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Summary of Country Monographs

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# PROBLEMS AND EXPERIENCES IN WASTE WATER TREATMENT FROM THE VIEWPOINT OF DEVELOPING COUNTRIES - A SUMMARY OF COUNTRY MONOGRAPHS

SYNOPSIS OF COUNTRY MONOGRAPHS PREPARED FOR THE INTERNATIONAL SYMPOSIUM ON WASTE WATER TECHNOLOGIES FOR DEVELOPING COUNTRIES, HELD AT KARLSRUHE, FEDERAL REPUBLIC OF GERMANY, 18 - 28 NOVEMBER 1980

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Participants from twenty-one countries were asked to prepare monographs, and an aide-memoire was sent to them outlining the kind of information wanted. Of the 21 countries, the following twenty submitted such monographs. They are (in alphabetical order):

1. Argentina
2. Bangladesh
3. Bolivia
4. Brazil
5. Colombia
6. Ethiopia
7. India
8. Jordan
9. Kenya
10. Korea (Republic of)
11. Mexico
12. Nigeria
13. Pakistan
14. Papua New Guinea
15. Peru
16. Saudi Arabia
17. Tanzania
18. Thailand
19. Turkey
20. Yemen Arab Republic

The country monograph for Venezuela has not been included because it was not available at the time this synopsis was prepared.

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## ARGENTINA

Argentina had a population of 23.75 million in 1970. Only one third of the country has adequate water, the most important region being the River Plate basin. Annual rainfall is 600 mm. Arid and semi-arid regions ($2/3^{rd}$ of the country) depend on underground water.

In 1973, 6,500 industrial plants were responsible for 74% of the pollution and by the year 2000, this was estimated to increase by 160%.

In 1975, there were 160 sewage services, serving 29% of the population. Over 75% of domestic effluents are discharged to water courses without treatment. Most industrial wastes discharge directly into water courses. There is almost no experience in the re-use of effluents, although this could be considered in agriculture and industry.

The Government operates 85% of the sanitary sewage systems, but there are plans to decentralize this service. Much of the equipment is obsolute, and there is a shortage of trained personnel.

Stabilization ponds and oxidation ditches are suitable for the country, especially in areas with less than 50,000 inhabitants. For larger populations, the activated sludge process could be used. At present, sludge is treated in dry beds after anaerobic digestion, but other cheap alternatives should be sought.

Less than 10% of organic industrial waste is removed in treatment systems, but the authorities are trying to improve the situation through gradual but strict control. Attempts are made to adapt known techniques to local conditions. Treatment in lagoons is used whenever possible. Strict control measures are applied in the Capital. Research and training is being intensified.

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In the next ten years, it is intended to extend sanitation services to over 10 million new users. Costs are expected to be very high.

If present trends in investments and implementation of plans continue, the problems could be solved in a few years.

## BANGLADESH

Bangladesh (144,500 sq. Km.) is a deltaic country with many water sources that are used domestically and for irrigation. These abound in fish. Almost all important towns and major industrial establishments are located along rivers.

Nearly 90% of the 89 million inhabitants live in villages. Most villages resort to either open air defecation or depend on simple latrines; only a few have sanitary water-sealed latrines. Practically no waste water treatment is carried out in rural areas. Sanitary water-sealed latrines are being popularized in some areas. The aim is to install 100,000 units to cover 15% of households by the middle of 1980. Rapid pupulation growth will make provision of adequate sanitary services very expensive. About 380,000 water-sealed latrines are planned to be installed by 1985.

11% of the people live in cities or urban centres. Most of these have no waste water treatment facilities. Dacca (population 2.2 million) has a water-borne sewerage system which covers 60% of the old and 20% of the new city. The system is not fully utilized because of lack of power, and house owners are reluctant to connect to the sewer system. The situation, in terms of coverage, is expected to improve when a new system of three lagoons becomes operational shortly. The city has 10,000 open latrines. Of these, 1,000 have been converted into sanitary latrines and may be connected to the

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existing sewerage system. Some houses also dispose waste water to open surface drains.

Chittagong (600,000 inhabitants) has no sewers. About 30% have septic tanks, which eventually discharge into water streams and open canals; 2/3 of the population depend on night-soil collection services.

Small towns and communities use septic tanks and open latrines. Increased pollution may damage aquatic life and cause other environmental problems. Municipalities are in charge of waste water collection.

Although industry is not very well developed, the major plants drain their often toxic wastes into nearby rivers. The Government is considering possible solutions to this problem. A water pollution control law has been passed and an Environmental Pollution Control Ordinance promulgated. Industry is advised about the importance of water treatment; but more needs to be done to control pollution.

BOLIVIA

The monograph described existing sanitary facilities in the main cities.

La Paz, with 600,000 people, has a separate system for collecting sewage and rainwater. Sewage is discharged into a river without any treatment. Industries contaminate water that is used for irrigation. In El Alto de La Paz (200,000 inhabitants) there are plans for building stabilization ponds. Santa Cruz de la Sierra, a rapidly growing city of 330,000 inhabitants has two collection networks, discharging into a river after retention in 4 anaerobic and 2 aerobic ponds; 95,000 people are served, and there are plans to expand the network. Cochabamba (280,000 inhabitants) has a separate system for sewage and storm water. Sewage is discharged into a river without any treatment. Oruro's 140,000 inhabitants are served by a separate system for sewage and storm water. In Potosi, sewage, rainwater and very contaminated

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water from two big ore treatment plants is discharged into two dry river beds without any treatment. Sucre (70,000 inhabitants) has a combined system serving the centre of the city, and two separate systems serving the outlying parts. All discharge goes into a river that is dry part of the year. Tarija (40,000 inhabitants) has sewage and storm water collection system discharging into a river without treatment. In Montero (40,000 inhabitants) storm water and sewage collection systems are in the final stages of construction. These will discharge into two anaerobic lagoons. The effluent is led into a permanently flowing river.

