUBSTANCES.

Chloride Transport River Rhine

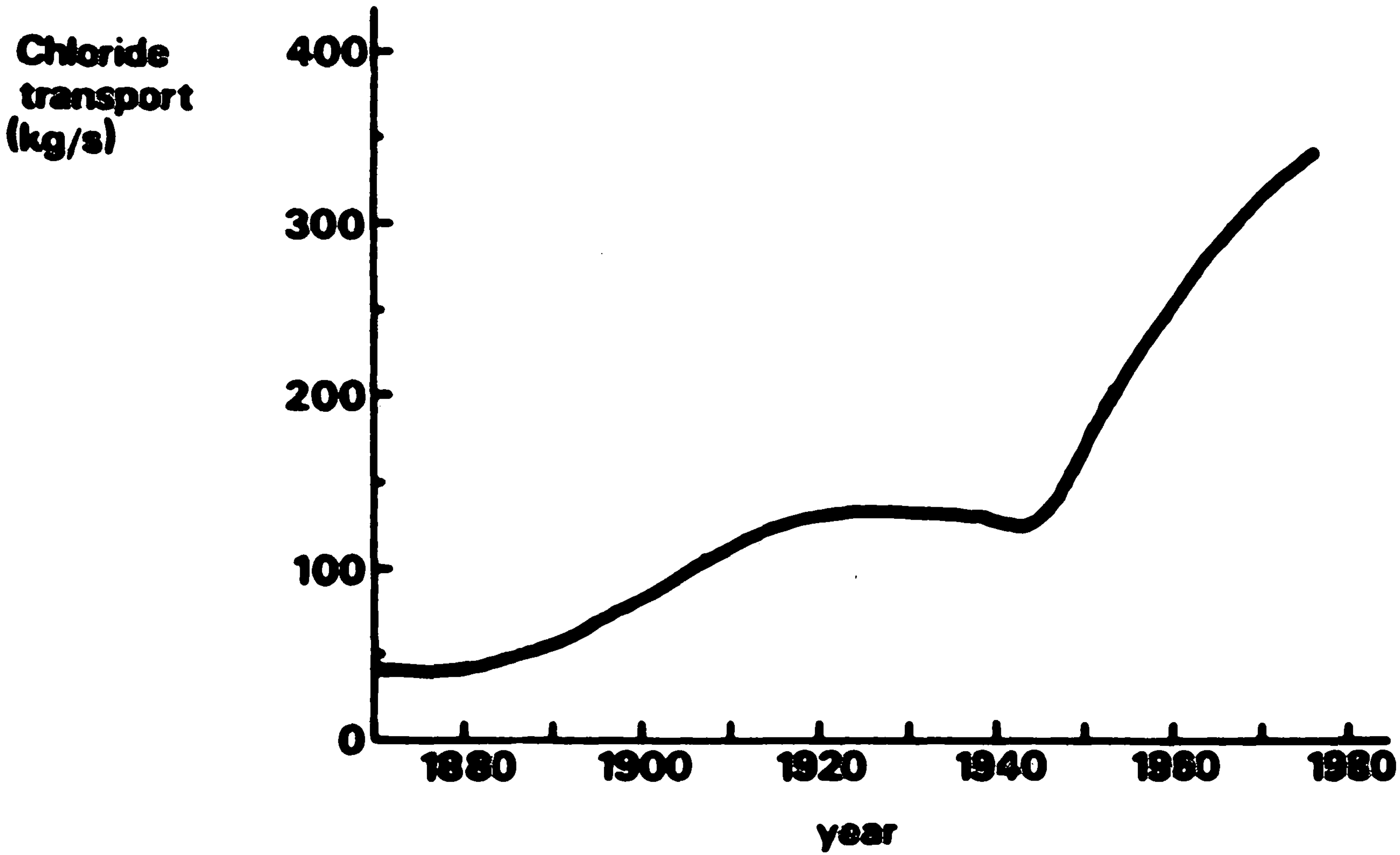


Figure 1

THE YIELD OF CUCUMBERS AS A FUNCTION OF THE SALT CONTENT OF THE IRRIGATION WATER

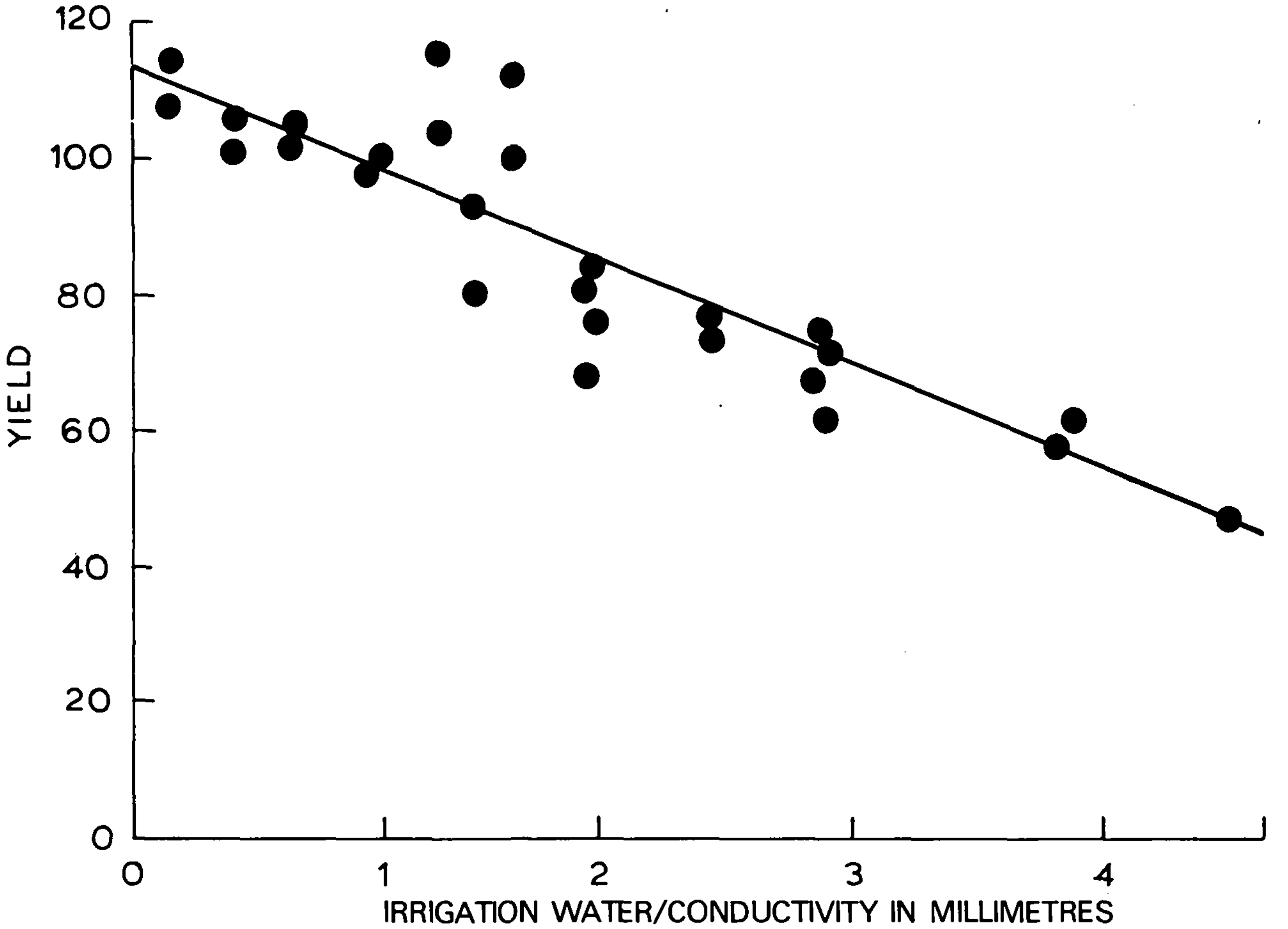


Figure 2

Figure 3

Paprika mis-shapen by blotchy ripening caused by too high saltcontent of the irrigation water.

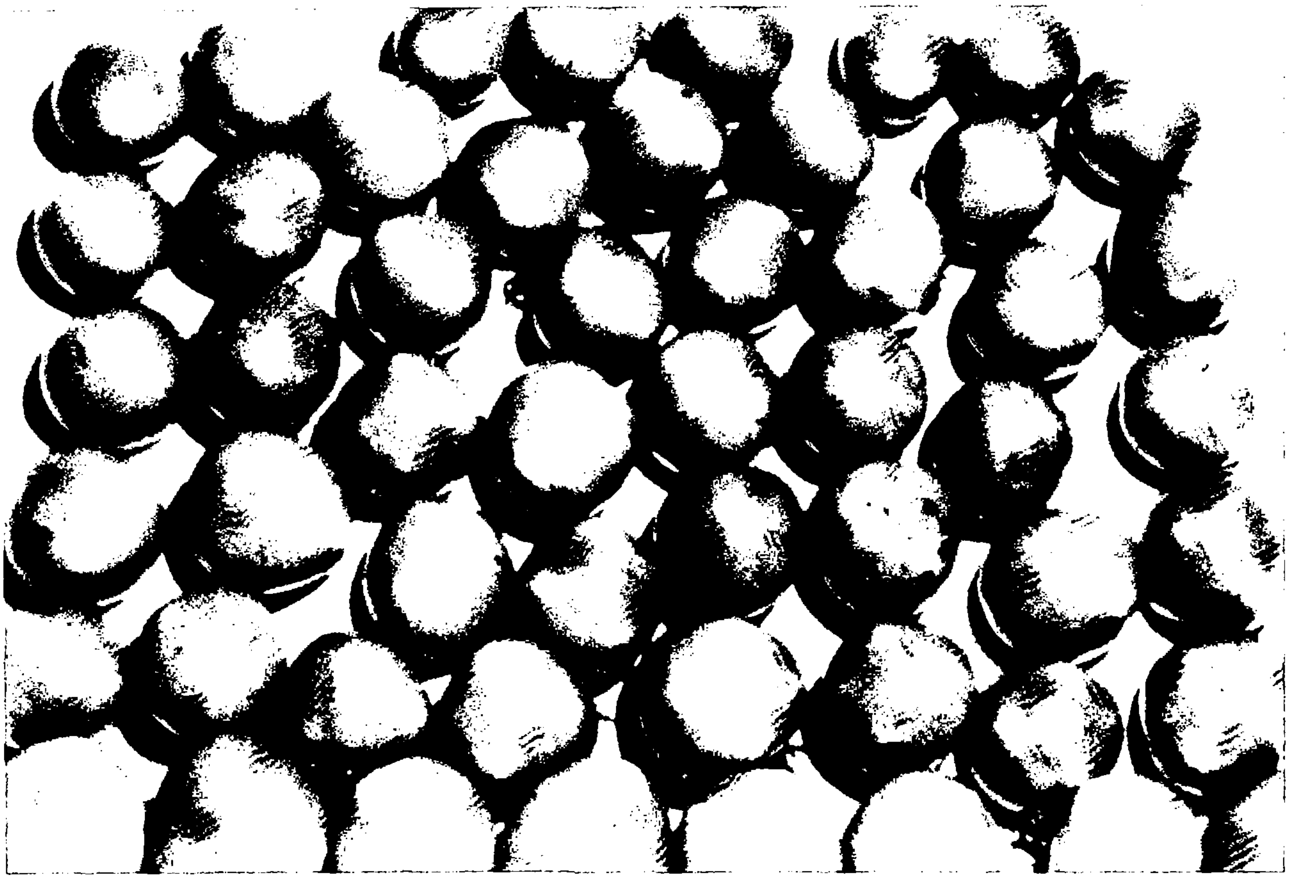


Figure 4 Tomatoes grown with desalted water.

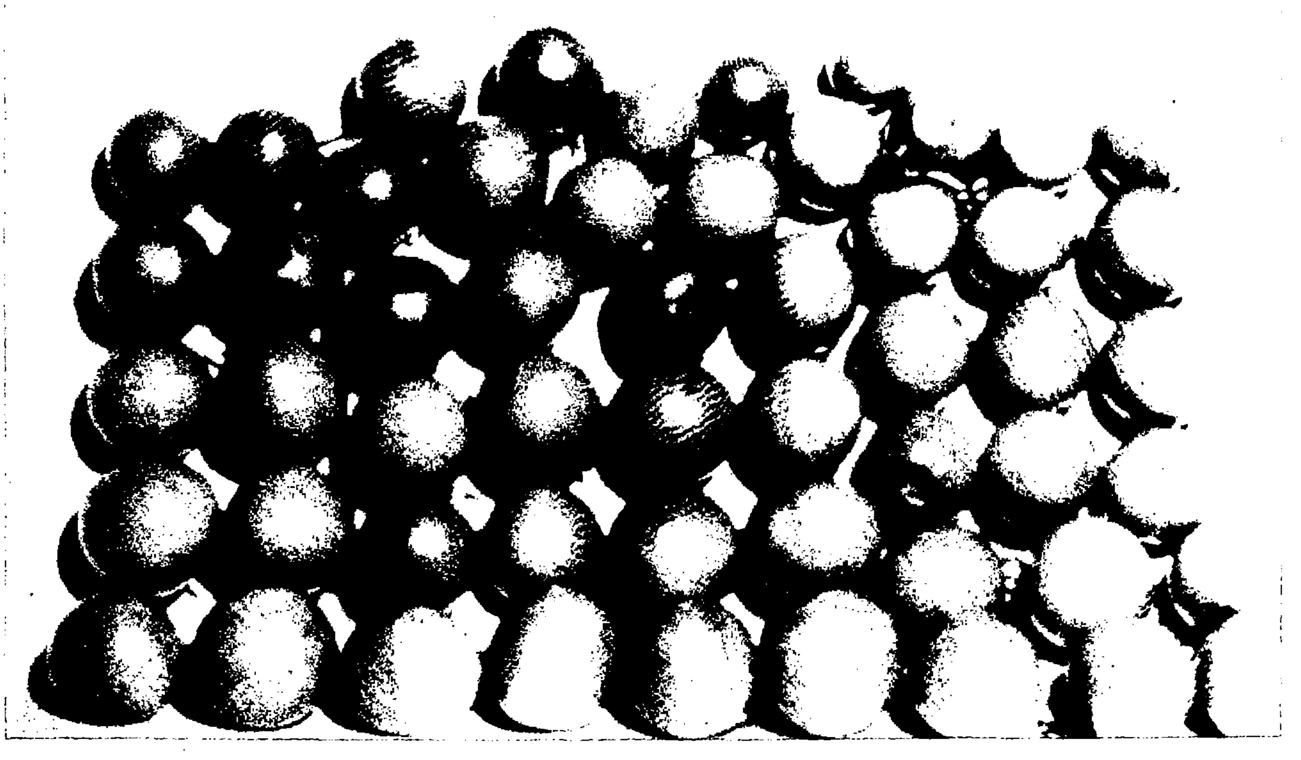


Figure 5

Tomatoes of the same culture as in figure 4, but irrigated with untreated water

PERFORMANCE DATA OF SOME R.O._UNITS

OPERATING IN THE WESTLAND_GREENHOUSE AREA.

