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REPORT OF THE INTERNATIONAL SYMPOSIUM ON WASTE-WATER TECHNOLOGY FOR DEVELOPING COUNTRIES

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Federal Ministry for Research and Technology
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REPORT OF THE INTERNATIONAL SYMPOSIUM ON WASTE-WATER TECHNOLOGY FOR DEVELOPING COUNTRIES

NUCLEAR RESEARCH CENTRE, KARLSRUHE
FEDERAL REPUBLIC OF GERMANY
18–28 NOVEMBER 1980

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I. INTRODUCTION

This report is the result of the International Symposium and Study Tour on Wastewater Technology for Developing Countries held at the Nuclear Research Centre Karlsruhe, from 18 to 28 November 1980.

The objectives of the Symposium and Study Tour were:

- to exchange information on current knowledge on wastewater treatment in developing countries and in the Federal Republic of Germany;
- to identify gaps in knowledge and action in wastewater treatment relating to information, research, training and operation in the developing countries;
- to examine current policy trends and management practices in wastewater treatment in developing countries;
- to examine new methods and technologies for wastewater treatment especially relevant to the developing countries;
- to indicate future co-operation in this area.

At the conclusion of the Symposium, participants recommended that the findings should be disseminated as widely as possible. It was felt that the information contained in this report would contribute to fulfilment of the relevant Governing Council decisions in this area and to the objectives of the International Decade for Drinking Water Supply and Sanitation (1981 - 1990).

II. STATEMENT AND RECOMMENDATIONS*

1. The International Symposium has been very useful in transmitting knowledge and information on wastewater management for developing countries and permitting an exchange of information in this field. In recognition of this, international organizations and donor countries should continue to support such symposia and related study tours, paying special attention to the participation of both professionals and persons responsible for decision making in the area of wastewater management.

In order to gain a high degree of effectiveness, the following additional activities are recommended:

(a) The report and other documents from this Symposium should be widely distributed;

(b) Specialized courses on specific aspects of wastewater management should be organized;

(c) Selected research projects, studies and a pilot demonstration project should be initiated.

2. The Symposium concluded that in the developing countries policy on sanitation has so far appeared to be less effective than that on water supply. In order to achieve balanced development in this field and to promote social benefits, it is recommended:

(a) That Governments should give higher priority to wastewater management as part of an over-all policy to improve basic infrastructure;

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* This statement was drafted by Symposium participants during the last plenary session held on 28 November 1980.

(b) That international and bilateral lending agencies should improve their appraisal and repayment conditions;

(c) That quality standards should be reviewed periodically, taking into account advances in technology, scientific knowledge and socio-economic conditions;

(d) That the search for affordable low-cost sanitation options should be intensified with a view to attaining the goals of the International Drinking Water Supply and Sanitation Decade, 1981-1990.

3. The major technical bottle-necks in the field of wastewater collection and treatment are lack of technical experience, shortage of trained manpower and insufficiency of infrastructure.

It is recommended that UNEP, WHO and the industrialized countries should assist developing countries in:

(a) training engineers, technicians and operators;

(b) preparation of guidelines to govern the collection and treatment of wastewater;

(c) devising incentive schemes to attract and retain staff in the sanitation sector;

(d) ensuring a high level of community participation and self-help;

(e) introduction of sanitation and hygiene in school curricula.

4. Industrial pollution is increasing at a more rapid rate than pollution from domestic sources. Therefore:

(a) priority should be given to incentive programmes to discourage pollution by industrial establishments;

(b) appropriate land use policies and zoning ordinances should be promulgated as a tool for ensuring control of water pollution;

(c) in many cases, combined treatment of municipal and industrial wastewater warrants consideration as a measure for pollution control, as is evident from the experience of industrialized countries;

(d) industrial polluters should be charged in proportion to their discharge of pollutants.

5. An important factor is the high cost of acquiring technical expertise and importing equipment into the developing countries. In order to improve this situation and to facilitate transfer of technical knowledge, it is recommended that:

(a) applied research and technical development in the developing countries should be increased;

(b) co-operation between manufacturers and researchers in developing and developed countries should be intensified;

(c) pilot plant projects in the developing countries should be established on the basis of bilateral co-operation;

(d) an internationally unified terminology should be developed and common information storage and retrieval procedures encouraged.

ANNEX A PROCEEDINGS

a. Background

The United Nations Environment Programme, and the Federal Ministry for Research and Technology through the Nuclear Research Centre, Division of Water Technology, Karlsruhe (of the Federal Republic of Germany) organized a symposium on wastewater treatment (both domestic and industrial) in developing countries in Karlsruhe, Federal Republic of Germany, from 18 - 28 November 1980.

The symposium brought together 45 administrators, policy makers and professional technicians from 23 selected countries for in-depth discussion and study of this area. The participants came from the following countries:

Argentina
Bangladesh
Bolivia
Brazil
Colombia
Ethiopia
India
Jordan
Kenya
Korea, Republic of
Mexico
Nigeria
Pakistan
Papua New Guinea
Peru
Saudi Arabia
Tanzania
Sweden
Thailand
Turkey
Yemen
Germany, Federal Republic of
Philippines

The World Health Organization (WHO), the Ministry of Technical Assistance and the German Association for Water Pollution Control were also represented.

The symposium consisted of an extensive study tour of wastewater treatment facilities in various localities in the Federal Republic of Germany as well as presentation and discussion of a series of papers on various aspects of wastewater treatment. Papers were presented both by experts from the Federal Republic of Germany and from the developing countries.

Country Monographs

Participants also prepared monographs on the following topics:

(a) Description of domestic wastewater treatment facilities (type; scope of coverage in terms of population and area; nature of treatment of wastewater; final destination and use - if any - of effluent);

(b) Operation and management problems;

(c) Urgent research and technological needs in domestic wastewater treatment;

(d) Possible solution of the problems identified in (c);

(e) Description of significant industrial wastewater problems;

(f) Current approaches to industrial wastewater problems;

(g) Identification of gaps in either knowledge or action and an indication of possible measures to close or narrow these gaps.

The summary of the country monographs was prepared by the Symposium Secretariat, and is attached in Annex D.

b. Opening

The opening session was addressed by Dr. Ekkeharu Abel, representing BMFT and Mr. H. Sakimura, representing UNEP.

In his opening statement, Dr. Abel said that the Federal Ministry for Research and Technology and UNEP recognized the fact that environmental problems were becoming increasingly important in most countries of the world and that research and technology were able to make significant contributions to the solution of these problems.

Dr. Abel further stated that while it was up to the countries of the third world to decide which technology was best suited to their development policy objectives, the Federal Republic of Germany was preparared to co-operate in the selection and development of suitable technologies by offering the experience available in this area.

Dr. Abel stressed the importance given to environmental protection in the Federal Republic of Germany since 1969. Environmental protection was on a level similar to that of such public services as social security, educational policy or economic and employment policy. An aspect of this policy of particular importance to the International Symposium concerns the prominence given to international co-operation.

Since the establishment of new policy, considerable improvement has taken place in regard to solid waste management, air pollution control, sewage treatment techniques, noise pollution control, etc.

In conclusion, Dr. Abel suggested that the task of providing acceptable sanitation and drinking water to the 75% of the people in developing countries who do not have such provision was indeed a major task, which he expected to be undertaken in the framework of the International Drinking Water Supply and Sanitation Decade. He reiterated the willingness of the Federal Republic of Germany to co-operate in this endeavour.

In his introductory remarks, the representative of the United Nations Environment Programme welcomed the co-operation between UNEP and the Federal Republic of Germany and stressed the importance of concerted action to improve the sanitary condition of settlements in the developing countries. Often, sanitation is given a lower priority in government action than water supply; in fact the two should be given equal attention in the interest of improving the health and well being of societies in third world countries. The statement suggested that water quality protection is a key element in any environmental protection endeavour, as such wastewater treatment and rejuvenation is a critical activity which UNEP supports fully.

c. Programme

Tuesday, Nov. 18, 1980

16.00 Welcome and introduction to the programme

17.00 Welcome reception

A. STUDY TOUR

Wednesday, Nov. 19, 1980

9.00 Travel by bus to Ludwigshafen

10.00 Visit to the treatment plant for industrial wastewater, Badische Anilin-und Sodafabrik (BASF)

16.00 Travel by bus to Essen

Thursday, Nov. 20, 1980

8.30 Visit to a co-ordinated system of treatment plants discharging into a river which is used for drinking water (Ruhrverband)

15.00 Travel by bus to Braunschweig

Friday, Nov. 21, 1980

8.30 Visit - Use of treated wastewater for irrigation (Abwasserverband Braunschweig)

Saturday, Nov. 22, 1980

Excursion

Sunday, Nov. 23, 1980

Travel to Munich

Monday, Nov. 24, 1980

8.30 Visit to the wastewater treatment testing field of the Bayerische Landesanstalt für Wasserforschung

14.00 Visit to lagoon techniques

Tuesday, Nov. 25, 1980

8.30 Travel by bus to Stuttgart

13.00 Visit to the wastewater treatment in the food industry (Naturella Südsaft AG at Winnenden)

16.00 Travel by bus to Karlsruhe

B. WORKSHOP

Wednesday, Nov. 26, 1980

9.00	Opening of the workshop
9.15	Mr. N. Gebremedhin (UNEP "Environmental aspects of wastewater treatment in developing countries"
9.50	Dr. G. Bachmann (WHO) "Health aspects of wastewater treatment and disposal"
10.30	Prof. Dr. S.H. Eberle, Nuclear Research Centre "Development of new technologies for wastewater treatment - the experience of the Federal Republic of Germany"
11.15	Coffee break
11.30	Mr. N. Gebremedhin (UNEP) "Problems and experiences in wastewater treatment from the viewpoing of the developing countries - a summary of country monographs"
12.30	Discussion
13.00	Lunch
14.15	Prof. Dr. B. Böhnke, University of Aachen "Operating requirements for wastewater treatment, facilities for practical requirements (standards, training, education and maintenance)"
14.45	Mr. G. Neubauer, Frankfurt "Practical experience of German institutions in wastewater treatment plants in developing countries"
15.15	Dr. Plümer, Association of wastewater techniques "Training and research requirements in wastewater management with special reference to wastewater"
16.00	Discussion
17.00	Travel by bus to the Black Forest region

Thursday, Nov. 27, 1980

9.00	Mr. Aragaw Truneh, Addis Ababa Water Supply and Sewarage Authority "Administrative, financial and management aspects of wastewater treatment in developing countries - a case study of Addis Ababa"
9.30	Prof. Dr. L. Hartmann, University of Karlsruhe "Ecological aspects of sewage treatment in developing countries"
10.00	Prof. Dr. H. Sontheimer, University of Karlsruhe "Influence of wastewater treatment on drinking water production"

Thursday, Nov. 27 (cont.)

