proceedings of the national symposium on

Wastewater Disposal

held in april 1975

INSTITUTE OF
PUBLIC HEALTH ENGINEERING
AND RESEARCH
UNIVERSITY OF ENGINEERING & TECHNOLOGY LAHORE PAKISTAN

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FOREWORD

The National Symposium on Wastewater Disposal was organized by the Institute of Public Health Engineering and Research at the University of Engineering and Technology, Lahore. It was held on 17 April 1975. This followed the National Symposium on Public Water Supplies in Pakistan organized earlier by the Institute in November 1973. The success of these Symposia was made possible by the co-operation extended to the Institute by the Public Health Engineering Departments in the Provinces, autonomous agencies of Karachi Development Authority, Capital Development Authority, Lahore Development Authority and the Pakistan Society of Public Health Engineers as well as by the personnel of World Health Organization based in Pakistan. The attendance at the Symposium was representative of the public health engineering profession in the country. In this connection Prof. Dr. M. Islam Sheikh, Vice-Chancellor of the University in his brief address of welcome made a specific mention of the presence of many distinguished delegates in the Symposium who had rendered valuable services in promoting the cause of public health engineering in the country. Besides, medical profession industries government planning agencies universities research organizations and others interested in the field of Wastewater Disposal were well represented. The nine Papers published in this volume represent those selected by the Symposium Preparatory and Organizing Committee which places on record the appreciation for the co-operation given by the authors of the Papers.

I wish to acknowledge my debt to a number of people who greatly influenced the success which the Symposium attained at the national level. In particular I profited from the continued advice of the Vice-Chancellor Professor Dr. M. Islam Sheikh. I am indebted to Dr. K. M. Yao WHO Sanitary Engineer for his active interest and helpful suggestions. It would be unfair not to mention the names of the members of the Organizing Committee on whose unstinted support and sustained efforts I particularly relied. With apologies to all those I have probably overlooked, they include Javed Anwar Aziz, Khadim Hussain Ziai, Mohsin Raza Ali, Asrarul Haq, Mushtaq Ahmad, Khurshid Ahmad and Mohammad Ibrahim. The financial assistance rendered in connection with programme arrangements by Packages Limited, Asbestos Cement Industries Limited and Bata Company is gratefully acknowledged.

Lahore
4 August 1975

DR. MOHAMMAD NAWAZ TARIQ
Chairman
Preparatory and Organizing Committee.

PROGRAMME OF THE SYMPOSIUM

INAUGURAL SESSION

0830	Reception and Registration
0900	Arrival of the Chief Guest
0905	Recitation from the Holy Quran
0920	Keynote Address
1000	Break for Refreshments

TECHNICAL SESSION I

Chairman of Technical Session I
Mohammad Fazil Qureshi
Chief Engineer
Public Health Engineering Department
Punjab Lahore

1030	A Review of Peshawar Sewerage and Drainage Scheme
1045	Survey of Sewerage Facilities in Baluchistan
1100	Outlook for Municipal Wastewater Treatment and Disposal for Greater Lahore
1115	Health Aspects of Wastewater Disposal
1130	Wastewater Disposal in Karachi
1145	Discussion
1245	Break for Refreshments

TECHNICAL SESSION II

Chairman of Technical Session II
Aminul Islam
Chief Engineer
Karachi Development Authority
Karachi

1315	Industrial Wastewater Disposal in the Punjab
1330	Maintenance of Municipal Sewerage Systems
1345	Oxidation Pond Research
1400	Mosquito Breeding in Oxidation Ponds
1415	Wastewater Disposal for Pakarab Fertilizers Multan
1430	Discussion

EXHIBITION ON ENVIRONMENT

Venue:
Institute of Public Health Engineering and Research Lahore

FILMS ON POLLUTION

Courtesy American Centre Lahore

KEYNOTE ADDRESS

DR. MOHAMMAD NAWAZ TARIQ
Director and Professor
Institute of Public Health
Engineering and Research, Lahore

Dr. Arif, Worthy Vice-Chancellor, delegates, ladies and gentlemen. Today the size of the available fresh water resource determines to a considerable extent the rates of growth of towns and industry. It also has a decisive impact on the health of the people. In essence it is the basis of our survival. Its development and utilization have consequently challenged man's resourcefulness and ingenuity for centuries. However, accelerating use of this resource has concurrently given rise to the problems of its spoilage. Lakes, streams, underground aquifers and other in-shore waters as well as the sea are now being extensively used to dispose of polluting substances such as sewage, infectious agents, nutrients, synthetic organic chemicals (such as pesticides), industrial pollutants, sediments, radioactive materials and heat. In an attempt to focus attention on the serious problems created by uncontrolled municipal and industrial discharges onto land and into streams the Institute of Public Health Engineering and Research has organized this symposium. The provincial and national organizations actively interested in the environmental health sector, notably the Pakistan Society of Public Health Engineers, gave their willing co-operation in arranging it. It comes at a time when growing concern for environmental degradation is attracting attention of the government and the need for providing basic sanitary services is urgently being felt. In the context of such situation, the symposium brings together eminent persons belonging to engineering, medical and scientific fields on a common platform with other citizens whose effective participation in problems of vital importance largely depends upon timely and adequate information made available from such forums. An informed public, I believe, can influence the availability of technical solutions to these problems.

A wastewater disposal system consists of sewers and a wastewater treatment plant. The sewers collect the wastewater from domestic, commercial and industrial areas and deliver it to the plant for treatment to make it fit for discharge into streams or for reuse. In providing an economical and efficient wastewater disposal system to a community the existing status of municipal water supply, the stage of industrial and economic development, demographic growth and financial requirements are all factors of considerable importance. In discussing them I consider it timely to point out that provision of water supply to a community should go hand in hand with wastewater disposal facilities. This being so because in our planning strategy provision of sanitary sewerage has generally lagged behind the provision of water supplies, and likewise wastewater treatment has lagged behind the introduction of proper sewer systems. Repetition of such mistakes should be avoided. Demographically the growth of population and exodus of rural population into urban centres have both resulted in substandard human settlements where people live without adequate sanitary facilities especially the wastewater disposal systems. The unplanned and uncontrolled development of fringe areas also poses very serious health hazards. In the industrial sector as a result of the rapid development and expansion of industry, the problem of satisfactory disposal of industrial wastes is increasingly assuming serious proportions. Major industrial units in Pakistan needing immediate attention in effluent disposal are textile, chemical, tannery, food and fertilizers. They are known to have neither any adequate arrangements for wastewater treatment nor effluent disposal systems. Future industrial expansion and increasing energy use both from conventional and nuclear sources are certain to accentuate the problems of industrial wastewaters.

Wastewaters from households is an important part of the overall problem. Pakistan is predominantly an agricultural country and has a high proportion of rural population. The water carriage system of excreta disposal which is almost universal in western countries is restricted in usage to the larger towns and cities here. Even in these cities and towns, not all the population is served by sewers. In most of the towns in Pakistan the sewerage system is either non-existent or not at all adequate for the population. In the villages even latrines, wet or dry, are scarce. With a view to quantify the domestic wastewater problem in Pakistan an approximate analysis is presented. Pakistan's present population is 64.89 million (provisional estimate 1972 census). About 20 per cent of this population is known to live in urban areas, amounting to 13 million persons. Out of total towns and cities in the country 15 major cities, having a combined population of 9.92 million, are known to have been partially provided with sewerage. Assuming that less than fifty per cent of this urban population has access to some form of wastewater collection systems or to sewerage, the percentage of country's total population which is so served amounts to less than 7 per cent. The types of domestic wastewaters in Pakistan consist of sewage and sullage, the latter being wastweater excluding faecal matter. Based on assumptions concerning per capita figures for water supply it is estimated that the sewered and unsewered population in urban section produces 229 million gallons of sewage plus sullage every day. Similarly the volume of sullage from rural section amounts to 207 million gallons every day. The problem of domestic wastewater collection in financial terms is thus enormous and so is the effort needed to solve it.

In the area of wastewater treatment the problem should be viewed in terms of local conditions rather than those encountered in developed countries where with the spread of protected water supply to the majority of the population and with the rivers flowing perennially, the major objective of sewage treatment is not to allow the dissolved oxygen in the stream to go below a certain limit. This is ensured in order to protect the fish and to prevent foul conditions from being generated in the streams. On the other hand, in countries like Pakistan where the protected water supply is still very limited, the wastewater treatment (especially domestic waste treatment) assumes a much greater importance. As a majority of the citizens depend upon shallow wells or surface water for drinking purposes, the contamination of these water sources through wastewater discharges will reflect on the health of the nation. Under the circumstances one of the important aspects of wastewater disposal here is the microbiological pollution which starts from human excreta and results in high incidence of water borne diseases. The situation is compounded by the seasonal nature of rainfall. During the dry season, the sewage or its effluents almost form the rivers from which the adjoining communities get their supply of drinking water (directly or from nearby wells) adding to the pollution recycle. As far as status of treatment and disposal is concerned, majority of the wastewater is being discharged into rivers or onto land with practically no treatment. A sizeable portion of the raw sewage is also used on land for crop irrigation which is not a sound practice. The few treatment plants which exist in the country have mostly not been working to their designed efficiencies, either because of poor design, or lack of maintenance, or lack of skilled operators. In this connection it is pointed-out that if sewage treatment plants are to work efficiently in developing countries like Pakistan, they should be of a simple design with little mechanisation and automation. Among the various treatment methods available, oxidation pond or its modifications, appear to be suitable. Research is, however, needed to establish their applicability.

A number of constraints, which are responsible for serious inadequacies of the wastewater disposal systems in the country, are recognised in this report. The basic problems are the lack of people with the necessary skills to design, construct, operate, and manage the systems and the difference between cost of the services and the ability of the communities to pay for them. The infrastructure required for the planning, implementation, management, administration and evaluation of national programmes for the provision of sanitary services needs considerable strengthening. I, therefore, take this opportunity to propose the following:—

1. Creation of Ministry of the Environment or establishment of the Office of Environmental Health Advisor to the Prime Minister to ensure integrated development so urgently needed in this area of our national endeavour.
2. Creation of Division of Environmental Engineering in the National Planning Commission to promote, co-ordinate and unify the various components of environmental health work performed by nation building departments and agencies.

3. Introduction of water pollution control legislation and establishment of necessary organisational set up for its effective enforcement at national and provincial levels.

4. Enactment of comprehensive legislation establishing public policies and responsibilities for specific governmental agencies including the delineation of inter-relationships between different levels of government and between agencies of governments for the provision of basic sanitary facilities, and provision for the financing of the functions.

5. Enactment of administrative and regulatory legislation.

6. Establishment of modern methods of organization and management to ensure both efficiency of operation and effectiveness in achieving the objectives of programmes.

7. Development of criteria and standards for the provision of basic sanitary facilities including guidelines, or codes of practice, for the planning, organization, implementation, operation, maintenance and surveillance of such facilities.

INAUGURAL ADDRESS

DR. A. ARIF
WHO Representative in Pakistan,
Islamabad.

It is my honour and privilege to be here as Chief Guest and it gives me great pleasure to greet with best wishes the Institute of Public Health Engineering Research on organizing National Symposium on Wastewater Disposal and welcome the distinguished participants and declare the Symposium open.

As you may be aware the Eastern Mediterranean Regional Office held a Seminar on Sanitation Problems of Rapid Urbanization about three and a half years ago at the University of Engineering and Technology here in Lahore. I am glad to see that this activity is being, in a sense followed up by the Institute of Public Health Engineering Research in organizing this symposium which appears timely and may prove quite useful to this country.

The expansion of public water supplies to which priority is often given naturally results in an increase in wastewater giving rise to problems in its disposal for which provision is not always made. Rapid urbanization and industrialization contributes to make the situation even worse. The problem is especially difficult in developing countries where the available resources are often limited.

For the present, it is worth noting that the World Health Organization has a number of programmes aimed at assisting member states in solving their wastewater disposal problems. For instance the Organization often undertakes pre-investment studies of sewerage and drainage schemes for major cities, organizes seminars and training courses in water pollution control, offers fellowships to engineers and scientists for advanced studies in various specializations and distributes technical booklets and bulletins of special interest. There is also a WHO reference centre in wastes disposal in Switzerland to provide an exchange of information and serve as a clearing house for wastewater disposal technology and distribution of relevant documentation which is at the disposal of member states. In general, special emphasis is laid by the Organization on helping member countries to develop national technical competence, so that problems in the country can be adequately dealt with by the country's own specialists. The Institute of Public Health Engineering and Research is the kind of institution which can shoulder a significant share of this task in Pakistan and certainly deserves our congratulations for their pioneering efforts by which they are showing the way for others to follow.

I am confident that this Symposium on Wastewater Disposal will provide you with the opportunity to discuss your common problems, take stock of what has been done in the field, identify areas where further efforts are needed and make appropriate recommendations.

I can also assure you that the World Health Organization is ready, within its possibilities and subject to the request of the Government, to support your efforts to promote the protection of the environment in Pakistan through adequate wastewater collection and disposal.

I wish you every success in your deliberations.

A REVIEW OF PESHAWAR SEWERAGE AND DRAINAGE SCHEME

ABDUL AZIZ KHAN
Executive Engineer
Public Health Engineering Department, Peshawar

Introduction

Work is currently in hand on a sewerage and drainage project for Peshawar which was planned and designed by the Consulting Engineers Parsons Corporation (USA). The writer was assigned to this project during planning and design stages.

In accordance with present financing arrangements the Provincial Government is providing funds to cover 2/3 of the capital cost—half of which is a grant and half is a loan; the Peshawar municipality is responsible for the remaining one-third (insofar as its area is concerned).

Due to the inability of the municipality to provide its contribution by due date the project implementation is now somewhat behind schedule.

The Problem

The first step was to define the problem; in essence this was that the existing drains and sewers in the city comprise a sewerage system which carry both sanitary and storm flows. The system, at best, only serves about 50% of the total population and even then is grossly inadequate and even a mild storm causes overflow and flooding.

No sewage treatment facilities exist and waste waters are discharged into Budni Nala North of the city.

The present water supply to Peshawar is similarly grossly inadequate and plans are well advanced for extensive augmentation works: once implemented such a project is clearly going to aggravate the waste disposal system.

While health statistics are meagre there is ample evidence to indicate an unduly high incidence of water and filthborne diseases in the area and unless corrective action is taken, by the introduction of adequate water and sewerage facilities the position will deteriorate further.

Description of the Area

The city of Peshawar is one of the oldest and most historic cities in Pakistan dating back as far as 400 A.D. Until recently the city was enclosed with a brick wall with twelve gates. Today much of the wall still remains but the city's area now extends far beyond the original "Walled City".

Within the Walled City are well planned masonry open drains built during the Moghal period; these are still in use (though grossly overloaded) and carry waste water from houses as well as storm run off during rains.

The population has shown appreciable growth since 1901 when the census figure was only 95,147. The 1972 census gave a figure of 273,000.

For the last decade it is perhaps pertinent to note that contrary to the global trend of migration from rural to urban areas the rural areas around Peshawar have had a growth rate somewhat larger than the urban area. This trend may continue as the older parts of the city are almost completely built-up and the cost of land in lesser developed urban areas is appreciably higher than in near-by areas.

Mean relative humidity during a day may vary between 30% to 81%.

Rainfall is slight and only averages about 15 inches a year, available records indicate a range of 6 inches to 26 inches per year.

Existing Facilities

The old walled city of Peshawar has a system of open drains aside the paved streets built during the Mughal period, discharging southwards into an earthen Channel leading to Budhni Nullah. Due to the old construction and lack of proper maintenance, the channel has lost capacity by silting up, which is aggravated by the dumping of solid refuse in the surface drains. In addition there are other channels terminating into fields and used for irrigation purposes.

The existing drains in the City area are open drains porous sections. These drains were constructed centuries back. The discharge from these drains is disposed off into a main drain known as Shahi Katha.

This main drain is also open and passes through the heart of the city, almost parallel to the famous Qissa Khawani Bazar. Most of the length of the drain has been illegally encroached and covered. Different solid refuses such as debries etc. are thrown in the drain, which has resulted in reduction of sections at various places. The open drains have thus become breeding centres of germs of various epidemic diseases.

The percentage of houses connected to this system is relatively small and other households use the dry carriage system.

No complete survey has been carried out but a study done by the consultants estimated that 70% of the population used the dry carriage system, 15% used the water carriage system while the final 15% has no latrine facilities.

The Solution

The solution is seen as the provision of a new sewerage system which would comprise separate sanitary sewers and storm drains except in the Walled City area where the buildings are so congested and access roads so narrow that laying a sanitary sewer is not at all feasible.

The construction works are planned for two phase implementation; phase I to provide facilities for the 1981 population while phase II would cover the foreseen needs upto 1991.

Phase I works will provide facilities for primary treatment of the sewage and these would be augmented under Phase II.

Consultant's Recommendations

The consultants recommendations are as under:

(*a*) *General:*

(*i*) Remove the accumulation of debries, household garbage and refuse which clog most of the drains and improve the maintenance system to ensure the drains can run free of obstructions.

(*ii*) New sewers should be of reinforced concrete while all open drains should be brick-lined.

(*iii*) The Phase I sewerage construction programme envisaged the completion of all design work by 1970, main sewers to be laid by 1973, Primary treatment facilities completed by 1975 while submains and laterals would be completed by 1976. Phase II: sewerage works would start in 1979 and be completed by 1983.

Under Phase I. Drainage Construction Programme: main drains to be constructed by 1972 and repairs to existing drains completed by 1974.

Phase II drainage works would start in 1977 and be completed by 1983.

The total cost of the project was estimated at Rs. 3,72,25,000.

(*b*) *Sanitary Sewage Flows:*

An assumption was made that the water facility would be augmented to provide an adequate service to all consumers. Projections of per capita daily water demands at the end of each phase, are shown in Table 1.

TABLE 1: Estimated Water Consumption for Peshawar

Year	Water Consumption/Gpd/Capita	
	Excluding Walled City	Walled City
1980	45 *	20
1991	50 *	20

*includes 5 gpd/capita for non domestic usage.

After reviewing the potential for house connections to the proposed sewers, it was projected that the position could be as shown in Table 2.

TABLE 2: Sewerage Service to Population

Year	Total Pop.	Population Served by Water Carriage System		Population Served by Dry-Carriage System	
	No.	%	No.	%	No.
1981	460,000	60	276,000	40	184,000
1991	710,000	80	568,000	20	142,000

Data on sewage flows is not currently maintained in Pakistan. The consultants, referred to data from outside Pakistan which indicated that 60-70% of water usage is normally reflected in the sewage flow the remainder being used for irrigation, vehicle washing, leakage etc. In their view situation in Peshawar was such that a sewage flow of 75% of water usage would be more appropriate in view of local conditions. This led to the conclusions.

TABLE 3: Sewage Contribution by Population Served by Water Carriage System.

Year	Population Served	Water Usage g.p.d.p.c.	Sewage Flow	
			gpdpc	Total mgd.
1.81	276,000	45	34	9.38
1991	568,000	50	38	21.60

Area still using the dry-carriage system will also make a contribution to the sewage flow by discharges from kitchens etc. This was projected as shown in Table 4.