Trinidad (30,000 inhabitants) has no rain or sewage collection system. Most houses use septic tanks.

Most of these towns have drawn up plans for improving sanitary services. Local authorities are, in all cases, in charge of water and sewerage systems.

In La Paz, chemical pollutants discharged into rivers from industrial plants continue to cause serious problems. There is also lack of a clear policy in this area. There appears to be little understanding of these problems by local authorities.

There is an urgent need for government regulations which guide industries and local authorities in the measures to be taken to control and treat waste water.

Industrial wastes contaminate agricultural land and rivers, and the problem persists because of a lack of understanding of what is involved in terms of the sources, kinds and amount of pollution existing. This has hampered development of effective government action to control pollution.

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## BRAZIL

Brazil (over 8.5 million sq. km.) has an unevenly distributed population, with highest density in the south-east. In this region water and pollution problems are acute. 64% of the population now live in urban areas. Sanitation is inadequate, and domestic wastes and chemical wastes are major sources of pollution.

São Paulo has a sewage collection system for 40% of its 11.6 million inhabitants; 4.3% of the sewage receives primary treatment. Rio de Janeiro has 3 treatment plants with a capacity to treat 20% of the sewage collected; 80% is dumped into the sea without treatment. Sewage in Salvador is discharged directly into the sea. Curitiba has a deep oxidation ditch for secondary treatment serving nearly 50% of the population. 95% of BOD is removed. Brasilia has two activated sludge plants providing secondary treatment to 55% of the sewage, which is finally discharged into a lake. Recife has two secondary treatment plants with biological filters for 30% of its sewage; 70% of the sewage collected receives primary treatment. Little industrial waste is discharged in public sewers. Belo Horizonte has no treatment plant, but 55% of the population is served by a sewerage network. In Porto Alegre, about 46% of the population are served, but only 3% of the sewage receives secondary treatment.

There are plans for expanding the facilities in these towns. The National Sanitation Plan for 1970 aims to co-ordinate the effort to improve sanitation in urban areas. Under this plan 134 systems have been built or renewed. Many more cities will be provided with sanitation services over the next five years.

Industrial pollution continues to pose problems, in many cases due to the fact that treatment plants have only recently been built. In some major

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industrial areas, 70% of the pollution is caused by industry. Over 50% of the most polluting industries have waste water treatment facilities.

Stillage from alcohol production (which may be used as fertilizer) has been deposited in lagoons, but as this is not safe enough, anaerobic digestion is recommended.

80% of the waste water in pulp and paper plants undergoes primary treatment, with secondary treatment for most of the rest of the waste water.

4 petroleum refineries have installed secondary treatment facilities and 7 primary treatment facilities. 2 petrochemical complexes have installed secondary treatment facilities (activated sludge).

Anaerobic followed by aerated and facultative lagoons have been installed in a few tanneries with good results. The same is the case for food processing plants in rural areas. Activated sludge treatment and extended aeration are being used for larger plants.

Combined treatment of domestic and other waste water has been encouraged in some cases, but this requires prior primary treatment.

In 1973, a Special Secretary of the Environment was appointed at the Federal level. Regulations and standards for waste water treatment to be followed by local authorities are needed. In 1976, standards for discharging wastes in different classes of water sources were issued. The treatment of domestic sewage is the responsibility of the Government, while industrial wastes are handled by industry, under State supervision. Larger plants are operated better than smaller ones. There is a need to train more personnel to make the best use of existing plants and to adopt treatment methods suited to local conditions, based on simple solutions. Anaerobic lagoons, anaerobic digestion, and lagoons with cascade aeration have given good results. The Brazilian climate favours anaerobic treatment with generation of methane

(an excellent fuel). Stabilization ponds and lagoons may prove suitable in some areas.

The public must be alerted to environmental pollution problems. Industry should be given economic incentives to better control pollution. Existing regulations should be enforced more rigorously. Better methods for re-use of wastes are needed; and joint treatment of industrial and domestic wastes should be encouraged. If industry could be decentralized, the pollution would not be as intensive as it is now in a few zones.

## COLOMBIA

There are not many waste water treatment facilities in Colombia. Existing ones are administered by local water authorities.

In rural areas, septic tanks and Imhoff tanks are used both by individual households as well as by groups of households. Latrines are also extensively used.

In the larger cities, downstream pollution problems are caused by effluents discharged into rivers without any treatment.

Domestic and industrial waste water is not treated. Some investigation is being carried out in this area. The investigation is concentrating on the following points:

- To collect more data about the nature and volume of the effluents;
- To collect data on the nature and size of receiving waters and how these are used;
- To collect more information on industrial production processes which give rise to the effluent;
- To know more about what economic and social implications any control measures would have, to compare benefits obtained from such control with the costs involved;

- To study the legal framework needed to effectively operate such control measures.

The result of these investigations and the pollution control laws enacted will provide the basis for administrative and financial measures to be taken in respect to waste water treatment. Inducement has been tried to encourage voluntary restraints in the quantity of waste water produced, but both industry and communities have not responded to such inducement, frequently for financial reasons.

To correct the situation, one needs to find low-cost treatment facilities; provide more technical assistance to industry; assist in designing and constructing domestic and industrial treatment systems, especially for the larger cities; initiate programmes in rural areas to prevent pollution from fertilizers and pesticides; and set up an efficient administrative organization to check observance of relevant laws.