10.30	Coffee break
10.45	Prof. Dr. B. Böhnke, University of Aachen "Recent developments in biological treatment of wastewater"
11.15	Prof. Dr. R. Kayser, University of Braunschweig "Wastewater treatment in lagoons"
11.45	Mr. F.Z. Njau (Tanzania) "Design and operation of a sewage lagoon in Dodoma, Tanzania"
12.30	Lunch
14.00	Prof. Dr. Jüntgen, Bergbauforschung, Essen "Biological treatment of difficult wastewater by application of activated carbon"
14.30	Prof. P. Khanna (India) "Sewerage and treatment problems of large metropolitan areas - the example of Calcutta, India"
15.00	Coffee break
15.15	Prof. Dr. H. Bernhardt, Wahnbachtalsperrenverband "Recent developments in the field of eutrophication prevention"
15.45	Prof. Dr. K.H. Krauth, University of Stuttgart "Dinitrification experience in the Federal Republic of Germany"
16.15	Uno Winblad (Sweden) "The needs and possibilities of disposing human faeces without water in the developing countries - Sanitation without water"
16.45	Discussion

Friday, Nov. 28, 1980

9.00	Prof. Dr. L. Hartmann, University of Karlsruhe "Treatment of concentrated wastewater from the food industry"
9.30	Joshua Gecaga (Kenya) "Wastewater processing in the food industry in Kenya"
10.00	Coffee break
10.15	Dr. Marcio-Braile (Brazil) "Wastewater treatment from the manufacturing of textiles"
10.45	Prof. Dr. G. Rincke, University of Darmstadt "Prevention and reduction of water pollution in the pulp and paper industry - the experience of the Federal Republic of Germany"

Friday, Nov. 28, 1980 (cont.)

11.15	Prof. Enyenihi (Nigeria) "Wastewater treatment in the oil refinery industry in developing countries"
11.45	E.A.R. Ouano (Philippines) "Wastewater treatment in the metal processing industries - an example from Asia"
12.15	Discussion
13.00	Lunch
14.15	Prof. Dr. R. Kayser, University of Braunschweig "Use of digester gas in sewage treatment and energy production"
14.45	Coffee break
15.00	Final discussion

d. Summary of discussions

Papers were presented in the sessions, discussions took place and responses to questions were given directly. This is reflected in the following pages. Participants also requested for additional information which was given during the discussion period. Finally, from the discussions, it was revealed that there may be gaps in knowledge and different approaches in wastewater treatment. The following points represent the main issues raised:

Applicability of the different processes for developing countries

(a) Ecological aspects of wastewater treatment - comparison between tropical areas and temperate zones

In conjunction with the presentation of the paper "Ecological aspects of sewage treatment in developing countries", a number of points were made. The main hypothesis presented was that the ecological frame for wastewater treatment in the tropical zones differed appreciably from that of the temperate zones.

The Symposium noted some of the inherent conceptual problems which hinder comparison of the ecological frames of tropical and temperate zones. Although such a comparison can provide a useful framework, the important exceptions must be recognized.

The ecology in some tropical areas is less disturbed than say in North America, where extensive development by man has caused perturbations.

Equally, it was not possible to generalize the applicability of certain methods to the tropical areas. For example the statement that 'the land application system for wastewater treatment is particularly suited to countries in the tropical zone', does not apply to Brazil. This is because 60% of the people reside in urban areas at densities in excess of 40 persons per hectare. The efficiency of different processes including the advanced processes should be tested under different climatic conditions in the developing countries.

There is an apparent need for demonstration projects to determine the process performance, design parameters and economic constraints involved in the selection of the appropriate wastewater treatment process operating under various environmental conditions. Pollution control from tropical agro-industries could be more important than domestic pollution due to very high BOD strength, nutrient deficiencies and very large volume handled. The factories are often located close to settlement centres which aggrevate the problem further.

Advanced processes

(b) Recent developments in wastewater treatment

The Symposium discussed recent developments in wastewater treatment in the Federal Republic of Germany and assessed their potential in the developing countries. Among the systems discussed were: the deep shaft system, the tower biological system, the multistage system and the pure oxygen process (see paper WP.12). These processes are particularly suitable for treatment of difficult wastewaters, where domestic and industrial wastewaters are combined. In many developing countries, e.g. Nairobi, Kenya, some industrial wastewater is combined with wastewater, but the extent of the combination, as well as the nature and characteristics of the combined wastewater, are not clearly known. In these circumstances, it may be useful to test advanced systems and when found appropriate, to provide training to enable the facilities to be operated efficiently and effectively.

It was generally recognized that although in the short term the application of these systems may be precluded in the long term, there may be a great deal of use for such systems. As purification requirements and effluent standards are raised, the techniques required to achieve this will be of necessity be complex. In Germany for example, the simple processes are no longer applicable in most cases. Research should be carried out to make the systems cost-effective.

In addition to the above systems, participants felt further consideration should be given to surface aerators with few (or no) moving parts; systems which use as little energy as possible. However, the experience in Germany with surface aerators is not completely satisfactory in view of the odour problems and the spread of spray droplets.

Where the water table is high the deep shaft system cannot be constructed without casing. The Tower biological system is particularly advantageous due to lack of odour problems, as it is completely enclosed. The tendency in Germany is to establish closed systems in order to avoid odour problems. In the long term, the same requirements will be established in many other countries.

(c) Costs and maintenance of wastewater treatment facilities

A pressing problem faced by many developing countries is that of reduction of the costs of facilities to a level at which the national economy can sustain the expenditure and user charges are compatible with user income. The Symposium was aware of the complexity and intractability of the problem, in view of the fact that in many developing countries, per capita income is about US$100 whereas per capita investment in conventional sanitation systems can be as high as US$60. It recalled the effort of IBRD in investigating alternatives to conventional systems because of the constraints in resources and the enourmous demand. The potential of improved acqua-privies which dispose sludge and wastewater into oxidation ponds was recognized.

The Symposium was aware that there will be no single comprehensive solution which can overcome the severe financial constraints under which developing countries operate. The key considerations are affordability and acceptance by users. Methods which have not been socially and economically tested should be avoided. Particularly when design is undertaken by expatriate consultants, local social and economic feasibility should be ascertained fully.

In developed countries, it is normal to install standardized equipment in wastewater treatment plants. Sometimes such standardized equipment is not suitable for tropical countries. But as there is no special equipment selection system, identical equipment is installed in developing countries (e.g. powerful heater for digester). This raises the cost of equipment unnecessarily. The need to establish equipment selection procedures was emphasized. An all important point is the high percentage of costs devoted to pipes. Developing countries should consider ways and means of reducing costs in wastewater treatment plants in general, but especially costs of pipes.

Where capital is available, the awareness of users on the needs for proper sanitation is very low. The wastewater treatment facilities are often neglected and poorly maintained. There is a need to evaluate wastewater pollution standards suited to the socio-economic conditions of the country in addition to the environmental constraints. It would be appropriate to develop and enforce standards with provisions for wide flexibility to accommodate changes. As the users social values change the willingness to pay and maintain the wastewater facilities will improve, thereby ensuring the continuity and success of the programme.

The importance of maintenance cannot be over-emphasized. A sewage treatment plant is like an industrial plant, with sophisticated technology and some complicated equipment. The requisite skills to operate and maintain it must be provided as an integral part of the system, in order to minimize deterioration of the facilities.

Developing countries should note the practice in Germany, whereby 5% of the estimated investment capital is devoted to research and development - to finding out what to improve and how to reduce costs.

The Symposium also took account of the graduated scale of costs used in Germany. Particular note is taken of the following factors when establishing and periodically revising user charges in Germany:

(a) Degree of purification required;

(b) Capacity for self-purification of receiving waters;

(c) Population density;

(d) Type of treatment and facilities.

At present, costs are of the following order of magnitude:

Population	Capital cost (D. Marks per person)	Operation costs (D. Marks per person/per year)
10,000	300 - 400	80
100,000	200 - 250	65
1000,000	100 - 120	50
5500,000	60	6

(d) Lagoons

Sewage lagoons are widely used for wastewater treatment in developing countries. The system has qualities associated with simplicity and inexpensive operation.

The Symposium noted a number of technical improvements in lagoon design and construction in Germany.

In developing countries, so far as lagoons are concerned, three factors need to be considered further. One is the problem of heavy rainfall and the apparent failure of design criteria to take account of this. Secondly, evaporation tends to be underestimated, leading to insufficient water cover. Thirdly, the grit removal is bothersom, because of the large amounts involved (mostly due to unpaved roads, etc.). The inclusion of grit removal so raises the cost of the facility that it is no longer an attractive alternative. Seperation of storm water from sewage water may be desirable in this regard.

Smell can be a problem in lagoon operating authorities. No simple method exists which satisfies everybody concerned. The question of using cascade aeration - as opposed to mechanical aeration - was mentioned. In Brazil the system has been utilized to great advantage.

In India, lagoons are not aerated. The 4-meter depth which is common for lagoons is emptied every 10 years. Retention time in lagoons is 1.3 days. The high temperature in India assures high levels of efficiency of treatment.

One of the problems of sewage lagoons is their susceptability to eutrophication. To prevent this would require removal of phosphorus through additional elements in the design of the lagoon. This could increase the cost of construction considerably.

Cursory review of the current state of the art for lagoon design shows a wide contradiction in design principles, criteria and parameters. The simplicity of the systems, especially those without mechanical reactors, has discouraged innovation. The current design practice is primarily based on experience and trial unless the client can afford to pay for expensive pilot plant testing. There is an important need to review and codify the existing design practice to facilitate the wide application of the lagoon system.

(e) Treatment of industrial wastewater by use of activated carbon

The developing countries will be more industrialized and with that the environmental problems, especially with wastewater, will increase.