TABLE 4: Sullage Contribution of Population Served by Dry Carriage System.

Year	Population Served	Water Usage g.p.c.p.d.	Sullage	
			gpcpd	Total mgd.
1981	1,84,000	20	18	3.31
1991	1,42,000	20	18	2.56

The combined sewage flows are computed in Table 5.

TABLE 5: Average Daily Flows

Year	Water Carriage System M.G.D.	Dry Carriage System M.G.D.	Average Daily Flow M.G.D.
9181	9.38	3.31	12.69
1991	21.60	2.56	24.16

In any sewer system infiltration of ground water through joints, and other openings can be expected; the volume of such infiltration will depend, to a large extent, on the height of the ground water table.

For parts of Peshawar the ground water table is very high and the areas are essentially "water-logged"; other areas are on relatively high ground where infiltration will be less.

With little reliable data to provide some refinement in the determination of the rates of infiltration, the consultants adopted a figure of 30,000 gallons per day per mile of sewer as applicable to the entire area. Total infiltration quantities are reported in Table 6.

TABLE 6: Infiltration Quantities

Year	Length of Sewer Miles	Infiltration g.p.d/mile of sewer	Total Infiltration Mgd.
1981	133	30,000	3.93
1991	296	30,000	8.88

There will obviously be variations throughout the day in the flow through the sewers. For 1981 the ratio of peak flow to average has been taken as 1.5:1 dropping to 1.4:1 by 1991 Table 7 summarizes the anticipated total flow variations:

TABLE 7: Anticipated Flows

Year	Av. daily flow mgd.	Peak to Av. ratio	Peak flow mgd.	Infiltration mgd.	Av. daily flow total mgd.	Peak flow total mgd.
1981	12.69	1.5	19.00	3.93	15.62	22.93
1991	24.16	1.4	33.80	8.88	33.04	42.68

The average daily flow is used for the determination of pumping and chemical costs, sludge solids, BOD load, cost of operation and of sewage treatment works.

The peak flow is used for the determination of the hydraulic capacity of the sewage treatment facilities, sewers and pumps.

(c) *Proposed Works:*

Due to the favourable ground slopes the entire sewer system can gravitate to the treatment works site, where however pumping facilities will be required.

Reinforced concrete pipes with an inert internal lining, were selected for the sewers as the more commonly used vitrified clay pipes are not manufactured locally and that the consultant's view was that asbestos cement pipes would be too prone to be attacked by hydrogen sulfide.

Phase I works envisage the laying of 133 miles of sewers of which 106 miles will be 6 inch diameter laterals and 27 miles would be of 12 inch to 45 inch diameter outfall sewer.

Phase II works will involve the laying of a further 163 miles of sewers of which 153 miles will be 6 inch diameter laterals and the remainder 10 miles being 15 inch to 24 inch main sewers.

The velocity in the sewers will not be less than 1.5 feet/sec (self-cleaning velocity).

The waste water treatment plant facilities for which final designs are not yet completed, will provide the conventional primary treatment involving wet and dry wells, screens, grit chambers, settling tanks sludge digestors, sludge drying beds, sewage and sludge pumping equipment, a laboratory and a staff quarter.

Oxidation ponds were considered but rejected on account of the high capital cost of land and possible treatment process problems which could arise with an erratic pH of the sewage.

Construction Detail

Work is currently in hand on a sewerage and drainage project, Phase-I which was planned by the firm of Consultant Parsons Corporation.

Short lengths of sewers have been laid in the past but these discharge into the open drains which eventually discharge the untreated wastes into Budni Nala.

While the full engineering details of the sewers and drains exist in the form of final drawings, no work on the engineering drawings for the sewage treatment plant has been initiated. The Walled City of Peshawar has been excluded from the sewerage project as the area is so congested that it is not considered feasible to serve the area with the system.

Financing Arrangement

For financing the project the funding is as under:—

1/3 Provincial Government grant;
1/3 Provincial Government loan; and
1/3 From municipal funds.

Expenditure commenced in the financial year 1963-64. The municipal committee Peshawar has paid 1.165 million rupees against the required contribution of 3.378 million rupees.

The inability of the local authorities to provide their share of the costs of the project is the cause of the protracted delays and, as far as can be ascertained, the prospect of the Peshawar municipality raising its contributions is not good. There is a clear need for a review of the project's financing arrangements.

The construction programme is now well behind schedule and no benefits have so far been derived from the sewerage element of the project; the drainage works have not yet started.

While houses within the municipal area have been permitted to connect to sewer which may have been laid, no charges are currently imposed; the sewerage facility hence generates not revenue but loan charges are accumulating.

The drainage system too generates no revenue to meet its loan charge obligations.

Discussion

The Author did not present the Paper in person and the discussion could not take place.

SURVEY OF SEWERAGE FACILITIES IN BALUCHISTAN

ITAAT HUSAIN
Chief Engineer
and Technical Advisor to Chief Minister
Government of Baluchistan
Quetta.

The province of Baluchistan comprises of arid and semi-arid lands extending over an area of 1,34,000 square miles. Its population was 24 lacs only according to 1972 census figures. It is the biggest province of Pakistan in area but smallest in population.

The lands of Baluchistan are mostly barren with rugged mountains and vast deserts. However there are a few fertile valleys with some ground water potential which is exploited by means of karezes, wells, springs or tube wells. Major part of its population is settled in these valleys. Total area of the province is roughly 90 million acres out of which only about 10% is culturable and has any prospect of water, either through rains, snow fall or ground water.

Rainfall in Baluchistan is very meagre; maximum average of 6" per annum occurring in the Northern parts only. In the North West it is as low as 2" near Nokkundi. Annual precipitation increases as we move east and north eastwards where high mountains ranges cris-cross the country. Here the annual average rainfall ranges between 8" & 16". But the mountains are barren and water from precipitation rushes down the steep gradients and erodes the fertile lands of the valleys. The flood water either goes to sea through coastal rivers or underground in closed valleys.

The province divides itself into four tracts:—

(*i*) Upper High lands.
(*ii*) Lower High lands.
(*iii*) Plains.
(*iv*) Deserts.

The upper high lands occupy the central and east central portion of the province. The lower high lands include the slopes of Suleman range in the East and Khirther range in the South along with Mekran and Chagai ranges in the West. The plains of Baluchistan include the flat triangular plan known as Kachi plain, the plains of Lasbela and Dasht river in Mekran. Deserts are situated in the North Western parts in Chagai and Kharan Districts.

Water has always played a very important role in the lives of the inhabitants of this region. In the past, entire tribes and families have moved from place to place in search of this most important element in nature. Consequently they lead an unsettled and nomadic life. A dominant feature of the life of the people is their nomadic way of life in which nearly one third of the population is involved.

Under these circumstances greater importance is given to the exploitation of water resources. Important cities and townships in the province are Quetta, Sibi, Pishin, Harnai, Usta Mohammad, Dhadar, Mach, Mastung, Kalat, Khuzdar, Bela, Uthal Turbat, Panjgur, Kharan, Nushki, Dalbandian, Loralai, Ziarat, Sanjawi, Dukki, Barkhan, ofortsandeman, Muslim Bagh and Gwadur. Government has already provided water supply to these towns.

Except Quetta there is no sewerage system in any of the above mentioned Town Committees. The refuse is so small in quantity that it would not be economical to provide a proper water born sewerage system. For example Loralai and Sibi are the biggest towns where daily 250,000 gallons of drinking water is supplied and if we assume a very high run off factor of 50% then only 125000 gallons per day will be available for treatment and then re-use for agricultural purposes, but this will be sufficient only for 30 to 50 acres fodder crops. Therefore it will not be economical to instal sewage treatment plants. Someone may suggest that in view of acute shortage of water why this water is not treated and re-used. The treatment will be uneconomical for this small quantity and also that the people will not use it and sufficient education will be required to make the people accept it.

Although the province has got an ambitious planning of water supply and sanitation but naturally water supply schemes are given higher priority.

There are 770 villages and towns which have got population more than 500 persons and this comprises about 80% of the population. Efforts are being made to supply water to all these 770 units within 5 years and so far only 40 units could be given water supply. This forms about 30% of the total population and 100% urban population. Foreign aid is being received for the rest of the work and it is hoped that the programme of water supply will be completed according to plan inspite of a big challenge of supplying water to nomadic population.

After water supply comes the priority of the Sewer System construction. It has got low priority for the following reasons:

(*i*) First water supply is to be arranged and if water is in excess of the demand only then sewer system can be constructed.

(*ii*) In the mountaineous regions the slopes are so steep that open drainage system is working satisfactorily and in plains the acute shortage of water does not justify sewerage schemes.

(*iii*) People are yet not aware of its benefits and therefore they don't demand it from the Government.

At present the stage of urbanization has not yet reached where such scheme could find a high priority in Provincial Annual Development Programme. It is quite easy, cheap and socially accepted process to drain the water into open fields from where the farmers collect the refuse if they like, and use it as manure.

There is only one sewerage scheme in Quetta. This scheme too was not constructed by the Quetta Municipality as they did not feel its necessaity. Actually in pre-partition days, Quetta being a cantonment, had a good number of foreign officers who felt the necessity and thus the present system was constructed in 1940 by M.E.S. It was meant exclusively for cantonment area, but later on the Civil Lines of the City was also connected with it and the arrangement is working. Thus Quetta City Wastewater is draining into Habib Nallah and Cantonment and Civil Lines is connected to a 24 inch Hume Pipe Sewer Line which leads to the Sewage Disposal Works. This is the conventional type of trickling filter plant consisting of grit chambers where grit is removed by hand, three settling tanks and trickling filter units, one digestion tank which remains inactive and a number of sludge beds.

This system was constructed in the year 1940 as mentioned above when the population was about 25,000 persons whereas now the Cantonment itself has over 500,000 persons and the city has got a population of 1,560,000 including Cantonment, therefore these works are over-loaded.

Keeping in view this inadequacy of the plant, Cantonment Board has framed a project which will now cost Rs. 30 lacs for upgrading the present works.

At the same time Quetta Municipality also became active and has appointed Indus Consulting Engineers to design a separate system for the city and the work is in hand. They shall soon be submitting their preliminary report.

Quetta is just in the foot of Murdar Mountains and in case of rains, the flood takes no time in reaching the city. While designing the sewerage and disposal system it will be an important point to keep this aspect in mind so that drainage of rain water is also made otherwise it will be an undue burden on the sewer system and frequent damage and choking will take place. In case the separate system is designed for the rains also then it will be very much expensive, therefore it is suggested that an earthen bund be proposed around the city which should divert the rain water to the Nullahs outside the city without entering it and city sewer system should be designed only for the rains falling within the diversion bund in the city. This will on one hand economize on the sewer lines and works and on the other hand it shall save the city from recurring floods.

Earlier there was a proposal to construct pit latrines throughout the province and aid was assured by W.H.O., but the scheme could not go ahead as in towns the work is already being done by the Municipal Committees and in the villages there is no dearth of barren lands. Therefore the present system does not warrant a massive construction of pit latrines. Also that facility will be arranged by rural works department whenever there is a need.

OUTLOOK FOR MUNICIPAL WASTEWATER TREATMENT AND DISPOSAL FOR GREATER LAHORE

NAZIR AHMAD
Project Director and General Manager
Lahore Development Authority
(Water Wing) Lahore.

Historical

Lahore is the second largest city of Pakistan having a population of about 2.5 million. It is a commercial and cultural centre and is famous for its hisotrical buildings of Moghal era such as Badshahi Mosque, Wazir Khan Mosque, Lahore Fort, Shalimar Gardens and Tombs of Emperor Jahangir and Queen Noor Jahan.

The city of Lahore is said to have been founded between 1st and 7th century A.D. The city limits were confined to the existing walled city. It was built high enough to save it from ravages of floods of the River Ravi, flowing close by. The city was protected by a wall and a ditch called "Moat" around with seven lofty gates. The moat was filled with water and draw bridges were provided to cross it. These bridges were used to be lifted up in case of a seiege. Keeping in view the strategic position of the city only a single outlet was provided for city drainage through the present Mori Gate. Consequent upon the invention of cannons, the protective wall lost its effectiveness, as a fortification, and as such, the outlets for city drainage were provided through all the gateways of the city. These outlets were made to fall in the moat surrounding the city, in which a large peripheral drain was constructed and connected to the Ravi River. This peripheral drain was constructed to receive the dry as well as the wet weather flows. The outfall drain had its alignment along the present Gandi Mori Road, the ramnents of which are still available in various portions of the road. All the old city drains have excellant slopes and hence no report of any inundation have ever been received even under the heaviest downpours in the recorded history of the city.

Development of Sewerage System

Upto the end of 16th century, the city of Lahore remained confined to its walled portion, with a few scattered villages like Ichhra, Mozang, Nawan Kot and Baghbanpura. During 19th century, the Civil Station, Railways and Cantonment areas were planned and developed by the British. With the introduction of piped water supply system in Lahore in the year 1874, sullage drainage system was also introduced here. Standard sections for constructing these drains were adopted which were known as "Punjab standard Drain sections". These drains were designed for carrying waste water from latrines and bathrooms of the houses.

In the year 1937, sewerage and drainage scheme for Lahore was developed under the supervision of Mr. D. A. Howell SE Public Health Engineering Circle, PWD Punjab. The scheme was to cost Rs. 244,160.00 and was designed to cater the maximum population of 950,250 persons to be reached in the year 1945. Under this plan, Mr. D. A. Howell, proposed to divide the whole municipal area of Lahore into a number of drainage districts in each of which an underground sewer system collected sewage and delivered it to the disposal works. At the disposal works the sewage was screened and pumped into open channels leading to agricultural lands to be used as irrigation water. In rainy season, when the sewage was not required for irrigation of land, it was disposed of into the River Ravi through storm water channels.

This sewerage system was designed on partially combined pattern which could admit rainfall upto an intensity of 1/10th of an inch per hour only. Average daily flow was taken as 25 gallons per capita per day for a population density of 100 persons per acre. The civil station, old city and part of the city north of Railway line were provided with sewerage system under this plan. The World War II, stopped the completion of Howell Plan, but, it was executed to a greater extent. It is not out of place to mention here that the Howell's Plan for sewerage was prepared to cater for the areas having both the water borne and the dry system in the city. It recommended adoption of both water borne as well dry system unless the pattern of development in respect of buildings and roads was completely changed under a Town Planning Scheme. As this end could not be achieved during the following years and flow from dry system continued to find its way into the underground sewerage system, the Howell Plan could not succeed.

Reasons of Howell's Plan Failure

The following are the major causes leading to the failure of Howell's Plan:

1. The appurtenances constructed to check the entry of garbage, grit and blocking material from open surface drains into underground sewer lines, such as Gully gratings and screening chambers were not maintained and kept in proper working order by the agency responsible for it.

2. Open surface drains contribute approximately all the storm water run off from the catchment area into the underground sewerage system, whose storm water carrying capacity has been kept limited. Due to this reason, sewer often overflows and inundates low lying areas.

3. The underground sewer lines do not work, their appurtenances and disposal stations were not kept in perfect working condition by their proper maintenance.

4. Due to the abrupt increase in the population of Lahore after 1947, the design criteria set for laying sewer system in Lahore under Howell's Plan in 1937 proved to be inadequate.

The Present Practice of Sewage Disposal

The present practice of sewage disposal consist of collecting sewage in circular collecting tanks at the disposal station, after removing the floating matter at the coarse bar screens and pumping it to the irrigation channels leading to agriculture land where it is used for irrigation of vegetable, sugar-cane and rice crops etc. Surplus quantity of sewage not required for irrigation is thrown into the Ravi River through storm water channels. In the case of flood in the River Ravi, the gates at the protective Bund are closed and the sewage and storm water is pumped and thrown beyond the bund into the River Ravi. At main outfall disposal station, fine screening and grit removal is done mechanically. At all other disposal stations, this is being removed manually.

In 1967, the responsibility for disposal of sewage in Lahore was transferred from LMC to the Water Wing, LDA. During the year 1967-68, a study was carried out to properly dispose off the sewage. Three major disposal sites were selected for this purpose, namely Shadbagh, Main Outfall and Satto Katla. The disposal of waste water can be accomplished in two ways, namely:

1. by irrigation of agricultural lands.
2. by discharging into River Ravi.

Disposal Through Irrigation of Agricultural Lands

Disposal of waste water through irrigation of agricultural land is one of the accepted methods being practiced in places where factors affecting irrigation are favourable. The loamy soil of the area around Lahore and its climatic conditions are well suited to irrigation through waste water. By the study of areas where the climatic and other conditions are similar to that of Lahore it has been established that waste water can be used for irrigation successfully if it is applied at the rate of 12,000 gallons per acre per day. For this rate of application, enough agricultural land will be available at Shadbagh and Satto Katla disposal sites upto the year 1986. In the case of Main Outfall disposal site, only limited quantity of land will be available beyond the Protective Bund. This implies that disposal of waste water from latter site is not possible entirely through irrigation. Such a situation is, however, not likely to be confronted at the remaining two sites. Sewage farming is therefore, being practised at all the present disposal sites, only a preliminary treatment involving screening and removal of grit is being given prior to application of waste water to agricultural land.

Disposal of Waste Water by Discharging Effluent in the River Ravi

With the passage of time, the agricultural lands around Lahore are being used for residential purposes very rapidly and in case of failure to reach at an effective agreement with the agricultural land owners either directly or under the protection of law, the only recourse before the LDA is to discharge the effluent from the disposal sites into the River Ravi. Extensive investigations of water both quantitively and qualitively in the River Ravi were carried out. The solution of the problem regarding disposing of the waste water was, therefore, found practicable with the assumption that enough quantity of fresh water flows into the River Ravi through the Marala Ravi Link Canal even after the implementation of Indus Basin Treaty.

Sewage Treatment

The magnitude of the problem of waste water disposal from all the disposal sites into the River Ravi after 1981 and upto the time when all the project areas are completely sewered has also been studied. In view of the limitations of the availability of assured minimum quantity of the river water, it has been proposed that the disposal of waste water into the river may be done only after giving a high degree of treatment to the effluent.

The problems of dealing with the polluted wastes of an evergrowing population and the parallel demand for more and more potable water has, throughout the world, led to much research and development of various methods of treatment. Some of these methods are comparatively simple in operation, while others are of a highly sophisticated type requiring skilled professional staff and experienced operators. All have their advantages and disadvantages and it has become a method of a combination of experience and technical skill to select the type best suited for the particular needs of any locality.

An extensive study was carried out to select one of the following three treatment processes:—

(*i*) Trickling Filters

(*ii*) Activated Sludge

(*iii*) Sewage Stabilization Ponds.

The final choice must depend on a carefully considered balance of the needs of the community served, the availability of land, the cost of that land, the availability of skilled technical staff, the availability of skilled operators, a balance between the initial capital cost and subsequent operational cost, the facility of repair of sophisticated equipment, the availability of electric power and its cost, the use, if any, which can be made of the treated effluent.