CUSTOMERS	FEMINI	SIONSGAARDE	VEMI	VERBEEK
MENBRANE TYPE	PERMASEP®, B9	PERMASEP®, B9	PERMASEP®, B10	FSD_UOP (TFC _ PA)
PLANT CAP. l/h.	1400	2500	1800	900
E.C. FEED (millim ho)	15.0	7.44	20.1	1.95
E.C. PRODUCT (" ")	0.24	0.31	0.22	0.05
Cl' FEED (p.p.m.)	4903	2203	6430	600
Cl' PRODUCT (p.p.m.)	58	71	37	12
T.H. FEED (°D)	138.3	61	160	18
T.H. PRODUCT (°D)	0.6	0.5	0,2	∠ 0.05
Fe, FEED (p.p.m.)	8	27	3	∠ 0.1
Fe, PRODUCT (p.p.m.)	0.2	0.9	0.02	NIL

Table 2

PRINCIPLES OF REVERSE OSMOSIS

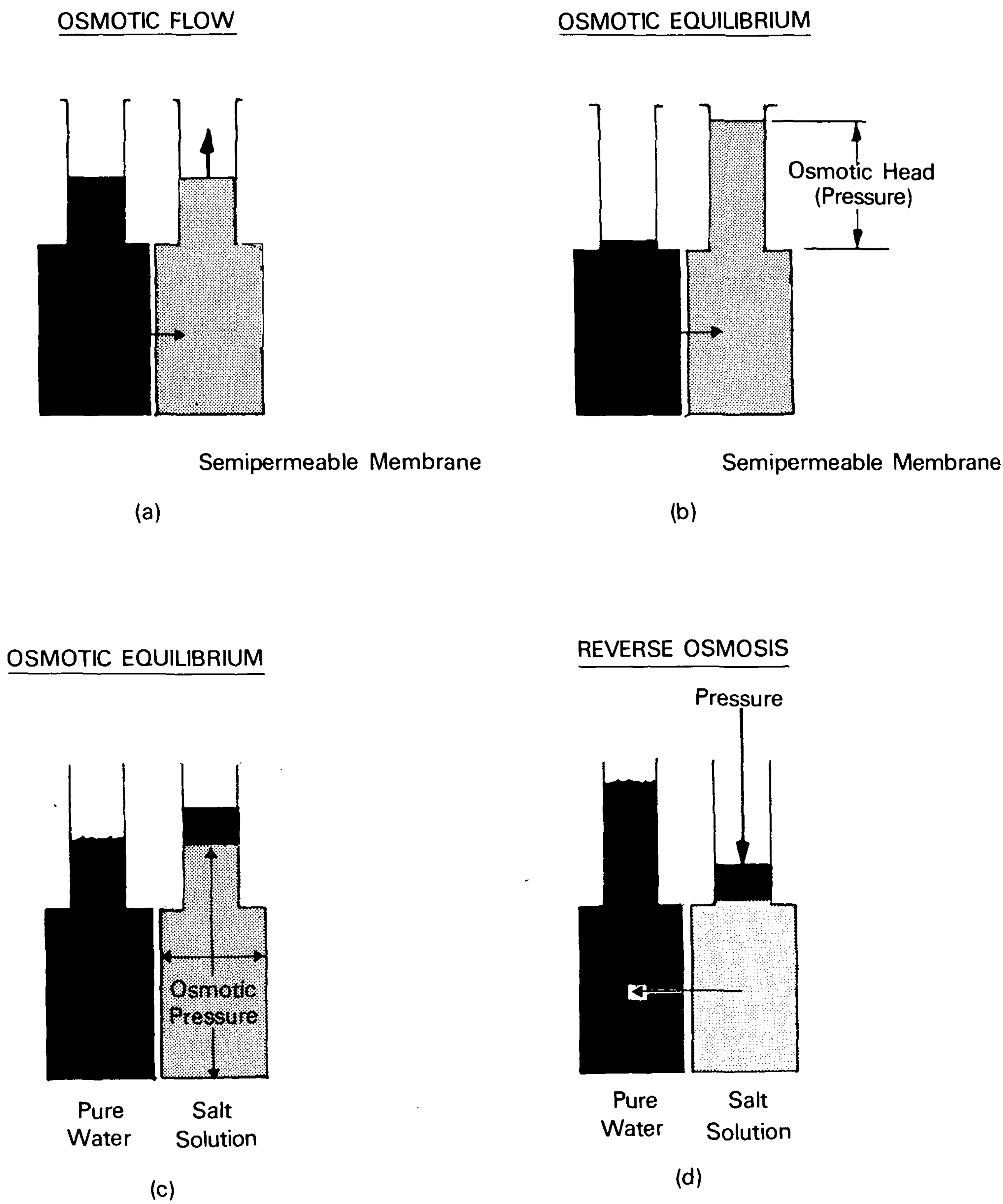


Figure 6

Fig. 7 *Hollow fine fibers 2,000 times enlarged.*

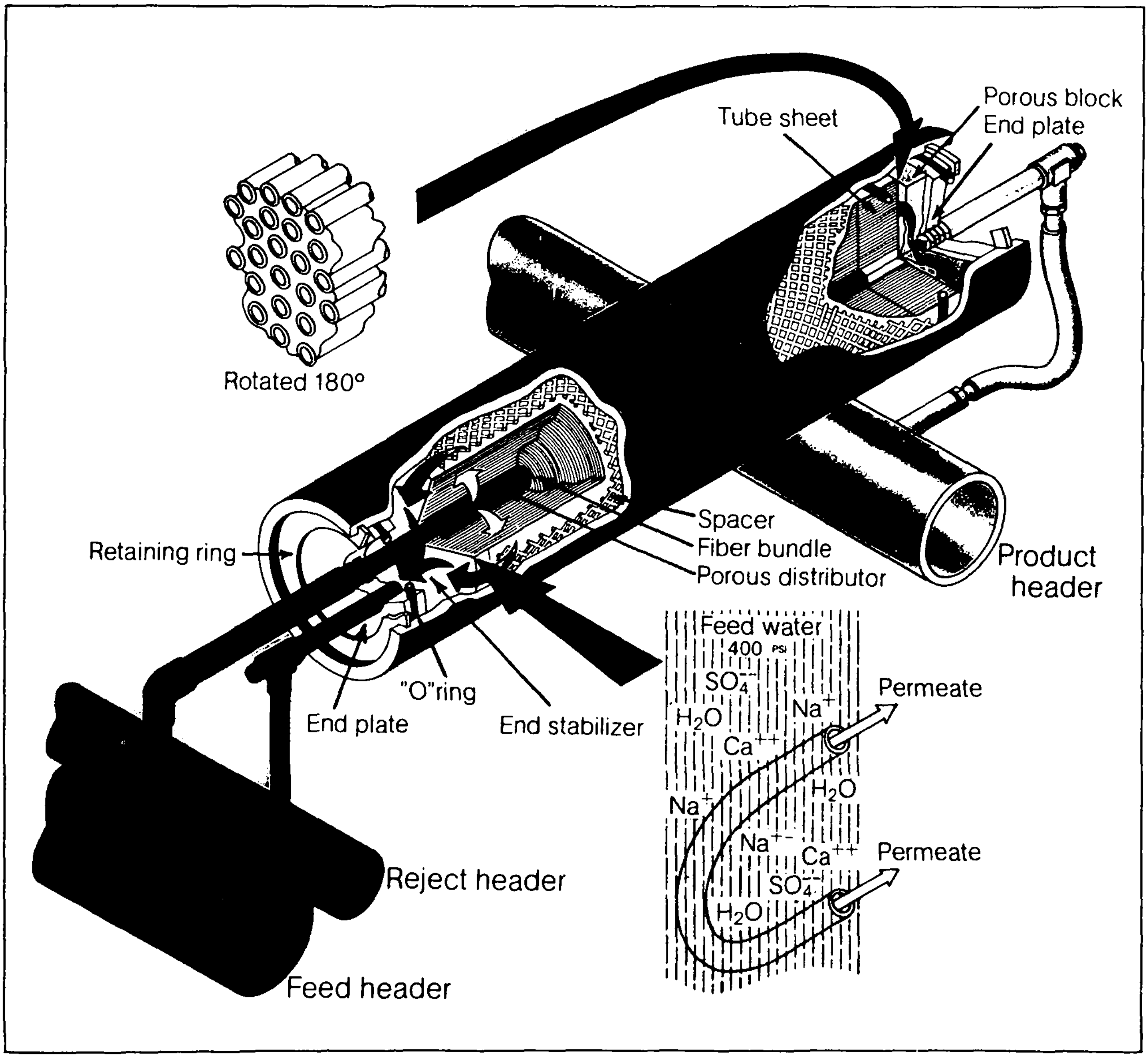


Fig. 8 *Typical hollow fiber permeator with piping.*

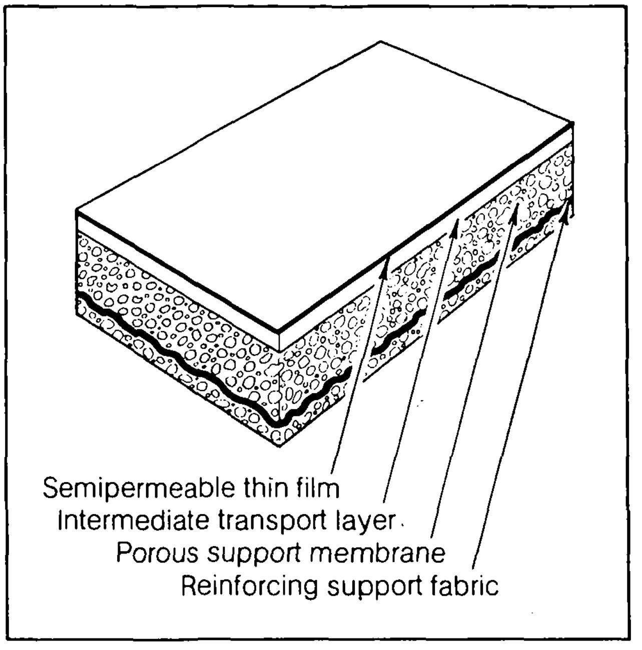


Fig. 9 *Cross sectional drawing of interfacially-formed thin film composite membrane.*