The treatment of difficult industrial wastewater by application of activated carbon or other adsorption materials, i.e. activated aluminium-oxide was discussed in some detail. This process is one way to solve this difficulty of industrial wastewater.

In regard to wastes from certain chemical industries with a high content of non-degradable substances with high COD/BOD ratio, the application of activated carbon is probably the best solution.

There are several techniques for treatment with activated carbon, depending on the type of wastewater:

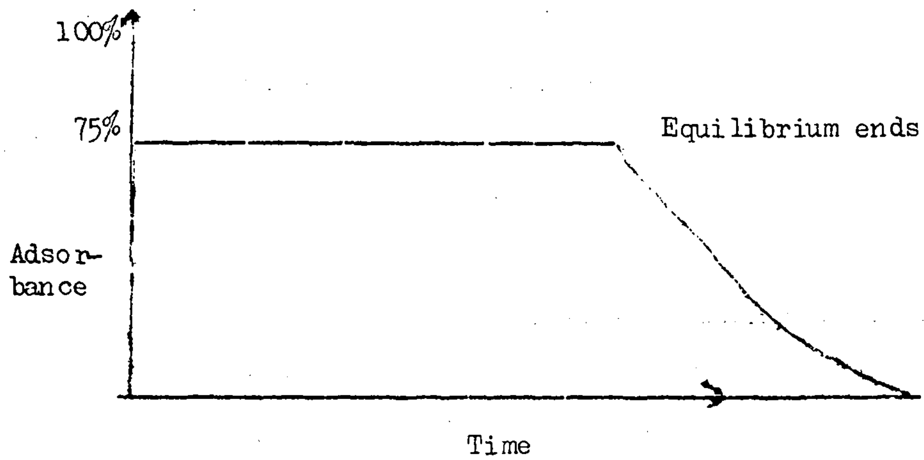
- Pure adsorption process for elimination of non-biodegradable substances;
- Pre-treatment for elimination of toxic substances which disturb the activated sludge process;
- Tertiary treatment, following the activated sludge process to improve the effluent quality, especially in view of the COD;
- Combined activated carbon-activated sludge process.

Usually the addition of activated carbon to the activated sludge improves the process stability of the biological treatment as well as the effluent quality. It is not completely clear why the activated carbon process increases the process stability; the mixed system is not fully understood and explained.

Sometimes there is biological activity on the surface or in the pores of the activated carbon (removal of organic compounds by bacterias). This prolongs the standing time of the activated carbon filters and improves the economy of the process.

The rate of recovery of the activated carbon in the regeneration process is usually more than 90%, and in Germany up to 98%, for the regeneration is mostly used water steam.

In designing the activated carbon reactor and the quantity of activated carbon required, it is necessary to first determine the capacity of adsorbance. This will then indicate the loading as well as the quantity of activated carbon. Secondly, the kinetics of adsorbance will give an indication of the control time. A laboratory test should be run to determine the residence of activated carbon before equilibrium is reached. The curve of adsorption is as follows:



The removal by activated aluminium oxide of organic substances such as chlorine, lignin and sulphuric acids, from the bleaching process in pulp and paper industry has been investigated at a small scale. Regeneration of aluminium oxide is achieved by heating to about 700°C. Further research is in progress to improve the cost effectiveness of the process and to apply aluminium oxide as an adsorbant for recovery of phosphates.

(f) <u>Eutrophication prevention</u>

The removal of nutrients from standing waters destined for drinking water production is a matter of concern to all countries.

The Symposium noted that the increasing use of fertilizers is the main cause of eutrophication. However, it would be impossible to create stringent legal barriers against the use of fertilizers under the pretext that this will retard eutrophication. However, it may be possible to create buffer zones where limited use of phosphate rich fertilizer is permitted.

The use of water hyacinth as a means of phosphate removal should also be considered. In this case the lake cannot be used for recreation and the evaporation rate is about ten times higher.

The provision of an effective sewage system is important in eutrophication prevention. Swedish experience in this area bears this out. Some eutrophication is of course beneficial to fish and acquatic life in general. Tropical fishes are often surface breathers due to naturally low dissolved oxygen in warm weather. The importance of eutrophication control in the tropics may not be as critical as in temperate climates.

(g) Disinfection and coliform count

The Symposium noted that disinfection should be placed in proper perspective in wastewater treatment. Disinfection cannot be undertaken in lieu of treatment. It has its place in the total wastewater treatment process, but its limitations must be fully recognized. It is not, as is often thought, a remedy or a panacea. The importance of establishing a sanitation system which is as complete as possible and as effective as possible cannot be over-estimated.

There is a need to resolve the carcinogenic impact of halogenated hydrocarbon due to chlorination of treated sewage effluent. Chlorine is the most common and practical disinfecting agent in developing countries today. Planners are often faced with the dilemma of choosing between cancer and enteric waterborne diseases in deciding whether to chlorinate the effluent from wastewater treatment plants. The high temperature in the tropics is very conducive for the reestablishment of E. coli colonies which makes disinfection impractical.

All too often in the developing countries the simple addition of chlorine is taken as sufficient treatment for wastewater. In general, where chlorine is used, it should be done with great care.

The coliform count continues to be the most widely used measure of the effectiveness of disinfection since coliform organisms are more resistant to disinfection than pathogenic bacteria. The disadvantage is that it takes twenty-four hours before results can be obtained.

Virus

The removal of viruses from wastewater was discussed and in general it was agreed that present techniques and tests do not give fully satisfactory results. The importance of further developing methods and techniques for detecting viruses was stressed, in view of the need to protect people in third world countries from this problem.

Analytical control of effluents

TOC and COD as parameters

Some participants requested information on the use of COD parameters in Germany. TOC can be associated with the effective protection of the environment and as such is a parameter for environmental assessment.

COD is a parameter which is not easy to measure, requiring sophisticated laboratory equipment and requiring one half hour to complete. TOC can be measured in one or two minutes. Therefore, adoption of the COD parameter in the developing countries may pose some problems.

Information about user and pollution charges in Germany

A measure of the success of wastewater treatment facilities is the equation of the effective capacity to pay and the charges established. In Addis Ababa, for example, an appraisal of several criteria for establishing user charges resulted in formulating a realistic user charge. A key element is to consider wastewater treatment from both the economic and the social points of view. Income per capita in many developing countries is so low that it is not possible at present to pass on to the user the entire package of costs to repay capital borrowed at high interest rates. In the case of Addis Ababa, the Government decided to meet the interest charges.

Another measure which will help alleviate the burden of repayment is the extension of the grace period for 10 years rather than the 40 year direct repayment plan. The Symposium noted with satisfaction that the practice of German loan institutions is to allow for a 10 year grace period.

Pollution charges

A number of countries are in the process of establishing systems of charging for pollution generated especially by industrial establishments.

The Symposium noted that in Germany the main parameter is COD. However, there are many other substances which are taken into account depending on the particular polluting industry. The German law in force includes 57 different standards for the different types of industrial establishments.

The system is based on "pollution units" which are related to equivalent population. The charge per kg. of COD is less than 1 Deutch Mark. The equivalent amount for mercury (Hg) is in the order of several thousand Marks. In principle, 1 pollution unit (related to 1 population equivalent) is charged 12 German Marks. The charge will rise progressively to 40 German Marks by 1986.

Training

The Symposium determined that training of all aspects, but particularly technical level training in wastewater treatment (plant operation and maintenance) is of paramount importance and should be given the highest priority. Training should be coupled with information exchange on appropriate technology, the establishment of a roster of consultants (perhaps by WHO/UNEP) and the periodic documentation of practical results from research.

Two levels of technician training may be considered. One level would be concerned with the training of plant operators and maintenance personnel for the conventional plants (primary and secondary treatment plants). These technicians would acquire the normal type of experience during training. The second level of training would be for tertiary treatment plant operators (e.g. phosphate removal, filtration, adsorption plants, high technology sludge handling, composting). These highly experienced technicians would operate sophisticated equipment and therefore their training should be qualitatively different.

In Germany, manuals of instruction exist for training the first kind of operators. Participants suggested that translation and revision of the manual to suit conditions of developing countries would be very useful.

Management and administrative aspects

Several working papers dealt with problems of administration in planning, designing and implementing wastewater treatment facilities. The Symposium recognized the importance of these aspects and in its recommendations called for raising the priority of sanitation in development plans of countries. It noted that wastewater treatment and related sanitation considerations are nearly always given lower priority than water supply. The two are almost inseparable and as such deserve equal consideration. The importance of joint administration of water and sewerage works was recognized. Combined administration would provide the necessary broader base for more effective manpower training and development. In the long run, this would ensure the building up of a large supply of local labour which could be depended on to do efficient and competent work on wastewater treatment.

Special problems

Leakage control

The Symposium recognized the seriousness of leakage in pipelines which reduces the supply of water and permits introduction of contaminating material, thus severely reducing potability of even piped and treated water. In many cases, e.g. Manila, "unaccounted for" water reaches 60% of available supply. This difficulty exists even in developed countries such as Germany.

Contamination by non-biodegradable material is potentially more bothersome and it would be more appropriate for countries to tackle this problem rather than the problem of colour. Oil spills and discharges have also to be considered and proper legislation introduced and strictly enforced. The problem of many developing countries in this regard can be exemplified by Nigeria. The National Petroleum Company insists that the existing standards, copied from industrialized countries, be met. The problem is that the oil companies do comply with the standards. Any oil spilled by an oil company should be cleaned up by the same company.

Unfortunately, the usual response to this sort of problem is not leakage detection and control, but rather the expansion of the system at very high cost, i.e. by building dams and pumping stations purification plants, etc.. The savings which could be made from proper leakage detection and control could in some cases more than offset the capital devoted to new water works. One important point is to develop better leakage detection methods.

Wastewater from refuse tips

In regions with heavy rainfall and where the location and operation of refuse tip is poorly undertaken, there is a constant health hazard as wastewater leaks and spreads in the surrounding regions. There is an urgent need for proper guidelines on the correct manner of handling wastewater from refuse tips. One key element is proper surface drainage and correct benching and treatment of the polluted water.

Sanitation without water

The main emphasis of the Symposium was on water borne sanitation, hence the theme of the discussion - wastewater treatment.

However, one paper was presented which dealt with the potential of sanitation without water.