Design Criteria—Waste Stabilization Ponds

Influent BOD. Table I presents a copy of the report of BOD_5 of several samples of sewage recently analysed in the laboratories of the Institute of Public Health Engineering and Research, University of Engineering and Technology, Lahore. The samples collected on January 21, 1975 were grab samples, and were generally somewhat stronger than the samples collected on January 15, 1975 which were composite samples.

The average of about 100 composite samples of sewage collected over a three year period at the Shad Bagh Sewage Pumping Station by the West Pakistan University of Engineering and Technology was about 200 mg/liter BOD_5, not very different from many of the analyses shown in table I.

Experience in India as reported by the Indian Central Public Health Engineering Research Institute, indicates that the per capita contribution of BOD_5 in sewage is about 0.1 Lbs/day "for predominantly domestic sewage", This may be compared with estimates in the USA made thirty and forty years age of 0.12 lbs/day for domestic sewage and 0.17 lbs/day for domestic plus some commercial sewage.

TABLE I

Sample No.	Sampling Site		BOD_5 (mg/liter) Sample taken on 21-1-1975	Sample taken on 15-1-1975
1.	Chotta Ravi	..	464	540
2.	LMB Block (Model Town)	..	349	144
3.	Bhoghiwal	..	330	240
4.	Shad Bagh	..	360	220
5.	Main Outfall (River Ravi)	..	473	—
6.	Bhuda Ravi	..	Sample not collected	174
7.	Nawan Kot	..	303	180
8.	Sodiwal	..	240	348
9.	Babu Sabu	..	Sample not collected	270
10.	Data Nagar	..	475	210
11.	Muslim Town	..	345	258
12.	Rajgarh	..	300	—

It seems proper to assume a per capita BOD_5 of 0.13 for these portions of Lahore tributary to the sewerage system. This may allow 0.1 lbs per capita for domestic contribution and an additional 30% for commercial and industrial contributions. Many of the large industries of Lahore are not to be tributary to the sewerage system. This 0.13 lbs per capita of BOD_5 will provide 200 mg/liter BOD_5 at a sewage flow of 65 Imp. Gallons per person per day.

An over-all average of 0.13 lbs BOD_5 per person, and 200 mg/liter will be assumed for this preliminary design.

Anaerobic Ponds

Design loadings for the anaerobic ponds will be 15,000 persons/acre in ponds with a design depth of 10'. This is equivalent to a loading of about 4.5 lbs BOD_5 per 1000 cu. feet, and in a pond 9' deep a detention time of about 2.3 days, at 70 gals per capita day. If per capita flows are less, detention time will be greater. Assuming that sludge accumulates at the rate of 4 cu. feet per capita per year, about 30% of the pond volume may be lost in two years, and the pond may then be cleaned.

The present preliminary design will provide 50% extra anaerobic pond area to allow for ponds out of service for cleaning.

The simplest and most economic design will be adopted. Ponds will therefore be large, with the maximum depth which will ensure that the pond bottom is above the ground water table at least part of the year, assumed presently to be ten feet.

Anaerobic ponds will be protected from flooding by a bund.

Operational difficulties with anaerobic ponds may be faced in their start up with odors, in the control of mosquito breeding, and in their periodic cleaning.

Aerobic Ponds

Design loading for the aerobic ponds will be 150 lbs. BOD_5/acre day after assuming a 50% reduction in the anaerobic pond. This is equivalent to 2300 persons per acre neglecting the anaerobic ponds. In ponds with a depth of four feet, this loading will provide a detention time of some what less than seven days, or if the depth is five feet, a detention time of approximately eight and a half days. The space provided will give a much longer detention time until the design population is reached, or until the design per capita flow occurs.

The aerobic ponds will have a maximum depth of five feet, with provision for operation at shallow depths, down to three feet.

The aerobic ponds will be designed so that sewage will be treated in two aerobic ponds in series, with three quarters of the volume and detention time in the first pond. This splitting the aerobic ponds into two sections will cause the first section to be loaded at about 200 lbs BOD_5/acre day with a detention time of about six days. The tertiary ponds will then be loaded at not more than 120 lbs BOD_5/acre day with 2 days detention.

Protection from flooding will be moderate only. The larger floods will be permitted to inundate the aerobic ponds.

Evaporation

At design condition, 0.00010 acres of pond will be provided per person in the anaerobic ponds and 0.00043 acres in the aerobic ponds. This is 0.00053 acres or 23 square feet per person total ponds area. At 70 gallons per person per day sewage flow, water, or sewage, equivalent to the height of six inhes over the pond area will be provided daily. Even if sewage flows are only a fraction of the design flwsc, they will be adequate for evaporation and although some concentration of the sewage may occur in the hot dry months it is not likely to affect operation of the pond system.

Miscellaneous Design Details

A. Anaerobic tanks must be piped so they can be used in series. Piping must be arranged so that anaerobic tanks can be filled from other anaerobic tanks, both from near the top and near the bottom of the tank. Such filling will be necessary after cleaning.

B. Pumping facilities should be provided to drain the anaerobic tanks.

C. Pumping facilities should be provided to recirculate plant effluent to the head of the dispersion channel for odour control. Capacity to recirculate 5% of the flow will be adequate. If odour control is needed at a nearby pumping station, recirculation may be extended to that station.

D. Anaerobic tanks should have multiple inlets to provide early mixing of incoming sewage with digesting tank contents. The first anaerobic tanks constructed should have facilities to recirculate tank contents to mix with incoming sewage. *If this recirculation proves unnecessary* such facilities will be emitted with later tanks.

E. Some tank berms must be wide enough for the travel of large trucks. Ramps should be provided for trucks to enter on the berms.

Location of Stabilization Ponds

There will be a waste stabilization pond associated with each sewage pumping station. In most cases these ponds will be located outside the Bund Road, where land costs are much lower.

Area Requirements

Table 2 presents, for each sewage district, the required surface area of each type of pond, and the total area requirements including berms and protective bunds.

Cost Comparisons

Table 3 presents a cost estimate for the stabilization pond required to serve the 1986 design population for the Central Sewage District, and a cost estimate for a standard rate trickling filter plant to serve the same population. The costs for this plant have been obtained from tables presented in "Estimating Costs and Manpower Requirement for Convertional Watermeter Treated Facilities" U.S. Environmental Protection Agency, Water Pollution Control Research Series, and have been projected to July 1975 base prices.

It can be seen that the cost of the stabilization Ponds is about one tenth of the cost of the standard treatment facility.

TABLE No. 2

AREA REQUIREMENTS—WASTE STABILIZATION PONDS

Sewerage District	Anaerobic Pond (Acres)	Faculative Pond (Acres)	Tertiary Aerobic Pond (Acres)	Total Land requirements (Acres)[1]
Northern ..	62.3	202.6	67.6	440
Northeast ..	23.5	76.8	25.6	170
Central ..	11.94	389.6	129.8	850
South Civil Line ..	81.6	266.2	88.7	580
Southwest ..	28.4	92.9	30.4	200
Southeast ..	21.2	69.3	23.1	150
Shahdara ..	10.0	32.6	11.2	100

1. Includes berms and protective bunds.

TABLE No. 3

COST ESTIMATE

(1) Vaste Stabilization Pond

Item	Description		Quantity	Unit Price		Cost
1.	Land	..	850 Acres	Rs. 8,000/Acre	Rs.	6,800,000
2.	Excavation	..	96,885,000 c.f.	Rs. 200/1000 c.f.	Rs.	19,377,000
3.	Fill	..	14,775,000 c.f.	Rs. 150/1000 c.f.	Rs.	2,216,000
4.	Misc. Piping, Manholes, etc.	..		L. S.	Rs.	4,757,000
				Total:	Rs.	33,150,000

(2) Stankard Rate Trickling Filter Treatment Plant

Item	Description		Quantity	Unit Price		Cost
1.	Grit Removal and Screening	..	—	L.S.	Rs.	10,700,000
2.	Primary Sedimentation	..	190,000 s.f.	Rs. 130/s.f.	Rs.	24,900,000
3.	Trickling Filter	..	8.5 million c.f.	Rs. 15.5/c.f.	Rs.	131,800,000
4.	Secondary Sedimentations	..	228,000 s.f.	Rs. 130/s.f.	Rs.	29,640,000
5.	Recirculation and Sludge Pumping	..		L.S.	Rs.	4,400,000
6.	Sludge Digestion	..	1.44 million c.f.	Rs. 25/c.f.	Rs.	36,000,000
7.	Sludge Drying Beds	..	840,000 s.f.	Rs. 16.5/s.f.	Rs.	13,900,000
8.	Lab. Facilities	..		L.S.	Rs.	6,200,000
9.	Garage & Shops	..		L.S.	Rs.	1,900,000
10.	Yard Piping, etc.	..		L.S.	Rs.	36,300,000
				Sub-Total:	Rs.	295,700,000
11.	Land	..	600 Acres	Rs. 8,000/Acre	Rs.	4,800,000
				Total:	Rs.	300,500,000

DISCUSSION

Following are the major points discussed after the presentation by Mr. Mehtab Butt, Director Construction, LDA (Water Wing), Lahore:

(1) The case study for the city of Karachi was discussed in relation to the raw sewage discharge into irrigation channels.

(2) The design parameters for sludge digestion and sludge disposal facilities for Lahore were discussed.

(3) Anaerobic oxidation ponds with optimum depth of 10 feet were suggested.

(4) The disposal of industrial waste water into sanitary sewers was one of the important aspects of discussion which highlighted the need for early introduction of water pollution control legislation in the country.

(5) Oxidation ditch process was favoured for small towns only.

HEALTH ASPECTS OF WASTE WATER DISPOSAL

DR. FAIZ ALI SHAH
Director Health Services, Punjab,
Lahore.

There are two facets of Health Aspects of Wastewater Disposal.

The First is Related to the Workers

There are injuries, infections, gassing from poisonous gases and asphyxiation from insufficient oxygen in the air of the working environment. Slippery ladders, walks and steps and quite often offensive working environment expose workers to various injuries. Presence of asphyxiating and toxic gases and insufficiency of oxygen are extremely dangerous and to be guarded against. The workers also are exposed to various types of infections, local and general, if they do not adopt personal hygiene practices and avoid ingestion of sewage and sewage contaminated materials and their contact with open cuts sores and mucous membranes. There also is the ever present danger of contracting leptospirosis through skin penetration.

Public Health Engineering workers need protective clothing including gum-boots, and gas masks where indicated, and training in safe and hygienic practices including the paramount importance of observing personal hygiene to save them from these occupational hazards. For protection against exposure to toxic and asphyxiating gases and explosive gas mixtures and to insufficiency of oxygen in the environment a worker may be going into various types of tests, including tube and flame test, are available and workers must be trained in their use and the use of other safety precautions against the hazards, their occupation exposes them to.

The Second is Related to Humanity

It goes even further and affects all life—human, animal and vegetable for water is essential for all life and safe or unsafe waste water disposal practices will affect favourably or unfavourably all life on this planet. Man must use water, and must therefore, dispose off waste water. He must dispose off this waste water in a way that is hygienic and keeps the planet a safe sanctuary for all life.

Wastewater, sanitary disposal of which must be arranged by the community as a collective effort, for it can be achieved only through collective effort. It includes domestic waste water and sewage, industrial, commercial, agricultural and animal husbandry wastes. It includes waste water in pools made by blockage of drainage channels and created by man as undrained and un-channelized borrow pits along roads, railway lines and irrigation channels where rain water and seepages from the canals collect. It also includes the stagnant standing water in water logged areas.

From the Public Health point of view, disposal of waste water must be such as to protect public health, avoid nuisance, and prevent pollution of natural waters and recreational facilities including beaches. It must also conserve natural resources, prevent stream and river pollution and should be conductive to maintenance and restoration of natural conditions meet requirements of human decency and elicit willing human approval so that necessary human, material and financial resources are ungrudgingly made available by the tax payers.

Waste waters domestic, industrial, agricultural and even rain and seepage water—can affect human health in many ways.

It can be mere nuia ncea and hardship as it is when defective drainage affects all traffic including pedestrian traffic. It may be offensive to eyes and nose and this nuisance may be quite out of proportion to its menace to health as it is when raw sewage irrigation channels carry domestic waste to vegetable farms and observing the vagetable gardeners washing fresh vegetables in raw sewage before the transport of their produce to the market.

Water is a direct or in direct carrier of large number of disases and disease producing agents. Insanitary, inefficient or ineffective disposal of waste water may therefore, be a hazard to human and animal life by conveying:

Various water borne communicable diseases which include:

(a) Such viral diseases as viral gastroenteritis caused by entro and adeno viruses and viral hepatitis commonly called infective hepatitis. It also has been implicated in carrying polio.

(b) Such bacterial diseases as typhoid and paratyphoid group of fevers, diarrhoeas, including infantile diarrhoeas, bacillary dysentries, salmonellosis, bacterial gastro-enteritis other than cholera, Asiatic Cholera, leptospirosis and rarely anthrax, tuberculosis and tularaemie.

(c) Parasitic and protozoal diseases such as amoebiasis, schistosomiasis, guinea worm disease and such intestinal worms as round worms, thread worms and rarely hook worms and strongyloidosis though these later are usually carried through infected soil and food.

Inorganic and Organic salts some of which are cumulative poisons while others are severe carcinogenic and these include arsenic, lead, mercury, nickel, cadmium, chromium, zinc cobalt and copper.

Insecticides, herbicides and pesticides, now used so extensively in the relentless struggle between men to produce in ever greater quantity and more nutritious foods, for the explosive population increase and the gradual decrease in mass of land available for agricultural practices due to invasion on this land by such monsters as the creeping Sahara in Africa and the water logging and salinity in Pakistan. Many of these are cumulative poisons for fish and other aquatic life and through the ingestian of fish and other sea foods for men.

Radioactive wastes through both atomic explosions and through the setting up of more and more atomic energy plants to meet the ever expanding and non satiable man's need for clean energy as provided by electricity. Table attached as appendix gives hospital attendance figures of some of the bacterial, parasitic and protozoal diseases carried directly or indirectly through water.

Careless or insanitary disposal of waste water may contaminate not only surface water supplies as of streams, rivers and lakes but also endanger underground water sources and endanger well water supplies. This is what has happened in our large urban areas as Lahore, Gujranwala and Sialkot cities where almost 100% of hand pump deliver polluted water and subsoil water at Lahore is unfit for human consumption upto great depths.

The vegetable growers in the Punjab call sewage as "black gold" under the erroneous belief that it has high fertilizing value. The fact, however, is that raw sewage has but slightly more, if any, fertilizing value than water; treated sewage has still less, in the form of nitrates, nitrites, phosphoric acid and potassium. It may be pointed out that water content of domestic sewage is 99.9% against 99.95% in case of river water and 96.5% of sea water. Most of sewage and other waste waters from cities and towns in the Punjab is disposed off mainly by land irrigation with particularly unhealthy, to the extent of positively dangerous, practice of vegetable growing. Where a city or industry is located on a stream or river, the raw sewage and industrial liquid waste is discharged directly into such a stream or river. The result has been that Leh Nala

TABLE

Showing Patients Treated from Various Water Borne Diseases in Hospitals/Dispensaries/Rural Health Centres/T.B. Clinics etc. in the Punjab During the Years 1970-73.

Name of the Disease	1970			1971			1972			1973		
	Out-door	Indoor	Deaths	Out-door	Indoor	Deaths	Out-door	Indoor	Deaths	Out-door	Indoor	Deaths
1. Diseases of the Intestines e.g. Diarrhoea, Dysentery and Tumours	256615	11891	374	212372	10373	316	171157	10503	390	162831	10740	378
2. Ameobic Dysentery	170441	1492	15	181418	1922	27	149913	1908	18	138991	2480	37
3. Bacillary Dysentery	410805	2310	10	366812	1837	23	356893	2233	13	357688	3877	21
4. Diarrhoea	900422	5225	83	886856	5981	344	804784	6376	288	813764	6392	183
5. Cholera	528	21	2	597	490	16	—	—	—	1	—	—
6. Liver Abcess	2798	682	28	9689	623	21	5609	559	25	2374	781	23
7. Ankylostosmiasis	25695	487	—	26362	328	2	28383	402	—	18007	418	1
8. Enteric Fever	92451	4115	72	95447	4143	56	87788	4428	100	90525	7037	165
9. Coitre	9736	144	1	12542	268	2	9216	181	2	11884	122	4
10. Malaria	306861	1803	7	402492	2272	19	818535	4139	26	1158800	5576	24
Total:	2176352	28161	592	2194587	28273	826	2432278	30729	862	2754865	34423	836
Total Patients treated from all Diseases	14399006	322349	6760	13456055	339569	7087	13295602	357051	7576	13606215	392837	7818
Percentage to Total patients	15.1%	8.7%	8.8%	16.3%	8.3%	11.7%	18.3%	8.6%	11.4%	21.2%	9.5%	10.7%

in Rawalpindi and Deg Nala downstream of Railway line near Kala Shah Kaku are now dead channels. Many years I investigated industrial waste discharges near Noshehra into river Kabul where high fish mortality was observed.

Granted Pakistan is an arid country and its water needs are such that every source must be tapped and the sewage water of Lahore may be used for irrigation not only for the above reason but also for the fact that so little water now trickles down the river Ravi that discharging Lahore sewage into it will repeat the results of industrial waste disposal into Deg Nala at Kala Shah Kaku. Measures, including legislative measures, are needed to prevent its use in vegetable growing. It may be used for fodder growing or for Cereals growth. A Committee of the American Society of Civil Engineers recommended years ago that raw sewage or its untreated solids or soil which has recently been treated by raw sewage shall not come in contact with food stuff for consumption. Nor shall live stock graze on pastures irrigated with raw sewage. Forage crops may be raised only if to be harvested and cured. And sewage water must be oxidized and thoroughly sterilized if it is intended to be used in cultivating human food stuff, particularly those eaten raw. There has been no such step in our country and use of raw sewage as irrigation water for vegetable gardens down stream of outfalls is one of the reasons responsible for a situation where over 80% of the child population of Lahore is infested with intestinal worms, in particular round worms and the incidence of hook worm is also high. Both these contribute to the appalingly high incidence of anaemia in Lahore population.

As earlier stated, disposal of waste water should be such as not to create nuisance or create conditions which are harmful to public health, safety and welfare. It should not cause harm to domestic, commercial, agricultural or recreational facilities nor to live stock, fish and other aquatic life. And if discharged into a body of water it must not cause such physical, including thermal, chemical and biological changes in this body of water as to be harmful and be termed as Pollutant.

The uncontrolled disposal of waste water, sewage and other liquid wastes from all sources including domestic, industrial, agricultural, live stock farms etc., and urban run off waters is a most common cause of water pollution. The increasing urbanization and industrialization and the rising standards and expectation of life are continuously increasing the per capita output of waste water and its character is continuously changing and becoming more complex. More and more toxic and biocidal agents are being introduced into it. Public Health Engineers have to work hard to keep human health and safety protected from dangers inherent in this ever changing situation.