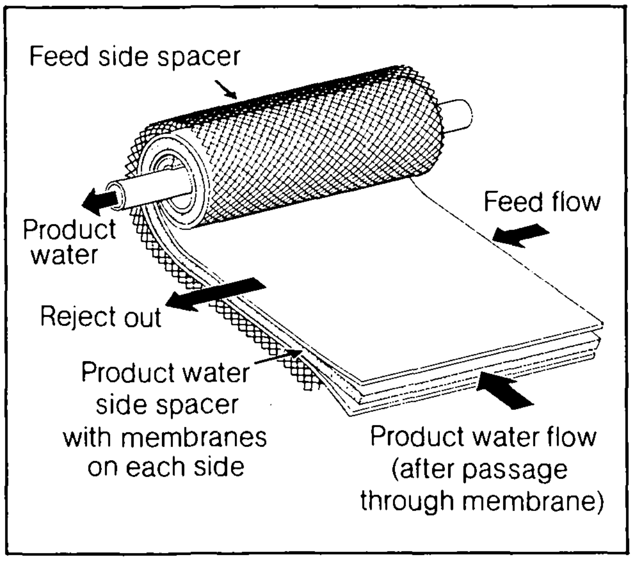


Fig. 10 *Spiral wound membrane element construction.*

SIMPLIFIED RO FLOW DIAGRAM

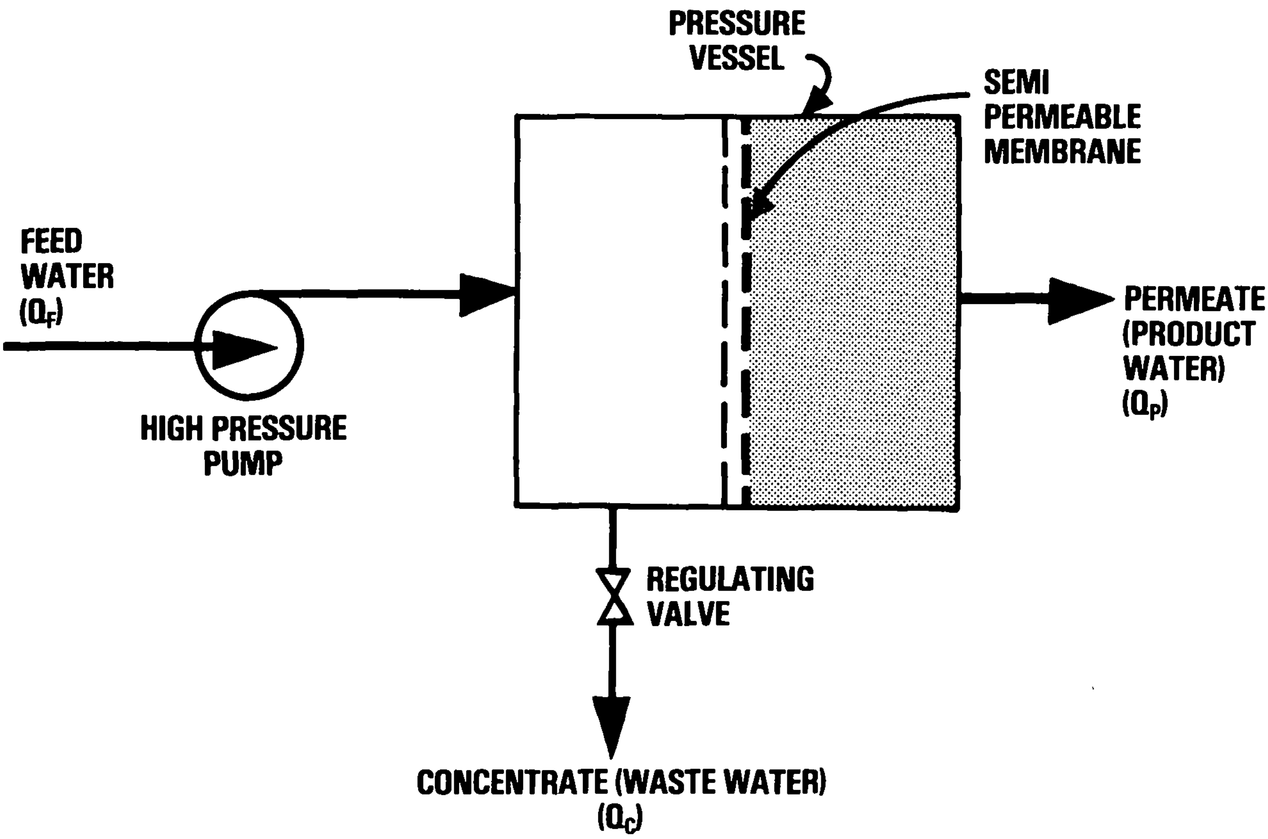


Figure 11

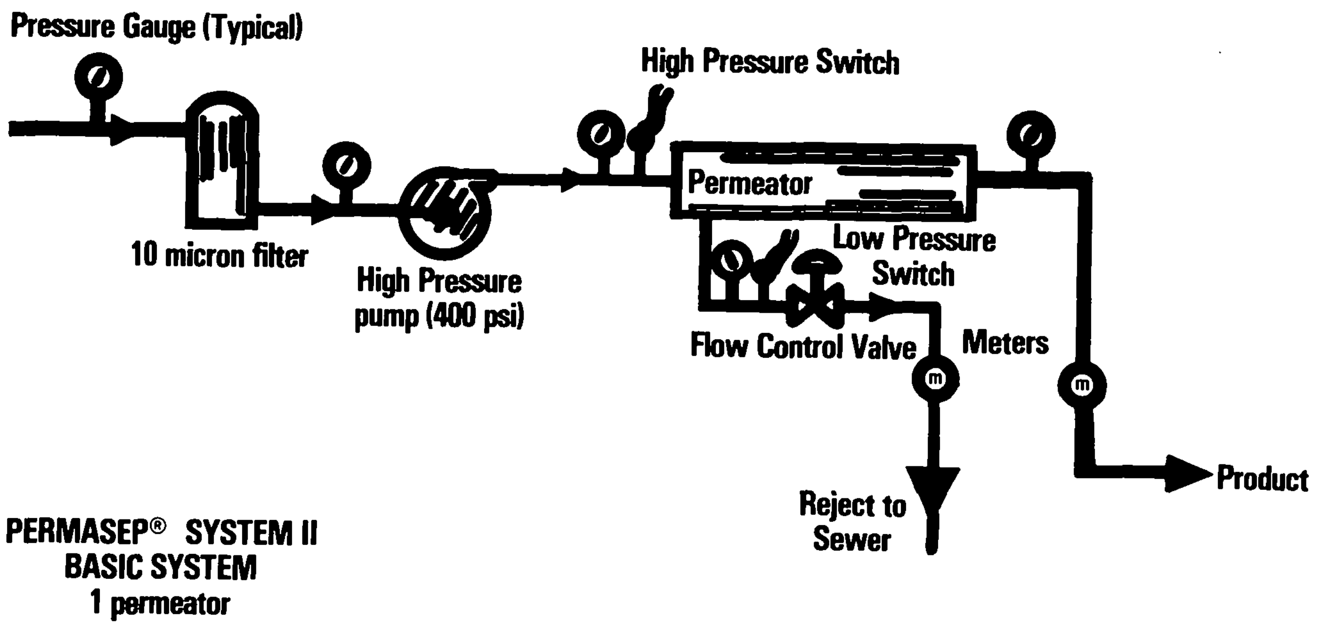
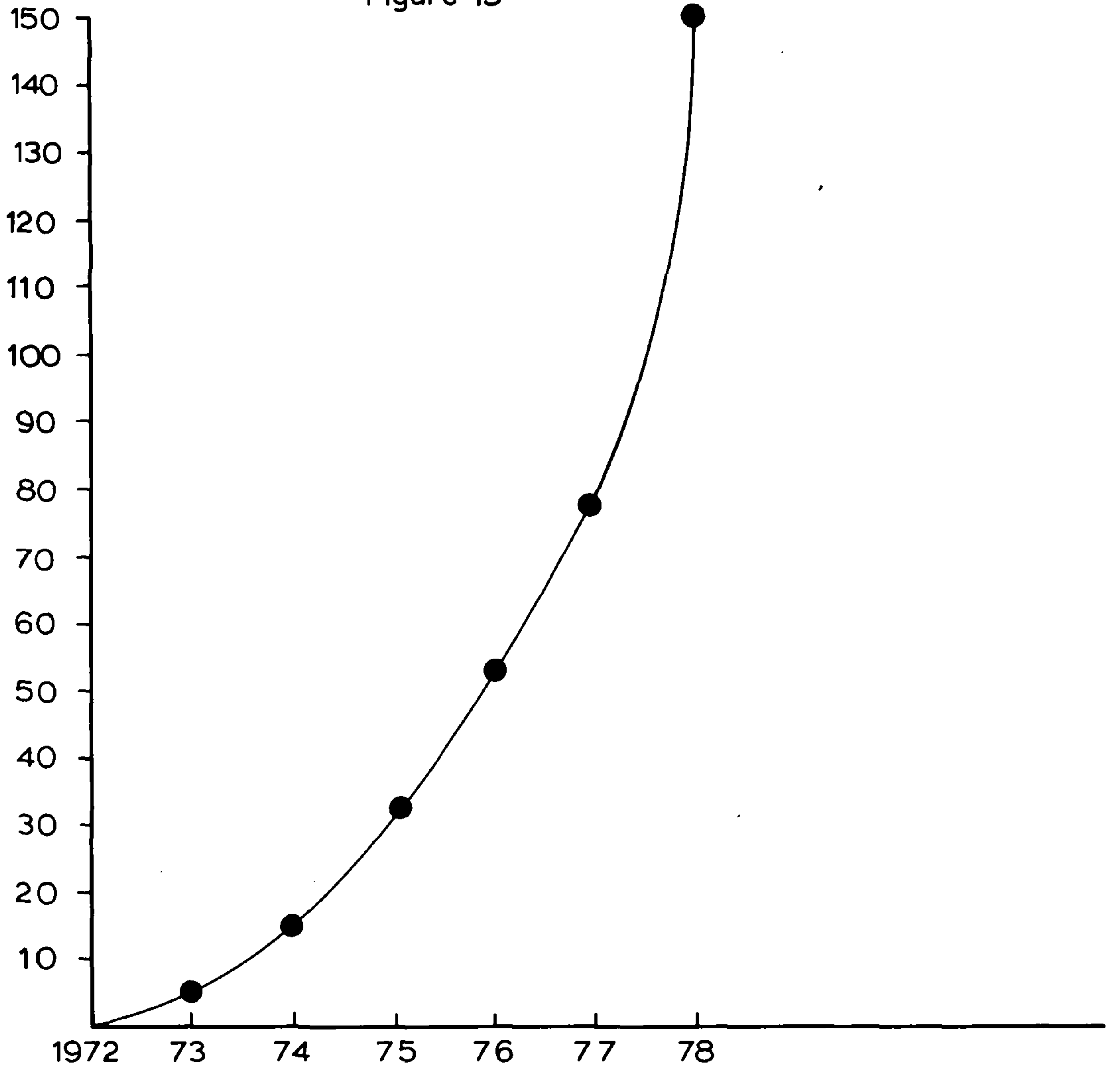


Figure 12

Figure 15



NUMBER OF REVERSE OSMOSIS UNITS IN
THE DUTCH GREEN HOUSE INDUSTRY

Paper 6e

Ozonization Place in Drinking Water Treatment

by J. P. Legeron, Societe Trailigaz

R E S U M E

La place de l'ozone dans le traitement de l'eau potable.

Mal connu encore au début du siècle, l'ozone grâce à ses propriétés physico-chimiques très intéressantes, a trouvé un terrain d'application de choix dans le traitement des eaux destinées à la consommation publique.

Si, dans certains cas, l'ozonation a remplacé des techniques existantes, il a cependant parfois complété heureusement les étapes du traitement. Puissant agent bactéricide, virulicide et oxydant, l'ozone a été et est appliqué en différents points de la chaîne de traitement, selon le but à atteindre.

Plusieurs exemples viennent illustrer et confirmer le choix rationnel de l'ozonation et des conditions qui lui sont liées.

A B S T R A C T

Ozonization place in drinking water treatment.

Ozone was still not very well known at the beginning of the XXth century. Because of interesting properties, it becomes of a great use in drinking water treatment.

If ozonization has sometimes replaced other existing methods, it has been shown as a complementary way of treatment.

Powerful bactericide, virulicide and oxidizing agent, ozone has been and is applied in different parts of the treatment, according to the purpose of its use.

Several examples are described ; they give an explanation for the choice of ozonization and for the conditions of its application

INTRODUCTION

Man and Industry are the two most powerful transformation machines in the world, but also the most dreadly. Both abstract good quality water and discharge it in nature with a more or less significant polluting load. Despite the natural self purification process, the deterioration in the quality of both surface and ground water has become a daily fact.

Therefore, water treatment has come to be a necessity, either before beeing discharged sometimes, or above all before consumption. There exists a wide variety of purification modes, however, all aim at restoring the best possible quality of water.

Treatment modes calling upon such diverse concepts as flocculation, settling, absorption, biological degradation, oxidizing, adsorption and filtration, make it possible to restore a good physical/chemical quality of water. As to disinfection, this process must provide the qualities whereby water will comply with Health microbiological standards.

The fact that a single reagent - ozone - can contribute at the same time to both types of purification processes directly or indirectly as shown by figure 1, may explain the ever increasing use which is made of that technique in the treatment of drinking water.

This report describes ozonization and its conditions according to the final aim.

I. EXPRESSION AND APPLICATIONS OF OZONE

It is convenient at this point to review briefly some facts about the chemical expression of ozone before we consider its modes of application.

The characteristic features of ozone are shown in Table I. Resulting from the combination of three atoms of oxygen, ozone is a particularly unstable gas : by decomposition, it essentially yields oxygen Its synthesis can take place in various ways, although the most usual from an industrial point of view calls upon the "corona effect" (also referred to as "electrical discharge").

I.a. Expression

When produced by ozonizers, ozone is never in a pure state but diluted in a carrying gas which is an oxygen rich or oxygen poor air, sometimes pure oxygen. This is where the concept of ozone concentration in a gas mix comes into the picture. Concentration is expressed in g/Nm3, % of weight or % of volume.

For the purpose of water treatment, ozone must be introduced in the liquid phase. This transfer is made totally or partially through an adequate diffusion system. T is the dissolution ratio of ozone as expressed in %.

In this way, ozone can be transferred more or less rapidly in water after a certain period of dissolution (TD). While in the liquid phase ozone can undergo various reactions : one part is spontaneously decomposed, another reacts to the dissolved substances, finally another part dissolves in the medium. This latter part can be quantified and its value represents the concentration of free ozone dissolved in water : RO_3 (expressed in gO_3/Nm^3 in % of weight or % of volume). As to the time during which this residual remains in the liquid phase, it is referred to as retention time (TC).

$$TC = TD \text{ if } RO_3 = 0$$

$$TC \quad TD \text{ if } RO_3 \quad 0$$

The expression "treatment rate" (TT) is usually used in the quantification of ozonization. The treatment rate is the quantity of ozone injected per unit of volume of the liquid to be treated. This expression does not take into account the diffusion efficiency that may vary, this is why the "actual treatment rate" (TTr) is used. It represents the quantity of ozone actually transferred per unit of volume of the liquid phase.

I.b. Modes of Application

Table II sums up the various parameters mentionned in the previous Section. Figure 1 summarizes the principal means of ozone diffusion in water. A first classification sub-divides the systems into traditional and mobile ones. In the latter systems, energy is essentially provided to the mechanical system : this applies to turbines, either suction or not. In the other systems the most part of energy is consumed in the pressurization of water and/or ozonated gas. Therefore, the systems can be subdivided into injectors, static mixers and porous diffusers respectively.

It is not within the scope of this report to compare these systems. They are only mentioned to help acquire a better understanding of the ozonization treatments that will be described below.

II. OZONIZATION - PURPOSE AND CONDITIONS OF TREATMENT

There are many applications of ozone to the treatment of drinking water all over the world. Millions of cubic meters of water are ozonated every day, and this implies ozonization of waters originating from very different sources and treatments for various final purposes.

Figure II shows the various possible reaction stages in the treatment of water as well as their possible relations with ozonization. There are three main purposes for the use of ozone : oxidizing, improvement of other treatments and disinfection. In the first and third case ozone has a direct action whereas in the second ozone is used to improve a treatment taking place later : either storage, or flocculation or a biological or non biological filtration.

II.1. Ozonization - a fully fledged oxidizing treatment

Due to its very high oxide-reduction potential, ozone happens to be an energetic oxidizer, which accounts for its use at the beginning of a treatment line in some cases. Moreover ozonization can be a means of substitution of chlorination at the head of a treatment process. In fact, chlorine leads to the formation of added compounds the toxicity of which has been evidenced in some cases. Therefore at the beginning of the treatment line, ozonization (pre-ozonization at that particular point in time) contributes to the decrease in colour and turbidity as well as concentration in mineral matters such as iron and manganese. On the other hand, it destroys some organic compounds such as phenols, detergents, pesticides, etc., bringing its contribution to the reduction of micro pollution. It would be boresome to describe all the applications of ozone, and this is why only a few examples will be presented.

II.1.a Colour turbidity and taste elimination

The colour of water may come from various origins, most frequently from vegetals. Surface water, more particularly standing water gets loaded with humic matters that tend to leave colours ranging from brown to greenish. When chlorination is made, these organic matters account for the formation of trihalomethanes that are sometimes mutagenous or even cancer inducing. While breaking these molecules - more particularly the chromophoric groups, ozonization is successful in decreasing the colour of water.

Figure III shows an example of this application in the United Kingdom where Barker and Palmer have obtained a 50 % reduction of colour with a treatment rate of 1.75 gO_3/m^3. At the same time, the taste of water has been improved and a rate of 1.4 gO_3/m^3 has resulted in a decrease by 50 %.
There are many examples of the efficiency of ozonization against turbidity. In general the kinetics of oxidizing are exponential : quick at the beginning, they tend to rapidly become asymptotic. This may account for the low values of treatment rate and dissolution time that are often used.

II.1.b Iron elimination and manganese oxidizing

Ozone oxidizes iron efficiently. Iron then precipitates into non-soluble hydrates. The reaction is very rapid when iron is not or only slightly complexed, which is the most frequent case. Otherwise it is necessary to carry out a gradual ozonization : discontinuous injections of ozone first release iron which is in turn oxidized in a second stage.
In the case of manganese, various degrees of oxidizing can be obtained. The most oxidized form is permanganate which is soluble in water and gives it a colour ranging from pink to violet according to concentration. Among the intermediate stages of oxidizing we should mention manganese bioxide which is a colloid and gives a champagne colour to water.

In practice three stages are necessary to eliminate the most part of manganese : first, ozone oxidizing transforms it into dioxide and permanganate ; second, some retention reduces permanganate into dioxide; finally, a filtration process - possibly through catalitic sand (sand coated with manganese dioxide) - separates manganese from water.

Figure IV gives some results obtained by Furgason and O'Day. The French regulations currently provide for a maximum iron and manganese concentration of .3mg/l (of which .2mg/l iron) which very often requires a treatment of water. In this case also, dissolution times are usually short, but the treatment rates depend upon the initial quantities of iron and manganese.

II.1.c Influence of pre-ozonization on some other parameters

Table III sums up the results obtained by SETUDE and Compagnie Générale des Eaux (C.G.E.) on water from a river (in this case, water from river Seine at Choisy-le-Roi near Paris (France). In addition to the fact that pre-ozonization decreases turbidity and manganese concentration as already mentioned, it should be noted that it produces reductions by about 25 % for COD, BOD and anionic detergents, at a low treatment rate (.4 mgO_3/l). Some disinfection also takes place, yielding a germ reduction by 25 % to 78 % according to the specific germ to be eliminated.

Ozonization by itself results therefore in an overall improvement in the quality of water, and this improvement can even be felt after all the various stages of treatment as shown in Table III. Moreover, use of pre-ozonization on loaded water allows savings on reagents : savings on post-ozonization ozone as demonstrated by Gerval, and savings on flocs because ozone can be a flocculating agent by itself (Schalekamp).

The latter aspect makes a good transition to the next chapter dealing with the rôle of ozonization in the improvement of water treatments.

II.2 Ozonization - a means of improving some steps of the treatment process

Storage, biological or non-biological filtration and flocculation are the principal water treatments that can be improved by pre-ozonization.

II.2.a Ozonization and flocculation/filtration

By modifying the zeta potential ozone entails the formation of a floc which is easily strained by filtration. This depends on the composition of organic matters in water. In particular, this phenomenon is considerable in lake or dam waters.

However, most of the time it is necessary to add a flocculating agent, although its amount can be reduced when ozone is used as already mentioned. Finally, we should mention here the miscellization-demiscellization technique which has been implemented in various parts of the world.

II.2.b Ozonization and storage

When surface water contains a large proportion of organic matters, the use and improvement of natural self-purification can be of advantage : the bacterial activity results in a better quality of raw water stored in a reservoir.

The use of ozone before storage yields the following twofold advantage : oxygenation and increase in the biodegradability of dissolved organic matters. For information, Table IV shows the treatment rate variations for two steps of the purification line according to storage and ozonization conditions.

On the whole, it is noted that ozonization has a positive effect on the chlorination rate at the breakpoint as well as on the ozone rate of post-ozonization. Thus, the combined "ozonization and two days storage" treatment has offered the best economic results in the case under consideration : .31 to .38 gCl_2/gO_3 less injected and .25 gO_3/gO_3 less injected in pre-ozonization.
Although results may vary with time this example shows that the general results are still largely positive.