The Symposium recognized that on one hand, it is impossible to solve the problems of sanitation, particularly in densely populated urban areas, using a system of pit privies, while on the other hand, flush toilets are beyond the means of millions of people. The dilemma was not fully determined during the discussion.

It was clear, however, that the objectives of the International Decade for Drinking Water and Sanitation (1981-1990) are not likely to be met unless advantage is taken of all alternatives, affordable systems to establish sanitation to the maximum extent possible and in keeping with sound environmental health practices.

At the same time the Symposium recognized that sanitation without water cannot offer a panacea. In fact if not properly planned and managed, it can cause potential hazards in terms of increasing environmental health and nuisance.

The Symposium noted that in reality, governments should display a broad spectrum of strategies for meeting the sanitation objectives of the decade. Full water borne sanitation would be at one end of the spectrum and sanitation without water at the other. The two systems, rather than being regarded as opposites, should be integrated in a complementary set of policy measures. This might provide an opportunity to assist the 800 million people in the world, who at present live in absolute poverty.

Disposal in the sea

The Symposium discussed waste disposal in the deep sea in connexion with the description of this practice in Bombay, India (see paper WP.16).

Although the approach cannot be compared to the highly efficient activated sludge or lagoons system of treatment, it appears to be widely used as it utilizes the diluting effect of large expanses of sea water.

In Bombay, 30% of industrial waste is disposed of in the seas. The outfall of 10 km. ensures that waves do not normally return the waste disposed. Solids are not separated before dumping, because this would add costs to the waste treatment for this city of 8 million inhabitants.

Participants could not agree with this method of waste disposal. The experience of Germany and Japan show that it will increase pollution of the sea and create new environmental problems. In Germany, at present, the disposal of sewage sludge into the sea is only 3% of the total amount and in future, it will not be allowed.

Spray irrigation of wastewater from the town of Braunschweig

The use of wastewater for irrigation in the vicinity of Braunschweig aroused a great deal of interest by the participants. Land treatment of wastewater has been employed by the City of Braunschweig since 1896. In 1954 the Braunschweig Sewage Utilization Association (SUA) was founded. Its members are the City of Braunschweig, a few smaller communities and about 450 farmers. 4000 ha is presently farmed under this system. Approximately 36,000 m^3 of sewage is utilized daily. Purification of the sewage is effected through land filtration and the activity of soil organisms. The advantage to the farms of using nitritious water enriched by humus substances and acceptable levels of trace elements is recognized. No disinfection is practiced and periodic surveys show that coliform counts are not high and water borne diseases are practically unknown in the area where irrigation is practised.

The possibility of using such a system in the developing countries was discussed. It was generally agreed that hygiene aspects and removal of metals should be carefully examined under the different climatic conditions of the developing countries.

Design approach

The Symposium noted the importance of evolving realistic design criteria taking local factors fully into account. Each country should, to the extent possible, establish design standards that are both cost effective and technically justifiable. Design formula for example, developed in other countries on the basis of impirical observations several decades ago, appear to lead to errors of estimation of considerable magnitude. In this regard the importance of allowing for tolerances was recognized. In many cases strict standards and yardsticks may not be made, but rather allow for an acceptable safety margin.

Centralized planning and land use

Most of the cities in developing countries are characterized by large urban sprawls. The expansion of the residential, commercial and industrial areas are often mixed and simultaneous. The problem created by the unplanned development often makes wastewater pollution control difficult and expensive. Proper planning of industrial estates and location of antagonistic industrial wastes discharges could alleviate the wastewater pollution problem.

ANNEX B

LIST OF DOCUMENTS

UNEP/KFK-PTWT/WP.1	Environmental Aspects of Wastewater Treatment in Developing Countries By N. Gebremedhin (UNEP)
UNEP/KFK-PTWT/WP.2	Health Aspects of Wastewater Treatment and Disposal By Dr. G. Bachmann (WHO)
UNEP/KFK-PTWT/WP.3	Development of New Technologies for Wastewater Treatment - The Experience of the Federal Republic of Germany By Prof. Dr. S.H. Eberle Nuclear Research Centre, Karlsruhe (FRG)
UNEP/KFK-PTWT/WP.4	Problems and Experiences in Wastewater Treatment from the Viewpoint of Developing Countries - a Summary of Country Monographs
UNEP/KFK-PTWT/WP.5	Operating Requirements for Wastewater Treatment and Effluent Standards By Prof. Dr. B. Böhnke University of Aachen (FRG)
UNEP/KFK-PTWT/WP.6	Practical Experience of German Institutions in Wastewater Treatment Plants in Developing Countries By Mr. G. Neubauer Frankfurt (FRG)
UNEP/KFK-PTWT/WP.7	Training and Research Requirements in Wastewater Management By Dr. Plümer Association of Wastewater Techniques (FRG)
UNEP/KFK-PTWT/WP.8	Training and Research Requirements for Wastewater Management in Developing Countries By Dr. B. Lohani Asian Institute of Technology
UNEP/KFK-PTWT/WP.9	Administrative, Financial and Technical Aspects of Wastewater Treatment in Developing Countries - a Case Study of Addis Ababa By Mr. A. Truneh Kassa Addis Ababa Water Supply and Sewerage Authority
UNEP/KFK-PTWT/WP.10	Ecological Aspects of Sewage Treatment in Developing Countries By Prof. Dr. L. Hartmann University of Karlsruhe (FRG)

UNEP/KFK-PTWT/WP.11	Influence of wastewater Treatment on Drinking Water Production By Prof. Dr. H. Sontheimer University of Karlsruhe (FRG)
UNEP/KFK-PTWT/WP.12	Recent Development in Biological Treatment of Wastewater in Germany By Prof. Dr. Böhnke/Mr. K. Vossbeck University of Aachen (FRG)
UNEP/KFK-PTWT/WP.13	Wastewater Treatment in Lagoons By Prof. Dr. Kayser University of Braunschweig (FRG)
UNEP/KFK-PTWT/WP.14	Design and Operation of Waste Stabilization Ponds for the New Capital City of Dodoma, Tanzania By Mr. F.Z. Njau Ministry of Lands, Housing and Urban Development (Tanzania)
UNEP/KFK-PTWT/WP.15	Biological Treatment of Difficult Wastewater by Application of Activated Carbon By Prof. Dr. Jüntgen/Dr. R. Jockers/Dr. J. Klein Bergbauforschung Essen (FRG)
UNEP/KFK-PTWT/WP.16	Sewerage and Treatment Problems of Large Metropolitan Areas - the Example of Calcutta, India By Prof. P. Khanna Indian Institute of Technology (Bombay)
UNEP/KFK-PTWT/WP.17	Recent Developments in the Field of Eutrophication Prevention By Prof. Dr. H. Bernhardt Wahnbachtalsperrenberband (FRG)
UNEP/KFK-PTWT/WP.18	Dinitrification Experience in the Federal Republic of Germany By Prof. Dr. K.H.Krauth University of Stuttgart (FRG)
UNEP/KFK-PTWT/WP.19	Sanitation Without Water (The needs and possibilities of disposing human faeces without water in the developing countries) By Uno Winblad (Sweden)
UNEP/KFK-PTWT/WP.20	Treatment of Concentrated Wastewater from the Food Industry By Prof. Dr. L. Hartmann University of Karlsruhe

UNEP/KFK-PTWT/WP.21 Wastewater Processing in the Food Industry in Kenya

By Mr. J. Gecaga
University of Nairobi (Kenya)

UNEP/KFK-PTWT/WP.22 Wastewater Treatment in the Textile Industry with Particular Reference to Latin America

By Dr. Marcio-Braile (Brazil)

UNEP/KFK-PTWT/WP.23 Prevention and Reduction of Water Pollution in the Pulp and Paper Industry - the Experience of the Federal Republic of Germany

By Prof. Dr. G. Rincke/Prof. Göttsching/
A. Geller/H. Irmer
University of Darmstadt (FRG)

UNEP/KFK-PTWT/WP.24 Wastewater Treatment in the Oil Refinery Industry in Developing Countries

By Prof. Enyenihi (Nigeria)

UNEP/KFK-PTWT/WP.25 Wastewater Treatment in Metal Processing Industries - an Example from Asia

By Dr. E.A.R. Ouano (Philippines)

UNEP/KFK-PTWT/WP.26 Use of Digester Gas in Sewage Treatment and Energy Production

By Prof. Dr. R. Kayser
University of Braunschweig (FRG)

ANNEX C ABSTACTS OF THEME PAPERS

WP.1 Environmental aspects of wastewater treatment in developing countries
(By N. Gebremedhin, UNEP)

Problems in wastewater treatment are common to both developed and developing countries, the difference being one of degree. The developed countries have some serious wastewater problems emerging from industrial establishment.

In the developing countries, the following aspects of wastewater treatment will be especially important:

(a) Water quality protection and conservation: Pollution reduces the water resource potential to only a fraction of what nature offers. The level of pollution in surface water, in streams and rivers is constantly rising. This is also true about ground water. In coastal areas, salt water intrusion poses a problem. The arid regions of the world, i.e. those receiving less than 6% of total precipitation face a particularly acute problem, even if these problems are not associated with wastewater. In eliminating harm caused by pollution, the following may be usefully considered:

- System of permits for certain enterprises;
- Control of the small number of large water users and polluters;
- Giving preference to individual assessment over rigid standards.

During recent years, water used per unit of production (and consequent effluent discharge) in industry has decreased significantly (e.g. 70 m^3/ ton to 30 m^3/ton) in pulp and paper industry. This trend should be encouraged.

(b) Lagoons and other "self-purifying systems: Such systems have special significance to developing countries because they do not require much maintenance; they use local materials and can be operated by semi-skilled persons. The economy of many developing countries can afford such systems. This system is especially applicable where land is readily available at reasonable cost.

(c) Renovation of water for re-use: The amount of water in the world which does not present serious difficulties for industrial or domestic use is rather limited. One estimate of annual precipitation (Van Te Chow 1964) is $437 \times 10^{12} m^3$ per year. Of this, 23% falls on land, 17% in humid areas and 6% in arid regions. According to one source (Valdisavljevic-Medak 1976) water resources can support from 1.5 to 4.5 persons per hectare, depending on the standard of living adopted. From a planetary water supply point of view, critical limits may be approaching - placing difficult obstacles in the path of the progress of the developing countries. Water re-use is increasingly becoming an important and necessary option. Industry can be a major user of renovated water. In this regard, there is need to establish different standards of water for different users. The single quality standard of water quality enforced by many developing countries is not advantageous and should be revised.