## ETHIOPIA

Ethiopia has an area of 1.2 million sq. km. and a population of 30 million. The high mortality rate is largely due to diseases caused by improper sanitation.

95% of the people live in rural areas, and only 1% have pit latrines, which are often poorly constructed and poorly maintained. Diseases arising from inadequate excreta disposal poses firmidable health problems.

General health education, including training in pit latrine construction, has in the past done little to improve public health conditions. People have not seen the need for pit latrines. These are often uncomfortable and dirty, and accidents have happened. Rural people often lack the means to make a proper pit latrine and so prefer to use the open field for defecation.

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In urban centres too, pit latrines are used as a means of excreta disposal. Sewerage systems do not exist in any towns excepting Addis Ababa. Urban communities have been poorly planned, and space is often lacking even for the construction of latrines. Private houses are required to have proper privies on their premises, but in most cases such facilities do not function properly.

Municipalities are responsible for providing and maintaining public latrines.

Addis Ababa, with a population of 1.2 million, has many dry pit latrines largely constructed in recent years, but often, due to lack of space, these are close to where food is stored and prepared. Modern villas and other recent buildings have water flush toilets. The waste is mostly deposited in individual cesspools and septic tanks. Because of impermeable soils, soaking pits often overflow. The contents of cesspools and septic tanks are collected by vacuum trucks, but this service is inadequate and very expensive.

A semi-conventional sewerage system is under construction in Addis Ababa. It will provide primary treatment to raw sewage and sludge treatment by means of staged lagoons, with final disposal of mineralized sludge. Since the cost is very high, the network will not cover the whole city. The possibilities of developing neighbourhood sanitary facilities need to be studied.

The following measures are needed to improve the situation:

- Teaching of sanitation and hygiene in all schools;
- Establishing research centres;
- The Government should set appropriate standards;
- Staff incentives should be provided;
- Low-cost sanitation systems should be developed;
- A greater number of people must be trained in this area.

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## INDIA

Data on water pollution is collected by the Central Board for the Prevention and Control of Water Pollution. The Board has found that the major source of pollution is waste water from big cities and towns that discharge wastes into fresh and coastal waters. A survey of 142 "class I cities" carried out in 1979 shows that of 60 million people living in these cities (which represents 10% of the national total), only 30 million (5% of the national total) are served with waste water collection, and only 18 million (3% of the total population) are served by waste water treatment facilities. The same cities cause 60% to 70% of the total pollution of waters in India.

It has been difficult to apply minimal cost doctrines in the design of waste water systems. As a result, systems are designed with exaggerated safety factors, leading to larger than required capacities of treatment facilities. The same thing holds true when it concerns design of sewer networks As a result these operate below design capacity. Further development in systems application and mathematical modelling may solve this problem.

Industrial water pollution is little by comparison, even in industrial cities like Bombay (13% of the pollution comes from industry), Calcutta (11%) and New Delhi (10%). Even so, the organic load from industry has already reached alarming proportions.

In solving the pollution problems of India, it is necessary to find solutions suited to the environmental conditions of the country. They have to be cheap and simple to build, operate and maintain. More research is needed to find the most suitable treatment methods.

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Water pollution control has been deficient because municipal collection and treatment systems have been lacking due to insufficient funds. Regional waste water systems may make it easier to solve the problems involved in pollution control.

Cheap systems are sometimes costly to operate and maintain. A simple method that gives satisfactory results should be devised.

More research and experiments are needed to determine the best ways to treat waste water in India.

JORDAN

Amman, the Capital of Jordan, is the only town with a sewage treatment plant. Some other towns have treatment plants under construction, and others are studying the question. The authorities are also taking a keener interest in the problems raised by industrial wastes. Lack of finance and trained personnel are the main problems.

In Amman, a sewage treatment plant was built in 1969 to serve 300,000 people. The population has now grown to 1 million. Sewage flows to the treatment plant by gravity. The sewerage system covers about 40% of the town area. Domestic sewage undergoes both primary and secondary biological treatment. About 50% of BOD and suspended solids are removed in the primary treatment. The sewage entering the secondary aeration tanks is highly concentrated and makes it difficult to obtain good stabilization. Retention time is from 3 to 10 hours.

Post-chlorination is also provided. The final effluent is discharged into a stream which is dry in summer. A dam has been constructed across the stream for waste water storage which is used for irrigation.

Per capita water consumption is 30l. per day. As a result, the sewage concentration is very high. More than 15% of the sewage is transported from cesspools and septic tanks by car-tankers. It has a high suspended solids content.

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There are plans to extend the waste water treatment plant.

KENYA

Kenya's present population of 15.3 million has increased by 40% over ten years. 12.6% of the population live in 24 towns of more than 10,000 people. Nairobi, with 835,000 inhabitants, accounts for 5.4% of the national total.

Less than 5% of the population in the country are served with water-borne sewerage systems. 40% use pit latrines and more than 50% have no form of regular sanitation.

Much is being done to improve the situation. Sewerage services are expected to improve in Mombasa, and Nairobi spends more than K£2 million annually on sewerage services, but this does not keep pace with the rapid pupulation growth.

At the national level, the Kenya Government is responsible for the provision of water and sewerage treatment plants through its Ministry of Water Development. The Nairobi City Council is the only local body with autonomy in this area.

In Nairobi, about 700,000 people are served by five sewage treatment works with hundreds of kms. of sewers. The city is drained by a network of rivers which eventually flows into the Indian Ocean. This network of rivers receive effluents from over 100 municipalities, townships and villages, before it reaches the Indian Ocean. Within the Old City, some combined sewers still exist, but newer sewerage networks are designed to carry sewage and storm run-off separately.