Another aspect of waste water disposal is non-disposal or insufficient or inefficient disposal of such waste waters as seepage water from canals and rain or other water collections in unchanneled or undrained borrow pits along our roads, rails and canals. These create excellent breeding grounds for A. Culifacies, the most important malaria fever carrier in our country. Then there are the ponds and pools in all our villages, towns and so called urban cities which are expanding through creation of slums. These are excellent breeding grounds for various culicine mosquitoes including Culex Fatigens, the carrier of filariosis, a disease now introduced into Pakistan from Bangladesh and Eastern India through Pakistani P.O.Ws. and Behari Muhajirs. This C. Fatingan finds most prolific breeding grounds in these slums and now poses an additional danger to Pakistan not only because it carries filariosis but also because of its remarkable adaptability to developing resistance to insecticides and its higher efficiency to treansmit filariosis in urban areas than in rural areas.

These aspects of waste water disposal have neither been investigated nor dealt with in our country and need urgent attention as also the subject of health education of the people in proper disposal of waste water. The Health Department and the Public Health Engineering Services have wide scope in collaborative effort in these so far untouched fields.

The subject of mosquito breeding in oxidation ponds is being dealt with in a separate paper in this session.

Discussion

The discussion covered the aspect of health education in the Province of the Punjab. It was pointed that the Directorate of Health as well as the Department of Public Health Engineering are making efforts in promoting the cause of health education in the Province.

SEWERAGE AND SEWAGE TREATMENT IN KARACHI

AMINUL ISLAM
Chief Engineer
Karachi Development Authority
Karachi.

The disposal of Waste Water has a great bearing on the total health problem of an area. Today the environment is being polluted so heavily as it never had been before due to the vast accumulation of wastes from residential and industrial areas—part of this accumulation is due to the increase in human activities. It is, therefore, necessary to adopt improved methods of collection, treatment and disposal in order to protect men and soil from the harmful effects of waste-borne pollution. Obviously the re-use of treatment products can play an important rol in the improvement of economic and social standard of the people.

Modern Treatment Plants can meet almost any performance standard required, but the type of process employed has to be in conformity with the local hygienic, economic and aesthetic standards. From this stand point the waste water treatment plants should be integrated into the general area plan in order to achieve optimal exploitation of the regional waste water resources.

Waste water collection and disposal systems are extremely complex and expensive in both initial and operational cost. The plant and its accompanying units must, therefore, be designed to meet more than minimum standards. If this is not done more money may have to be spent after the initial cost due to overloading and breakdown of the system. These factors also prove detrimental to the health of the community.

Sewage disposal systems are provided by Public Agencies as a community service. The cost of these systems may be substantially reduced by utilising the products such as effluent water, sludge gas and manure. Although the collection and disposal of waste water is not the responsibility of the individual user but his personal attitude and civic sense is of a great importance in preventing the indiscriminate scattering of the waste material on the landscape.

There are various methods of collection, treatment and disposal of sewage in a city. For example, there are two most modern Treatment Plants in Karachi but there is still a large gap between sewerage services and the substantial growth rate of the population. The huge increase in production of waste water is actually due to the growth in population and industries which results in a high per capita rate of generation of pollution. The availability of increased water supply, improved living standard and the use of labour saving devices are responsible for increase in volume and the amount of organic and inorganic pollutants in the waste waters.

Karachi, youngest of the great cities of the sub-continent had its origin as a fishing village, bordering on the Lyari River, close to its mouth at the Arabian Sea, sixty five miles to the extreme north west end of Indus River Delta. Endowed with a natural harbour, which has been progressively improved over the years, Karachi became a first class port of call for ship sailing the trade routes between the West and the East and assumed increasing importance as a trade gateway to all Provinces of Pakistan and also to Afghanistan and Central Asia. After Independence, with tremendous growth in population, Karachi started growing into a major industrial-cum-commercial centre.

Karachi has a moderate climate which occasionally becomes sultry due to intense humidity in the air. May and June are the hotest months of the year with temperature as high as 110 F, while January is the coldest with temperature as low as 40°F. The humidity usually ranges between 10 and 85% during December and August. The city lies at the fringe of the Monsoon belt and, therefore, receives a low rainfall during July and August—the mean annual rainfall being about 7 inches.

In physical terms low, flat topped parallel hills devoid of vegetation and wide intervening plains with dry river beds, are the characteristics of the area. There is but one scanty perennial river—the Hub River with a limited supply of water. The heights within the present greater city area generally do not exceed 260 feet and gradually fall to 5 feet above mean sea level, at Keamari.

Topographically Karachi has been clearly divided into two hydrological areas on account of the ridge running between M. A. Jinnah Road north and the Drigh Road south of it. This ridge forms also a natural barrier between the Lyari and Malir Streams.

The first mechanised sewerage system in the sub-continent was located in Karachi. In 1884 a Scheme was prepared to establish Shone's Ejector System in the city to pump the sewage to nearby lands proposed to be developed into Sewage Farms. The earliest sewerage system was designed on the basis of separate system and consisted of a sewer net work of several thousand running feet of glazed earthen ware pipes and five ejector stations located in the old city. With the improvement in the system more and more areas were added. The sewage from various districts was pumped through twenty one pneumatic ejectors to the two pumping stations from whence it was again pumped through rising mains to the two sewage Farms one at Manghopir road in Lyari basin and the other at Chaneser Goth in Malir basin where it was utilised for irrigation. The ejectors used compressed air which was supplied through a system of air-mains connected to Compressor Stations. In addition to this Ejector System a network of gravity sewers also existed which drained some areas to the nearby pumping stations. Moreover, the open drains located inside the central city served as a relief to the system at times of an overloading or breakdown. Thus, the raw sewage from the North-West part of the city was pumped to the sewage Farm No. 1 and from the South-East part to sewage Farm No. 2, where it was utilised for irrigation. Vast areas of land were developed and fruits and vegetables were grown on a commercial scale. The sewage Farm products carried no appreciable value in the market owing to their quality. After continued use these farms became sewage sick and the cultivable land gradually reduced and the area became covered with bushes. Ultimately these farms had to be abandoned.

After independence, with tremendous growth in population Karachi city started growing into a major industrial and commercial centre. The city water supply was increased but the sewerage facilities remained the same. The old sewerage system could not cater for the increased water supply. The sewerage services stood far below the requirements of the size of development taking place in the city. Consequently the system became surcharged and sewage started over-flowing through the manholes into the city streets.

The Government of Pakistan realised the seriousness of the situation and inspired to develop the city in a controlled manner invited foreign experts to prepare a Master Plan of the city. Messrs Merz Randel Vatten (Pakistan) of Sweden were appointed as Consultant for Town Planning while two American Consultant Mr. Carell Hill and Mr. Licher were engaged to survey the water supply and sewerage problems of the city. Based on their recommendations, "Greater Karachi Sewerage and Sewage Disposal Scheme" was prepared in 1952 by Central Engineering Authority, which was handed over to K.D.A. (formerly Karachi Joint Water Board) for its execution after the sanction of the Government. According to this Scheme the plan was to cater for an anticipated population of three million people by the year 1980. The base figure used for estimating the quantity of sewage was 40 gallons per capita per day against a water supply figure of 75 gallons. Thus, the total quantity of sewage in the final phase came out to be 120 MGD against a total water supply of 225 MGD. In the Scheme Karachi was divided into four sewerage Districts each had to incorporate a network of trunk and sub-trunk sewers leading eventually to a treatment plant. The ultimate capacity of the treatment plant No. 1 and No. 2 was to be 40 MGD each. While that of treatment plant No. 3 and 4 to be 20 MGD. The above scheme was to be implemented in four phases spread over a number of years. The first phase which was executed and completed by K.D.A. was handed over to Karachi Municipal Corporation for its maintenance. This phase was concerned with the development of the system in Sewerage Districts No. 1 and 2, envisaging a network of trunks and sub-trunks sewers with 20 MGD treatment plant in each district.

Total lengths of trunk and sub-trunk sewers laid in the first phase of this scheme were 20.20 miles in sewerage district No. 1 and 26.22 miles in sewerage district No. 2. The pipes used were of reinforced cement concrete of A.S.T.M. Specifications ranged from 15″ϕ to 66″ ϕ. The capacities of the pipes were based on the quantity of sewage influent for the population of the area to be served at the rate of 40 gallons per head per day. A separate margin for infiltration from subsoil water was also provided at the rate of 1000 gallons per acre. The maximum flow in trunk sewers has been taken as doubled in average flow, i.e. the design flow has been taken as 2 DWF in trunk sewers. Whereas in sub-trunks the maximum flow has been taken as 2.5 times the average flow. The minimum velocity has been fixed at 2.25 ft. per second, which is self cleansing. The diameters of the sewers were designed according to William and Hazen's formula, taking the value of the co-efficient of roughness as 100. Sewers were designed on the basis that they will carry the design flow when flowing full. In the sewers the soffits of joining pipes of different sizes were laid at the same elevation. The Rising Mains from different Pumping Stations to the Treatment Plant were of pre-stressed concrete pipes, cast iron pipes and of Ductile Iron pipes as per required pressure.

The capacity of each Treatment Plant is 20 MGD with a provision of 100% expansion in future. Both Plants were designed on the same principles and differ only in minor details. The plants are of the trickling filter type with sludge digesters. Each Plant is capable of treating an average dry weather flow of 20 MGD at a maximum discharge of 1.25 million gallons per hour. Both Plants consist of two units of 10 MGD each.

The following description is applied to each plant:

The Raw Sewage Pumping Station

Each plant receives the inflowing sewage at the deep inlet chambers of two raw sewage pumping stations. The inlet chambers are each provided with a mechanical deep screen. This screen is in reality a vertical Bar Rack with 3" clear opening between the bars, regularly combed out by a fully automatic cleaning mechanism, and serves the purpose to withhold the larger screenings, which are harmful for the pump impellers, or likely to cause clogging in pumps and pipes, such as floating logs, rags and even cadavers of animals, which sometimes are found in large sewers. The Pumping Stations all have centrifugal pumps with vertical shafts. The pumps are set in dry well with a suction pipe extending-into a wet well. They are driven by electric motors in a motor room at ground level situated above the pump cellar.

The Unit Bar Screen

From the raw sewage pumping stations the sewage flows to a distribution chamber where the total quantity is split up in exact two even parts for the two treatment units of the plant. The first step in sewage treatment is the Bar Screen, fine screen essential for removal of screenings, rags, coal etc. which have slipped through the Bar Rack (coarse screen). The 4 feet deep entrance channel to the unit, in which channel a Bar Screen has been placed, is designed for a certain minimum velocity of the sewage in order to prevent the grit to settle down. The Bar Screen consists of bars with a 1″ clear opening between the bars and is also provided with a fully automatic cleaning mechanism, which is float controlled.

The mechanism operates as soon as the head loss of the flow through the screen exceeds a certain minimum, which is recorded by an adjustabled float control apparatus situated next to the channel. However, it can also be operated manually. The amount of screenings in the sewage of countries like Pakistan vary from 3 to 7 cub. ft. per mgs. The screenings are cut and reduced in size by a screening shredder, after which, the ground screenings are returned into the channel down stream of the Bar Screen.

The Grit Chambers

The sewage of this sub-continent contains an abnormal amount ot sand and other heavy solids compared to sewages elsewhere. As soon as grit settles down in the settling tanks, or gets into the pipes, it is difficult to remove. We may, therefore, consider a pre-removal of this inorganic matter as the second essential step in the treatment process. It is now a generally accepted fact that the sand and inorganic matter which is of 0.2 mm size or coarser with a specific gravity of 2.65 causes the most trouble and that at least 95% of this material should be removed before the sewage enters the treatment plant proper.

In the Karachi Plants, the grit chambers are equipped with the Detritor, which is a highly efficient mechanism collecting all grit larger than 0.2 mm at a minimum loss of head. Under normal operating conditions the grit removed contains only a very little percentage of decomposable matter on account of the presence of a Grit Washing mechanism. Without washing, the decomposable matter out of the grit, odour and fly nuisance are most likely to result.

The Primary Sedimentation Tanks

The third step of treatment is the removal of all settleable solids which are in the sewage, floating in suspension or in solution. The floating and suspended solids mainly consist of organic and inorganic silt smaller than 0.2 mm, whilst the dissolved matter consists of 1/3 organic matter and 2/3 minerals (partially these minerals will not be decomposed in the treatment process). All the settleable solids which will be removed in the primary sedimentation tanks form the essential part of the so-called raw sludge. The finest material such as the colloids will be removed later on.

The four sedimentation tanks of each Karachi Plant are designed as typical Clarifiers and are relatively shallow circular reinforced concrete basins of 138 feet inside diameter. The sewage flows towards the basin through a pipe under neath the bottom and is introduced in the centre, where it enters the basin through an influent well with max velocity. The influent well (usually a steel plate drum without top and bottom) breaks this velocity down immediately and trans- forms the kinetic energy to potential with some head loss. The sewage is forced in a downward direction and flows underneath the influent wellrim, whereafter it flows in radial and inclined upward direction towards the perimeter of the basin, over the V-Notched Weir plate all along the top of the perimeter wall. Hereafter it drops down in a launder through which it is led to the outlet chamber and continues its way to the structures for the next step of treatment.

The radial velocity of the sewage decreases rapidly when it moves from the centre of the basin towards the perimeter well. This is obvious as the sectional area of the sewage flow increases in the same time, proportional with the radius of section. Theoretically speaking the particles of large sizes and greater specific gravity will be apt to settle down first, much nearer to the centre of the basin than the smaller particles.

The Clarifier is equipped for mechanical removal of the settled solids, called "raw sludge" and also for removal of the surface floating material, called "scum". The sludge is raked to a sludge pocket near the centre of the basin from which it is removed by means of sludge pumps to the digesters. The scum is removed by a special scum skimmer towards a scum trough. Both settleable solids and the scum are pumped to the digesters. The sedimentation tanks are designed in such a way that the sewage is detained in the basins for a certain length of time, called the detention time, which usually averages 2 hours.

The Trickling Filters

The Karachi Plants are designed in accordance with the Biofiltration method of treatment with high rate filtration for domestic and industrial sewage. A trickling filter consists of broken stones, piled up in reinforced concrete containers of almost cylinderical shape, (for the Karachi Plants these containers are about 7 feet high and 136 feet diameter with a level top surface). The sewage coming from the sedimentation tanks flows through a pipe underneath the concrete bottom slab and then through a vertical pipe in the centre of the filter in upward direction. On top of the filter a steel distributors is mounted consisting of two horizontal) pipes left and right of it. These two pipes (they may have a rectangular cross section) are on one side provided with one horizontal row of small holes (orifice). The water under pressure of the hydrostatic water surface in the outlet chamber of the sedimentation tank is forced through the orifices and develops a turbine (or jet) action in horizontal direction, upon which both pipes, i.e. the distributor, turn around. It may be emphasized that no electric power is used for this merrygo round movement. The water streaming through the orifices are equally distributed over the top area of the filter bed and "trickles" downwards to the bottom slab and sideways to the launder running alongside the perimeter of the filter to a discharge chamber further downstreams.

Soon after the trickling filter is put into operation a microbiological life develops. Bacteria, protozoa, microworms, etc. settle on a micro-botanical growth as algae, mosses, and fungi, rapidly appearing on the wetted surfaces of the filter material. The typical sewage Bacteria of which the "E. Coli" is most frequent, are very useful. Being aerobic bacteria, they need a constant supply of oxygen flowing through the pores between the filter stones. The activated bacteria and other micro-organisms are capable to break down (by oxidation) all colloidal and dissolved organic matter and partly to convert it to settleable matter.

The Final Sedimentation Tanks

After the sewage leaves the trickling filters it has received its "mechanical and biological steps of treatment" and may be considered to have reached a high grade of purity. During the biological treatment the colloidal and dissolved, organic impurities have been partly converted into solids, which should be removed again. This is done in secondary sedimentation tanks, almost similar to the Primary Clarifier, except that no skimming is done because of the absence of scum.

The sludge settling in the secondary clarifiers is mostly of an organic nature and neither for quantity nor quality comparable with the great amount of corrosive raw sludge on the bottoms of the Primary Clarifiers. It is generally referred to as "humus". It is customary to pump this humus simply back into the pipe running to the primary clarifiers where it is settled together with the primary raw sludge. After having left the secondary clarifier, the purified sewage now called the effluent of the plant, leaves the treatment unit through a sewer running to the effluent pumping station.

The scheme makes the simple process of recirculation more clear. The raw sewage with a flow of Q cub. ft./hr enters the unit upstream of the primary clarifier. Just before entering the clarifiers a certain quantity Qr is introduced into the raw sewage flow, after which it is introduced in the primary clarifiers. This quantity Qr is maintained until the sewage leaves the trickling filters at the downstream end, but before it enters the secondary clarifier a quantity Qr-Q is separated from it and pumped by means of the pumps of a special recirculation pumping station back to the abovementioned spot directly upstreams of the primary clarifiers. The quantity Qr is the constant flow through the recirculation pumping station, therefore, varies.

The Sludge Digestion Process

The raw sludge settled on the bottom of the Primary Clarifiers is pumped by means of special sludge pumps to the Primary Digesters. This is done by special plunger Sludge pumps constisting essentially of a cylinder large diameter eccentric driven piston, and ball valves on the intake and discharge with no possibility of clogging by the high proportion of solids in the sludge.

The sludge is by no means thick or tough and has a large percentage of water content (about 95%). The solid part of this sludge consists of 60 to 70% organic matter. It would not be advisable to take the raw sludge directly to the sludge drying beds without the risk of serious odour and fly nuisance and endangering public health in the vicinity. To annihilate the harmful qualities of the raw sludge it is to be subjected to an anaerobic process of digestion in the four reinforced concrete digesters of the plant, two primary and two secondary digesters each of 85 feet diameter and 50 feet height. This digestion process decomposes the raw sludge first in the primary Digesters, which are completely closed tanks. The sludge is heated to a temperature of about 80 to 90°F during which anaerobic bacteria transforms the sludge into gas, fluid, and settleable (harmless) solids.

The anaerobic process of digestion may be of an acid or a basic (alkaline) character. The acid process has to be avoided and the alkaline to be maintained in order to avoid stench, foaming and retardation of the process. The general practice is a two stage digestion. Usually the digestion is partially achieved in the primary digesters in which the sludge is heated and mixed. The solids in the sludge cannot settle properly because of the mixing so that the primary supernatant (sludge water) is not easy to withdraw. In this condition the supernatant with a BOD of 2,000 to 3,000 p.p.m. will put a heavy burden for suspended solids and B.O.D. on the point where it is discharged. This will be omitted if the sludge from the primary digester is first given a tranquil settling in the secondary digesters, so that a clear supernatant is obtained, which can be discharged to the primary sedimentation tanks.

The settled sludge of the secondary digesters is occasionally withdrawn to the shallow compartments of the sludge Drying beds, where it is disposed of in layers of approximately 8" thick. This sludge still contains 88% to 90% water. It is not mal-odourous and is easy to dry. It has the property to remain stable after drying. The water is drained off in the sand and gravel layers underneath the sludge beds. The sludge is finally disposed off as a fill for low areas or given or sold to farmers. It is in the first place to be considered a soil conditioner and not manure.