WP.2 Health aspects of wastewater treatment and disposal (By G. Bachmann, WHO)

Transmission of water-borne diseases, in particular enteric and diarrhoeal diseases, is most frequently by water pollution causing food contamination, use of nightsoil as a fertilizer and by unsafe drinking water. While in urban areas of industrialized countries sewerage systems have been developed to a great extent, these are not available in large cities and in the scattered urban fringe and rural areas of developing countries because of the considerable investment required. Nevertheless, the sanitary disposal of human wastes is necessary to eliminate water and food contamination. However, to assure the effectiveness of these measures, sanitation programmes should include components of health education, water supply, personal hygiene, waste disposal and community participation to support the adequate operation and maintenance of facilities.

Methods of wastewater treatment have been developed to a high degree. Their effectiveness is normally measured by the reduction of pathogenic indicators, mainly the coliform organisms. Reduction of coliform organisms by 90 to 99 percent have been shown by full biological treatment and by stabilization ponds respectively, the latter method being increasingly important in developing countries. Regarding the re-use of effluent treatment for land irrigation, farmers may meet with difficulties if sewage utilization is restricted to certain types of crops, while unrestricted use may warrant a fairly high degree of treatment including disinfection of effluent. As concerns the health aspects, further studies are required on the danger of disease transmission by irrigating crops with reclaimed water. Provisionally, it can be said that good agricultural and water management combined with reliability and safety of the irrigation system are as important as proper treatment prior to re-use. Furthermore, size and location of a system as well as costs and economies must be considered before deciding on effluent re-use, including recovery at source of by-products of industrial and other wastes. Water management practice has changed and its objectives now also include reduction of wastewater volume, improved treatment effects, water conservation and raw materials recovery.

The planning and design of wastewater systems should follow new patterns, technologies and standards, with the understanding, however, that each developing country must evolve and modify them to suit its own needs. International organizations, including the World Health Organization, have a role to play by assisting these countries in developing appropriate technologies, designing national programmes, building up laboratory surveillance mechanisms and training personnel. Further development will require that countries set realistic targets, make more use of community resources, use inexpensive suitable technology, integrate programmes with other sectors and include the achievement of health components as a principle objective of their national plan. In recognition of this situation, the International Drinking Water Supply and Sanitation Decade (1981-1990), was proclaimed and many countries now show in their development strategies an awareness of the need to improve water supplies and sanitation facilities for their population.

WP.3 Development of new technologies for wastewater treatment - the experience of the Federal Republic of Germany
(By Prof. Dr. S.H. Eberle)

The focus of the paper is on the interaction between legislation, technology and natural systems. Historically, interest in and awareness of wastewater treatment in Germany emerged in conjunction with the dramatic decrease in quality of surface and even ground water in the sixties. The deep concern for environmental protection in the seventies led to the promulgation of goals for the environmental aspects of water. The main goals are: (a) conservation or re-establishment of the ecological balance of natural waters, (b) guarantee of water supply for population and industry, (c) preservation and utilization of water for recreation.

In the framework of the above goals, a multitude of activities were planned, ranging from legislative measures to intensification of research and development. 36 new acts and regulations have been issued or revised, the two most important being (a) the water ecology act and (b) the effluent charge act.

In regard to these two acts, the following points are particularly important:

- All wastewaters must be rendered harmless before discharging into receiving waters;
- Minimum requirements are established for effluent quality in accordance with commonly accepted technical specifications (best available technical standards);

- Introduction of the COD as an additional pollution parameter;
- Limiting values for individual substances.

In order to achieve the goals mentioned above, the Federal Ministry for Research and Technology (BMFT) considerably increased its support for research and development.

In 1978, 80% of the funds for research in the field of the environment were contributed by the BMFT. Up to 1980, the amount spent on research and development in the field of wastewater and sludge treatment by the BMFT was about 130 million DM.

Two studies ("New Technologies for Wastewater Treatment" and "New Technologies for Drinking Water Supply") carried out in 1975-76 in association with the German Association for Water Pollution Control (ATV) and the German Association for Gas and Water Supply (DVGW) were instrumental in clarifying the gaps in knowledge and action in this area. A consequence of this study was a significant increase in the number of sponsored research and development projects.

The present state of wastewater treatment technologies is outlined in the following sketch:

State of development ↑

Science and research	- chem. oxidation - therm. oxidation - membrane processes - irradiation - wet oxidation - non-carbon absorbants - special micro-organisms
State of the art	- filtration - dinitrification - flotation - activated carbon adsorption - evaporation - electrolysis - ion exchange - contrifugation
Common standard	- biological (secondary) treatment + nitrification - coagulation/floculation - neutralization - oxidation ponds - extraction
Simple (standard) treatment	- sedimentation clarification - land treatment

→ efficiency

WP.5 Operating requirements for wastewater treatment and effluent standards
(By Prof. Dr. B. Böhnke)

The recent legislations of the Federal Republic of Germany for the prevention of water pollution will contribute to an improvement of the quality of the inland waters to correspond with those of the European Communities. The major parameters in the German legislation are COD- and BOD_5 levels. In the Federal Republic of Germany, treatment plants must operate at an efficiency which ensures 95% BOD_5 removal. The effluent may not exceed a total oxygen demand of maximum 15 mg O_2/l. An examination of 10,000 samples from 213 plants reveals that a sludge loading rate of 0.15 kg BOD_5 (kg ss.d) meets the minimum requirements. In order to ensure that only sewage with a maximum oxygen demand of 15 mg O_2/l passes into lakes and rivers, it is necessary to plan stabilization plants with maximum loads per unit volume of 250 g $BOD_5/(m^3.d)$ or treatment systems with a similar efficiency. The minimum NH_4-N- content of the sewage should be fixed, otherwise an O_2 shortage in the water will result.

WP.6 Practical experience of German institutions in wastewater treatment plants in developing countries (By G. Neubauer)

The main German institutions concerned with sewage and sewage treatment problems in developing countries are private consultants (including universities), the "Deutsche Gesellschaft für Technische Zusammenarbeit" (German Agency for Technical Co-operation, GTZ) and the "Kreditanstalt für Wiederaufbau (KFW)" (German Bank for Reconstruction). While the GTZ provides technical assistance, the KFW provides financing for projects.

In so far as densely populated and built up areas are concerned, the only alternative seems to be conventional sewarage systems, whether for developed or developing countries. There is therefore a common basis for transfering certain technologies in this area to developing countries, through German technical assistance.

However, some problems persist in connexion with transfer of technologies, such as unsuitability of plant layout, heavy mechanisation and compact solutions. Most developing countries importing plants have failed to establish adequate and sustained maintenance by properly trained people. As a result, the life span of plants is shorter in developing countries as compared to developed countries. The energy consumed is often very high, and the process does not allow even minor interruptions.

The utilization of plant effluent for irrigation, fish breeding, etc., could be further considered.

Plants are seldom able to retain skilled employees because the conditions of employment are not attractive enough. Water and sewage disposal rates are kept at such low levels that revenue is not enough to provide for basic maintenance and operation costs. As a matter of priority, countries need to establish cost covering graduated rates in order to provide financial solvency to sewarage authorities.

WP.7 Training and research requirements in wastewater management
(By Dr. C.H. Plümer)

In the past, treatment plants were more simple. However, today's highly complicated installations and processes require well-trained operators. The operation of many plants without qualified staff results in an economic loss of approximately 15% or more. In the Federal Republic of Germany, this amounts to more than 60 mio.DM per year without considering the effects of pollution on the receiving waters. The duties of most of the consultants are limited to design, tender and supervision. The operation of plants (staff and spare parts) is not considered sufficiently in advance.

In the Federal Republic of Germany, the ATV is training engineers, scientists and operators for operation of sewer systems and treatment works (training by local and correspondence courses with examinations). The trained staff are 2nd class operators, 1st class operators and master operators. The medium of instruction is German, but the courses can be attended by participants from other countries.

Research is one of the most important activities as concerns increasing the efficiency of treatment and of construction, because energy and labour costs are rising.

To comply with the most important activities and to reach the required goals, a significant programme of research is being carried out and will be pursued continuously. Technology transfer, co-ordination of research with legal activities as well as establishment of rules and standards are also important.

WP.8 Training and research requirements for wastewater management in developing countries (By Dr. B.N. Lohani)

Of all environmental resources, water is the most severely threatened by pollution. Therefore water pollution control is given high priority in many countries, including the developing countries.

Land intensive systems (oxidation ponds) may provide a sound solution where capital intensive systems may be out of reach. In these systems, organic matter is broken down by bacteria as in conventional biological treatment processes - aerobically in upper layers and anaerobically on the bottom. Ponds (facultative) can be loaded up to about 400 Lb BOD per acre/day without lowering BOD removal per unit of area, while anaerobic ponds or lagoons have been operated up to 46,000 Lb BOD per acre/day with high efficiency. A somewhat more expensive alternative is the oxidation ditch.

Land treatment systems can also be applied where land is readily available. Land treatment is not dumping or simply disposal. Considerable research is underway in the developed countries to improve this approach.

Research into resource recovery through fish and algae cultivation shows a good deal of promise. Experiments at AIT, Bangkok, show yields approaching 20 ton/ha/yr of fish based on a three-month growing period.

Training requirements should reflect the need to increase environmental awareness, to expand formal training at the professional level and to substantially add to the facilities for training technicians.

Suitable management strategies will centre around the establishment of rational effluent standards, regulating and controlling uses and abuses, and establishing charges on effluent services that are flexible and take into account the annual charge to the industrial user. A formula for establishing a user charge is given below:

$$Ci = Vo\ Vi + bo\ Bi + So\ Si$$

where Ci = Charge to user i, in US dollars per month

Vo = Cost of transport and treatment chargeable to volume in US dollars per cubic meter

bo = Unit cost of treatment, chargeable to BOD reduction, in US dollars per kilogramme

so = Unit cost of treatment (including sludge treatment), chargeable to suspend solids in US dollars per kilogramme

vi = Volume of wastewater from user i, in cubic meters per month

Bi = Weight of BOD from user i, in kilogrammes per month

Si = Weight of suspended solids from user i, in kilogrammes per month

WP.9 The administrative, financial and technical aspects of wastewater in developing countries - a case study of Addis Ababa, Ethiopia (By Mr. A. Truneh Kassa)

Addis Ababa's population is in excess of 1.2 million. In the past the city used a combination of septic tanks, cesspools and associated irrigation systems to move fecal wastes, via percolation into the ground. Vacuum sewer trucks were also used to pump out septic tanks.