By the year 2000, it is intended that about 80% of the city pupulation will be connected to the water-borne sewerage system. In the year 2000 the population will be three times as high as the present population.

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Of the five sewage treatment works in Nairobi, three consist of a system of ponds, and two are conventional mechanical/biological plants. At one site, a single pond is in operation functioning at about 30% of design capacity. At another, two ponds are in operation and these receive much industrial waste, beside domestic waste. 75% of BOD and 60% of suspended solids are removed. A large pond has been newly constructed, but this does not yet operate to full capacity. Of the two conventional works, the smaller plant removes 80% of BOD and 85% of suspended solids.

Analysis of waste water at one works has shown that up to 50% of the effluent is from industrial sources. However, industry accounts for only 10% of revenue from the provision of sewerage sources. Sewerage charges should be revised so as to reflect the actual situation.

Other urgent requirements are for more and better trained manpower, technical and financial assistance.

KOREA (REPUBLIC OF)

The Republic of Korea is industrialising fast. Trade is expanding, and the standard of living is improving.

All existing sewage and drainage systems in urban and industrial areas are combined systems receiving both storm water and household wastes. Conservancy tanks are used to collect excreta. The combined network consists of closed culverts, open channels and streams discharging runoff to the nearest river. 10% of urban dwellers are provided with flush toilets. The effluent from flush toilets flows into septic tanks which are emptied periodically as night-soil. New sewerage systems are mostly planned as seperate systems, i.e., one sewer for storm water and the other for sewage.

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Most urban districts have night-soil collection systems with buckets, or storage privies emptied by vacuum trucks. Night-soil is usually put into storage tanks or dumped into the sea. Some night-soil is dumped into rivers, thus contaminating them. Night-soil was earlier used as fertilizer, but now this has been replaced by chemical fertilizers. Rapid urban growth has aggravated the problem of disposal. Many treatment plants have been built recently or are under construction.

At present, the extent of the sewerage system in Korea is insignificant. Seoul has two treatment works serving 2 million of the city's 8.5 million inhabitants. The plants provide mechanical treatment, activated sludge treatment and chlorination. The sludge is stabilized in heated digesters and the treated sludge is mechanically de-watered, normally in a chamber filter press. In one new digester under construction, the gas produced will be used for heating and electrical power generation. Busan, with a population of 3.5 million, has a mechanical sewage treatment plant with a long sea outfall under construction which will provide full treatment to 20% and partial treatment to 12% of the sewage generated in the city. No other major municipal sewage treatment works are under construction.

The sewerage system needs to be further developed, particularly in view of the rapid industrialization of the country. Provisions are being made for sewage treatment at five out of 20 specific industrial sites. Waste water from industry and large urban areas located on the south-eastern coast are polluting major fishing waters.

The country is in urgent need of legislation related to pollution control and waste water treatment. Existing laws and regulations in this area are insufficient. Both national and regional authorities are involved with pollution control. In the future, highly qualified engineers will be needed to plan and implement sewage treatment projects. These are now in short supply.

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After pre-treatment and removal of toxic components, industrial waste water should be treated together with domestic sewage. The combined treatment process should consist of mechanical or mechanical-biological systems. In the future, larger night-soil plants should adopt the digestion type of treatment. Efficient and simple low energy-consuming solutions are recommended, such as the biological treatment process with trickling filter. In future, new sewerage systems should be designed as separate system. Existing combined systems could be separated into storm sewers, and sanitary sewers flowing into sewage treatment facilities. This can reduce contamination of rivers and reduce pipe dimensions and the size of many pumping stations.

MEXICO

Mexico's population was 48.2 million in 1970. This is increasing by 3.4% per year. Industrial and economic growth has also been accelerating.

The country is divided into 96,000 localities, 1,000 of which have sewerage systems, serving about 40% of the total population. 48% of the population residing in towns with more than 2,500 inhabitants have a sewerage system. In towns with more than 10,000 inhabitants, 60% are served. The most common systems are stabilization ponds, followed by Imhoff tanks and to a lesser extent, systems treating activated sludge. 97 towns use some or all the waste water for irrigation. Where towns have few industries and little toxic pollutants, waste water is re-used after treatment.

The major problems in water treatment plants are maintenance and availability of spare-parts. There is need to develop low-energy biological treatment systems with a minimum of mechanical and electrical components. These systems should be built within the country. Other low-cost treatment

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systems, such as oxidation ditches, trickling filters and stabilization ponds should also be popularized.

Industrial wastes are of different kinds. Biological treatment decomposes wastes from food and fruit plants and sugar mills with a high concentration of organic matter. Chemical and petrochemical wastes and detergents used in textile industries are not easily degraded biologically. Water used in industry has a high concentration of dissolved solids. Fertilizers and dyes contain large quantities of salts. Metal finishing plants, tenneries, and plants for chemical and petrochemical derivatives discharge toxic compounds. 60% to 70% of water used by industry in Mexico is drained as waste water. For the sugan industry, the figure is 54% and for the chemical, petrochemical and paper industries about 30%.

The main problem in pollution control is the financial one. Sanitation districts could be created and made responsible for pollution control. Costs may be lowered if large volumes of waste water could be treated in fewer but bigger plants. The different treatment systems proposed are:

(1) The individual solution, where each producer of waste water must build his own treatment plant. This solution is costly for industry and difficult to control properly.

(2) The municipal solution where one treatment plant treats both industrial and domestic waste water. Industries could still have their own treatment plants if they find this cheaper.

(3) The regional solution would consist of a control system with drain nets, collectors and a general treatment plant where all waste water from the region is collected.