II.2.c Ozonization and biological filtration

The use of porous filtering materials has promoted the retention of bacterias in filters and hence the biological purification of water. In this case, pre-ozonization will serve the same purposes as in the preceding case : oxygenation of water and improvement in the biodegradability of dissolved organic matters. The results of Figure V confirm the fact that this is favorable to the bacteria growth in the filters. Figure V also shows the results obtained in terms of organic matters reduction versus time and according to the different stages of treatment. It appears that ozonization by itsel entails a reduction by about 10 % and more provided that it is made after prior clarification without activated carbon. More variable results are obtained when we compare filtration on activated carbon according to whether there is pre-ozonization or not : results are first similar, then reductions differentiate increasingly with time. As a rule pre-ozonization is all the more positive when some time has elapsed after filtration on activated carbon is started. Whilst ozone seems to promote indirectly bacterial growth, it can also be used for the opposite purpose of water disinfection.

II.3 Ozonization - a means of disinfection

This is one of the oldest applications of ozone. In this respect it should be recalled that as soon as the turn of the Century, the city of Nice (France) already treated the water of river Vésubie with ozone. Since that time, very many studies have supported the fact that ozone is a very powerful bactericide and virulicide agent Figure VI shows a few examples from the litterature. These indicate the kinetics of disactivation of poliovirae, Escherichia Coli and spores according to time and ozone residual in water.

It is on the basis of the works of Coin, Gomella and Hannoun that the bactericide and virulicide conditions (also referred to as true conditions of ozonization) have been defined (Figure VII). They essentially consist in maintaining a free dissolved ozone residual of .4 mgO_3/l during a minimum of 4 minutes. In practice ozonization is made in two stages of injection : a first stage of 2 min. satisfies the short-range chemical demand in ozone and therefore yields a residual of .4 mgO_3/l. This stage is essentially an oxidizing stage. In a second stage, this residual is maintained during 4 min. This is the main disinfection stage.

This technique which is widespread in Europe - more particularly in France - offers several advantages. As it takes place at the end of a treatment process, it contributes to the delivery to the consumer of a water presenting a very high bacteriological quality and eliminates at the same time the viral risk, which is not the case of the other usual disinfecting agents. On the other hand, it is during this stage that the organoleptic qualities of water are considerably improved. Water becomes colourless or slightly blue, odourless most of the time and without any particular taste.

Some examples of the application of ozone in the treatment of drinking water have been described. Due to the wide range of ozonization uses, one of the present trends is ozonization by stage that is injection of ozone at several points of the treatment line. A specific example is described in the following chapter.

III. AN EXAMPLE OF MULTIPLE INJECTION OF OZONE - LA CHAPELLE TREATMENT PLANT IN ROUEN (FRANCE)

With a capacity of 50,000 m^3/day, the drinking water treatment plant purifies a raw water (from the water table) containing, among others, the following elements :

- ammonia : 2 to 3 mg/l
- manganese : 0 to .2 mg/l
- various micropollutants such as detergents, phenols, ...

Moreover, this water is totally deprived of dissolved oxygen. Pursuant to tests in a pilot plant that lasted three years, the following treatment line has been selected :

- pre-ozonization for manganese oxidizing, decrease in the micropollutants and water oxygenation ;
- filtration on catalitic sand to retain oxidized manganese and colloidal or suspended matters ;
- percolation on activated carbon for the adsorbtion of organic matters and particularly to obtain a double biological purification (ammonia and the other biodegradable elements) ;
- post-ozonization for water disinfection and improvement of organoleptic qualities (bactericide and virulicide conditions).

Figure VIII sums up the average results obtained on the main physical-chemical parameters. Further to the influence of pre-ozonization, it should also be mentioned that post-ozonization reduces the concentration of the various measured parameters, although it is not its primary purpose. This phenomenon is very clearly demonstrated in the case of phenols, detergents and chloroformic extracts.

Finally, experience has shown that some biological activity takes place even in the sand filter, and that in addition to nitrification, an initial stage of denitrification takes place in the activated carbon filter.

The water plant of La Chapelle is also a very good example of the recycling of residual ozone from the breathers. In fact, after diffusion through the porous tubes in the post-ozonization columns as well as in the second unit of pre-ozonization, ozone is recovered and injected in the raw water by means of a turbine contained in the first unit of pre-ozonization, thereby reducing ozone losses to a minimum.

This example offers a double interest in terms of ozonization as the conditions of ozone application take into account both essential factors, namely efficiency and economy.

CONCLUSIONS

Although brief and non exhaustive, this review of the various uses of ozone in the treatment of drinking water was meant to highlight the rôle played by this technique which is advancing at great strides. While it is difficult to generalize its applications - each case beeing a case by itself - some basic concepts can however be drawn as shown in Table IV. For instance, ozonization when used for its direct effects is placed at the head and/or at the end of the treatment line. On the contrary, when its purpose is to improve an existing technique, ozone can only be input at the head or in the middle of the water purification process.

In addition to the advances achieved in the treatment per se - some very recently - it is only fair to underscore the improvements which are continuously brought to the technology of ozonizers. On the other hand, resort to microprocessors made it possible to achieve full automation of the production system and ozonization treatment so as to cope with all variations in water quality and quantity.

Ozone is used in most countries of the world and is particularly adapted to developping countries. As a matter of fact, as it can be produced locally it does not require any procurement, storage or handling efforts, whereby all related contingencies are eliminated. Finally, its synthesis only requires air, water and energy : therefore, the use of ozone is made possible and even advantageous in the most inaccessible regions where treatment by ozone can play a major rôle due to its efficiency and dependability, two basic criteria in such remote areas.

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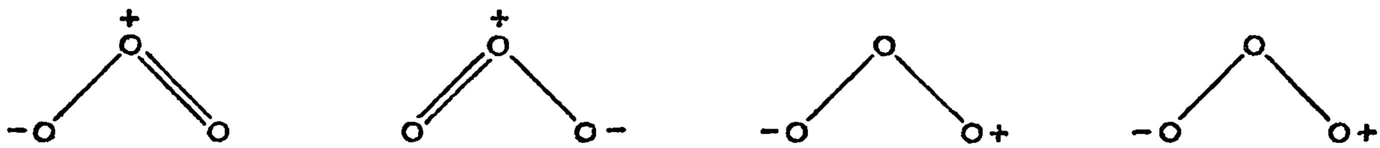
o O o

OZONE

$$O_3$$

$$3\ O_2 \rightleftharpoons 2\ O_3$$



PHYSICAL CONSTANTS	
MOLECULAR WEIGHT	47.9982 g/g.mol
CRITICAL TEMPERATURE	– 12.1 °=C
CRITICAL PRESSURE	54.6 atm
GAS DENSITY (0°=C, 760 mm pressure)	2.144 g/liter
HEAT OF FORMATION (25°=C)	–34.4 Kg cal/mol
DISTRIBUTION FACTOR (Water/air, 25°=C)	0.24
DISTRIBUTION FACTOR (Water/air, 20°=C)	0.29
DISTRIBUTION FACTOR (Water/air, 0°=C)	0.49
OXIDATION POTENTIAL (in water)	2.07 volts

TABLE I

GENERALITIES ABOUT OZONE

CONCENTRATION		
C	OZONE CONCENTRATION IN GAS ($g\ O_3/Nm^3$, % by weight, % by volume)	
RO_3	OZONE CONCENTRATION IN WATER ($g\ O_3/m^3$, $mg\ O_3/l$)	
TIME		
TD	OZONE DISSOLUTION TIME (h, mn, s)	
TC	OZONE CONTACT TIME (h, mn, s)	
QUANTITY		
TT	OZONE TREATMENT RATE ($mg\ O_3/l$, $g\ O_3/m^3$)	
TTr	EFFECTIVE OZONE TREATMENT RATE ($mg\ O_3/l$, $g\ O_3/m^3$)	
DIFFUSION		
T	OZONE DISSOLUTION EFFICIENCY (%)	

TABLE II

MAIN PARAMETERS OF OZONIZATION

WATER SOURCES / DOSAGES	RAW WATER	PRE-OZONIZED RAW WATER (0.4 mgO_3/l)	TREATED WATER	TREATED WATER WITH PRE-OZONIZATION
TURBIDITY (Mastic drops)	37	34 (8.1)	0	0 (0)
C.O.D (mg/l)	20.5	15.4 (24.9)	14.4	11.8 (18.1)
B.O.D (mg/l)	8	6 (25)	3	3.5 (-14.3)
MANGANESE (mg/l)	0.045	0.043 (4.4)	0.031	0.024 (22.6)
ANIONIC DETERGENTS (mg/l DBS)	0.312	0.232 (25.6)	0.043	0.023 (46.5)
TOTAL COLIFORMS (by 100 ml)	24 000	18 000 (25)	12	8 (33.3)
E. COLI (by 100 ml)	4 400	2 800 (36.4)	0	0 (0)
FAECAL STREPTOCOCCI (by 100 ml)	2 350	500 (78.7)	0	0 (0)
CLOSTRIDIUM S.R. (by 100 ml)	1 660	1 200 (27.7)	0	0 (0)

( ) : Percent removal due to pre-ozonization

TABLE III

PRE-OZONIZATION INFLUENCE ON RIVER SEINE WATER QUALITY

(From C.G.E - Setude)

STORAGE AND OZONIZATION RESULTS ON A RIVER WATER (From C.G.E / Setude)

TABLE IV a : Ozone treatment rate = 1.25 mgO_3/l b : Ozone treatment rate = 2.5 mgO_3/l

EXPERIMENTATION NUMBER		CHLORINE DOSE FOR BREAKPOINT ($mgcl_2/l$)		OZONE TREATMENT RATE FOR DISINFECTION (mgO_3/l)	
		Δ_1	Δ_2	Δ_1	Δ_2
1	a	- 0.1	+ 1.5	+ 0.2	+ 2.4
	b	+ 0.1	+ 3.2	+ 0.2	+ 1.5
2	a	+ 3.4	+ 3.6	+ 0.5	- 0.1
	b	+ 3.1	+ 3.2	+ 0.5	- 0.1
3	a	+ 1.5	+ 5	0	+ 0.4
	b	+ 1.5	+ 5.5	+ 0.5	+ 0.2
4	a	+ 0.8	+ 4.3	+ 0.1	0
	b	+ 0.9	+ 4.8	+ 0.1	0
5	a	0	+ 0.9	+ 0.5	+ 1.6
	b	+ 1.3	+ 3	+ 1.2	+ 1.7
5	a	+ 0.7	+ 3.6	+ 0.6	+ 2.4
	b	+ 0.7	+ 3.4	+ 0.9	+ 0.6
7	a	- 0.5	+ 0.5	+ 0.8	- 0.9
	b	- 0.8	+ 0.1	+ 1.1	- 0.7
6	a	+ 0.5	- 2.1	- 0.1	- 1
	b	+ 0.9	+ 0.5	+ 0.3	- 0.5
9	a	+ 0.1	- 0.4	0	- 0.4
	b	+ 0.8		+ 0.8	+ 0.1
AVERAGE	a	+ 0.389	+ 1.877	+ 0.289	+ 0.489
	b	+ 0.944	+ 2.711	+ 0.622	+ 0.311

Δ_1 = Treatment doses differences between waters from "ozonization + storage" and "storage"
Δ_2 = " " " " " " "ozonization + storage" and "ozonization"

WAY OF OZONIZATION		PLACE IN THE TREATMENT PROCESS	PURPOSE
SIMPLE		First step	Oxidization
		Last step	Disinfection (and oxidization)
COMBINED	+ storage	First step	Oxidization and oxygenation
	+ filtration	At the beginning	Oxidization
	+ floculation	At the beginning	Oxidization
	+ biological filtration	At the beginning or in the middle	Oxidization and oxygenation