But because the city was growing at an annual rate of 5% and because of generally poor leaching capability of the soil, another solution was required to dispose of the wastewater. The decision was made to construct a semi-conventional treatment plant consisting of recirculating oxidation ponds in series preceeded by bar screen and gut chamber. The construction is being undertaken in two states; state 1 consisting of treatment plant and major outfall sewers, and stage two of inverted-siphon river crossings and secondary mains. Stage one is limited to serving ten percent of the population.

A key problem is how to pay for the public investment (approximately US$ 20 million). Early estimates showed depreciation to be 32% and interest on loan 33%. It was assumed that if 3000 connections could be made at an approximate monthly tariff of one half US dollar per cubic meter of water purchased, the revenue raised would fully cover operating costs. However, 55% connections were eventually accounted for. Projected costs had therefore to be reviewed and instead of calculating depreciation using the "straight line method", the "compound interest method" was utilized. In this way depreciation in the first four years was reduced from US$1.8 million to US$157,000. Despite this, revenues still showed an annual shortfall of US$215,000. Furthermore, the small customer was expected to pay US$30 per month for sewer services, which represents 62% of the monthly income of the average family in Addis Ababa.

After considering a number of alterations the Government is likely to adopt a plan whereby it will subsidize 100% of the interest cost on the capital invested. This plan will result in the customer paying about US$12 per month for sewer services.

A novel feature of the Addis Ababa scheme is the direct disposition of truck collected fecal matter at selected points in the sewer.

The importance of proper training of personnel working in sewer works is emphasized. The division of labour between a central government agency such as the Addis Ababa Water and Sewerage Authority and local entrepreneurs is a matter to be fully explored. Also of importance is the level at which effluent standards are to be established. This matter is ultimately linked to treatment methods and efficiencies. In Addis Ababa, this matter will be studied and monitored for the next 5 years before a decision is made. A matter of urgent importance is the provision of community sanitary centres to be operated along sewer lines. These centres will serve those parts of the community unable to be connected to the sewer lines.

WP.10 Ecological aspects of sewage treatment in developing countries
(By Prof. Dr. L. Hartmann)

Sewage treatment in developing countries should not be a copy of sewage treatment in industrialized countries. Even the basic philosophical approach must in many cases be different. Though also in industrialized countries the ecological approach gets increasing importance, in developing countries, considering ecology is an absolute must.

The most important ecological/economical facts are:

Most developing countries lack highly sophisticated techniques, they are exposed to tropical climates and in many cases depending on food production from low technology agriculture on soils of low fertility. Natural ecosystems in many cases are highly diversified and fragile. Under positive conditions, there is still a partnership between rural and urban areas, in other situations ecological balance between ruralism and urbanism has collapsed. Other handicaps are connected with high rates of infestation of the population with water or food borne intestinal and blood parasites. All these facets narrow down the variety of treatment potential and call for special attention.

The philosophical basis has to depend on the situation mentioned above. The technical approach calls for isolation of wastes from the population to control parasites and at the same time for reuse of water and organics.

The real solutions depend on the climatic conditions. In countries lacking precipitation, agricultural use should be favoured. Wherever possible, it should be connected with low energy techniques, for example rotating disc.

In countries with high precipitation and rain-fed ponds, fish farming can be the method of choice, as a second facility. But in all cases, intensive ecological surveys before and continuous monitoring of health after installation are an absolute must.

WP.11 Influence of wastewater treatment on drinking water production
(By Prof. Sontheimer)

The experience of drinking water works using polluted river waters helps to explain the possible influence of wastewater treatment on drinking water quality. Considering the German experience, ground filtration is one of the most important and effective treatment steps for river water treatment. Similar effects can be achieved only in activated carbon filters working biologically.

For this reason a testing method has been developed using this type of treatment in a small test unit for evaluation of the treated wastewater of chemical plants. The effluent of the testing unit contains only those substances which can enter the water works after river bank infiltration or some other types of ground filtration. This helps to identify the problems for drinking water quality originating from this special waste and can be an aid in optimizing waste treatment.

The non-biodegradable substances are very important with respect to the influence of wastewater on drinking water. Of special importance are the organochloro compounds. Experience in this field in Germany clearly indicates that improvement of river water quality through better waste treatment will lead to better drinking water quality. This experience from densely populated and industrialized areas of Germany will have some applications for other countries.

WP.12 Recent developments in biological treatment of wastewater in Germany
(By Prof. Dr. Böhnke/Mr. K. Vossbeck)

The Environmental Protection Programme of the Federal Republic of Germany stipulates that 90% of the sewages will be treated in biological treatment plants until 1985. In order to fulfill the minimum requirements in accordance with the Wastewater Charges Act, the problems of efficiency and process stability have to be considered so that high rates of purification may be obtained with a minimum of energy input as the greater part of the energy input in the treatment plant is required for supply of oxygen for sewage treatment.

Multistage systems are favourable, particularly when sewage of high concentration is to be treated.

The paper deals with an equipment for supply by fine bubble aeration. An intermittent aeration and saving of energy input may be obtained by separation of the energy input for (a) aeration and for (b) circulation.

As to new developments, the paper reports on the Deep Shaft Process, the Bayer Tower Biological Process and pure oxygen aeration. Among the multistage systems, the two stage adsorption activated sludge process represents a purification method characterized by a very highly loaded first stage - the adsorption stage, and a normally loaded second stage.

The paper reports on the results of experiments which show that the quality of the effluent of these two stage biological treatment plants is generally better than that of one stage activated sludge plants. The paper concludes with a comparison of a two stage adsorption activated sludge plant with a one-stage nitrification plant, which reflects the space saving possible.

WP.13 Wastewater treatment in lagoons (By Prof. Kayser)

In West Germany, more than a thousand lagoons for wastewater treatment are in operation. Due to climatic conditions and stringent effluent quality criteria (effluent BOD less than 25 mg/l) the permissable load is 4 g BOD/m^2d. It is recommended that the lagoons should be subdivided into three parts of about equal surface areas. The water depth should be 1.0 to 1.5 m. The design criteria match very well with internationally recommended criteria, if the lower temperature is taken into account.

Because of the large areas required for lagoons, aerated lagoons are becoming increasingly popular. Due to the fact that the usual aeration equipment used in activated sludge plants is designed for high oxygen transfer rates and high mixing levels, some special lagoon aeration systems are produced, which achieve a sufficiently high degree of mixing at low oxygen transfer rates.

Two of these aeration systems are modified diffused aeration devices (fine bubble) which require a depth of at least 2.5 m. in order to be economical. There are also surface aeration systems which can be installed in rather shallow lagoons. These last ones are very useful for improving the loading capacity of existing (non-aerated) lagoons.

It is recommended to install the aeration device in such a way that either clarification is obtained within the aerated lagoons (partially aerated lagoon) or the effluent from the aerated lagoon passes through another lagoon for clarification. The best solution is a combination of both a partial aeration and a clarification lagoon.

WP.14 Design and operation of waste stabilization ponds for the new Capital City of Dodoma, Tanzania (By F.Z. Njau)

The decision to transfer the National Capital from Dar-es-Salaam to Dodoma was made on 5 October 1973. At that time the population of Dodoma was estimated at 23,000 inhabitants and was expected to reach 45,000 in 1975 and 92,000 in 1980 when most Government Ministries would have moved. At the time of preparing the master plan there was no sewerage system and most inhabitants were using septic tanks, soak away systems and pit latrines. The master plan therefore called for immediate construction of a sewerage system to meet the needs of the growing population expected to number

350,000 by the year 2000. Consultants were then appointed to prepare a five-year development programme (1976-1981). The preliminary design of the sewerage system was prepared by Project Planning Associates of Toronto, Canada, in February 1976.

Design criteria

(1) The Dodoma Capital City Master Plan assumed an average per capita water consumption of 225 litres and a sewage contribution of 180 l/c/d. The average water consumption in 1976 was only about 82 l/c/d and it was assumed that in four years the consumption would rise to some 112 l/c/d and an average sewage flow of 90 l/c/d which is the figure used in the design.

(2) Because of the low water consumption the sewage strength would be high and the biological oxygen demand (BOD) and suspended solids (SS) were taken as 0,027 Kg/c/d respectively and based on these values, estimated BOD and SS concentration was taken as 300 and 450 mg/l respectively.

(3) The waste stabilization ponds should be located not less than 1000 meters away from the nearest residential area. The plan provided that with the spread of the residential area to the vicinity of the oxidation ponds their use would be discontinued and waste water would be treated in the waste reclamation plant.

(4) The magnitude and composition of commercial and industrial wastes were not known, making it difficult to assess the volume of waste waters and hence the following equivalent populations were used: Commercial, 50 persons per hectare; industrial, 100 persons per hectare with wastewater flows of 180 litres per capita per day.

(5) The design equation for the waste stabilization ponds was that of E.F. Gloyna, Waste Stabilization Ponds, WHO 1971, page 65.

(6) The residential population was estimated at 65,660 (1980) people comprising the existing population of about 40,000 (1976) and the expected additional population from new developments. Equivalent population from industry, commercial and schools was assumed as 2,340, bringing the total equivalent population to 68,000.

(7) Total sewage flow into the ponds is 6120 m^3/d. The pond volume gives a retention time of 35 days.

WP.15 Biological treatment of difficult wastewater by application of activated carbon
(By Prof. Jüntgen/Dr. R. Jockers/Dr. J. Klein)

To meet the requirements for advanced water pollution control, the combination of activated carbon adsorption and biological treatment is supposed to enable more efficient process configurations for removal of various water pollutants, which up to the present time have been difficult to remove.