The whole process of primary digestion lasts about 3 to 5 weeks and the total digestion including the secondary digestion 5 to 7 weeks, however, entirely depending on circumstances such as outside temperature etc. As said above, during the digestion a great quantity of gas is developed, of which the composition will approximately be:

65 to 90% Methane (from the alkaline digestion)
10 to 35% Carbondioxide (from the acid digestion)
0 to 5% Hydrogen.
0 to 10% Nitrogen.
0 to 0.5% Hydrogen sulphide.

The Power House is provided with four huge 8-cylinder dual fuel engines of K.H.D. Type BWV 8 M366 of about 1300 HP each, complete with a set of accessories for starting fueling etc. Each machine can be driven either by gas or by diesel oil. Directly coupled to the engines are four 3 phase synchronous alternators of A.E.G. Design D3 of 1130 kW. Furthermore, the power house gives room for a large Main Switch Board for controlling the generators, the electric motors all over the plant and the remote control of the floating devices, pumping stations, motors etc. etc. A large water tank supplies cooling water for the engines whilst the hot cooling water is partially used for heating the sludge in the primary digester such being done by means of sludge Heat Exchangers. The transport of electric power from the Power House to the distant pumping stations is done by means of several huge A.E.G. transformers.

Other Service Building

A Chemical Laboratory is provided for testing of sewage and effluent, and further research work. A Workshop is provided complete with all sorts of machine tools besides a completely carpentry shop, a blacksmith and a store room.

The Piping and Storm Water System

Each Plant is provided with several piping systems which may be divided into:—

(*a*) The sewer lines, which are generally speaking with top of pipe about 4 feet below ground level and mainly made of reinforced concrete or prestressed pipes with inside diameters from 24" upto 60".

(*b*) The sludge lines which are made of Cast Iron with centre line about 31/2 feet below ground level and inside diameters of 6" and 8".

(c) The hydrant water line made of Cast Iron with centre lines about $2\frac{1}{2}$ feet below ground level and inside diameter of 3". This piping system is supplying re-circulation water to the great number of hydrants all over the site and which will be used for cleaning the well and launders of clarifiers and trickling filters, and for other purposes.

(d) Gas warm water and cooling water lines between the Digesters, the Power House, the gas purification chambers, and the cooling water ponds. A storm water system of earth and concrete ditches is designed all over the site and alongside the roadways.

Final Observations

(a) It cannot be over emphasized that the main point in sewage treatment should be the sanitary disposal of sewage and not the production of by-products (effluent, gas and dried sludge) to fetch revenue.

(b) A well designed and well operated plant will not produce offensive odours. It is not necessary to locate it too far away from residential localities. What is mainly responsible for odour, and this determines the location of the plant is the condition of the sewage as it arrives at the plant. Other important factors are the good operation and the cleanliness of the plant.

So long as aerobic condition prevails in sewage, that is, it is not septic, its odour is not offensive. The shorter distance the sewage has to travel to reach the plant the less the likelihood of septicity and odours.

A "Sewage Renovation Scheme" for older part of the city was also introduced. The main object of this Scheme was to improve the system by renovating the old sewers laid more than 50 years ago, and eliminating the ejector system already overloaded and getting extremely costly to maintain. All the trunks, sub-trunks and laterals of different diameters from 9" to 72" diameters in a total length of about 30 miles have been laid by K.D.A. Now K.M.C. is transfering the house to house connections to this newly laid system. As soon as these connections will be made, the ejectors stations will be eliminated.

Now developments like North Karachi etc. fall outside the sewage districts No. 1 and 2; hence, the second phase of the Greater Karachi Sewerage and Sewage Disposal Scheme has to be taken up immediately for which separate scheme has been prepared and Form P.C.I. is being submitted to the Government. The internal system of sewerage has already been provided in this area.

As the population projection of M.R.V.P. has failed, a comprehensive development programme with population densities has been prepared by the Master Plan Department of K.D.A. In this plan it is optimistically proposed to give a water and sewage connection to every dwelling by 1985 when the population of the city will be approximately 70.0 lacs. Thus, the water supply demand in 1985 will be approximately 391 MGD of which 22 MGD will be required for the Steel Works leaving 369 MGD as the rest of the city demand. It is estimated that 270 MGD of this or appromxiately 70% will end up in the sewerage system. If 40 MGD is regarded as a reasonable size of treatment plant for Karachi, atleast seven such plants will be needed by 1985.

Water borne pollution carried by the waste water is now-a-days expressed in terms of Biochemical Oxygen Demand (BOD) i.e. 5 day BOD at 20°C.

The sewage quality in terms of part per million BOD, is the combined effect of the polluting material generated by human activities and quantity of water discharged after use. The essential function of a sewerage system is to protect the environment against the harmful effects of water-borne pollution carried by the sewage. This can only be achieved successfully when the actual amount of pollution and its distribution over the given area are known. The effective sewerage area can be compared with it and may be adjusted accordingly. The calculation for waste-borne pollution in accordance with above mentioned presumptions have been carried out under the different zones, residential, industrial, agricultural and technical infrastructure zones. Briefly, the per capita BOD load for the low income group to be 62 grams. For large industry, commerce and special institutions separate provision was made on a prorata basis from the 1972 calculations and water supply demand. The water-borne pollution generated in the whole urban area of Karachi in 1985 will be 2790 tons BOD per day. The sewage influent which is closely co-related with water supply has also been calculated on the same basis as water supply i.e. from the household socio-economic category and other consumptions according to the actual demands. Thus, for the 1985 Development Plan, Karachi has been divided into eight sewage districts instead of four, as originally provided for in the past.

It has also been established that the existing trunk sewerage system will not be able to cater for the projected sewage flow likely to obtain in 1985 and a network of trunks and sub-trunks in each district have been proposed in addition to the existing sewers. Thus, approximately 88 miles length trunks and sub trunks have still to be laid for 1985 stage. Eight Treatment Plants, separate for each district capable of treating the calculated sewage influent have been proposed. The eight plants will be of 70, 60, 20, 30, 20, 50, 20 and 10 MGD each. The total capacity will be of 280 MGD.

Discussion

The desirability of discharging 40-60 MGD of poor quality effluent containing both industrial and sanitary flows into the river Lyari came up for discussion. It was pointed out that this places a heavy pollutional load on the stream. The author was of the view that for more than one reason it is essential that industrial flows should be excluded from sanitary flows before reaching the waste-water treatment facilities which at present consist of two major trickling filters installations in Karachi.

INDUSTRIAL WASTEWATER DISPOSAL IN THE PUNJAB

MOHAMMAD FAZIL QURESHI
Chief Engineer, Punjab
Public Health Engineering Department
Lahore

Introduction

In order to meet the increasing economic needs of a developing country, industrialization is absolutely essential. Pakistan is not highly industrialized yet, but is going fast in that direction in order to strike a balance between agricultural development and the industrial growth. The associated problems of industrialization cannot, however, be avoided, With the introduction of wide range of industry it is imperative to preserve as far as possible the chemical, physical biological integrity of nation's waters, air land, forests and environments.

Industries in Punjab have been located without any predetermined plan. These are discharging their wastes with very insufficient or no treatment at all over the precious fertile land and into valuable natural streams or seepage drains. This has resulted in the deterioration of environment by pollution of receiving waters, air and land. Several deaths of animals and aquatic life have been reported in Deg Nallah near Kala Shah Kaku and other streams. The pollution of receiving waters has also affected the agricultural out-put adversely. The Governor of the Punjab took serious view of the situation created by industrial waste discharges at Kala Shah Kaku Industrial Complex. He ordered that detailed study be carried out to identify the problems and suggest how to control the increasing nuisance without retarding the industrial development. Consequently a report was prepared based on the detailed field investigations of the effluents. Several recommendations were made in the report. The important among them were that an Environmental Sanitation Cell be created within the Public Health Engineering Department to study the industrial waste problems in greater detail and that an ordinance be prepared to control the quality of industrial liquid solid and gaseous waste discharges.

A Cell has since been created which is expected to start as functioning full-fledged Directorate from July 1975. Pollution Control Draft Act had since been vetted by the Law Department and is expected to be presented to the Provincial Assembly in the form of a Bill for enactment.

GENERAL SITUATION

Presently there are more than 300 major industries established in Punjab causing the aggressive discharges requiring immediate attention for treatment and control. Following is the brief situation of the few receiving waters and land pollution situation in Punjab due to the indiscriminate discharge of industrial and municipal wastes.

Pollution in River Ravi at Lahore

The industrial and domestic waste of Lahore city is being discharged into River Ravi from three major sewage pumping stations namely Shad Bagh disposal works, Sant Nagar disposal works and Nawankot disposal works. These wastes are creating pollution in River Ravi as the raw sewage surplus to the cultivators flows into the river.

Satto Katla Seepage Drain Lahore

Industrial waste of Packages Limited and Glaxo Limited is being discharged into Satto-Katla seepage drain. There is fertile land around this seepage drain. If no treatment is given, this water will affect the fertility of land. The bad smell and the ugly sight is a great nuisance on the highway.

Deg Nallah Muridke Sheikhupura

The waste from industrial complexes at Kala Shah Kaku, Muridke and Mandiali is being dumped in Deg Nallah without proper treatment. This has resulted in gross pollution of this water which has destroyed aquatic life, affected the agricultural land adversely and presents a great danger to public health.

Leih Nallah Rawalpindi

The industrial and municipal waste of Rawalpindi city is being discharged into Leih Nallah. This nallah leads to River Swan. Due to presence of untreated municipal waste water this nallah is being polluted badly affecting the surroundings. Stagnating pools of the Leih Nallah within city and Cantonment area are washed only during floods. All waste water from Islamabad falls in this Nallah crossing through the city.

Seepage Drain Jaranwala Lyallpur

Some industrial waste and domestic waste water of Jaranwala is being discharged into a seepage drain. The water flowing in this seepage drain containing untreated industrial and municipal waste will affect the aquatic life and soil fertility, if no check is applied on waste discharge. Animals drink water from the drain which is dangerous to livestock.

Land Pollution in Lyallpur

In Lyallpur industrial and municipal wast water is combined and is discharging on open land from three major points namely Satiana Road Disposal Works, Narrwala Disposal Works and Abdullahpur Disposal Works. No Treatment is given to the combined wastes. All the wastes are being collected in the form of ponds. The stagnant water in these ponds is polluting air and soil. The textile industries, soap manufacturers and ghee mills are depositing wastes in the ponds near their premises and large areas are depositing wastes in the ponds near their premises and large areas are becoming worthless. The seepage drains Paharan and Sumandari will carry these wastes to Chenab and Ravi respectively.

Seepage Drain Gujranwala

Industrial and municipal waste water of Gujranwala city and its suburbs is being discharged into a seepage drain where quality of soil and air are being damaged. Also distributory canal passing through the city is nothing more than a sullage drain which created the most unhygienic condition in the heart of the city. Trunk sewer is proposed to get rid of the nuisance.

Aik and Bhed Nallah Sialkot

Industrial and municipal waste water of Sialkot city and its surroundings is being discharged into Aik and Bhed Nallahs. These two nallahs are flowing through fertile land. If no check is applied on the pollutants fertility of land will be affected adversely. There are so many factories on either side of each nallah and the discharge of their waste in these two nallahs has grossly polluted the water and presents a great danger to public health.

Land Pollution in Multan

The major types of industries in Multan are textile Industries, tanneries, vegetable oil and ghee mills and fertilizer factory. Most of these factories are discharging their waste on the land which is usually not acceptable by the farmers for irrigation purposes. This is affecting the fertility of the land and presents a great health hazard. Apart from dumping the untreated industrial waste, the municipal sewage in Multan is being discharged from the major disposal works without any treatment. Some of the municipal waste water is being used for irrigation while the remaining is being collected in the form of big ponds.

P.I.D.C. Factory Daud Khel

The obnoxious waste flowing in an open channel passes through the fields and discharges into the River Indus. Not only the fields are being damaged but also the acquatic life is put to danger.

INFORMATION COLLECTION AND LABORATORY INVESTIGATIONS

To know the extent of the problem qualitatively and quantitatively it as been programmed to circulate a proforma to the industrial units for filling in the basic data. The information so collected shall be used for further design and implementation of the plans to clear the sites from pollutants. Industries are not co-operating so far and only few industries have rendered the information.

Laboratory investigations have been undertaken by the Public Health Engineering Department to analyse the waste water effluents from various industries and waste water disposal works in the areas of industrial concentration. The laboratory analysis of the following have been carried out: industries and waste water disposal works in Lyallpur, industrial complex at Kala Shah Kaku and Muridke, industries located at Sheikhupura Road and tanneries in the Punjab.

Laboratory Investigation in Lyallpur City

The waste water effluent samples from various industries indicated a high concentration of total solids, dissolved solids and suspended solids. The total dissolved solids concentration ranged from about 1500 ppm to about 11000 ppm. It was observed that most of the industries are using their private tube wells as the source of water supply and these sources in majority of the cases have higher dissolved solids concentration than permitted by international standards (500 ppm). Municipal water supply should be extended to all the industries using private tube wells as the source of their water supply. The concentration of suspended solid in various industrial waste samples ranged from about 1000 to about 9000 parts per million. This is very much on high side when compared with domestic waste where suspended solids concentration normally ranged from about 100 parts per million to about 500 parts per million. The pH value showed a range from 5 to 9 for most of the industries but some industries showed a pH value from 11 to 13. The overall pH results showed that most of the industries had alkaline wastes except for Kohinoor Textile Mills the only one which has process to neutralize the wastes and settle the solids.

The total Nitrogen concentration in most of the industrial wastes ranged from 30 ppm to 80 ppm as compared with the sanitary flow which normally exhibits a range of 20 ppm to 30 ppm. The total phosphate was found to be in lower concentrations in most of the industries.

A composite sample collected from the disposal works at Satiana Road on 24 November 1973 and 25 November 1973 showed a dissolved solids concentration of 3720 ppm and suspended solid concentration of 380 ppm. The pH value was observed to be 9.6 which is slightly on the high side because a pH range of 6.0 to 8.0 has been recommended for proper biological processing. Total nitrate and phosphate concentrations were found to be 11 ppm and 5.6 ppm respectively and B.O.D. was estimated to be 750 ppm. Normally the ratio of B.O.D.: N:P. should be 60:3:1 for proper functioning of any biological process. This shows that the quantities of nitrogen and phosphorus are less in the waste for efficient biological functioning and supplementary nutrients will be needed. The waste water at Satiana Road disposal works is pumped in a channel about 2 miles long. After flowing through this channel the wastewater enters the waste area, selected for creation of stabilization ponds.

Wastewater samples were taken from various points in the channel to see the reduction in various parameters like B.O.D., C.O.D. total solids, suspended solids as the water flows in the channel from disposal works to the existing pond. The results indicated insignificant reduction in these characteristics. From this it can be inferred that the aeration and sunlight has not rendered much of natural treatment to the flow in the channel.

A sample of wastewater was also tested from the pond where the waste water had been reported to be standing for about two months. The results of this sample showed some reduction on BOD, total solids, dissolved solids, suspended solids and settleable solids. The B.O.D. of this sample has been found to be 240 ppm wbereas for the composite sample from disposal works it was determined as 750 pp,m. This shows a reduction of about 67%. Assuming some experimental error it can be safely said that bacterial activity is taking place and that biological processing of this waste water is possible inspite of the presence of industrial waste. This needs, however, further studies.

Treatment with Oxidation Ponds

An applied research project has been undertaken by the Public Health Engineering Department in Lyallpur to study the effects of various types of oxidation ponds on the treatment of the combined industrial and municipal wastes collected at Satiana Road Disposal Works. The waste treatment for Lyallpur city is very important because there is no natural stream or river nearby. The waste water is not acceptable by the farmers and hence is accumulating on land and creating lot of health problems. Specific studies are needed before any rational treatment could be adopted. Asian Development Bank under Technical Assistance Programme have engaged Binnie and Partners as consultants for Greater Lyallpur Water Supply, Sewerage and Drainage Project. Treatment Process of sewage will be recommended by them. Preliminary design of treatment plant is to be given by them.

Industrial Complex at Kala Shah Kaku

The laboratory investigations of the various industries located at Kala Shah Kaku and Muridke showed that the effluent from all the industries was of undesirable quality. Ittehad Chemicals is dumping hydrochloric acid of high concentration in Deg Nallah. Although Ravi Rayon Mills have a good waste treatment plant but is not being operated properly with the result that the discharge is not of desirable standard. The effluent discharge from Koh-i-Noor Oil Mills was, however, satisfactory. In collaboration with U.N.D.P. and E.P.A. the Public Health Engineering Department have prepared research pilot projects to study the problems of industrial waste disposal and find their economical solution for this industrial complex. Allocation of funds have been made by UNDP.

Dawood Hercules Industries Sheikhupura

The waste water generated from Dawood Hercules Chemical Factory is creating a lot of problems. It has destroyed the aquatic life and affected the agricultural output adversely. Any cattle drinking this water dies because of toxic wastes. The effluents from various sections of industry were analysed. The effluent showed high concentration of total solids, and chromium. There is an immediate need that the waste should be treated to bring it within desirable standards prior to its discharge on the land or in the receiving water. The industry could be forced only after the legislation.

Tanneries Industries in the Punjab

The tannery waste is one of the most complicated waste in particular. The survey and laboratory analysis of tanneries waste through the province indicated that they are creating a great nuisance basically because of odour associated with their processing waste. The tanneries of Kala Shah Kaku on G. T. Road are discharging their waste on open land. They are creating terrible odour problems to the people living in the vicinity and travelling on G. T. Road. The tanneries in Sialkot are discharging their waste in Bhed Nallah, public sewer and open land. Muslim tannery is located well within the city and is a source of great nuisance to the people living nearby. The tanneries in Lahore, Sheikhupura, Sahiwal, Gujranwala and Multan are mostly discharging their waste on open land without any treatment.

The tanneries waste exhibited a very high concentration of total solids, dissolved solids and suspended solids. The B.O.D. and C.O.D. values were also very high. It is strongly recommended that the tanneries should treat their waste before dumping. Mr. Kashiwaya a Japanese trade waste expert, has prepared a report for the treatment of tanneries waste. This report can be of a great help in the treatment of tanneries waste.

FUTURE PLANNING

With the passage of time the population is growing and the rate of industrialization is also increasing. Consequently the pollution created by indiscriminate discharge of industrial and municipal waste is going to increase tremendously. The problems of pollution are already very apparent in the areas of industrial concentration. The need to regulate the pollution problems created by industrial and municipal waste discharges through legislation is, therefore, very essential.

Legislation for Pollution Control

The Draft of this legislation namely "Draft Pollution Control Act 1974" and "Draft Waste Standards under Pollution Control Act 1974" have been approved recently in the Cabinet meeting, and the Chief Minister, Punjab, had been pleased to tell the press (Daily Pakistan Times of 20 August 1974):

> "The words 'pollution of the environment' will shortly become part of the statute book of the Punjab for the first time in its history.
>
> Draft legislation to control pollution was approved in principle by the Cabinet which met on Monday under the Chairmanship of the Chief Minister Mohammad Hanif Ramay who described the legislation as a 'land mark' in progressive administration."