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NIGERIA

The population estimate of Nigeria is over 80 million. This is growing at the rate of 2.5% per year. Average rainfall is 200 cm. in the south, 100 cm. in the centre and 60 cm. in the north.

In major towns, excreta and sullage are mainly disposed of by means of latrines, dry conservancy systems and septic tanks.

Public latrines are established in towns and cities, often contaminating water sources, as many are near streams and rivers. Night-soil is collected in major towns, and some is composted with solid wastes and used as manure. When municipalities are in charge of collecting night soil, the service is acceptable; but contractors frequently dump buckets into ditches and water sources, thus polluting them. In Lagos, each local council is responsible for collection and disposal of night-soil. In new towns, septic tanks are now common. A pre-condition for building plan approval is the availability of a septic tank system.

Complete sewerage systems are virtually unknown in Nigeria.

Much refuse is also dumped directly into streams, and particularly during the dry season, these become very polluted.

In Lagos there are several localized sewerage systems in addition to the open drain system. Where sewers exist, pumping is necessary due to the flat landscape. At least 4 institutions have small sewerage plants and pumping stations. The plants are of conventional type and give primary and secondary (i.e. physical and biological) treatment; but operation and maintenance of the system is unsatisfactory. Spares are often not available. Such highly mechanized plants are not suited to the needs of Nigeria. Simple, low-cost fool-proof plants that are easy

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to operate and maintain is what is needed.

Industries established within industrial estates simplify inspection. A common treatment plant can be used for all effluents from an industrial estate. Operation, maintenance and control are easier in this way.

A central plant, such as the one at Ikeja Industrial Estate, is equipped for full treatment of concentrated industrial waste, with chemical treatment and neutralization, sedimentation, trickling filters, aeration, final settlement and sludge digestion. The residual sludge being dewatered by vacuum filtration. About 80% of the strength of the combined wastes are removed. Cost of treatment is borne by the factories in proportion to the volume and strength of the effluent they generate.

A survey of textile mills in Lagos State in 1978 showed that no treatment was given to waste water (but one factory had plans to build a treatment plant). Textile mills did not know the volume or strength of effluent they produce. Much of the effluent was discharged just outside the mills and spread around the adjoining lands, properties and roads, causing much nuisance.

Lagos City has no system of drainage. Thus industries cannot be directed to discharge their wastes to specific locations. No legislation exists on the disposal of waste waters from the trade, industry or household premises; neither are there any standards for limiting the pollution load from any waste water discharded. Data on existing water sources are lacking. The City needs a modern sewerage system. Legislation setting standards about effluents must be prepared and approved. Well-trained personnel will be increasingly needed.

Low-cost and simple treatment methods that shoul be considered are waste stabilization ponds (facultative ponds), aerated lagoons, and oxidation ditches. One should also try to devise simpler aeration methods and aerators requiring little or no electric power and moving parts.

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PAKISTAN

Pakistan (70 million inhabitants; over 804,000 sq. km) is predominantly an agricultural country. There are hilly areas, plains and deserts. Average rainfall is from about 15 to 50 cm. per year.

Most waste water comes from households. In most towns, sewerage system is either non-existent or inadequate. 95% of the population live in the Indus Basin and almost all the water resources and agricultural potential is concentrated in this area. Rapid industrialization and urbanization is creating serious environmental problems. 30% of the polulation now live in urban areas. Perhaps 230 million gallons of sewage/sullage are produced daily by the urban population. Rural people may produce around 207 million gallons per day. 34.8% of urban dwellers are served with sewerage and drainage facilities. This represents about 10% of the national population.

The sewage is generally not treated. Most water is discharged into rivers or onto land for cultivation, with practically no treatment. Much drinking water is contaminated. The few existing plants have not worked to full capacity because of a lack of skilled operators and inadequate maintenance. Simply designed plants with little mechanization or automation are needed. Of existing methods, the oxidation pond or its modifications seems most suitable. Oxidation ponds or aerobic ponds not deeper than 5 feet may be found suitable, but research is needed to establish this. Trickling filters have been installed in a few towns.

Karachi has four conventional trickling filter treatment plants with sludge digesters. Lahore, with 3 million inhabitants, has no treatment facility at all, but one is under consideration with either trickling filters, activated sludge or stabilization ponds.

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Little attention has been given to industrial wastes. These are either discharged into streams without treatment or applied to land. Both water and soil become contaminated by this practice. There is, however, growing awareness of the acute situation. An Environment Sanitation Cell has been established, and a Pollution Control Act has been passed. More technical know-how is needed. Research has contributed to the improvement of methods of measurement, sampling and analysis of pollutants, and the effective means of detecting pathogenic organisms. However, research is needed on different types of waste management plants and simplified systems which make good use of local resources. Ways of reclaiming heat from wastes needs to be found, and the possible re-use of wastes in agriculture should be studied.

Laboratories to carry out routine sanitary analysis exist in five towns, but these do not have the means to detect synthetic compounds. Only one institution trains public health engineers. It also carries out research into sources of pollution. Emphasis should be given to training and building up research facilities. The general public must also be educated in regard to pollution control. Existing practices of waste water treatment should be adapted to suit each region of the country.

## PAPUA NEW GUINEA

Papua New Guinea consists of eastern New Guinea and several smaller islands. The total area is 213,500 sq. km. Generally the country is mountainous and the rainfall high (over 2,500 mm. per year); there are, as a result, many swift-flowing rivers, and transport and communication is difficult. The population is about 3 million, with 85% to 90% living in rural areas and mostly active in the agricultural sector. Towns are, however, growing in population. Beside primary production, manufacturing

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and light industry (especially mining) are expanding rapidly. The volume of waste is also increasing and some of it undergoes treatment, while the rest is just dumped into water courses.