Toxic matter is removed by adsorption to granular activated carbon upstream of the biotreatment, while downstream, the metabolic matter is removed again by adsorption to granular activated carbon (tertiary treatment). In another process configuration powdered carbon is added to the activated sludge. Here, the activated carbon prevents, by adsorption of toxic matter, the bio-treatment from being affected, so that the special microbial population can take on the biodegradable matter more effectively. Operational plants for each of the above mentioned configurations are briefly discussed.

WP.16 Sewage and treatment problems of large metropolitan areas - an example of Calcutta, India (By Prof. P. Khanna)

A major source of pollution of fresh and coastal waters in India is the community wastewater generated by major cities and towns. It is from these 142 Class I cities that 60 to 70 percent of the pollution responsible for deterioration of the quality of aquatic waters in India is generated. The contribution of industrial wastewaters even in the industrialized cities of Bombay, Calcutta and Delhi amounts to a meagre 13, 11 and 10 percent (by volume) respectively, of the total wastewater flows although the organic load contributed by industry in India has already reached an alarming level.

In view of the fact that lack of infrastructure such as municipal wastewater collection and treatment systems due to limited financial resources was mainly responsible for the deficient water pollution control programme, the problem could only be solved effectively by exploiting the available assimilative capacity of the receiving bodies of water to its maximum. Decentralized wastewater outfalls and treatment systems have therefore been adopted in Bombay effecting substantial reductions in the costs of wastewater collection and treatment.

Identification of appropriate waste treatment technology in the Indian context, exploiting fully the advantages of bright sunshine, high temperatures, soil conditions and agricultural use are the high mark of treatment technology in tropical developing countries. Employment of machinery and equipment requiring considerable skill in installation, operation and maintenance in a country where such skill is only scantily available would result not only in huge expenditure on treatment but also in non-functional systems.

WP.17 Recent developments in the field of eutrophication prevention (By Prof. Bernhardt)

The paper describes the causes of eutrophication of still waters applying the results of the international OECD investigation. Phosphates being the minimum factor in the development of algae, the tolerable phosphorus load for lakes and drinking water reservoirs is stated as related to the morphological conditions, paying attention to the fact that drinking water reservoirs should be cligotrophic or, at the most, mesotrophic.

Different processes for reduction of the phosphorus concentration in the effluents of urban sewage treatment plants, considered to be point-sources, are described. Not only conventional processes of chemical precipitation are discussed but also new processes, such as the adsorption of p-compounds to alumina or contact filtration after chemical treatment of sewage which has been mechanically or biologically purified.

The paper also deals with the process of biological elimination of phosphorus and nitrogen by anaerobic/aerobic run of a biological sewage treatment plant.

New processes which can now be carried out on a large scale for the reduction of the phosphorus input from diffuse nutrient sources are explained. One of these is the seepage filtration of the input into reservours and lakes. This process is particularly suitable for small inputs and owing to the filtration of the soil, it leads to a distinct reduction of the phosphate concentration in these inputs. The application of alumina-filtration which is a newly developed method of treating the effluents of fish hatcheries is also described. Finally, the author describes the process recently developed by the Wahnbach Reservoir Association involving the chemical treatment of large tributaries in order to reduce the phosphorus input to the tolerable phosphorus load for drinking water reservoirs. Similar processes which have been developed and are in operation in the lakes around West Berlin are also discussed.

WP.18 Dinitrification in the German Federal Republic
(By Prof. Dr.-Ing. Krauth)

At present only a few sewage treatment plants in West Germany have practiced dinitrification as a tertiary treatment step. In general, neither nitrification nor dinitrification is required at the present stage.

Besides laboratory scale research, full scale dinitrification processes have been investigated recently. Two technical solutions for dinitrification are recommended:

Simultaneous dinitrification: The volume of the activated sludge plant is determined by the sludge age necessary for nitrification. Fundamentally, a slight dinitrification can be observed with all lowly loaded activated sludge plants.

To promote dinitrification, it is important that zones with dissolved oxygen are followed by zones without dissolved oxygen. This can be achieved by adding oxygen to the system at one point or by intermittent oxygen input. The activated sludge, however, must not settle to the bottom of the basin. Consequently, only an appropriate control of the oxygen supply is necessary to achieve simultaneous dinitrification.

Primary dinitrification: The volume of the activated plant is again determined by the sludge age necessary for nitrification. Primary dinitrification is characterized by the mixing of sewage, return sludge and nitrate containing sludge in a zone that is largely free of dissolved oxygen.

An extensive nitrate removal can only be achieved with a correspondingly high internal recirculation and a high dinitrification respiration, the rate of dinitrification increasing BOD_5 in the influent and increasing solids content in the activated sludge plant.

A nitrogen removal between 50 and 60% can be reached without any control. Control should be considered for higher nitrogen removal.

Since a continuous measurement of NO_3 cannot be carried out in practice, monitoring of the NH_4 and the alkalinity in the influent and the effluent is under investigation.

WP.19 Sanitation without water (By Uno Winblad)

The wastewater technology developed in the western world over the past one hundred years can only to a limited extent be applied in the developing countries. The two major constraints are water availability and costs.

In much of the third world, water is much too precious to be flushed away in sewers. Where water is available, the costs of house connections, collection networks and treatment plants are normally far above what most communities can afford.

Satisfactory alternatives to conventional wastewater treatment can normally be found. The traditional pit latrine can, with simple modifications, be turned into an odourfree sanitary latrine. Compost latrines of various types can be used under the most difficult soil and ground water conditions. They have the additional advantage of turning human excreta and organic household refuse into fertilizer. Soakpits and evapotranspiration beds can take care of grey water from households, not only in rural areas but often in low-income urban communities.

The problem is not one of technology but of social acceptability and health education as well as community participation in decision making, construction, operation and maintenance.

WP.20 Treatment of concentrated wastewater from the food industry (By Prof. Hartmann)

Treatment of wastewaters from food processing should be given special consideration in many developing countries for a variety of reasons.

1. The economy of most developing countries is normally based on agriculture and agroindustries, which is a natural starting point for development of industries. This includes food processing industries such

as canneries and industries dealing with extraction or refining of raw products. In many cases, these activities produce wastes with organic pollutants far exceeding those of municipal waste.

2. Liquid wastes from food processing activities normally lack significant characteristics typical of wastewaters, such as metals and bacteria. The pollutants consist in most cases of saps liberated from cells by mechanical injuries. The chemical composition of the wastewater is in most cases a copy of the chemical composition of the food being processed. Thus there may be a high concentration of proteins in the case of potatoes or peas and beans, etc., or of sugars in the processing of sugar cane or sugar beets, or a mixture of sugars and organic acids as in many fruits.

3. Food processing plants should be located far from urban settlements and should be centred in the rural areas of the production zone. Food processing plants are in many cases sited far from important infrastructure.

4. The lack of food in many developing countries indicates the importance of recycling of valuable raw material to the highest degree possible.

5. Nascent industrialization indicates the necessity of initially developing small food processing industries in rural areas.

6. Those methods which are energy saving or which permit the generation of energy should be encouraged.

7. The special composition of certain liquid wastes from food processing permits direct feed-back into the human economy.

WP.21 **Wastewater processing in the food industry in Kenya**
(By Joshua Gecaga)

Agriculture based industries predominate in Kenya and consequently have the major impact on the country's environment. Most of them are located in rural areas or small centres where there are no communal wastewater treatment and disposal facilities. Furthermore the effluent-receiving water bodies also serve as sources of domestic water supplies for the surrounding communities. These two constraints would require each factory to have its own treatment facility capable of treating the wastewater to a high degree of effluent quality. However, a survey of the existing industries shows that pollution abatement units are either non-existent or very rudimentary and generally discharge very poor effluents.

Coffee and sugar processing industries produce the bulk of the industrial wastewater in Kenya. Coffee processing factories in particular pose the greatest problem because of their scattered geographical distribution and the fact that the effluent contains a relatively high organic load. The present practice is to recirculate the process water with the objective of achieving zero discharge into the receiving water body. The goal has been attained in some factories but a significant number of others do not yet have recirculation facilities. The sugar factories are mainly concentrated in the western part of Kenya and all of them have a form of wastewater treatment installation. By and large, the factories do not meet the effluent standards stipulated by the Ministry of Water Development. Wastewater stabilization ponds seem to be the preferred method of treatment for all the factories surveyed.

Besides the coffee and sugar industries, there are other minor agricultural based industries which although small are expanding rapidly.

These are: the dairy, fruit and vegetable processing and meat industries. A few of these discharge into public sewers and others have small treatment plants which nevertheless do not meet the effluent standards.

The pollution control section of the Ministry of Water Development is currently the body in charge of controlling the quality of the effluent to be discharged into receiving water bodies. The regulations laid down appear to be satisfactory but the enforcement machinery has not yet become effective and overall compliance from the industries has yet to be achieved.

WP.22 Wastewater treatment in the textile industry with particular reference to Latin America (By Marcio-Braile)

The textile industry accounts for from 10 to 52% of total industrial activity in Latin American countries. It is very important in these countries because it provides clothing and employment.

Brazil and Mexico are the leading countries with regard to export earnings, while Argentina and Uruguay export mainly wool fibres.

The largest textile manufacturing plants in Latin America are located in Brazil, Colombia and Argentina.

Textile processing plants utilize a wide variety of dyes and other chemicals such as acids, bases, salts, wetting agents, retardants, accelerators, detergents, oxidizing agents, reducing agents, developers, stripping agents and finishers. Unfortunately, many of this wide variety of substances are not biodegradable, and after secondary treatment they may cause public health hazards.

The control and treatment of textile mills effluents in this part of the world are presently being accomplished by industrial wastes reduction only. This reduction is generally obtained by higher costs of water and chemicals, and sometimes by greater demand of state agencies for wastewater pollution control. Regarding treatment in industrial areas, if they are located in urban areas, they usually do not have area available for biological treatment. According to Prof. Dr. Karl Imhoff, combined treatment of industrial wastes with domestic sewage is the best practice.

In the near future, three huge sewage treatment plants in Sao Paulo area will treat wastes from textile mills.

The table on the next page gives comparison characteristics of unit processes used in sanitary engineering to treat textile mills wastewater.