The Draft Act provides for the establishment of a Pollution Control Council and a Pollution Control Authority under the Chief Executive of the Province. The Authority would be entrusted with the job of establishing waste and effluent standards (which have already been drafted), formulating rules and regulations and enforcement of the provisions of the Act. The Pollution Control Council will perform its function in a supervisory capacity. Under the Draft Act the Authority is empowered to formulate Effluent and Waste Standard Advisory Committee whose members will be selected from the scientific community.

With the enactment of this legislation there will be statutory powers with the Pollution Control Authority to regulate the indiscriminate discharges of industrial and municipal wastes. We can thus hope of better environment in the Province of the Punjab in future. It is recommended that all the other provinces of Pakistan should also have a legislation for pollution control. The legislation for Punjab can serve as a guideline for other provinces in the preparation of their legislation and suggesting improvements.

Establishment of an Agency at Natioanl level

The protection and improvement of human environment is of great importance. It is continuing responsibility of the Federal Government to use all practical means consistent with national policy to improve and coordinate Federal plans that the "Nation may fulfil the responsibility of each generation as trustee of the environment for succeeding generations." This is a recommendation of Stockholm Conference which was held on 5 June 1972. United Nations General Assembly acted in December 1972 and created Governing Council and Environment Programme Secretariat as well as Environment Coordination Board and Environment Fund amounting to $ 100 million over next five years. United Nations Environment Programme (UNEP) is based in Nairobi, Keynia. The three functional tasks of United Nations Environment Programme (UNEP) are:

(*a*) Environmental assessment,
(*b*) Environmental management
(*c*) Supporting measures—information, education, training and technical assistance.

Six priorities fixed by United Nations are:—

(1) Human settlements, health and habitat
(2) Land, water
(3) Trade, economics, technology and transfer of technology
(4) Oceans
(5) Conservation of nature
(6) Energy.

It is necessary that there should be an autonomous agency on the national basis and a separate ministry be formed. Pollution Control problems and industrial wastes regularization are inter-provincial problems requiring guidance and help of the Federal Government. The complexity of the problem requires greatest powers for execution at the quickest pace.

Capital, administrative and operating costs can be minimized by the introduction and by incorporating industrial wastes for utilization in the system of production wherever technically feasible and economically marginal revenue equals marginal cost. The economic advantages of large scale operations are highly significant in collection, transport, treatment and discharge of wastes. Equally important advantages of establishing a Ministry at National level are the ability to employ more competent technical and administrative staff, and the management of a significantly large, self contained geographic area as a whole rather than individual small political units.

Economic Management

Until now, the cost of management and control of wastes has fallen upon local and provincial Governments. When the problem was small the cost of such services could be absorbed by Government and incentives for economical solutions were absent. Now, however, the magnitude of the problem requires sound economic analysis to rectify the neglect of the past and to provide for the needs of the future. Since the magnitude of the country's waste problem generally reflects its economic capacity, the financial ability to manage the problem is usually ensured. However, neither the administrative institutions nor the political initiative to undertake the required investment is necessarily ensured.

Methods are needed for the assessment of charges upon those who are responsible for and who benefit from the creation of wastes. A system for charging those who create wates in the manufacture, use, or packing of products is necessary. They provide incentive to manufacturers and other producers of wastes to reduce waste at the source, and they avoid the slow and expensive legal controls that are otherwise necessary. However, the threat of legal regulation does have a salutary effect on an industry that prefers to police itself rather than to submit to Government regulations.

There is a need for analysis of the effectiveness of various types of economic control, for the wider application of such controls, and for their introduction into the more complex field of industrial waste disposal.

Public Education

Most people have very little interest in cleanliness outside their homes. The sweepings are thrown in the streets. Many public authorities pay little attention to sanitation and usually look for the cheapest solutions, especially of refuse disposal problems. This is one of the main reasons for the deteriorating cleanliness of cities recreational grounds, etc. However, some sanitation departments have begun to educate the public, although with indifferent results, by several means, including pamphlets, advertisements, news-papers articles, television broadcasts, and talks in schools and elsewhere, often with the use of films or slides. Police enforcement of the laws seems to have more effect.

No study has been made of ways to improve public interest and cooperation. Social and psychological research would be of interest to gain a better insight into the attitude of man in relation to the cleanliness of his surroundings. Studies of such attitudes might reveal approaches to a sounder public policy in the disposal of wastes.

Manpower

The engineering problem of waste disposal must be evaluated in the same way as any other important engineering project, and disposal systems must be designed and operated similarly. The management of wastes requires intensive study and industry, consulting engineers, universities, and Government have major roles to play. In many places the disposal and treatment of wastes is not handled by engineers or other professionally qualified personnel. A great effort is necessary towards better education and training of those professionals already engaged in the field as well as towards recruiting others to study and work in it.

The greatest advances in the management of wastes have taken place in those countries that have made a special effort to give graduate and post graduate training to engineers already in the field as well as to professionals of other disciplines. There is a need for further training programmes in a country like Pakistan.

In addition to managerial and engineering personnel, installations for the collection and disposal of wastes require well trained technicians and operational and auxiliary personnel. Such skilled personnel are essential to the efficient operation and maintenance of these services and there is an ever growing need of training programmes for them. Full utilization should be made of short term courses, in service training, and regular academic courses for such technicians.

Institute of Public Health and Research

The Institute of Public Health Engineering has conducted research as well as several inservice training courses in the field of environmental engineering. Presently this Institue is operating at Provincial level in collaboration with Engineering University, Lahore and is providing graduate and post graduate education facilities to the engineers as well as consulting and advisory services. In order to make it more effective and extend its facilities the status of this institution should be raised from provincial to national level.

Research Need

Research into the physical, chemical and biological principles involved in waste water collection treatment and disposal, and into the application of these principles, should be intensified. Research in this area, until now, is very much lacking. Research can be stimulated, it can be conducted at existing institutions and through the use of pilot plants. Regulatory agencies should be sufficiently flexible to permit innovation and research as waste managements programmes are undertaken. Research should also be supported by governments and Universities, as well as by specialized laboratories and industry in particular.

Among the almost unlimited areas requiring investigation the following areas have been considered important for research purposes within Pakistan.

Related to Basic Data

(*a*) The measurement of the quality of wastes and the development of more rapid methods of sampling and analysis and sensitive techniques for measuring trace pollutants. The development of standard methods of analysis should be emphasized.

(*b*) Criteria for determining the quality of natural waters, including physical, chemical, and biological indicators of pollution.

(c) The development of better indicators of the presence of pathogenic bacteria or viruses in water.

(d) Epidemiological studies of the effects of long term exposure to trace levels of contaminants in the environment, including food as well as air, water, and land.

(c) Determination of the minimum infectious dose of enteric viruses.

Concerned to Technology

(a) Comparative research on construction, operation, and costs of waste management plants.

(b) Simplified system for the collection, treatment and disposal of wastes designed to make optimum use of local resources of men, materials, land and funds.

(c) Laboratory and field studies of new materials and method of handling wastes.

(d) Improved equipment, instruments, and controls for the replacement of manpower in areas where labour is scarce.

(e) The hazards of the re-use of waste water and solids removed from it, with special emphasis on health aspects.

(f) The compatibility of industrial wastes from manufacturing processes, and of wastes from product use, with domestic waste water plants and with the environments.

(g) The management of waste water solids, and their integration with community and industrial solid wastes.

(h) Economic studies, by systems analysis techniques, of various combinations of unit processes for the collection, treatment, and disposal of wastes, of their incorporation into other waste systems and of the eventual discharge of wastes to the land, water or air, Due consideration should be given to the effect of reclamation and/or disposal of the liquid, gaseous, and solid residues, and of waste heat produced by treatment plants on the environment.

(i) The use of wastes and Residues, and of waste heat, for agricultural, horticultural and other purposes.

Induttrial Planning

We should learn from the problems faced by industrialized countries and plan the development in such a way that the expenditure involved is minimised on the treatment of waste water, which might have to be disposed of in public sewers natural streams, seepage drains or on the land.

Industry has usually not considered the effects that the wastes from new products or new industrial processes may have on the water environment. Government also rarely considers the possible long term effect of such products and processes on the environment when industrial projects are conceived. Highly persistent detergents, pesticides and other toxic wastes are becoming an ever-increasing problem in developed countries and in time will present a similar challenge to Pakistan.

Particularly persistent and toxic chemicals should not be disposed of by way of the public liquid-waste disposal system, consideration must be given to the possibility of establishing regional "burial grounds" for such wastes. There is, furthermore, a need for industry to pre-treatment wastes so that they will damage neither the waste water conveyance and treatment system nor the receiving waters.

Collection and Dissemination of information

Different countries, in attempting to deal with their wastes and pollutants, frequently arrive at a wide variety of solutions. Only by analysis can it be shown whether or not such solutions are suitable for local conditions of geography, climate, administration, economics, etc.

In many cases, the methods devised and research results obtained by a country are of general interest to all countries. Of equal importance has been a lack of communication between disciplines. For example, waste water management can profit from developments in the chemical and biological industries. Engineers and scientists in such field must be encouraged to apply their knowledge to the problems of the disposal of wastes and those in the latter field must be encouraged to search out publications in a wide range of tedhnologies. Information retrievel system must be established, both nationally and internationally if full use is to be made of research accomplishments without an unconscionably long lag..

In Pakistan it is very important to set up, as soon as possible, a procedure for the collection of information, and to have exchanges of view on research work that has been carried out and on the practices of other countries. Such procedures make it possible to avoid unnecessary duplication of research, to apply research results to the related problems, to assess fully and comprehensively the techniques proposed or actually used, and finally to elaborate well founded criteria to be applied by the administrative organizations concerned with planning, design, and construction.

The Institute of Public Health Engineering Research can also serve as a national centre for the collection, evaluation and dissemination of technical information. It should work in close collaboration with the World Health Organization and federal agencies like Federal Institute for Water Resources and Water Pollution Control (FAWAO) at Dubendorf, Switzerland.

In conclusion I would submit that thought provoking material has been presented for the Scientists and Engineers to join heads and take care of the country's ecology, economic development without deterioration of the environments. Steps should be taken to improve the existing conditions and make the country more beautiful to live physically, mentally and socially.

Discussion

The disposal of industrial and sanitary flows generating from the cities of Lahore, Lyallpur and some other areas came up for discussion. The main discussion included the conditions in Lahore where an appropriate body of water for dispersion is available. It was pointed out that the conditions are the worst in areas like Lyallpur and certain colonies where we do not have appropriate points of discharge for the waste waters. It was suggested that a nearby canal in Lyallpur may provide sufficient dispersion of pollutional load.

Following main points also developed during the discussion:

(1) Sanitary Sewers and storm drains should be integrated for Lyallpur area.

(2) The provision of grit chamber before discharge of waste waters to the treatment facility.

(3) Oxidation pond research study for Lyallpur waste waters.

(4) Comprehensive plan for introduction and implementation of regulations and ordinances regarding the effluent quality criteria for discharge to canals and water courses.

MAINTENANCE OF MUNICIPAL SEWERAGE SYSTEMS

A. H. ASHWORTH
WHO Senior Advisor
Islamabad

General

The maintenance of Municipal Sanitary Sewerage Systems includes inspection, flow measurement, cleaning, flushing, supervision of new connections, protection of existing sewers, prevention of explosions, and repairs.

The two main sub-divisions of sewer maintenance are:

(*a*) Maintenance by necessity, and
(*b*) Preventive Maintenance.

This concept means that a distinction is recognised between dealing with day to day problems of operation of the system and carrying out work in anticipation of possible break-downs.

The most frequent complaints regarding sewers requiring maintenance by necessity involve clogging, breakage of pipes, and odors. The main cause of clogging is sand, grease and roots.

Broken sewers are caused by poor foundations, excessive superimposed loads, vibration, undermining and general deterioration, while odors are caused by the accumulation of organic matter. All of these conditions can be anticipated or alleviated by preventive maintenance.

Construction of sewers should be carefully supervised by the Municipal sewer authorities' maintenance personnel as part of a preventive maintenance programme.

Maintenance Personnel and Equipment

The minimum sized sewer maintenance crew should include 3 men, provided with a 1-1/2 ton capacity or larger truck. Equipment should include:

(*a*) Diaphragm pump—power driven from truck
(*b*) 600 feet of sewer rods
(*c*) Root cutters, assorted sizes
(*d*) 600 feet of flexible rods, power driven
(*e*) Fire hose with flushing nozzles
(*f*) Power winch, plus a portable, manually-operated winch
(*g*) 1000 feet of flexible wire cable
(*h*) Sewer brushes, assorted sizes

(*i*) Sand buckets, scoops and drags, assorted sizes
(*j*) Turbine flushing heads
(*k*) Steel sewer tapes and heavy wire for small sewers
(*l*) Waterproof clothing, including boots
(*m*) Miscellaneous tools—hammers, shovels, crowbars, wrenches, buckets, rope ladders, hydrant wrenches.
(*n*) Flood lights, power driven, and fl sh lights
(*o*) Safety equipment, including: gas detectors, gas masks, safety harness, first aid kit, skull guards with electric lamps and dry cells, manhole guard rails, traffic signs, flags, oil lamps and flares
(*p*) A complete map of the sewer system, showing details.

Inspection

Inspection of sewers is made to reveal clogging; to find illicit connections; to study condition of control mechanisms and to service them; to examine condition of the structure; to measure the load on the sewer with respect to its capacity; and for reasons arising from complaints. Inspections and flow measurements may be necessary during storms to determine sewer flow/capacity relationship.

Routine inspection of small sewers made by examination at the manhole:

(*a*) If water is running as freely at one manhole as it is at the next manhole above, it is assumed that the sewer between these manholes is clean and no further inspection is necessary.

(*b*) If the sewage is backed up in a manhole, it indicates that there is an obstruction downstream.

(*c*) If sewage flow in manhole is sluggish, and covered with scum, it indicates clogging, slow velocity, and septic conditions in the sewer.

(*d*) Sludge on the manhole bottom or signs of sewage high up on manhole walls indicates occasional flooding due to inadequate capacity or clogging.

If there exist indications of clogging, manhole should be entered and sewer should be more carefully inspected. This may be done using mirrors or a periscope, using explosion-proof flashlight, electric light, or reflected sun light, as a source of light.

Sewers large enough to enter should be inspected by wading.

The inspection of sewers should include all flush tanks, control devices, grit chambers, and other appurtemances.

A record should be kept of all inspections made, including an account of the inspection, date, conditions encountered, inspector's name, and remedies taken to effect repairs.

Cleaning Sewers

Sewers too small to enter are cleaned by rodding or dragging. Common methods are:

(*a*) Sewer rods (wood or light metal) with couplings, are joined as required to reach and dislodge obstructions. The front section of rods may be fitted with special cutting tools, and may be pushed manually 400-500 feet.

(*b*) Flexible steel bars; 1/8" thick × 1" wide. Rod is manually inserted and rotated by motor.

(*c*) Fire hose with small nozzle. Distances of up to 100 ft. A self-propelling nozzle may be used, as well as cutter blade attachments.

(d) Sewer balls made of heavy, specially compounded, high grade neoprene rubber may be inserted into sewers to remove sludge deposits, the balls jam against the obstruction, and the increased sewage velocity may gradually clear the channel.

(e) Scraping instruments are dragged through sewers to loosen sludge banks, cut roots, or dislodge obstructions. Scoops are pushed against the flow and withdrawn and emptied.

(f) Flushing with water, at high velocity and producing a hydraulic bore, or by temporary damming, with sand bags, and then suddenly releasing sewage to dislodge the obstruction. Low level connections must be checked to avoid backing up into houses and the flooding of basements.

Repairs

Common repairs to sewer systems consist of adjustment of manhole covers, replacement of broken pipes, loosened bricks or mortar; and other miscellaneous items.

Protection of Sewer

Sewers can be protected against abuse by vigilance and by municipal ordinances, wisely drawn and strictly enforced. These ordinances should prohibit the discharge into the sewer of corrosive, inflammable or explosive substances; high temperature liquids or gases; clogging solids such as sand, ashes, rubbish, and grease; dead animals, offal or unground garbage. It should also clearly define the permitted uses of the sewer and methods of connection from homes, business premises and industrial sites.

Flow Control

Ground and surface water infiltration may be reduced by repair of leaks, and manholes subject to inundation can have tops plugged; unplugged openings left for house connections can be closed; unauthorized connections such as roof, yard, and floor drains can be discovered and disconnected; large industrial plant water discharges can be controlled.

Explosions and Their Prevention

The principal cause of sewer explosions is the presence of petrol, naphtha, and other cleaning fluids and solvents, and methane or natural gas in the sewer.

Explosions in sewerage systems may be prevented by installing traps in waste lines of garages, cleaning, establishments etc., and by ventilation. Vigilant inspection, to detect the presence of explosive gases and to locate and teminate their source, is the best method of prevention.

Costs—Municipal Operated Maintenance Programme

An estimate of cost of a sewer maintenance programme can be illustrated using that of the Los Angeles County which maintains over 3,400 miles of sewers, ranging in size from 8 to 36 inch, and which includes several pumping stations. Sewer maintenance staff consists of 70 personnel, including nine supervisors, a yard foreman at each of three maintenance yards, 8 pumping plant maintenance men plus two painters, and 48 sewer maintenance men. With this crew, they were able to maintain the system for $400 to $ 500 per mile per year, prior to 1970, according to the office of the County Engineer.

A cleaning crew consists of 4 men, using one or two trucks. With this team, they can average cleaning of 0.5 mile per day. Maintenance and inspection crews of three men handle inspection stoppages. They can inspect about 80 manholes per day or approximately 20,000 ft. of sewer.

Rodding crews consist of three men, hydraulic bailing crews consist of four men.

Costs and Contracting of Maintenance Services

Municipalities sometimes do not employ their own forces for maintenance, but rather contract this work out to private firms, an example of this being the City of San Francisco. Anchorage, Alaska after the earthquake, used a two-men remote T. V. crew; they inspected and photographed from 1500-2000 ft. per unit per day, at approximately a cost of $ 0.60 per foot. Cleaning was done at a cost of about $2.00 per foot. The crews rodded 37,000 ft. of sewers per week, under difficult conditions, using flexible sewer rods, according to the City Engineer, Anchorage.

Los Angeles owns a television unit, but uses it only rarely. With a crew of four men, it can set up and inspect and photograph up to 700 ft. of sewer per day.

A city in the Los Angeles area, with 30 miles of sewers, contracts to have these inspected and cleaned annually for approximately $15,000 or $500-550 per mile/year.

Typical Preventive Maintenance Programme

The chief objectives of services to maintain sewers, under preventive maintenance, are as follows:

1. Elimination of potential stoppages that create hazardous and unhealthy conditions.

2. Reduction of sewer stoppage occurrences and thereby reducing the requirements of unscheduled work.

3. Reduction in complaints of odors, noisy manhole covers, vermin, and street cave-ins.

4. Elimination of potential law suits claiming "negligent operation of the sewerage system"

5. Extension of useful life of sewerage system by maintaining maximum sewer capacity and eliminating structure-deteriorating sewage gases.