Four methods are used for treating domestic wastes:

1. Complete treatment;
2. Stabilization ponds;
3. Dilution, and
4. Septic tanks.

Complete treatment of domestic wastes (found suitable for institutions with 1,000 to 2,000 people) consists of screening, grit removal and primary sedimentation; secondary treatment with biological percolating filters and activated sludge, and final sedimentation and chlorination, before discharge into receiving waters.

Many towns, schools and institutions use stabilization ponds, involving screening, primary and secondary sedimentation ponds, a polishing pond and sometimes chlorination. Port Moresby, the Capital, with 150,000 people, uses sewage lagoons, but some of the sewage is discharged directly into the sea. The method with stabilization ponds is cheap and simple and extensively used in the country.

Treatment by dilution in the sea, a lake, or a river for natural purification is inexpensive and widely used for domestic wastes in some areas such as coastal towns, including Lae, the second largest town.

Septic tanks are also extensively used and many small towns are totally dependent on them. The effluent is put into absorbtion trenches. Overloading and pollution of underground waters are the main problems with this type of treatment.

Pit latrines are also used.

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Research is needed urgently to find low cost and simple treatment methods that give satisfactory results. Possible choices are stabilization ponds, biological trickling filters and bio-digesters. The gas produced from bio-digesters can find use for domestic purposes.

An Act of 1978 sets standards and regulations for the control of toxic contaminants etc., but the act is not rigidly enforced. Public health regulations exist in draft form, but the need for early control measures in the short run has not yet been recognized. Most people fail to see the need for sanitation, which they cannot afford. Improvement in the education of the general public in this area is urgently needed.

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The country needs to develop low-cost methods of waste water treatment, in order to save money for many other development tasks which remain unsolved. Stabilization ponds have lately been constructed, as this system is adequate and relatively inexpensive; pathogenic organisms are destroyed and it is possible to use the effluents in agriculture. Of 30 treatment plants installed, 22 (or 73%) are stabilization ponds. Over the next couple of years more will be built. Activated sludge, oxidation lagoons, Imhoff tanks and sedimentation tanks are also used in some cases.

Existing plants treat only a small percentage of all waste water produced. Most wastes are discharged into rivers or the sea without treatment.

In Lima, there are two lagoon systems for treating domestic waste water, serving 90,000 people out of a polulation of 4 million (or 2.25%). Most of the waste water from Lima and Callao is discharged into the sea, causing heavy pollution.

The population is growing fast and enourmous pollution problems are likely to arise. The authorities are aware of the problems and have produced a master plan to solve some of them, but greater attention should be paid to waste water treatment. Research is needed in this field. Most treatment methods are based on foreign experience and studies as to their performance in Peru are needed. Effective control is also required.

The stabilization ponds in San Juan are being evaluated to find out about their performance, possible re-use of treated sewage in irrigation, effects of such re-use on the soil, and effects on the fish. During the course of the evaluation, new research methods will be developed and the question of information collection and dissemination will be examined.

Anaerobic digestion of sludge is also an interesting possibility that could produce energy in the form of methane (biogas) and bio-fertilizers.

Industrial waste water is not treated in Peru. Especially, mining operations discharge wastes and pollute many rivers. Some of the resulting "acid water" is used for drinking. One mining company has begun to study the problem. Other industries discharge much organic waste matter.

More money is needed for training, equipment and research. Expansion of international co-operation can also help in solving these problems.

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## SAUDI ARABIA

Much attention is now paid to sewerage and waste water treatment in Saudi Arabia. The Water and Sewerage Authorities, under the Ministry of Municipal and Rural Affairs, are responsible for such services.

Two methods of physical and biological waste water treatment are used:

1. aerated lagoons and stabilization ponds; and
2. activated slude and trickling filters.

Chlorination is used in some of these facilities.

The first method is found to be suitable and inexpensive for small towns and rural areas. It usually consists of rows of stabilization ponds with aerobic and anaerobic digestion; aerators are also used.

The second method is used in larger towns and consists of screens and grit chambers, aeration tanks, sedimentation tanks, trickling filters, aerobic and anaerobic digestion tanks, sludge drying beds and effluent disinfecting equipment. Five treatment facilities of this kind are in operation (in Riyadh, Jeddah, Mecca, Medina and Damman). Others are under construction or planned, and existing ones will be expanded.

The effluent from plants in Jeddah and Damman is discharged into the sea; that from Riyadh and Medina flows into "Wadis", where some evaporates and some percolates into the ground. In Medina, some of the effluent is used for irrigation. There are plans to re-use more of the waste water in agriculture or for cooling in industry.

Lack of trained personnel is a major problem in the operation and management of these facilities. Foreign contractors are used at present, but they are obliged to train Saudi personnel.

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The public needs more education in the use of sewerage facilities. Materials such as nylon bags, clothes, plastic and tin cans are found in sewer lines and treatment plants. These complicate the treatment process. The Government is preparing to set standards for materials allowed to be disposed of in sewers, and to determine if pre-treatment is required before disposal in the system.

Industrial wastes are still not a serious problem. All treatment facilities have been built mainly to treat municipal waste water.

Scholarships are now offered for environmental (sanitary) studies. International organizations are asked to provide consultants in this area. Training of personnel is a priority.

Because of the rapid growth, cities are still not fully served with treatment facilities in spite of heavy investments in this sector. The aim is to provide all settlements with sanitary facilities.