TABLE V

MAIN APPLICATIONS OF OZONE IN DRINKING WATER TREATMENTS

6e20

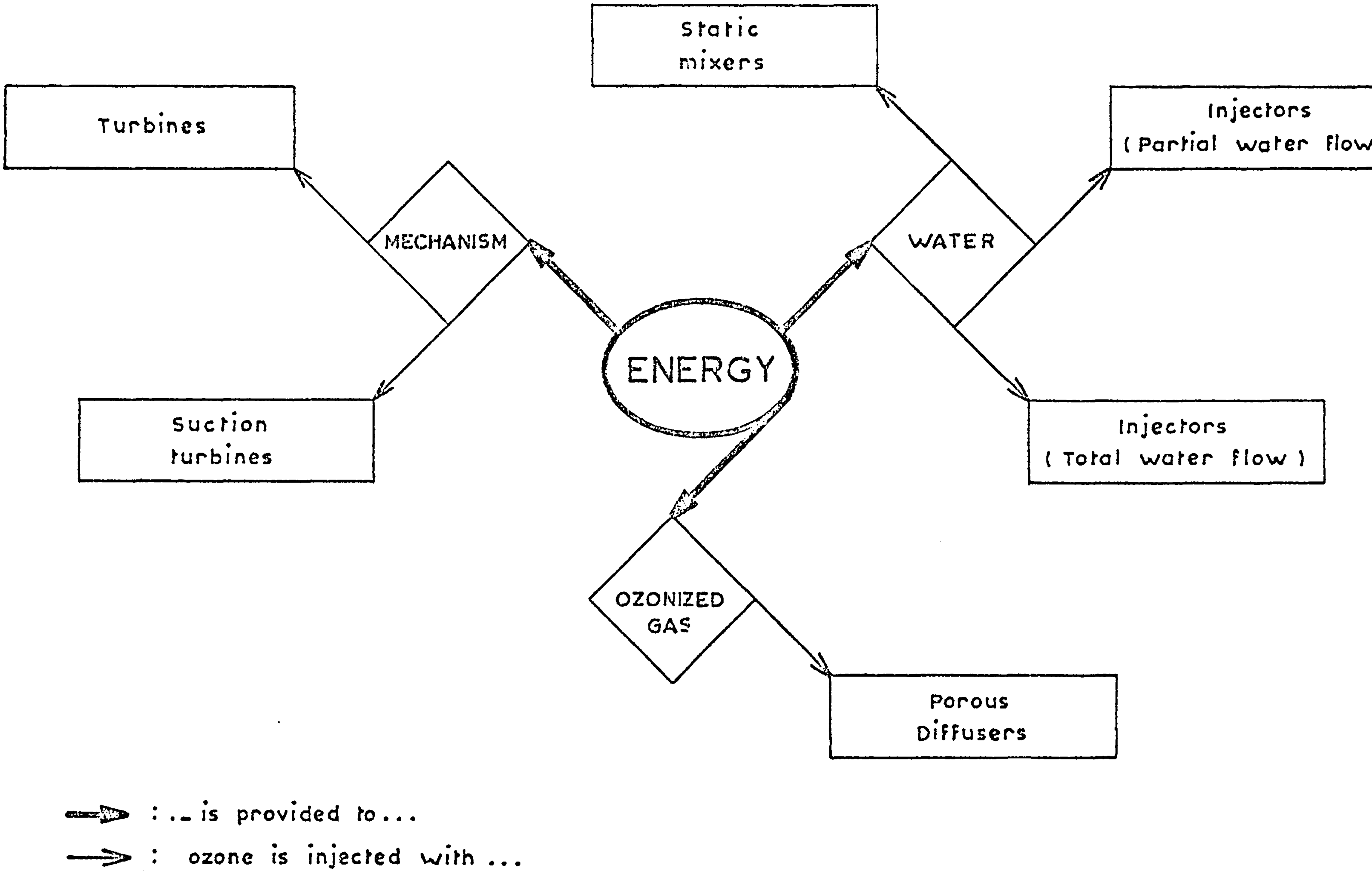


FIGURE I

MOST IMPORTANT DIFFUSION SYSTEMS FOR OZONIZATION

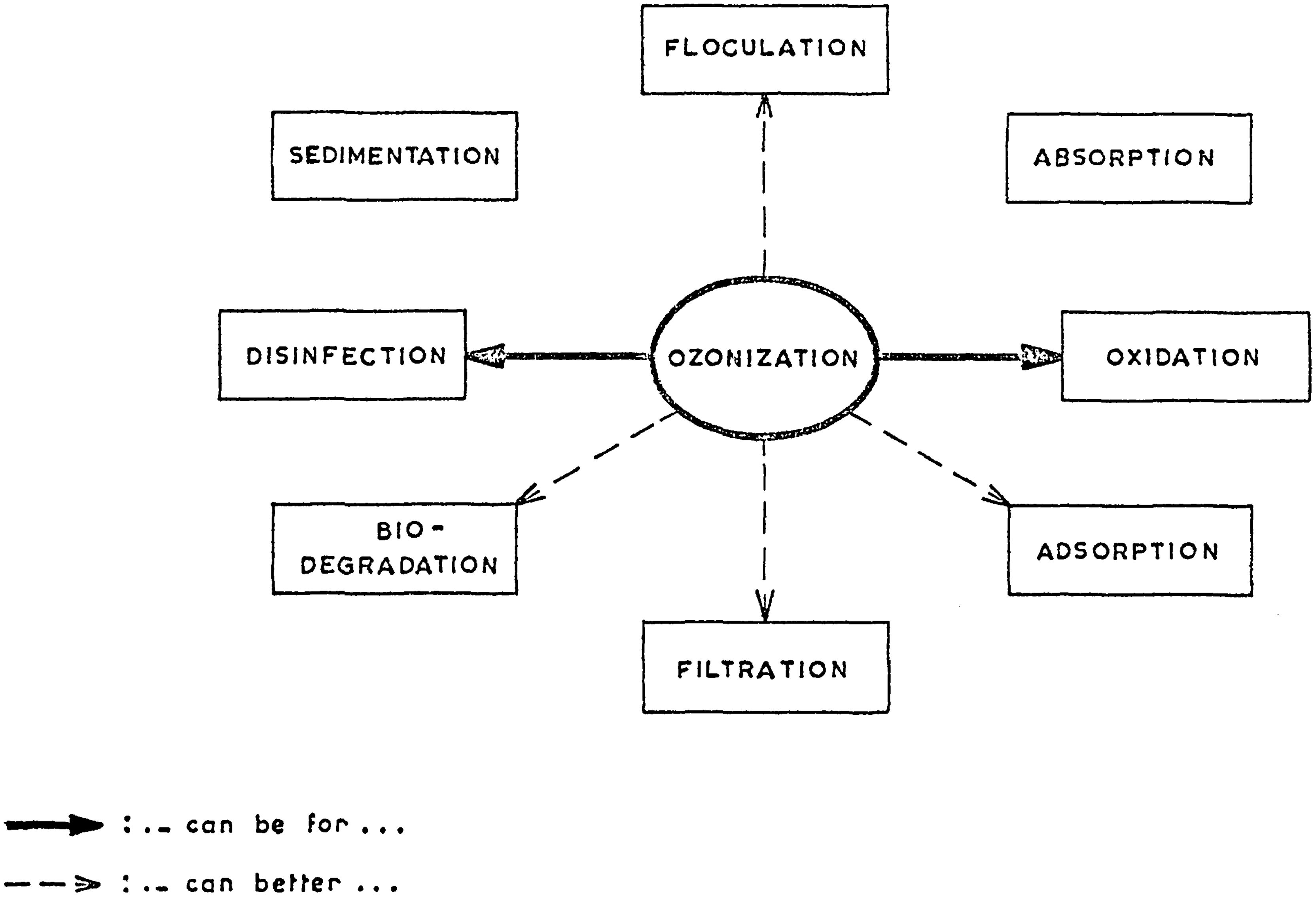
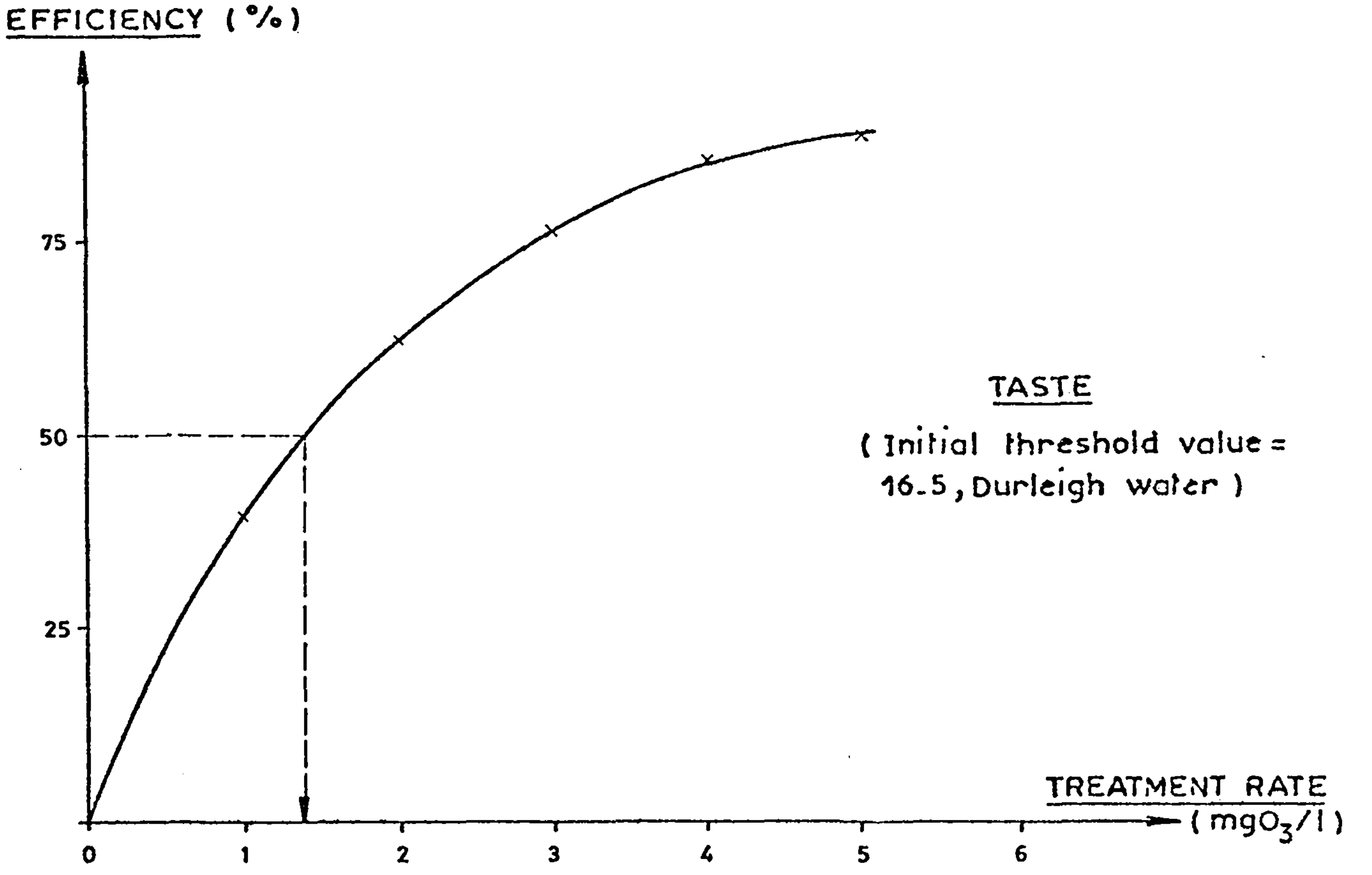


FIGURE II

OZONIZATION AND DIFFERENT REACTION STEPS IN WATER TREATMENT

6e22



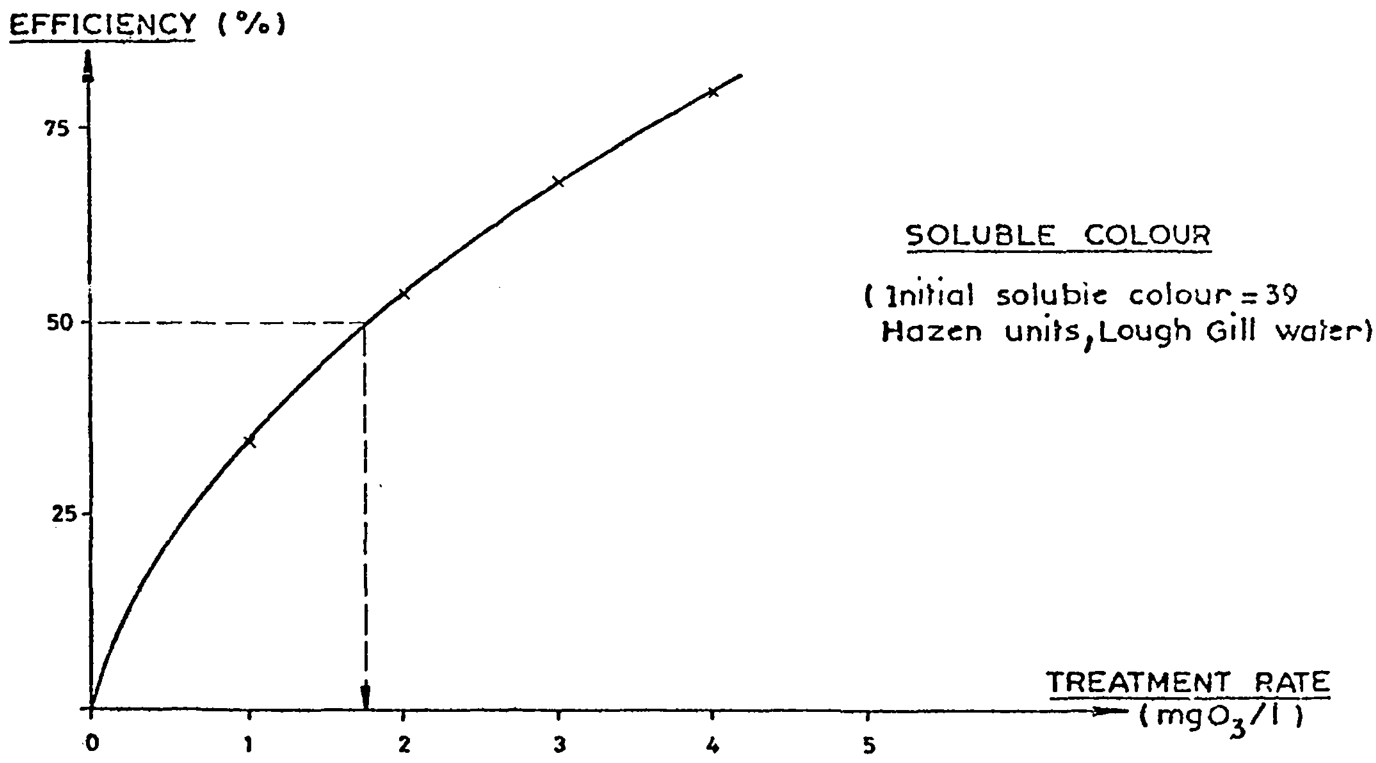


FIGURE III

OZONE INFLUENCE ON TASTE AND SOLUBLE COLOUR REMOVAL

(From Barker and Palmer)

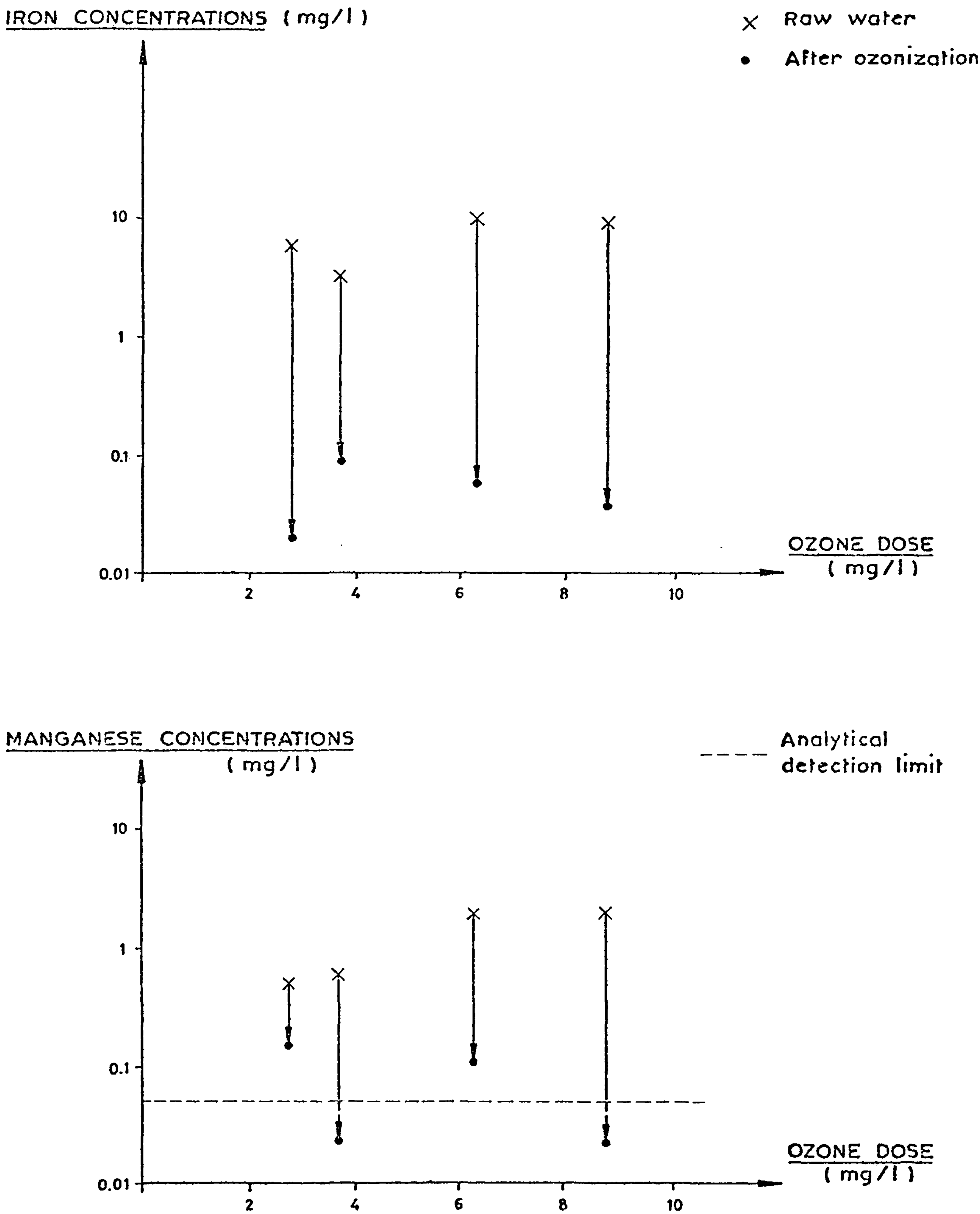
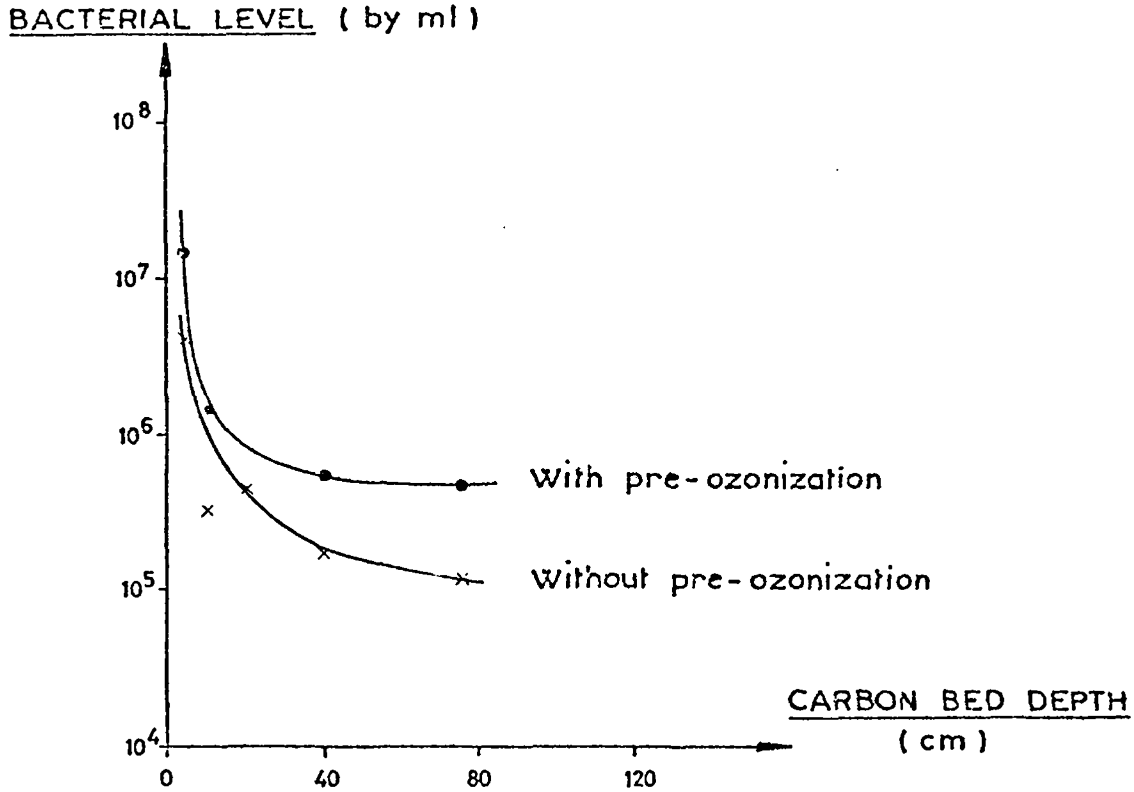