A programme for preventive maintenance to accomplish these objectives consists of the following:

INSPECTION

Sewers—Inspection of sewers should begin during construction and thereafter as follows:

Every three months where trouble has been recorded.

Semiannually where no trouble reported.

Routine, monthly to weekly, in intercepting sewers and flush tanks.

Inspections should determine the following:

(*a*) Stoppages or restrictions

"Usual" deposits, such as sticks, rags, grease, and garbage grindings.
"Unusual" deposits, such as large rocks, metal objects, sand, and root growths.

(*b*) Need for repair or adjustment

(*c*) Presence of vermin or rodents

(*d*) Miscellaneous conditions covering:

Abnormal flow, deleterious industrial wastes and odors.

2. *Special Manholes and Siphons*—Inspected monthly to weekly for stoppages or restrictions.

3. *Sewage Pumping Plants*—Inspected daily and the following performed:

   (*a*) Pumps and motors checked and lubricated.

   (*b*) Control mechanisms and valves checked and adjusted as required.

   (*c*) Equipment repaired or modified as required.

   (*d*) Structures maintained as required.

4. *Manholes*—tested continuously for the presence of:

   (*a*) Explosive and sulphurous or other toxic gases.

   (*b*) Oxygen deficiency.

B. CLEANING

1. **Sewers**
   Cleaned on a scheduled basis: all lines at least annually, more often when known to accumulate grease, garbage grindings, sand, or root growths.
   Cleaned on an unscheduled basis when inspection discloses this requirement.

2. Special manholes such as gas-traps and drop manholes are cleaned at the time of inspection.

3. Siphons are cleaned only when this need is disclosed as a result of inspection.

4. Sewage receivers (wet wells) and screens at pumping stations are cleaned as required.

C. OTHER MAINTENANCE OPERATIONS

1. Main line sewers tapped and Wye or Tee saddles installed by sewer maintenance personnel for a nominal permit fee.

2. Handling of complaints and emergencies

   Personnel available to receive and act on any call relative to main line trouble.

   All complaints investigated and acted upon.
   Reasonable attempts made to locate and recover articles of value reported lost in the sewers.

Vermin and rodent control

Sewers and structures sprayed or baited when inspection discloses evidence of infestation.

Manhole Maintenance

Manhole covers silenced, sealed, or adjusted to grade. Manhole repaired or reconstructed. Manhole steps replaced as required.

Industrial Waste Control

An industrial waste division performs periodic and special inspections to prevent the discharge into the sewer system of any wastes that cause excessive maintenance, harm the system, or that present a hazard to either crew men or the public.

Discussion

The points which were raised included the possible effects of industrial waste pollution potential on the maintenance of sanitary sewers and storm drains. The author recommended that detailed study on quality of industrial effluents should be made. He further suggested pre-treatment at source for all industrial wastes so as to approach the BOD and solids level of domestic sewage and pre-treatment of certain wastes because of their harmful nature.

OXIDATION POND RESEARCH

DR. MOHAMMAD NAWAZ TARIQ
Director and Professor
JAVED ANWAR AZIZ
Assistant Professor

Institute of Public Health
Engineering and Research, Lahore.

INTRODUCTION

Much work has been done in recent years in Southeast Asian countries in establishing the applicability of oxidation ponds as an economical waste water treatment device. The tropical temperatures and long hours of sunshine available in Pakistan suggest its suitability to our conditions. As a result the Institute of Public Health Engineering and Research undertook feasibility study of oxidation ponds alongwith laboratory scale investigations. This was eventually followed by pilot scale set-up. The work described in this paper is based on a research study conducted by this Institute on four pilot scale oxidation ponds constructed alongside Shadbagh Pumping Station belonging to LIT WW. A portion of the waste water received at the pump house is diverted for use as influent to the oxidation ponds. The wastewater consists of domestic sewage, sullage and factory washings. The ponds operate in parallel as aerobic/facultative type and were started in October, 1972.

The plan of work as laid down in Table I aims at determining the pond performance in terms of effluent quality, relationship of BOD reduction efficiency with loading rate, depth and climatological variations. The basic process of photosynthesis in relation to pond ecology is also being studied. This pilot-scale oxidation pond set-up also acts as an excellent demonstration unit and is of immense educational value to the undergraduate and post-graduate students of the University.

PILOT PLANT

Description and General Conditions

The Pilot Plant consists of four brick lined oxidation ponds each having the following features:—

Section	Trapezoidal
Top length	150 ft.
Top width	60 ft.
Total depth	3-5 ft.
Side slope	1:1½

All the ponds were operated in parallel during the period under review. Various BOD loadings were applied to the ponds and the flow to each pond was adjusted on the basis of the composite average BOD result of 200 mg/l. Water in the ponds maintained light to dark green colour. However, blue green algae were also found in considerable amounts in all ponds. No odour problems were present during the entire period of investigations. The aspect of mosquito breeding in the pond area is described in a separate paper.

TABLE I

Plan of Work

Period of investigation	1st Dec. 1972—31st March, 73				15th Sep. 74—15th Jan. 75			
Pond No.	1	2	3	4	1	2	3	4
Loading (lbs BOD/acre day)	75	150	250	200	75	150	250	200
Operational Depth (ft)	3	3	3	4	4	4	4	4
Surface Area (Sft)	7775	7775	7775	8380	8380	838	8380	8380
Volume (cft)	20700	20700	20700	28800	28800	28800	28800	28800
Residence period (days)	19	8.5	5.7	9.5	25	12.5	7.5	9.5

PLAN OF WORK

Table I summarises the plan of work. Loading rates and operational depths are the selected parameters, whereas ponds' surface areas, volumes and residence periods are corresponding computed figures.

Methodology

Loading rates:— Conservative loading rates of 75,150, 200 and 250 lbs BOD/acreday were chosen on the basis of being usual figures adopted for the operation of aerobic and facultative ponds in various countries.

Operational Depth:— The first three ponds were operated at depths of 3 ft in the first phase and at a depth of 4 ft in second phase.

A constant depth of four feet for entire period of investigation was selected for pond No. 4 to study the effect of seasonal variations on process efficiency. Rate of loading and the depth selected for pond No. 4 were also expected to be the optimum values for the operation.

Experimental

Grab samples of the influent and effluents from all the four ponds were collected twice a week. Composite sampling for BOD assessment was done once a month to maintain the required loading rates for various ponds.

Temp, pH, colour, and dissolved oxygen were determined insitu whereas alkalinity, settleable solids, suspended solids, BOD and COD determinations were carried out at the Institute. Nutrient content determinations were made only once a month.

Total bacterial count and MPN of coliform bacteria were also calculated to judge the removal efficiency. Investigations were also made for qualitative and qualitative aspects of phytoplankton and zooplankton found in the ponds.

RESULTS

The detailed characteristics of influent and effluents from the ponds have been listed in the oxidation pond Research Reports for the periods mentioned in table I. Here only the results of one month analysis performed on influent are presented in Table 2 as general characteristics of oxidation pond influent.

TABLE 2

Influent Characteristics

Month	October 1974
pH	7.2
Alkalinity	368 mg/l as Ca Co_3
Settleable Solids	1.8 ml/l
Suspended Solids	175 mg/l
BOD	204 mg/l
COD	850 mg/l
Total Nitrogen	19.8 mg/l
Total Phosphate	3.7 mg/l
Total Bacterial count/100 ml	240×10^8
Coliform (MPN) per 100 ml	23×10^6

The general characteristics of the effluent from pond No. 3, loaded at the maximum rate of 250 lbs BOD/acreday are presented in Table 3. The reported results correspond to the month of October 1974.

TABLE 3

Effluent Characteristics

Pond No. 3	Month Oct. 1974
pH	8,4
Alkalinity	325 mg/l as Ca Co^6
Suspended Solids	45 mg/l
BOD	23 mg/l
COD	232 mg/l
Total Nitrogen	9.5 mg/l
Total Phosphate	1.2 mg/l
Total Bacterial Count	24×10^8 per 100 ml
Coliform MPN	80×10^4 per 100 ml

The percentage reduction in various parameters as observed in pond 3 during the second phase of study is reported in Table 4.

A number of genera of photosynthetic organisms were observed in the plankton present in the pond. The predominant species observed in various ponds during second phase of investigations are reported in Table 5.

TABLE 4

Pond 3 PERCRNTAGE REDUCTION IN VARIOUS PARAMETERS
(Loading 250 lbs. BOD/Acre Day)

Month	Total Alkalinity removal	Suspended Solids removal	BOD removal	COD removal	Total Nitrogen removal	Total Phosphate removal	Bacterial removal	Coliform removal
September	15	87.0	74.6	—	—	—	—	—
October	11.7	74.5	83.4	72.7	52.0	67.8	85.83	96.52
November	13.2	85.5	74.4	48.4	50.8	71.5	88.42	97.92
December		63.5	77.7	34.2	55.5	50.0	85.71	99.37
January	1.15	70.5	69.5	49.0	58.6	31.8	87.27	98.83

TABLE 5

Most Occurring Algal Species

Pond No.	Dominant algal species	Sub-dominant algal species
1.	Euglena gracilis	Oscillatoria lauterbornii
2.	Oscillatoria lauterbornii	Euglena gracilis
3.	Euglena gracilis	Phacus pyrum
4.	Euglena gracilis	—

In zooplankton Paramecium and Rotifers were recorded as the predominant microscopic animals. On two occasions, the problem of daphnia was also faced in various ponds. However the species disappeared in a weeks time.

Coliform Removals

During the first phase, coliform removals from various ponds ranged between 88.6 to 99.0 % whereas in the second phase they ranged from 95.2% to 99.67%. In both the phases, maximum removals occurred in pond I, which also showed a relatively better efficiency throughout the investigation period.

Comparison of BOD removal efficiencies

Table 6 compares the BOD removal efficiencies of Pond Nos. 1, 2 and 3 during the two phases of investigations. Variation in operational depth is the basis of such comparison. Pond No. 4 was operated at a depth of four feet during both the phases. However, the removal efficiency in the second phase was somewhat better and the pond removed the BOD in a range of 61.5 to 82.3%.

TABLE 6

Comparison of BOD Removal Efficiencies

Pond No.	Range of % BOD Removal	
	at 3 ft operational depth	at 4 ft operational depth
1.	69.8 — 82.9	70.6 — 84.5
2.	67.0 — 82 0	72.7 — 82.5
3.	63.5 — 70.5	69.5 — 83.4

DISCUSSION OF RESULTS

Detailed discussion has been made on the results of the investigations in the oxidation pond Research Reports as mentioned previously. Here only a few important aspects are discussed.

Biochemical Oxygen Demand

During the first phase, BOD of the influent ranged from 207 to 241 mg/l whereas in the second phase it ranged from 147 to 235 mg/l with a gradual increase from Sep. 1974 to Jan. 1975.

During first phase, effluent BODs from the four ponds ranged from 43 to 77 mg/l as compared to the range of 32 to 85 mg/l found in the second phase. The respective removal ranges have been shown in Table 6.

It is interesting to note that the average effluent BODs did not show any relationship with load and there was no significant difference between the performance of various ponds.

Particularly mentionable are the results of second phase. In Pond I maximum BOD removal of 84.5% took place in the month of October whereas Pond 2 had its best performance in the month of December. For Pond 3, October was the month of best performance when a BOD reduction of 83.4 was achieved. Pond 4 achieved maximum BOD reduction of 82.6 in the month of November.

No relationship between the loading rates and BOD reduction can, therefore, be established on the basis of these results as the variations are insufficient to suggest any particular advantage for any rate of loading. However, it may be concluded that the ponds loaded at a rate of 250 lbs BOD/acreday can work quite satisfactorily in locations like Lahore. Higher loadings are recommended to be tried to reach at a definite conclusion regarding optimum load rates.

From the results obtained during the two phases, the effect of operational depth on BOD removal is depicted very clearly. The removal efficiencies were found improved at four feet operational depth. This confirms the views of ARCHEIVALA (1970) and GLOYNA (1971) that deeper ponds appear to give more consistant performances.

Noticeably in the second phase of study, the detention time also increased in the first three ponds. It is established by many workers that longer detention time with same BOD loadings may produce better effluents. This aspect is believed to be an important factor for better performance of the ponds in the second phase of investigations.

Nutrient Removal

Reduction of nitrogen took place in all the four ponds during both phases. In the first phase, the reduction ranged from 36.4 to 58.6% in various ponds whereas in the second phase it ranged from 49.2 to 67.8%. Pond No. I, having the maximum residence period achieved the maximum removals. Although exact mechanisms are unknown, it is thought that organic portion of total nitrogen was reduced by bacterial action whereas ammonia nitrogen was chiefliy utilized by algae. Since the unfiltered samples were analysed, it can be gathered that the sedimentation was the main reason for such reduction.

Degree of phosphate removal in various ponds was only determined during the second phase. Removals in various pons ranged from 31.8 to 71.5%, However, no particular relationship of phosphate removal to loading could be claimed. As in the case of nitrogen removals those of phosphates were also, to a large extent, due to the sedimentation process.

Bacterial and Coliform Reduction

In the first phase, reductions in total bacterial counts ranged from 89.0 to 99.6%. During second phase, such reductions ranged from 81.43 to 92.73%. Maximum removals were achieved in Pond 2. However, Pond I showed relatively better performance during the entire period of investigations.

The results confirm the findings of many authors, as cited in literature, that long detention times used in stabilization ponds result in better reduction of bacterial count. During long detention periods, sunlight contributes significantly towards the reduction of bacteria. Longer detention times also help the growth of zooplankton which considerably reduce the bacterial number. Lack of nutrient availability and the presence of any toxic material in the industrial waste component of the influent may constitute a reason for the reported bacterial reduction.

Coliform removal efficiency as achieved during the two phases cannot be considered as outstanding, in general, as no cell was able to remove 99.9% of coliform type bacteria. With long detention times employed during the investigations, it should have been possible to achieve the said degree of die off.

The importance of such investigations cannot be over emphasized as the removal of BOD without regard to the destruction of pathogenic organisms is inadequate. All pathogenic bacteria must be destroyed in a wastewater treatment system or diluted to a level in the environment where the chances of disease being caused in a given population are negligible. Estimation of coliform removal is, therefore, necessary to indicate the degree of 'purification' of the treated effluent or in other words the process efficiency.

Conclusions

The following conclusions are made as a result of the present investigations:

1. Based on the quality of final effluent, the pond performance was satisfactory during the period under review.

2. The variations in operational parameters were not enough to suggest any particular advantage for any rate of loading. However it is concluded that a loading of 250 lbs BOD/acreday can satisfactorily be chosen for domestic sewage treatment in oxidation ponds. Higher loadings are suggested for further investigations to arrive at an optimum loading figure.

3. During the investigations, longer detention times and deeper depth of four feet, resulted in better performance of the ponds in terms of BOD removals. Coliform removal efficiencies were also markedly improved.

4. Phytoplankton observed were predominately green algae Euglena gracilis which exhibited the greatest adaptability to the pond conditions.

5. The facility showed an overall satisfactory performance in the removal of various sewage components.

Discussion

The discussion mainly centered round the experimental results as reported by the authors in their paper. Of particular interest was extra BOD removal as a consequence of depth change from 3 ft to 4 ft as shown in Table 6. The aspect of optimum depth in conjunction with optimum detention time was discussed. The authors were of the view that to arrive at optimum detention time further investigations were needed.

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MOSQUITO BREEDING IN OXIDATION PONDS

DR. K. M. YAO
WHO Professor of Sanitary Engineering
Institute of Public Health Engineering
and Research, Lahore.

INTRODUCTION

Oxidation ponds have been reported to be susceptible to mosquito breeding (1). This could be a significant factor for serious consideration in promoting the use of oxidation ponds as a low-cost wastewater treatment method, especially in malaria-infested areas where oxidation ponds often represent an attractive alternative for wastewater disposal. It was estimated that, in the Eastern Mediterranean Region alone, 194 million persons lived in malarious areas in 1973(2). Pakistan is one of the major countries in the area with a reported malaria incidence as high as 15.5 percent in 1960. This was reduced to 0.07 percent in 1973(3). Due to unfortunate circumstances resulting in inadequate insecticide supply, the number of malaria cases rose to almost one percent of the total population in 1972(2).

The following item appeared in a news report in 1973(4):

"Umerkot these days is under attack from strange big sized mosquitoes which resemble flies. Following the appearance of these mosquitoes, malaria has taken the form of epidemic among the population."

It is obvious that, if oxidation ponds are to be used in countries such as Pakistan, the mosquito breeding aspect must be examined carefully in order not to perpetuate a serious health hazard in the country.

In addition to being a vector for propagating malaria, mosquitoes are also responsible for transmitting a number of harmful viruses including that for the dreadful yellow fever. Mosquitoes have also been found to be the unwilling carrier of botfly eggs in Mexico and South and Central America. The eggs hatch immediately upon contact with the warm skin of a mammal and the larvae bore underneath the skin to develop causing large painful lumps (5). Apart from spreading diseases, many female species of mosquitoes feed on the blood of man and cattle.

Observations of mosquito breeding in anaerobic and aerobic ponds in India tend to indicate that the key to eliminate the problem is to keep the banks clear of vegetation. No mosquito breeding was observed in an anaerobic pond over a period of 18 months in Madras as long as "marginal vegetation was prevented"(6). The observation of three stabilization ponds operated in series indicated negative results in mosquit breeding in a three-year period in Nagpur(7). In both cases, no proof was given to show that mosquito breeding would be a problem if vegetation was allowed to grow. Surveys of two facultative ponds in Madras over a period of one year indicated, however, "that larval breeding could be induced in the ponds by allowing marginal vegetation to grow into the water and that it could be prvvented by trimming the vegetation"(8). The latter observation gives the uncomfortable indication that oxidation ponds are definitely not immune to mosquito breeding.

It has been suggested that the selection of an egglaying site is to a large extent a matter of discretion of the female mosquito and its preference to sites with vegetation in shallow waters is probably either for the convenience of the egg laying operation or based on the mother instinct to provide a sheltered place for the larvae to develop. The question is whether we can rely on this female psychology in an absolute term. In other words, some female mosquitoes may deviate from the rule and lay eggs in open waters without vegetation.

In all the cases described above, there was no mention of the possibility that the existence of certain pollutants such as residual insecticides and oil might have suppressed mosquito breeding in the periods of negative results.

The purposes of the present study are:

(1) To observe any sign of mosquito breeding in oxidation ponds with absolutely no possibility of vegetation growth on any portion of the ponds.

(2) To verify that, in the case of negative results in the above-described ponds, mosquito breeding does occur if the pond water is diverted to an environment where weeds are allowed to grow in shallow water.

(3) To examine the health significances if mosquito breeding does occur in oxidation ponds.

The study was made at an experimental site approximately ten miles from the center of Lahore, Pakistan.

Mosquitoes Around Study Area

Mosquito belongs to the order Deptera, considered to be the fourth largest in the insect world. The same order also includes flies, gnats and midges(5). There are approximately 2,500 known mosquito species spreading from tropics to the Arctic regions(9). Not all the species are harmful or a nuisance. As an example, out of over 200 species of Anopheles, the subfamily known to be responsible for transmitting malaria, only about 50 are actually involved in the life cycle of the organism causing malaria(5). In addition, the important or dominating species tends to be different in different localities. For instance, the species requiring special attention in the malaria eradication programmes in Tunisia, Egypt and Syria are, respectively, A. Sergenti, A. Gambiae and A. Sacharovi(2). A. culicifacies is the most important vector of malaria in Pakistan(10).