## TANZANIA

Tanzania's location and climate favour the use of non-mechanical, biological methods of sewage treatment. On the mainland, 2.33 million people live in 55 towns of more than 5,000 inhabitants. Only seven of these towns have sewerage systems serving about 10% to 20% of the polulation. Tanga discharges all its sewage directly into the sea without treatment. Dar-es-Salaam discharges part of its sewage through a long sea outfall, and the rest is treated in stabilization ponds in series with maturation ponds, of which it has more than nine, all facultative. Only Moshi has a mechanical sewage treatment system consisting of inlet works (grit removal channel, coarse screens, float operated flow recorder), primary tanks, biological filters, humus tanks, cold digestors and drying beds. Sewage from other towns is treated in stabilization ponds and discharged into rivers, streams or dry valleys.

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The abolition of local government in 1974 was followed by a period of neglect and structural decay of sewerage works. Funds were lacking and skilled personnel shifted to other duties. Maintenance and spares are lacking for the mechanically operated sewage treatment works at Moshi and operators are poorly trained. As a result, the effluent from the works which is of very poor quality, is discharged into a river used for irrigation and domestic purposes,downstream.

Stabilization ponds in Dar-es-Salaam have not operated properly (except one serving the University). The reason is that the ponds have received so little sewage that it is below the normal operating depth. In one case, a pond receives industrial wastes and waste oil. This has affected the colour and the biological life in the pond.

Waste stabilization ponds rely on plenty of sunshine and relatively high temperature to function well, but the sewage works must be cleaned and maintained by trained personnel who can also undertake necessary measurements and tests. The country needs more sanitary engineers and public health engineers.

Urban councils (restored in 1978) are responsible for maintenance and operation of sewerage systems.

After a cholera outbreak in 1978 the government has been alerted to the need for better sanitation programmes and is doing its best, but lacks adequate funds.

Where public sewers exist, industrial waste waters are discharged directly into these without or with only partial treatment. Where there are no public sewers, some industries, especially those generating large volumes of wastes, construct their own sewers and treatment plants; otherwise, effluents are discharged to ditches or valleys. In general, most private works treat wastes poorly.

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Where industries discharge their waste into public sewers, these tend to create odour problems. The Tanzania Effluent Standards Committee has set temporary effluents standards which require industries to install pre-treatment plants if the wastes they produce do not conform to the minimum requirements set for public sewers. Comprehensive waste water management programmes are needed to safeguard surface and underground waters.

THAILAND

Nearly 80% of the people live in rural areas. Waste water problems are greater in towns. 60% to 70% of the waste discharged into the Chao Phraya River comes from households in the Bangkok area, while about 30% comes from industries in the same area.

Domestic waste water management is the responsibility of each city or local authority. At present, no city has waste water treatment facilities, not even Bangkok. The waste water is discharged directly into natural receiving waters. Funds are lacking and the need to establish treatment works is often not realized except in some major cities where the problems are being surveyed and studied. Central government initiative may be needed to solve the problems in this area.

Although there are many industries in various parts of Thailand, most are sited in the Bangkok area. Industrial water pollution control is the responsibility of the Industrial Environment Division in the Ministry of Industry. Standards are set, but some industries lack the resources to install treatment plants. The plants that have been built are in need of proper operation and maintenance, as the effluent is still below standard. A treatment facility is now a requirement before a permit is granted to establish a factory which produces wastes in its day to day operations. This permit must be renewed every three years.

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Many treatment plants have been put into operation during the past five years, mostly stabilization ponds and aerated lagoons, as these utilize locally made equipment and are inexpensive and simple to operate. But different treatment methods may be found more suitable for different industries. White sugar canemills recycle water used for cooling and washing after treatment in aerobic ponds. Most pulp and paper mills are located around Bangkok; pulp plants use aerated lagoons, and most paper mills incorporate fine screening, chemical coagulation and sedimentation in their treatment processes. Waste water from molasses distilleries has a high BOD content. Private distilleries have treatment facilities for this purpose, but government-owned ones remove their wastes by truck.

The country's two breweries have chosen the activated sludge process for treating their waste water. Newer tapioca starch factories have stabilization ponds, but older ones often lack treatment facilities. Most small-scale factories in the country provide no treatment to their waste water.

The rivers that are receiving waste waters from domestic and industrial sources are also the sources of domestic and industrial water supply. This is often polluted. This holds true for the main river in the country, Chao Phraya River, which passes more than 9 big cities including Bangkok. Many industries are also built on the banks of the river. More than 400,000 kg. BOD/day are dumped into this river, and the water quality is very poor, especially near Bangkok; the dissolved oxygen concentration is almost 0 mg/1 in the summer. Other rivers are in a similar situation. This also affects fisheries and agriculture around these rivers.

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Several ministries are involved with pollution control legislation. Local government authorities check water quality in their areas of responsibility. The National Environment Board was created to have a single organization in charge of policy making, co-ordination, data collection and dissemination of information.

## TURKEY

Turkey's area is 776,000 sq. km. amd has a population of 45 million, which increases by 2% per year. The country is surrounded by seas on many sides. For one third of the population, these seas are natural receiving waters for domestic and industrial waste water. People inland in many cases discharge their domestic wastes to rivers that eventually reach one of these seas. Laws and regulations set limits to the kinds of domestic and industrial wastes that can be discharged into rivers or seas. These regulations are inadequate and not strictly observed. What is lacking is waste treatment technology adapted to local conditions. Furthermore, the systems used are in some cases costly. The public needs to be educated about environmental protection and public health. Some seas and rivers are highly polluted. The Government is aware of the issues and is trying to improve the situation.

Turkey is an agricultural country, but industrialization has started and many people move to urban areas, especially to the ten towns where most industries are located.