FIGURE IV

REMOVAL OF IRON AND MANGANESE IN WELL WATERS BY USE OF OZONE (From Furgason and O. Day)



BACTERIAL LEVELS IN OPERATING CARBON FILTERS
(From Benedek)

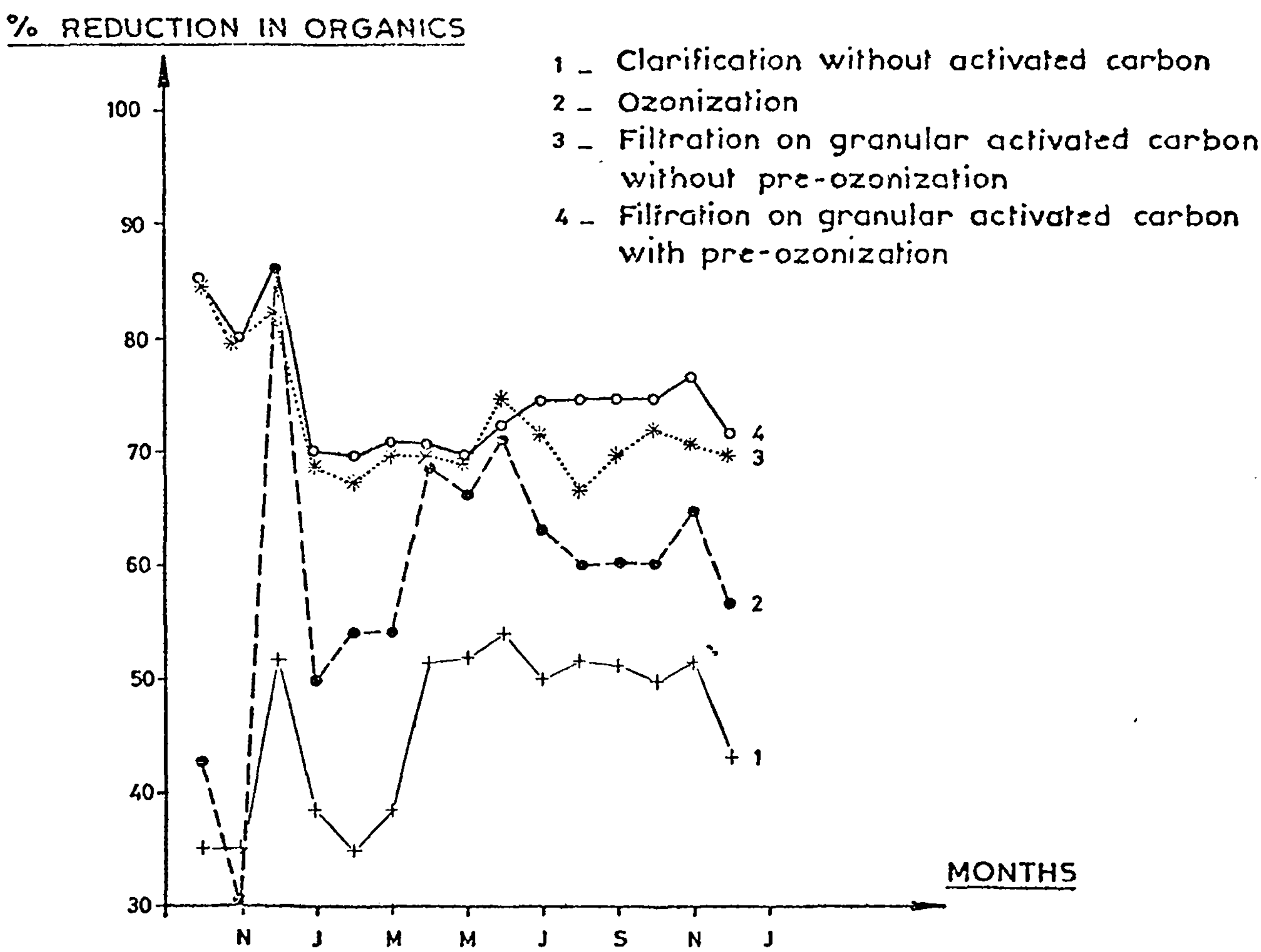
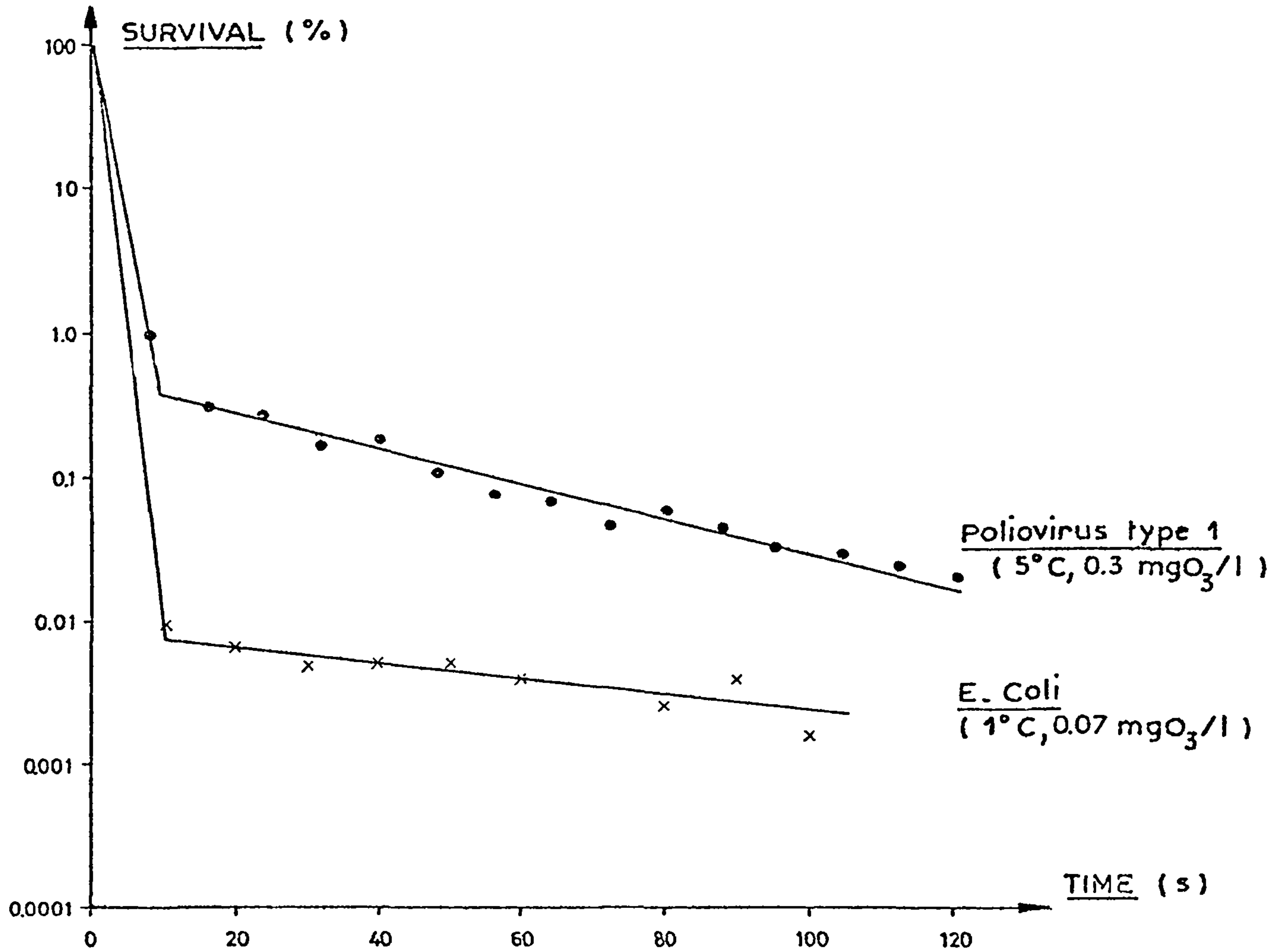


FIGURE V

REMOVAL OF ORGANIC MATERIAL (From Benedek)



INACTIVATION KINETICS BY USE OF OZONE
(From Katzenelson Kletter and Shuval)

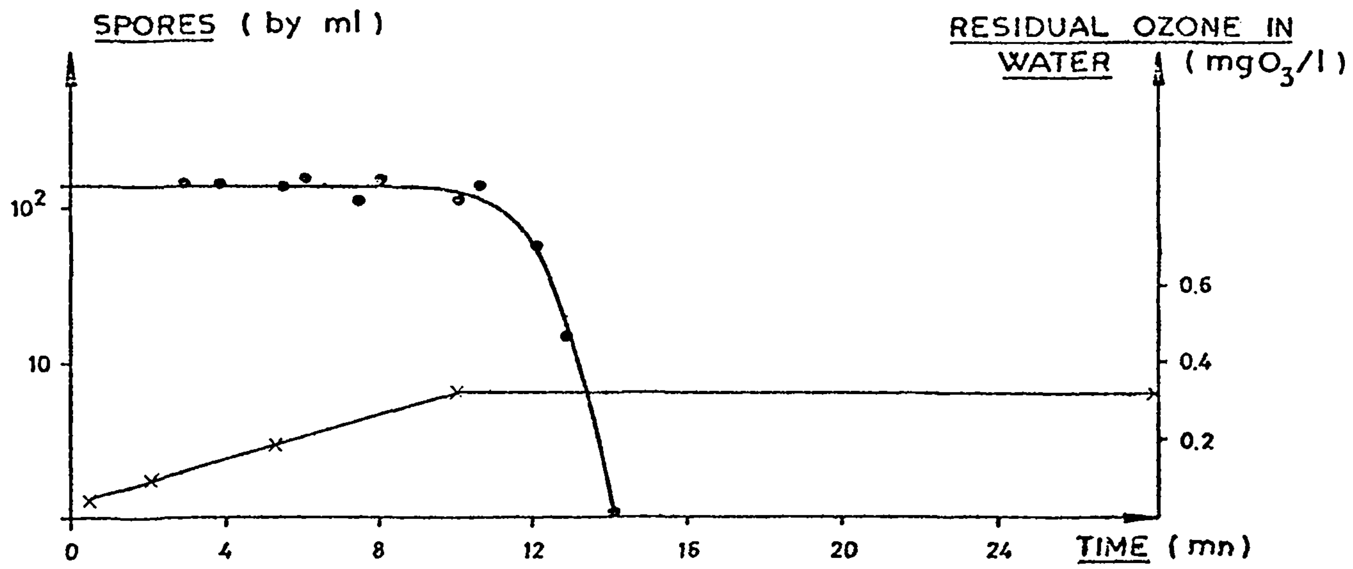
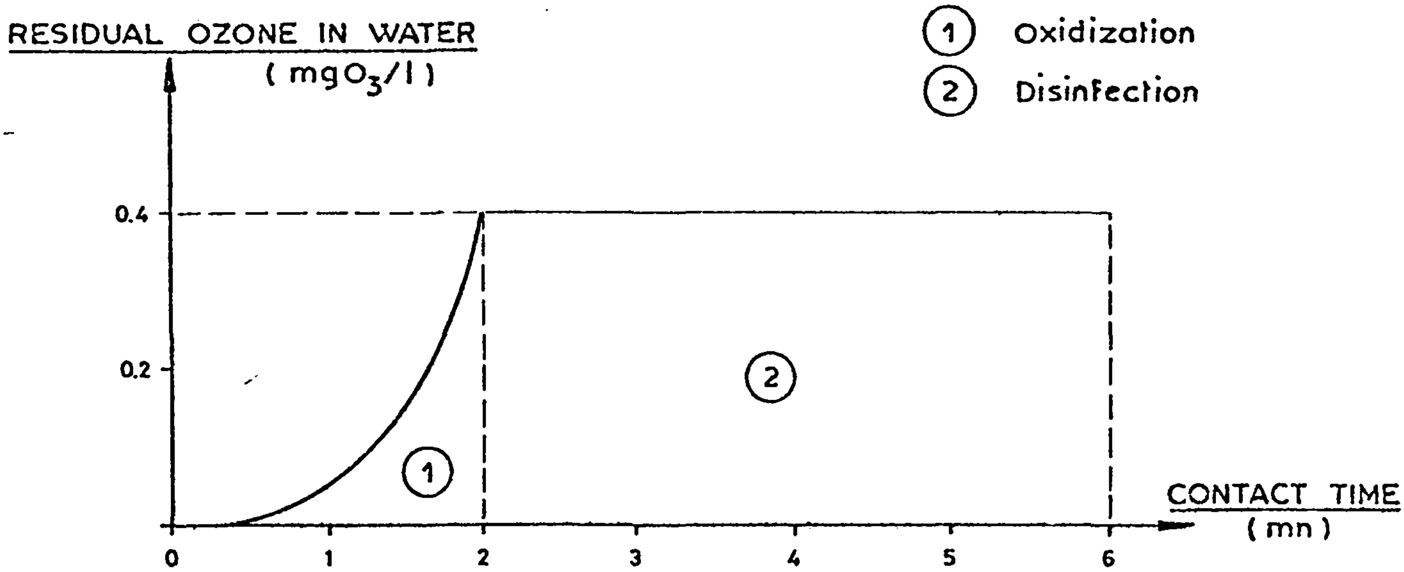


FIGURE VI

INACTIVATION AS A FUNCTION OF TIME AND RESIDUAL OZONE IN WATER
(From Drapeau and Paquin)