The behavior of mosquitoes is extremely variable among different species. Many mosquitoes prefer tree holes or clear water ponds as the breeding ground. If all the species in the region are the tree-hole or clear water type, there would be no mosquito breeding problem in oxidation ponds. On the other hand, if all the mosquito species present in the area do not feed on blood or transmit diseases, the problem would be minimized even if oxidation ponds do breed mosquitoes.

An ecological survey of mosquitoes of the Changa Manga National Forest located 48 miles from Lahore was made from November 1963 to March 1965 for identifying the types of mosquitoes in the area and their behavior(10). Altogether 29 species were collected. Out of these, 16 species were attracted by exposed human skin. This indicated a high percentage of species harmful to human being in the area. Among the species collected, Culex pipiens fatigan preferred dirty domestic collection of water and C. theileri, weedy ground pools. There was also a very interesting species, Aedes culicinus, which gave its special favor to ground pools with grassy margins and decomposing alagae on the bottom. Some species bred throughout the year and others had different major breeding seasons. There was no single period in a year free of mosquito breeding. If the survey results are a good indication of the situation in Lahore, mosquito breeding in oxidation ponds could present a potential year-round problem with possible public health implications.

Experimental Facilities

There were four rectangular oxidation ponds at the study site, each 150 ft by 60 ft (46 m by 18 m) on the top and 5 ft (1.5 m) deep with a side slope of 1.5 (horizontal) to 1 (vertical). The ponds were lined with bricks on the s des and bottom and were numbered from 1 to 4. During the period of study, the ponds received municipal sewage and were operated in parallel with a water depth of about 4 ft (1.2 m). The ponds were in proper perating conditions giving varying shades of green color.

The pond effluent was collected in a round sump and was pumped to either an earthen pond or crudely formed shallow channels for intermittent irrigation of an experimental field. The earthen pond was 64 ft (20 m) square at the top and 3 ft (0.9 m) deep with banks of natural slopes. There was abundant weed growth on the shallow portion of the banks in the initial period of study. The channels formed a series of puddles with varying degrees of weed growth.

Methodology

The observation of mosquito breeding was made by using a cream-color enameled sauce-pan about 6 in. (15 cm) in diameter and 4 in. (10 cm) deep with a long handle. Water samples were taken with the pan along the edge of the ponds and from the puddles for close examination of the sign of mosquito breeding. The presence of larvae at different developing stages was taken as a positive indication. If no larvae were found in the samples taken from a particular pond, a visual search of the pond was then made for any floating discarded skins produced in the successive stages of molting of mosquito larvae. The presence of discarded skins is considered as sufficient to indicate mosquito breeding in the present study.

When identification of the predominating species was desired, a number of larvae were picked up with a laboratory dropper from the sauce-pan and placed in a capped test tube for transportation. The actual laboratory identification was conducted by the Pakistan Medical Research Center, University of Maryland, USA, located in Lahore, Pakistan.

The inspection was made once a month during the study period for sign of mosquito breeding in the oxidation ponds, earthen ponds and shallow puddles at the study site.

Study Result

The study was made from January to May, 1973 and was discontinued in June 1973 due to the temporary suspension of the operation of the oxidation ponds. Table 1 presents the average climatic conditions in Lahore for the relevant period of the year furnished by the Pakistan Meteorological Department.

There was no evidence of mosquito breeding indicated by the presence of either mosquito larvae or discarded skins throughout the period in Oxidation Ponds No. 1 and 4.

For Oxidation Pond No. 2, no evidence of mosquito breeding was observed for the entire period except in March. In that month, a young mosquito larvae was found in one of the samples dipped up by the sauce-pan during inspection. There were also a small number of discarded larval skins on the inlet side of the pond. This was of course no comparison with the situation in the shallow puddles where every sample picked up contained a large number of mosquito larvae. Neverthelees, evidence of mosquito breeding was present in a pond with no weeds on its banks.

A somewhat similar situation was true for Oxidation Pond No. 3 where some discarded larval skins were also found floating on the water surface during the March inspection. No larvae were caught, however, in all the samples. For the rest of the study period, no sign of moqsuito breeding was observed in this pond.

The earthen pond provided an interesting opportunity for the observation of mosquito breeding under different bank conditions. In January, there was profuse growth of grass on the banks reaching into the pond water along the slope. There were numerous mosquito larvae in every sample scooped up along the edge of the pond. The bank along one side of the pond was cleared of weeds in February. As a result, no mosquito larvae were caught in samples taken along this side during the February inspection. However, along the other sides of the pond, small numbers of young mosquito larvae in the order of 1 to 2 in each sample were observed and discarded skins were present on all sides. During the March inspection, the results were very similar except that a few mosquito larvae were also found in some of the samples taken along the weed-free side of the pond. In April, all sides of the earthen pond were cleared of weeds. Consequently, no mosquito larvae were observed in all the samples picked up along the banks during the April and May inspections. Discarded larval skins were, however, found to be present in both inspections.

The puddles presented, in a sense, a control for the study. These puddles were shallow in depth and covered with vegetation providing ideal mosquito breeding ground. Invariably, a large number of mosquito larvae of various sizes were observed in every sample dipped up from these puddles with, perhaps, the only exception during the inspection in May. In that month, the number of larvae tended to be fewer in each sample but there was no question of their being present. These results tended to indicate that nothing in the wastewater could have suppressed mosquito breeding during the study period.

During the January inspection, specimens of mosquito larvae were collected from the earthen pond and nearby puddles for identification of the predominating species. The results were as follow

In earthen pond:	Culex pipiens fatigans
In puddles:	Culex pipiens fatigans, culex theileri and Anopheles stephensi

No larval specimens were collected from the oxidation ponds since none were found in the oxidation ponds during the January inspection.

Discussion of Results

The same wastewater source was used as the sole supply to the brick-lined oxidation ponds, earthen pond and puddles. The only difference in their mode of operation was that the oxidation ponds were operated on a continuous flow basis and the others were fed with intermittent flow. In view of the long detention period of the oxidation ponds, this difference in mode of operation cannot be the cause of such drastic observed contrast in mosquito breeding between the oxidation ponds and the puddles or earthen pond before its banks were cleared of weeds. In fact, there were many dead corners in the oxidation ponds with very little flow movements. Hence the observed results seem to confirm that the key to mosquito breeding control in a wastewater pond is to keep banks clear of weeds. This was further demonstrated by the observed results of the earthen pond. Before its banks were trimmed, the observed larval population was almost the same as that in shallow puddles. There appeared to be a great reduction in larval population in comparison with that of the puddles after the banks were cleared of vegetation. Since no evaluation was attempted as to the actual population density, the results were purely based on observations of samples and general inspection of the pond condition.

The observed results during the March inspection on the other hand indicate a possibility that mosquito breeding may occur in oxidation ponds with absolutely no chance of weed growth on their banks. No attempt was made to find out why evidence of mosquito breeding was found only in this particular month and only in two of the four oxidation ponds. One thing was certain that nothing in the way of pond operation could have introduced mosquito larvae into the ponds. In addition, clearing of the weeds on the banks of the earthen pond did not completely eliminate mosquito larvae. Admittedly, the clearing was done in a crude manner. This is probably the type of maintenance an oxidation pond can possibly have in rural areas. Hence if oxidation ponds are to be promoted for villages especially in countries where malaria is still a problem, measures in addition to keeping pond banks clear of weeds should be investigated to insure public health and welfare of the inhabitants. One possibility is to introduce larvivorous fish such as Gambusia affinis and Notobranchins(2).

The predominating species identified confirmed the fact that mosquito species preferring dirty water pools overgrown with weeds as the breeding ground were the main potential hazard. The presence of the malaria mosquito, Anopheles stephensi, indicated the gravity of this possible hazard. It is also known that the distribution of the most important vector of malaria in Pakistan, Anopheles culicifacies, closely resembles that of Anopheles stephensi. This may mean that improperly constructed and maintained waste-water ponds could be a cause of spreading of malaria in the area.

Summary and Conclusions

Regular inspection of the mosquito breeding potential of oxidation ponds with absolutely no weed growth on their banks located in Lahore, Pakistan, was conducted over a period of five months. Inspection of an earthen pond and shallow puddles fed by the same source of wastewater as that for the oxidation ponds was also made to provide reference data for comparison purposes.

In comparison, ponds with weedless banks appeared to have an extremely high chance of free of mosquito breeding. An earthen pond with weeds grown into water on its banks and later crudely trimmed seems to result in reduction in larval population in the pond.

Keeping banks free of weeds did not insure an absolute control of mosquito breeding. Hence if oxidation ponds are to be promoted for wastewater treatment, control measures in addition to bank trimming may have to be considered especially in rural areas where pond maintenance is usually not up to a desirable level.

Specimens of mosquito larvae collected from an earthen pond and shallow puddles containing oxidation pond effluent included that of the usual dirty water mosquitoes as well as malaria mosquitoes. This indicates the possible serious nature of mosquito breeding in oxidation ponds in malaria-infested countries.

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Discussion

The factors that must be considered in the planning for the best use of water in terms of ecology and the environmental goals of society came up for discussion. In this connection the need for nutrient removal (nutrients and phosphates) before effluent discharge into natural water courses was emphasised. It was pointed that the effluent discharges high in nutrient content should be disallowed as they were responsible for algae growth and for adverse effects on aquatic life and oxygen balance in the stream.

TABLE I

Meteorological Data in Lahore, Pakistan

Month	Mean Rainfall, in.	Mean Daily Temperature, °F Max.	Min.
January	1.23	66.8	41.2
February	0.91	72.4	46.5
March	0.96	82.1	55.6
April	0.62	94.7	65.1
May	0.32	104.4	74.7

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WASTEWATER DISPOSAL FOR PAKARAB FERTILIZERS MULTAN

M. NASIR BUTT
Deputy Chief Engineer
Pakarab Fertilizers Limited
Multan.

INTRODUCTION

Pakarab Fertilizers Ltd. Multan is installing an ammonia plant of 910 tons per day capacity. It will later be converted into 1200 tons per day of HNO_3, 1050 tons per day of Nitrophosphate and 1500 tons per day of calcium ammonium nitrate. These plants are expected to be in production in early 1977. The water effluents emanating from these plants are posing a serious problem for their disposal. The total effluents coming out from these plants are 434 m^3 per hour, having the following composition:

(ammonical and nitrate) N_2	903 P.P.M.
P_2O_5	187 P.P.M.
Flourine	30 P.P.M.
The Dissolved Solids	5500 P.P.M.

In addition to 434 m^3 per hour effluent water from Pakarab Fertilizers Ltd. nearly 200 m^3 per hour of waste water from the existing factory is being disposed off safely for irrigation purposes. As it contains low concentration of nitrogen, therefore this water does not require any dilution.

The above analysis clearly indicates that the waste water is rich in nitrogen and phosphorous: the two valuable nutrients required for the enrichment of agricultural land, alongwith the poisonous flourine compound which has injurious effect on animal and plant life. As such the effluent water cannot be used for irrigation purposes.

P. F. L. has the intention that after the removal of injurious flourine, the nutrient content of this waste water must be properly utilised for irrigation purposes.

Keeping in view the location of Pakarab Fertilizers Ltd. Multan, it was decided to consider the following four possibilities of safe disposal of the effluent water:

1. The chemical and the biological treatment within the factory premises.
2. To mix the water in the nearby Multan branch canal.
3. To mix the water in the Multan Sewerage System.
4. To mix the water in the Chenab River.

It may be noted that for irrigation purposes, the water should not have more than 35 P.P.M. of Nitrogen P_2O_5 and Flourine should be nil or at most less than 1 P.P.M. each.

Kellogg International Corporation, the Engineering Contractors of P.F.L., have suggested a chemical and biochemical treatment process for the removal of flourine, P_2O_5 and nitrogen.

The process is briefly described below:

The effluent water is first treated with slaked lime and ferric chloride to remove the flouride and phosphorous compounds in form of precipitation.

The nitrogen contents of the water are reduced in an algae pond or through anaerobic denitrification followed by Cascade aeration. Nearly 30 days retention time is required for complete reaction; as such an area of 322000 m^2 is required for the pond. For anaerobic denitrification, an organic source like methyl or ethyl alcohol, acetic acid sugar or acetone is required for the growth of bacteria. If for example, methanol is used for the purpose nearly 50 millions rupees are required in foreign exchange every year for the purchase of 150 metric tons of the chemicals. Experiments have indicated that anaerobic denitrification is successful if the water contains upto 20 mg/l of nitrate and for high nitrate contents in water as in our case, a pilot plant study is required. P.F.L. rejected this proposal due to the following reasons:

1. The high recurring cost in addition to initial cost would adversely affect the profitability of the project.

2. This method still requires further study on pilot plant basis to establish its effectiveness.

3. The useful nutrients content of nitrogen and phosphorous are totally lost, which P.F.L. intends to utilise for irrigation purpose.

Multan Branch Canal

The Multan Branch Canal is nearly three miles from the factory, near the WAPDA Thermal Power Station. Its normal flow is between 400 to 600 cusecs. To bring the nitrogen, P_2O_5 and flourine contents to minimum acceptable level, a dilution of nearly 32 times is required. Therefore the flow of water in the canal should be 220 cusecs but the canal has also to be stopped for annual repairs and for other minor repairs. The total stoppages and the flow less than 220 cusecs, comes out to be nearly 50 days in a year. This is an average figure for the last five years. During the stoppages or less flow of water in the canal, the factory waste water will have to be safely disposed off somewhere else, because the untreated and undiluted water is very injurious for animals and irrigated land. Therefore the Multan branch canal cannot be a good solution for the safe disposal of the waste water.

Multan Sewerage System

Another alternative is to mix the factory waste water in the Multan Sewerage System and finally send it to the river Chenab. The Multan Public Health Department claims that the Sewerage pipe line has not the capacity to take the additional load of 6.5 cusecs of waste water. The total capacity of Sewerage is 17 cusecs whereas the normal expected Multan Sewage flow is 14 cusecs. As such MPHED has expressed their inability to mix P.F.L. waste water in the Multan Sewerage system.

Disposal of Waste Water in the River Chenab

Another proposal is to dispose off the waste water in the river Chenab which is flowing at a distance of nearby 9 miles from the factory. It requires a long pipe line of nearly 20" dia to be laid from the factory to the river. Accordingly acquisition of land, laying of pipeline, some booster pumps to increase the velocity of the waste water, provision of operational and maintenance staff is required. It may also be noted that the pipeline will have to pass under the roads, bridges and irrigation canal. The total investment cost is between

1.5 to 2 crores rupees. If the waste water sent to the river is untreated, then the pipe line going to the river should be of stainless steel or of any other material which could resist corrosion and erosion. As such the cost will increase tremendously.

At present, this is, actually the proposal with some modification, which is now under active consideration.

All the four above referred proposals could not be adopted as such due to the reasons mentioned above. The Engineering Contractor of PFL have given another suggestion that the waste water stream having fluoride and P_2O_5 contents may be treated in the factory premises and after treatment mixed with the main stream of effluent water. As such the cost of treatment will be comparatively less and the water required for dilution will be only 60-70 cusecs. The process for the treatment of the stream having fluoride contents is described below:—

The total flow of stream having flouride and P_2O_5 contents is 138 m^3/hr. The composition of the water is:

Ammonical and Nitrate Nitrogen	2640 Kg/D
P_2O_5	1944 Kg/D
Flourine	320 Kg/D

The dirty cooling water of Nitrophosphate plant is mixed with lime "CaO" water to precipitate the CaF_2 salt. It may be noted that the precipitation of flourine salts is possible only when all the phosphorous compounds have been precipitated as CaHP04. The consumption of lime per day is nearly 8.5 tons (100 CaO basis).

The flocculant as Aluminium Sulphate or Starch is added to produce properly crystaline precipitate. A retention time of one hour is required for complete reaction. The water will be highly alkaline and ammonia will be released in the atmosphere, therefore, the reaction basin should be covered with a provision for vent. From the reaction basin, the water goes into the settling tank or clarifier where the sludge is removed and the clear water goes into another reaction basin where carbondioxide is passed through the water to remove the unreacted CaO. If this lime rich water is not treated with CO_2, there is possibility that the atmospheric CO_2 will form $CaCO_3$ which will settle down in the pipeline and ultimately block the line. Sedimentation of $CaCO_3$ will also occur in the river or canal due to atmospheric carbondioxide.

Again after the CO_2 Reaction basin, the water goes into the clarifier to remove precipitated calcium carbonate in the form of sludge.

The sludge from the clarifier No. 1 and 2 goes to the sludge thickners and finally the sludge goes to sludge presses and disposed off. The water from the effluent treatment plant is mixed with the main effluent stream. The composition of water after treatment is:

Ammonical and Nitrate N_2	5592 Kg/D
P_2O_5	16 Kg/D
Flourine	32 Kg/D

As already stated above this water after treatment requires only 60-70 cusecs of water for dilution, therefore, the Multan branch canal can be safely utilised for its safe disposal and proper utilisation of its nutrients contents. Keeping in view the demand of lowest flow of water in the canal, still the stoppage for 25-35 days per hour is required. During these stoppages the water cannot be thrown in the dry canal. Therefore provision of a pipeline of 9 miles length will have to be made to throw the water into the river Chenab.

At present P.F.L Multan is concentrating on this last proposal of partial treatment of the wastewater and its dilution to the safe limits of nitrogen P_2O_5 and flourine compounds. As already explained this treated stream is then mixed with the main stream of the waste water and finally disposed off to the river. Although P.F.L. is working on this proposal but due to the huge expenditure involved for the waste water treatment and the cost of 9 miles long channel, the electric/diesel booster pumps required, the recurring cost of maintaining the long pipe line etc. P.F.L. is not satisfied with this arrangement and requests the distinguished experts of pollution to advise some cheaper and safe method for the disposal of 6.5 cusecs waste water, so that the toxic effect of flourine compound on plants and animal life is removed and the nutrient contents are properly utilised. The total nutrient contents going in the waste water amount to Rs. 62,00,000/- per year. P.F.L. sincerely wishes that these nutrient contents alongwith 6.5 cusecs of water per hour must be freely utilised by farmers for irrigation purposes, instead of disposing it off into the Chenab River.

Another proposal to dispose off the waste water rich in nutrient contents is to dispose it off by using heavy tank/trucks for use in the nearby irrigation land. This system is being practised in some of the U.S. fertilizer industries. This will also involves a huge expenditure of more than 70 millions rupees excluding the huge recurring expenditure of Labour, diesel, maintenance etc. etc.

Discussion

The points raised included discharge of toxic chemicals into the canal and the provision of treatment facility for their removal. The author explained that the quantity of chromium (+++) and Nickle (++) in conjunction with total dissolved solids are safe. Oxidation pond as a possible treatment facility for this particular waste needed some investigations the author explained.