Municipalities are responsible for sewerage systems. Due to a shortage of funds, few towns have complete sewerage systems. In most cases, domestic wastes are discharged to private septic tanks; in other cases sewage is discharged into rivers and lakes without any treatment.

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Municipalities have also been unable to cope with the rush of people from rural to urban areas. Priority has been given to water supply rather than sewage services. Still, much money has been invested also in the latter sector and many sewage systems have been constructed over the past decade.

Most waste water is of the domestic type. Suburban areas and small communities with sewerage systems discharge domestic wastes directly into rivers or lakes without any treatment; septic tanks are used in some regions. The wastes are removed by sludge lorries. Tourist resorts built recently have waste water treatment plants for primary and secondary treatment. Bigger houses built by the government have at least primary treatment facilities.

Since 1978 the discharge of industrial waste water harmful to flora and fauna in lakes and seas is restricted by laws. Almost all new big industrial complexes have, therefore, treatment plants for their waste water. Foreign technology has been used together with systems designed and constructed by local contractors such as oxidation ditches and activated sludge systems. Old industries continue to pose environmental problems. It is difficult to force them to comply with existing regulations. The state may have to help financially. Combined simple treatment facilities for industrial zones with several factories may also help to solve the problem. Foreign economic assistance will be needed to achieve satisfactory results, but the stress should be on low-cost systems.

The importance of waste water treatment has been brought to the attention of people and authorities over the past 10 years. Technical personnel have been educated and several training facilities now exist in the country. But there is not enough work for all the staff that has been trained in this field. Most of the equipment needed to treat waste water can be manufactured locally.

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YEMEN ARAB REPUBLIC

The country consists of three distinct regions, the central highlands, the coastal plains and the eastern plateau with a desert climate. The estimated population is about 6.5 million, with an annual growth of around 2.2%. About 20% live in urban areas, primarily Sana'a, Taiz, Hodeida, Ibb and Dhamar. With the exception of Taiz, there are no municipal sewer systems yet in operation in the Yemen Arab Republic.

Sana'a has about 180,000 inhabitants. A water supply system was initiated in 1976, but no sewer system has so far been constructed. Waste water is collected and disposed of by means of pit latrines, deep cesspools and septic tanks, used by only a small number of new buildings in Sana'a. Waste water seeps into ditches and causes unsanitary conditions, and contaminates ground water. Deep cesspools made of masonry or concrete are used for new buildings. The wastes seep into the soil through the bottom of the well; the solid wastes are partly decomposed by bacterial action. Groundwater is, however, polluted by seepage from cesspools.

Taiz, with 109,000 people, has the only waste water collection system in the country, but it has a minimal effect on the city's sewage disposal problem. The system is 9 km. long, has 263 connections, and serves only about 3,800 people in a service area with a population of about 12,500. 95% of the houses in Taiz are not connected and waste from these houses is discharged directly into ditches or cesspools. Surrounding areas and water lines are contaminated.

Hodeida, Ibb and Dhamar use the same systems as Sana'a and Taiz. No municipal sewer systems are in operation.

The National Water and Sewerage Authority, established in 1973, is responsible for planning and managing water supply and sewerage systems,

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and water supply and sewerage projects are being implemented for the five major cities and will be functional by 1985. The projects are designed so that expansion is possible. All waste water generated in the project areas will be treated in stabilization lagoons and the effluent will be used for irrigation. This mode of treatment is inexpensive and relatively easy to operate and maintain.

Shortage of trained engineers and technicians is the biggest problem at present, but a long-range training and recruitment programme is being developed.

Industrialization has not yet advanced so as to create waste water problems in the country. When this occurs, industrial waste water treatment will be co-ordinated with the municipal waste water facilities.

## CONCLUDING OBSERVATIONS

From the country monographs that have been submitted for this symposium, it is clear that the 1970's has been a decade when individuals and government bodies have been alerted to the hazards of pollution and the need to establish control measures to slow down or stop environmental deterioration through damage to plant, animal and fish life and the soil, and to protect human health.

All countries can be said to be doing something to solve the problems caused by waste water pollution. But particularly developing countries feel the heavy economic burden associated with waste water treatment because this causes an addition to many other costly development schemes that usually receive higher priority. Those directly involved with waste water treatment feel that the allocation in this sector is too small to enable them to take the necessary steps to provide satisfactory protection to the surroundings.

Three causes are generally recognized as contributing to waste water pollution and the deterioration of the environment associated with it:

1. Rapid population growth;
2. Rapid urbanization; and
3. Accelerated industrialization.

The actions that need to be taken involve the education of the people in hygiene and sanitation, as well as the development and application of systems that can remove, treat and neutralize harmful waste water. A central concern of developing countries is to design and construct facilities that are low-cost, use little energy, are easy to operate and equally simple to maintain and repair without resorting to expensive importation from abroad. Locally made equipment should be encouraged and nationals should be trained to take care of all aspects

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of the construction and operation of sanitary facilities.

In seeking suitable solutions, one needs also to bear in mind that water is a scarcity in many developing countries. On the other hand, land may be readily available in many, but not in all cases.

A method for treating waste water mentioned by many countries is stabilization ponds or lagoons. A hot climate together with easy access to large areas of land makes this solluti on attractive to many. It is relatively inexpensive and simple to construct and maintain and does not need imported components or foreign experts. Oxidation ditches or ponds, trickling filters and chlorination are other treatment methods that several countries have found attractive. Self-purifying or extensive systems are preferred by many, for financial and technical reasons, to some sophisticated, mechanical systems.

All countries seem to realize the need for more research in waste water treatment technologies. Finance is a recurrent problem in almost all cases. The question of re-use of waste water is also a pressing one for some countries, either for irrigation or for other uses where water quality standards can be relaxed.