TRUE OZONIZATION CONDITIONS IN WATER TREATMENT

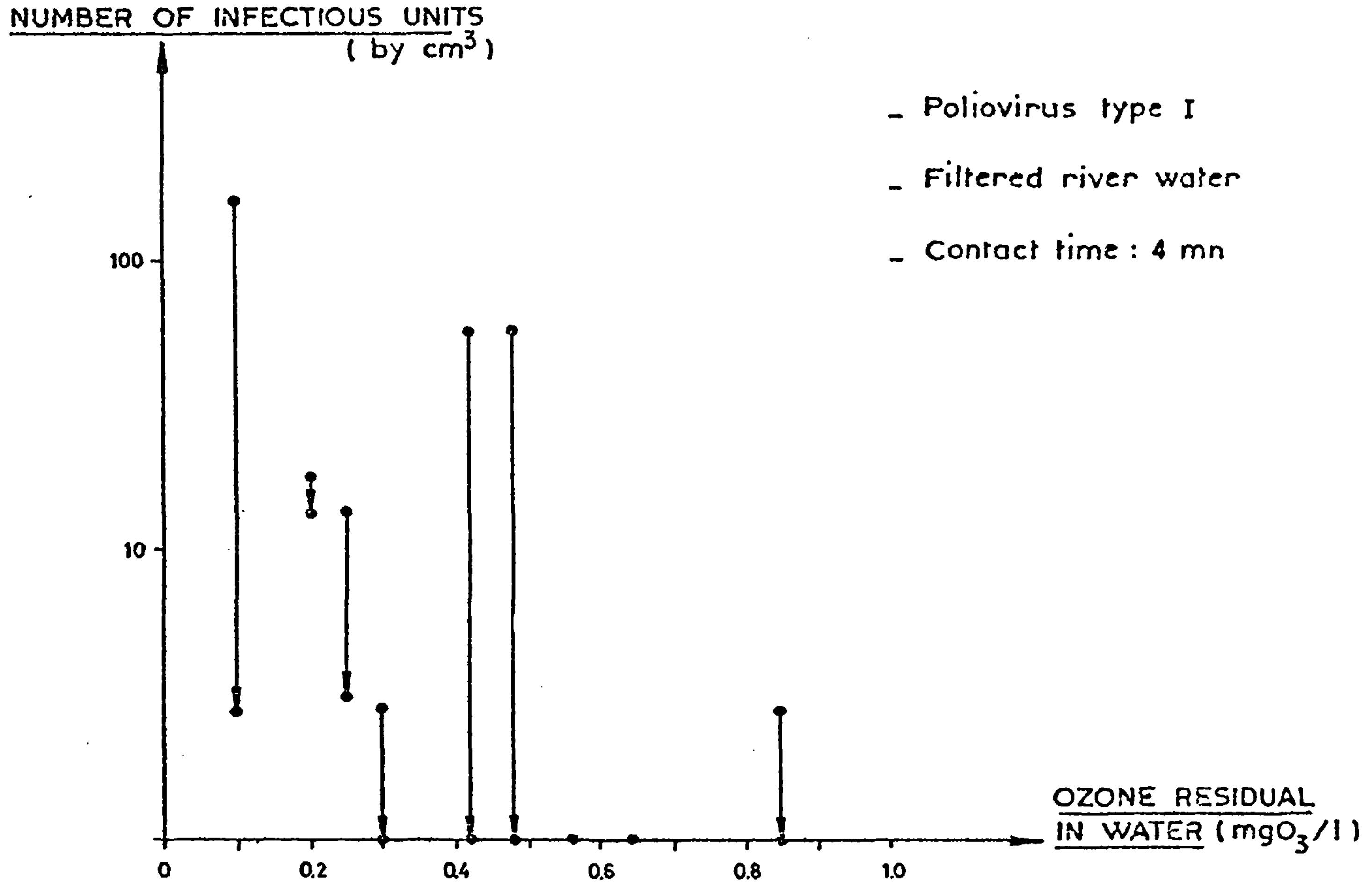


FIGURE VII

POLIOVIRUS INACTIVATION BY USE OF OZONE

(From Coin, Hannoun and Gomella)

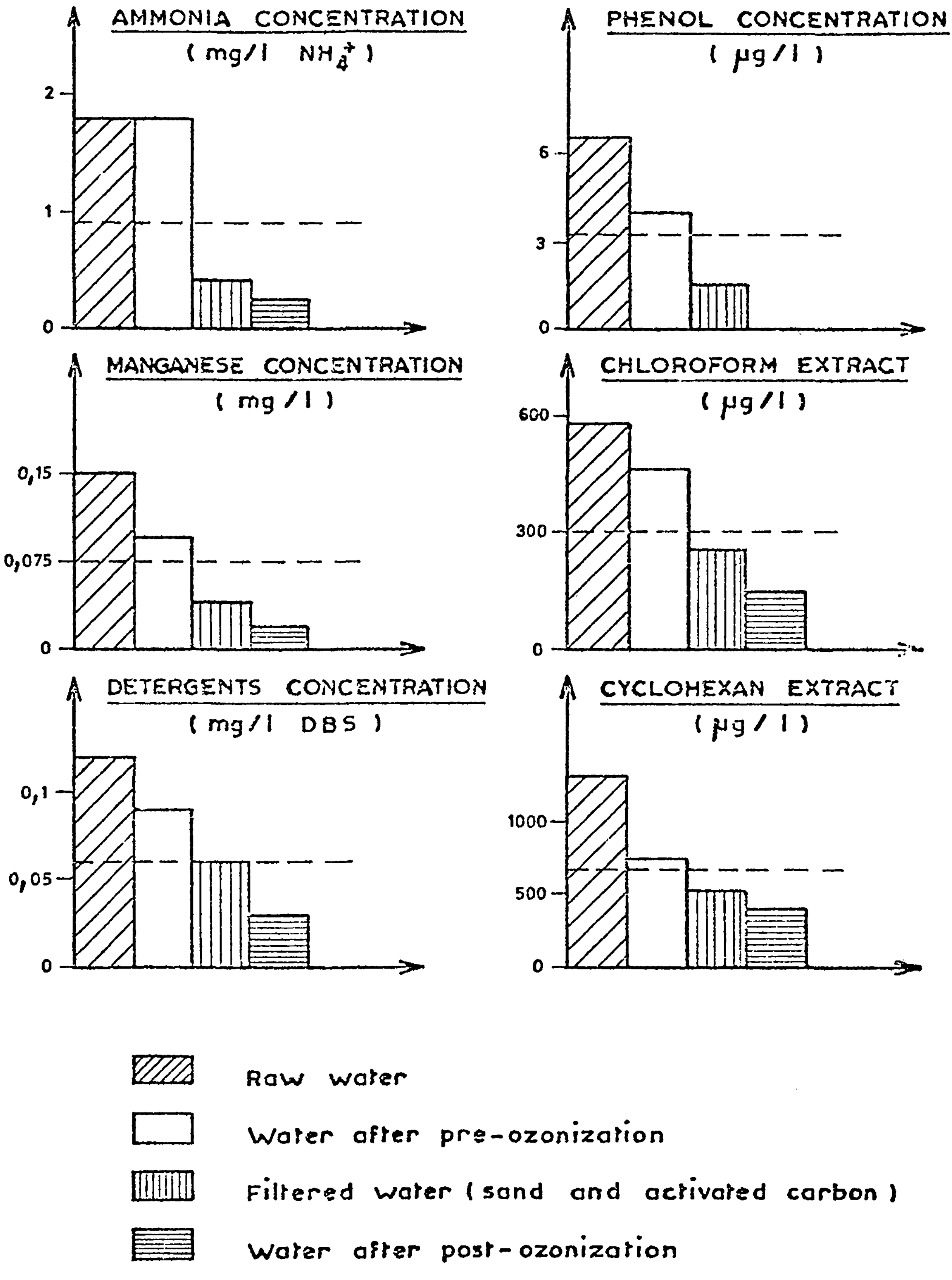


FIGURE VIII

DATA FROM LA CHAPELLE TREATMENT PLANT (FRANCE) (From Gomella and Versanne)

Paper 6f

"Industrial Water Supply and Water Quality"

by Hidenori Aya, Associate Professor, University of Tokyo
and Munenobu Nakao, Executive Director, Japan Industrial Water Association

Summary

Public industrial water supply works are unique and highly developed system, contributed to rapid growth of economics in Japan. A third of industrial water demand is supplied by them. Ground subsidences were controlled by the developments of the works. The works supply cheap and adequate quality water for manufactures.

Adaptation of branched distribution pipe lines, requirements of lesser water quality and smaller operational costs contributes cheap supply costs and economic activities. Usual practices of treatment for surface water are chemical sedimentation only. Less chemical demand and solid waste discharge are advantages to common drinking water treatment practices.

The authors will present some brief status of industrial water works in Japan and discuss on water treatment practices and water qualities.

1. HISTORY OF INDUSTRIAL WATER SUPPLY WORKS IN JAPAN

Industrial water supply works [IWSW] in Japan are unique in the world and reasonable systems which are regimented and planned to supply required amount of water for manufactures reasonably and constantly by the local governments utilizing water resources reasonably, under the circumstances of the demands of efficient utilizations of water resources to support the rapid growth of industrial activities.

Industrial water is used for many purposes, about 70% is for cooling water. So, usually there are no needs of considerations of hygience problems such as drinking water treatment, but there are demands of bigger quantitiy and the lowest costs as possible than potable water works.

According to these requirements, in the process of rapid industrial growth, IWSW's were borned separated from potable water works since 1930s. In the years of low industrial activities, manufactures obtained water from the near-by rivers or undergound by their own facilities. As the demands of water increased at the industrialized areas, private water intakes became difficult by shortages of surface water resources, excess pumpages of ground water and water right problems between irrigational water. At 1935, a n industrial water corporation was established by the supports of customers commenced to supply at Niigata, which was the first typical IWSW. At 1937, the first public IWSW was developed at Kawasaki City, followed by Shizuoka Prefecture, at 1939, planned at Akita City and Matsuyama City.

After the World War Second, the Japanese Government planned reconstruction programs, since 1952, to recover from economic chaos by means of developing industries, especially heavy chemical industires, succeeding rapid increase of productions at main industrial areas. At these areas, convenient nearby water sources being already consumed, evident severe water resources short-ages compeled them to obtain water from sources of long distance. To solve the problems of the new water sources, such as land uses, water rights, environments, water transports and funds of developments, public IWSW which are believed most reasonable and economical began to be planned and developed at heavy industrizlized areas.

To support such projects, the National Government registrated the Industrial Water Law in 1956, regulating excess ground water pumpages at the ground subsidence areas and supplementing industrial water demands to be replaced by means of promoting developments of IWSW with governmental financial aids for local governments. The aids of national government were extended for the new industrial area then, resulted the Industrial Water Supply Law in 1958, and promotions of IWSW to all main industrial areas in our country.

2. IWSW IN THE NATIONAL ECONOMICS

Being industrialized country, the healthy growth of industries is the necessity for Japan to support stable growth of economics and living standards of people. Water supply is essential to maintain and expand product of industries. IWSW are developed as fundamental facilities of regional developments and as control facilities for excess pumpage of ground water to meet those requirements. About 200 works are in operation. At 1975, total industrial water intake is 46,000,000 cu. m. per day, IWSW supplies 1,240,000 cu. m. per day that is about 27% of the above figure. Since the proposal of rapid industrialization policy at 1955, by the double income scheme, the Pacific Coastal Belt DevelopingProject and by the National Development Plan, New Industrial City Plan and Regional Industrial Developing Scheme were in action. These projects expanded further to Large Scale Industrial Base Schemes by the New National Development Plan. IWSW supported those plans to come true, realized big coastal industrial areas and promoted rapid growth of economy of Japan.

IWSW are in development at 66 places and in planning stage at several areas. By the long term projection of national industrial water demands and supply plan, at 1985, demands of fresh industrial water will be 68,000,000 cu. m. per day, of which IWSW will be 30,000,000 cu. m. per•day. IWSW is going to supply 44% of fresh industrial water demands. Future fresh water supply must depend upon IWSW in Japan. IWSW is aparantly essential works in further development of Japanese economy.

The works of IWSW as preventive facilities of ground subsidence and saline water intrusion into aquifers are great importance. Until now, 15 IWSW were developed to replace excess ground water pumpage in the areas of ground water troubles with successful performances. Actually in those areas, ground water levels are raising rapidly and subsidences of ground stopped or remarkably slowed down, enabling to maintain production or increase of further industrial development.

3. SUPPLY SYSTEMS OF IWSW

IWSW are the systems to supply water of adequate quality and of sufficient amount for manufactures with minimum costs. Requirements for IWSW have several different features from common potable water works.

1] Less and different requirements of water qualities;
2] Number of customers is smaller than potable water works;
3] All customers are big consumers;
4] Large portion of customers have their own storage tanks or treatment plants.

Less water quality requirements introduce simpler treatment systems or sometimes raw water supply. Small number of customers requires simpler distribution net works. Big consumers mean high efficiency of distribution systems. Storage tanks of customers reduce peak of demands and result smaller distribution pipes.

General outlines of supply systems of IWSW are same to common potable water works--intake, transport, water treatment [with waste water disposal], reservoir and distribution. But, design requirements are different in many features.

At 1976, Japan Industrial Water Association [JIWA] published a design standard of IWSW. The differences with potable water works are presented in Table 1.

Table 1: Design Standard of IWSW and Potable Water Works

	IWSW	Potable Works
Design Drought Flow	2nd Drought in 10 Years	Once 10 years
Water Quality	Contract with Customers	Drinking Water Criteria
Treatment Plant		
Plain Sedimentation Tank	Min. Detention Time 4 hr.	
Floculation Tank	Min. Detention Time 20 min.	
Chemical Sedimentation Tank	Min. Detention Time 2 hr.	
Reservoir	Min. Capacity 30 min.	
Distribution Pipe	Daily Maximum	Peak Flow
Minimum Pressure [kg/cm^2]	0.5	15

Once a drough in 5 years means smaller construction costs of water resources developments. Water quality can be determined with customers who prefer cheaper water if tolerable.

Distribution costs are small. Unit length of pipe lines per unit amount of water is about 20 times of potable water works. Number of employees to supply the same amount of water is only 12%. Many IWSW are designed on the base of maximum daily flow and contract with customers to supply by constant flow with surcharge for excess flow rate. This system requires installations of recieving reservoirs to the customers, but reduces the capacity of distribution reservoirs and pipe lines of IWSW and costs also. Of course some distribution flow variation will remain. Capacity of 2∿4 hours for distribution reservoirs are recommended.

Smaller minimum pressure requirement enables adoptation of cheaper low grade pipes, such as reinforced concrete pipe. Application of prestressed concrete pipe is possible for distribution because of no corporation taps installations.

Semi-constant flow and low pressure distribution systems of IWSW anable not only low costs water distribution but reduction of energy consumption evidently. Simple water treatment systems reduce costs and energy consumption also. Average supply costs are less than 20% of potable water works.

Design practices of IWSW are unique and independently developed in Japan by particular considerations to reduce industrial water supply costs and to meet rapid growth of industries. Low construction costs of IWSW require less investment with bigger quantity of water supplyed and reduce duration of construction.

4. WATER QUALITY REQUIREMENT

High quality water needs expensive water treatment. Manufactures can adopt various grades of water quality suitable to specific purposes. High pressure steam boilers demand the highest pure quality water. But, for general purpose in the plants, there are no needs of pure water which is sometimes very corrosive. Demands of pure water are small comparing to the amount of cooling water or other process water and are better to be produce from lesser quality water.

Industrial water quality requirements are very difficult to determine. Cooling water is generally recycled by cooling pond or tower, and recycling water is usually very dirty. Pulp and paper mills can be operated with rather polluted water. But food industries need potable grade water. Most manufactures concern disolved mineral contents, such as chloride and hardness, then organic pollutant. Disolved mineral contents are the cause of corrosion or scale in recycling water.

But, the allowable contents are obscure, because comes of those troubles can be prevented by careful selection of materials, use of inhibitors and water treatment. Even saline water is adopted for cooling at major power plants and manufactures. JIWA studies extensively on quality problems of IWSW and published the recommended standard of water quality for industrial water supply, which is shown in Table 2.

Table 2: Recommended Standard of Water Quality for Industrial Water Supply [JIWA, 1971]

	Unit		
Turbidity		20	[Caoline Standard]
pH		6.5∼8.0	
Alkalinity	mg/ℓ	75	[as $CaCO_3$]
Total Hardness	"	120	"
Residual	"	250	
Chloride	"	80	
Fe	"	0.3	
Mn	"	0.2	

Usually, ground water of confined and unconfined aquifer meets standard and do not need treatment, with occasional exceptions by Fe and Mn contents. Water quality of river water, in Japan, is very good, average quality well below the standard. In storm weather, high turbidity occurs at many major sources, exceeding turbidity standard.

Usually, each IWSW set their own standards as the one of conditions of supply contracts with customers. Common practices are not to mention of disolved mineral contents which are specific to their water sources and are to propose criteria on temperature, T.U., pH, Fe and Mn. The lowest T.U. criteria is 5 units, the highest is 30 units. Common criteria is between 10 to 15 units.

Average raw river water qualities are below the criteria for the duration of about 70% in a year. For the short period of high turbidity, water treatment plants are provided. Several IWSW supply raw river water directly without treatment.

Current rapid urbanizations are increasing pollution of surface water to increase troubles of slime and corrosion at customers and evern at IWSW.

The customers who receive industrial water treat or do not treat further to meet their water quality requirements. It seems that only small portion or receiving water is treated further and remaining portion is utilized directly for many purposes. It is evident that lesser quality criteria than drinking water is reasonable and meets fundamental conception of low costs water supply to promote industrial activities.

5. WATER TREATMENT PLANT

Common practices of water treatment plants of IWSE are screening, grit removal and sedimentation, without filtration. Since there are no hygienic requirements, chlorination is adopted only to remove Fe and Mn or to control slime growth in the treatment plants and distribution facilities.

A few works are provided with plain sedimentation tanks, of which water sources are rather excellent. Major practices are chemical sedimentation with high rate sedimentation tanks or horizontal current tanks. High rate tanks seem to be obsolete. They have advantages of small area requirement. But they need continuous coagulant dosage to operate, which are not necessary at low turbidity period. Current practices are sloping plate sedimentation tanks which can save plant site and can operate safely without coagulant. Sloping plate tanks, of which several types are now in market, are more flexible in tank design than tube settlers. Some variations of those instruments are developed, in Japan, such as sloping plate with baffle and hexagonal tube.

Treatment plants for sewage reuse are provided with chemical sedimentation, rapid sand filtration and pre- and post- chlorination of which purpose is slime control.

Coagulants are liquid alum, PAC and organic polymers in case of high turbidity as coagulation aid. Solid alum is used seldom because of difficulty of handling. Crude alum containing iron salt is the cheapest coagulant and also effective, but not widespread use.

Recent plants are considerably automated to reduce operational personnels. Almost of all treatment plants are provided with sludge treatments facilities by the water pollution regulation. Sludge treatment systems are of variety from simple drying bed to freeze and thawing. Recent interests are concentrated to utilization of sludge as resources for agricultural usages or construction materials, some of them in practice.

The biggest advantage of low water quality supply is saving of chemicals. In low turbidity period, raw water can be supplied directly to customers. Even in case of excess turbidity, full plant coagulation is not necessary, treating raw water by the some parts of plant and produced water being mixed with raw water to meet quality criteria.

Small chemical requirement contributes for easy sludge treatment. Solid of raw water is carried out of plant, as the turbidity of effluent, to customers. Sludge from plain sedimentation is compact and easy to be dewatered. Chemical sludge which is difficult to treat is produced for short duration with large volume, occupying large portion of annual sludge production.

To treat sludge by mechanical mean, storing of raw sludge must be provided. High rate sedimentation tanks produce low solid concentration sludge and can not hold excess sludge by the need of control of solid concentration in the tank. While conventional or sloping plate tank can hold sludge for some duration, enabling maximum capacity of sludge treatment plant smaller.

Treatment of polluted surface water demands large chemical dosage and produces large amount of low concentration and high organic concentration sludge which is difficult to treat and dispose. In general, water treatment plant of IWSW is simple plant, easy to operate and produce less sludge that is easy to treat.

6. CURRENT STATUS OF IWSW

IWSW promoted and supported industrialization and rapid economic growth of Japan. But recent slowdowned economic growth, IWSW meet some problems. Rapid increase of supply costs of new works comes from high costs of water resources development and low efficiency of distribution, since new service areas being rather dispersed industrialization. Intended customers delay their plants construction, resulting unsold water to remain.

In the circumstance of recent severe pollution control regulation, manufactures became very conscious of their water use. Saving of process water and efficient raw material consumption control were found to reduce pollutant discharge and save production costs.

Intensive water recirculation and cascade application reduce waste water discharge and consequently cut down fresh water demand. The Government and JIWA promote "reasonable water use of industrial water" scheme to reduce ground water pumpage and to utilize precious water resources effectively. Reasonable water use scheme has been so successful that demands of old IWSW are declining.

Decrease of income of IWSW is embrassing. They are seeking for new demands such as non-potable consumption by dual supply system for big buildings and housings. But neither are promising, because of new customers being small consumers. Non-potable dual systems for domestic usages will be one of the answers certainly. Regretfully their supply costs are estimated very high.

Advantage of IWSW of low costs will be lost. IWSW are flexible systems and can be applied variety of water sources. At 1978, Kita Kyushu area was suffered severe drought. Kita Khyshy City IWSW, of which raw water is river water, blended reclaimed sewage to 36% into distribution main and successfully saved fresh raw water. Similar procedures can be applied in emergency.

7. CONCLUSION

Industrial water supply works are public works to support industrial activities and legional development. IWSW contributed very much to the rapid growth of Japan.

IWSW have following features:

Low water quality and simple distribution systems result low cost water supply. High efficiency and cheap distribution, energy and resources saving, simple water treatment, less solid waste discharge, ease of solid waste disposal, etc.

Development of IWSW are still continue. But their costs are increasing and efficiency decreasing. Decline of demand is results of reasonable industrial use policy which is resources saving and has merit of pollution reduction.

In spite of some problems, the authors believe that IWSW are good systems and have further possibilities.

# # #

Paper 7a

Session by the Committee on Co-operation in Development

The Jakarta-Amsterdam Co-operation in the Field of Water Supply

by Mr. P. Haverkamp Begemann (Netherlands)

JAKARTA-AMSTERDAM CO-OPERATION

1. How the Co-operation was initiated.
2. How the Co-operation was implemented
3. What results have been accomplished
4. In what way can IWSA assist in this type of Co-operation?

---

1. How the Co-operation was initiated

In April 1972 a delegation from Amsterdam headed by the Mayor of Amsterdam, Dr. IVO SAMKALDEN, paid a visit to Jakarta. The delegation consisted of representatives of private enterprises and civil servants of the municipality of Amsterdam. The governor of Jakarta, Mr. ALI SADIKIN and the Mayor of Amsterdam agreed to continue the good relationship between the two capitals and to strengthen the co-operation, as part of the activities in this field by the respective governments of Indonesia and the Netherlands and subject to the approval of these governments.

In October 1972 a fact finding visit was paid to Amsterdam by a delegation from Jakarta, consisting of 3 persons, i.e. the Chief Executive of Municipal Planning Board, Mr. Piek Mulyadi, head of Governors' Bureau, Mr. Wardiman and Mr. Bun Yamin Ramto, director of Public Works.

During this one-week visit numerous consultations and meetings took place, as well as visits to various departments of Public Works, and Municipal Water Works and the City Administration Organisation.

As the field of co-operation the following municipal activities were recommended for exchange of experience and knowledge:

(i) Public Works

a. civil technical laboratory
b. soil mechanics
c. underground structures
d. technical aspects of high rise buildings
e. sewage and drainage

(ii) Town Planning

a. detailed planning
b. development problems especially in relation to high rise buildings and high density of population
c. land management
d. site preparation of new development areas
e. cartography and filing system of maps and planning documents
f. building control

(iii) Water Supply

a. organisation and management of a municipal water supply
b. distribution system
c. water resources and water treatment
d. quality control of drinking water
e. water pollution

(iv) Restoration of Historical Buildings

a. techniques of restoration
b. laws and bye-laws concerning restoration
c. management and maintenance of historical buildings
d. organisation of tourism as regards historical buildings

(v) Other subjects of interest

a. parks and landscaping
b. garbage disposal
c. fire brigade
d. computer centre
e. city administration (population registration, statistics, etc. etc.)

2. How the Co-operation was implemented

Agreement was reached with the Directorate of Technical Assistance of the Ministry of Co-operation in Development (part of the Dutch Ministry of Foreign Affairs) that financial aid would be given out of the funds which the Dutch Government allocated yearly for assistance to the Indonesian Nation.

The Indonesian Government had the final say in the matter as in the yearly meetings between senior civil servants of the two nations the programme of aid is initiated and submitted by the Indonesian representatives.

The cities of Jakarta and Amsterdam took it upon themselves to pay for salaries of their own civil servants involved in the Jakarta-Amsterdam Co-operation (in short: Jakams). The financial aid by the Dutch Government covered travelling expenses and subsistence allowance only. The advantage of this approach to the financial side of a co-operation of this nature is obvious. Travelling expenses and daily subsistence allowances come to about 1/3 rd of the actual costs involved. With an aid budget of 300.000 guilders yearly 900.000 guilders of real aid can be given. Basically civil servants from Amsterdam would stay 6 weeks in Jakarta, while civil servants from Jakarta would stay 3 months in Amsterdam.

Each year a programme was made for the following year. This programme was submitted for approval in Jakarta to the Central Government and in the Hague to the Directorate of Technical Assistance. After approval the actual implementation could start.

The ratio between Indonesians in Amsterdam and Amsterdam civil servants in Jakarta was about 2 : 1. Yearly about 25-30 civil servants in total participated. The organisation was looked after by a secretariat, consisting of Mr. Wardiman in Jakarta and 2 senior engineers in Amsterdam, one of whom is myself.

The Indonesian participants of this exchange have to have a basic knowledge of English. A certificate to prove this is part of the procedure necessary to obtain approval by the Dutch Government to get an entry visa and to be eligible for a grant (a so-called fellowship).

The Indonesian "trainees" travel - preferably - in a group. For many participants it means a first visit to a country with a historical background of culture and religion, completely different from their own background. In view of this a consultant was appointed by the municipality of Amsterdam who once a fortnight in briefings dealt with this subject in group discussion.

3. What results have been accomplished?

In the field of Public Works and Town Planning road construction and road maintenance have received much attention. In this field assistance in the setting up of a material laboratory and the operation of same has been given.

Building Control regulations have been drawn up in Jakarta with the assistance of experts from Amsterdam.

The so-called "sea sand" project, where sea sand would be reclaimed and used for the necessary heightening of existing low-lying land to make it usable for building projects, both for industrials and for houses, received much attention.

In the field of City Management exchange on information on Archives and Documentation has had remarkable success and has been instrumental in the setting up of a Jakarta Archives and Documentation Service. A building was constructed and the Service is developing well.

In the field of Parks and Gardens the start of the Jakams Co-operation co-incided with the formation of a separate Parks and Gardens Division in Jakarta. Exchange of personnel has brought about a good base from where this Division can tackle the overall development of Jakarta Parks and Gardens.

In the field of Restoration Service much benefit has derived from the assistance of "Monumentenzorg" to pay attention to the upkeep of old monuments in Jakarta, including old buildings and whole parts of old Jakarta.

In the field of Data Processing the Jakarta Government has taken great strides towards an effective registration of their subjects, their taxes, payment for water rates, vehicle taxes, business licences, social security benefits, etc etc. Exchange of information in this field has been most fruitful.

Multi project planning has been a subject of intensive exchange of knowledge.

Fire Brigade activities. In a city like Jakarta with a high number of people per square km. good functioning of a fire brigade is a must. Anyone who has seen the after effects of a kampong-fire can confirm this. The co-operation between the fire brigade of Jakarta and Amsterdam covered fire fighting in kampongs and in high rise buildings, as well as general tuition in fire fighting. As a result of the Jakams Co-operation the D.K.I. Jakarta built a fire fighting school, where circa 100 persons can be taught. The Central Government has made this school into a national school.

With the help of the Dutch Government some laboratory equipment has been supplied. The school is an example of co-operation, with a lot of good results.

Water Supply

The water supply of Jakarta started in 1873, when three artesian wells were established in Parapattan, Batoe Toelis and Glodok Old. Depth of bore holes was about 140 m. In 1916 some 23 artesian wells were established. The production of each individual well had a tendency to decrease, whilst the head of delivery diminished as well. In 1917 a well-water supply system was designed. The well water was to be collected near Bogor (300 l/sec) and to be transported to Jakarta. The most important reason for this proposal was a financial one. Apparently the water from Bogor was cheaper than the water pumped in Jakarta out of wells which had been artesian originally but which needed pumping now.

In 1922 the well water supply was completed, and this is still in use! After World War II, two modern surface water cleaning drinking water supply factories have been built at Pejompongan (Jakarta). Capacity is 5000 l/sec. (jointly). A Japanese Consulting Engineering firm made in 1972 a master plan for Jakarta water supply to the year 2000.

Some parts of the town developed so rapidly that the P.A.M. decided to build so-called miniplants (capacity 100 l/sec). The Amsterdam Water Supply Company made a design, which was worked out in detail by a civil consulting engineering firm in Jakarta and a Dutch manufacturing firm in Holland. The P.A.M. was co-ordinator and the P.A.M. could - whenever wanted - fall back on the expertise of the sister company in Amsterdam.

Over the years this 100 l/sec plant was increased to a 200 l/sec plant, with the possibility to increase this capacity to 400 l/sec. Furthermore, advice was given on the construction of a central lime dosing plant.

In the field of groundwater-winning assistance has been given to motorise some of the watermills.

Laboratory and production plant personnel have been to Holland to get training.

Groundwater management is becoming more and more important, especially as for some kampong improvement projects new deep-well pumps are being contemplated.

It is essential to have a detailed insight in this matter and in both subjects Amsterdam is trying to assist.

Disinfection and leakage control are also matters of concern. In March this year a hydrogeologist and a technologist will be travelling to Jakarta to give their views on the ground water balance and on the present purification steps. Network planning of the distribution pipework is also important.

On the subject of the organisation of the P.A.M. itself many discussions have taken place and advice is continuously given.

4. In what way can IWSA assist in this type of co-operation?

It is apparent that the IWSA has enormous possibilities to offer assistance in the field of co-operation between water supply companies and/or water supply organisations around the globe.

- it can promote the establishment of bilateral co-operation between these water supply enterprises.
- it can provide assistance to identify suitable persons for international assignments.
- it can form committees or compile IWSA documentation to develop technical manuals and guidelines.
- it can form a Databank from where prospective clients can draw relevant information they require.
- it can offer non-aligned objective assistance.
- it can be instrumental in obtaining financial assistance from international agencies.

Recently the Committee on Co-operation in Development applied for financial assistance from the World Bank for a twinning project, consisting of 3 twinning operations. An amount of 190.000 US$ yearly is involved.

The IWSA should not infringe on the working territory of the Consulting Engineers. It should work as a "Katalysator", so that water supply organisations in developing countries know that what they intend to order or what they most likely will get is what they need - nothing less, nothing more.

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