COMPARISON CHARACTERISTICS OF UNIT PROCESSES USED IN SANITARY ENGINEERING TO TREAT TEXTILE MILLS WASTEWATERS			
UNIT PROCESS	INDUSTRIAL PROCESS		
	Wool scouring	Wool finishing	Woven fabric finishing
SCREENING	It is usually necessary to provide coarse and fine mesh screening for removal of fiber. Devices such as fine mesh vibrating screens have proven excellent for the removal of wool fiber.	Wool finers are removed using fine mesh type screens. Vibrating machines have been successful with these fibers.	Cotton impurities, fiber and other solids are removed by fine mesh screening. A screen with mesh size of 80 has been effective for the application
EQUALIZATION	It is required because of the batch dumps of waste.	It is used to combine process and sanitary wastes prior to subsequent treatment. Adequate mixing is recommended to prevent solids deposition and septicity.	------
PH ADJUSTMENT	------	------	------
ULTRAFILTRATION	------	------	------

WP.23 Prevention and reduction of water pollution in the pulp and paper industry - the experience of the Federal Republic of Germany

(By Profs. G. Rincke/L. Göttsching/A. Geller/H. Irmer)

Wastewater pollution from pulp and paper industries can severely alter water quality and conditions of aquatic life in the receiving waters.

Due to the high density of population and industry in the Federal Republic of Germany and the unavoidable use of the receiving waters as a source of potable water, a high degree of pollution control is needed. Therefore, biological purification of pulp mill wastewater alone is not sufficient, as the greater portion of non-degradable contaminants, especially lignosulfonic acids, must also be eliminated.

Continuing development over several decades, of the sulphite cooking process and pulp washing systems, has led to a recovery level of 97 percent spent liquor reached by internal measures. Furthermore, the non-degradable organic compounds in the condensates can be reduced to 15-20 kg CSB/t by neutralization of the spent liquor, stripping of furfurole/methanole and partial recycling to the cooking and washing process.

Technological principles are presently available to reduce the wastewater emissions from the bleaching process. These technologies have been tested; and full scale application seems to be possible in 1982. If necessary, a final biological treatment is added.

The waste load from paper mills can be minimized by two ways; alternatively or in combination.

- Recycling of process water (internal measures);
- Effluent treatment by chemical, physico-chemical and biological methods (external measures).

The biological treatment of paper mill effluents is possible. The efficiency of the biological treatment is good as the process water may be reduced by preventive and/or supplementary measures. Concurrent use of internal and external measures minimizes the load in the process water cycle and the effluent.

WP.24 <u>Wastewater treatment in the oil refinery industry in Nigeria</u>
(By Prof. U.K. Enyenihi)

The basic wastewater effluent treatment processes for the Warri and Alesa Eleme refineries is presented here. The untreated wastewater from the Alesa Eleme refinery contains pollutants such as oil, sulphides, and total dissolved solids in quantities far in excess of those prescribed for effluent refinery wastewater by API, Canada, England, Sweden and Australia. No records of total heavy metals and phenols contents of the effluent water are kept for this refinery. The water characteristics of the receiving water of Okrika Creek and Okrika river showed evidence of pollution.

In contrast, the Warri refinery satisfies the basic requirements of API wastewater quality regulation and the treated effluent wastewater has characteristics similar to those of the typical mangrove swamp river which it is discharging into.

However, the ecological implications of gaseous discharges from flared hydrocarbons and burnt mixed sludge and the effects of burying ash arising from burnt sludge are not known.

Policy and strategy guidelines for improvement of the treatment of refinery wastewater are outlined and specific recommendations made for the Nigerian tropical environment.

WP.25 Wastewater pollution control of the metal processing industry in developing countries (By E.A.R. Ouano)

The following guidelines are suggested for development of wastewater pollution control technology for the metal processing industry in developing countries:

(a) Inactivation of a particular pollutant specie rather than complete destruction;

(b) Solid chemicals especially in packed towers preferred due to lower instrumentation;

(c) Utilization of waste materials and locally available materials.

A number of promising technologies for control of acidity, cyanides, heavy metals and reduction of hexavalent chromium are reviewed and their application in developing countries assessed. Those techniques are compared with the conventional process commonly used in developed countries.

The minimization and prevention of wastewater discharge from metal processing industries could be achieved by proper industrial estate planning, collective utilization and reuse of facilities.

For example, the pulp and paper industry discharges thousands of cubic meters daily of highly alkaline wastewater and buys acids for wastewater treatment, while the metal processing industries buy truckloads of alkaline substances to neutralize acidic wastes. Industrial planners should consider the wastewaters discharged by different industries and match them in order to minimize the cost of treatment.

Evaluation of wastewater treatment demand could reduce the volume and size of wastewater treatment plant, and hence the initial capital investment. For example, the air pollution scrubber for removing sulfur dioxide, hydrogen chloride could be reduced in size if the scrubbing liquid were rendered alkaline. The weak alkaline solution from the scrubber could be utilized for acid neutralization.

The metal processing industry is one of the major sources of inorganic pollutants. By providing for the necessary institutional planning and research needs of the specific environment of developing countries, the impact of the wastes discharged could be minimized.

WP.26 Use of digester gas in sewage treatment and for energy production (By Prof. Dr. Kayser)

Digester gas is a by-product of sludge digestion with a high calorific value. In western Europe, about 25 l of gas per capita per day are produced in mechanical-biological wastewater treatment plants.

If the sludge has to be pasteurized, the gas may be used to heat up the sludge. Today, pre-pasteurization is recommended. In order to save energy, it is very attractive to feed the gas to gas-engines. The engines may be connected directly to pumps, blowers or mechanical aerators, or to electricity generators. It can be assumed that up to 2kWh mechanical or electrical energy can be produced from one cubic meter of digester gas. The thermal energy (cooling water and exhauster) of 2.6 kWh/m^3 may be used for digester heating or pasteurization.

If the sludge has to be dried, digester gas may be used as fuel. The heat of the vapor from the drier is recovered by the Alfeld process and used for digester heating.

ANNEX D SUMMARY OF COUNTRY MONOGRAPHS

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.

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. The arid and semi-arid regions (2/3rd of the country) depend on underground water.

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

In 1975, there were 160 sewage services, serving 29% of the population. Over 75% of domestic effluent is discharged into water courses without treatment. Most industrial waste is discharged 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 ervice. Much of the equipment is absolete, 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.

Present plans are to extend sanitation services to more than 10 million new users over the next ten years. The costs are expected to be very high.

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

BANGLADESH

Bangladesh (144,500 sq. Km.) is a deltaic country with many water sources that are used for domestic purposes 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 instal 100,000 units to cover 15% of households by the middle of 1980. Rapid population 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 existing sewerage system. Some houses also dispose of waste water through 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 communites 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 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 to guide industries and local authorities in the measures to be taken to control and treat water.

Industrial wastes contaminate agricultural land and rivers, and the problem persists due to 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.

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 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 collection; 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 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.

Four petroleum refineries have installed secondary treatment facilities while seven have primary treatment facilities. Two petrochemical complexes have also 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 true 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 mathane (an excellent fuel). Stabilization ponds and lagoons may prove suitable in some area.

The public must be alerted to environmental pollution problems, and existing regulations should be enforced more rigerously. Industry should be given economic incentives to better control pollution. 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. The existing ones are administered by local water authorities.

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

In the larger cities, there are downstream pollution problems caused by the discharge of untreated effluents into rivers.

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. Inducements have been tried to encourage voluntary restraints in the quantity of waste water produced, but both industry and communities have failed to respond to such inducements frequently for financial reasons.

To correct the situation, there is a need 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% pf 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 pose formidable 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, in some case have led to accidents. Rural people often lack the means to make a proper pit latrine and so prefer to use the open field for defecation.

Pit latrines are also in urban centres 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 deposted 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 menas 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 se 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.

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 respresents 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 servied 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 facilities with unnecessary large treatment capacities. The same is true as 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.

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 in the country with a sewage treatment plant. Some other towns have treatment plants under construction, while 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.

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 population 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 population 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.

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 a great deal of industrial waste, as well as domestic waste. 75% of BOD and 60% of suspended solids are removed. A large pond has been constructed recently but does not yet operate at 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 actual situation.

Other urgent requirments are for more and better trained manpower and 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 area 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 run-off 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 separate systems, i.e., one sewer for storm water and the other for sewage.

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 insiginificant. 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. Pusan, 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.

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 systems. 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 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, tanneries, 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 sugar 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 might 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.

NIGERIA

The estimated population 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. What is needed are simple, low-cost fool-proof plants that are easy to operate and maintain.

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 is 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 produced. Much of the effluent was discharged just outside the mills and spread around the adjoining lands, properties and roads, creating many problems.

Lagos City has no drainage system. 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 discharged. 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 should be considered are waste stabilization ponds (facultative ponds), aerated lagoons, and oxidation ditches. There is also a need to devise simpler aeration methods and aerators requiring little or no electric power and moving parts.

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 systems are either non-existent or inadequate. 95% of the population live in the Indus Basin and almost all the water resources and agricultural potential are concentrated in this area. Rapid industrialization and urbanization are creating serious environmental problems. 30% of the population 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 facilites. 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 do not work 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.

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 waste need to be found, and the possible re-use of waste 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 are difficult. The population is about 3 million, with 85% to 90% living in rural areas and most active in the agricultural sector. Towns are, however, growing in population. Primary production, manufacturing 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 simply 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 is extensively used in the country.

Treatement 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.

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.

PERU

The country needs to develop low-cost methods of waste water treatment, in order to save money for many other development taks which remain unsolved. Stabilization ponds have lately been constructed, as this system is adequate and relatively inexpensive; it destroys pathogenic organisms and the effluents can be used in agriculture. Of 30 treatment plants installed, 22 (or 73%) are stabilization ponds. More will be built over the next two years.= 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 population 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 enormous 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. Industries, 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 a great deal of organic waste matter.

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

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 Rual 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 sludge 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 percolated 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.

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 sewege 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 population. 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.

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 were 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-Salaan 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 into ditches or valleys. In general, most private works treat waste poorly.

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 studies. 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. 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 cane mills 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 do not treat 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.

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. and 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. In inland areas domestic waste is often discharged into 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 are moving 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 into private septic tanks; in other cases sewage is discharged into rivers and lakes without any treatment. 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, there has also been a great deal of investment in sewage services and many sewage systems have been constructed over the past decade.

Most waste water is of the domestic type. Sub-urban 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 law. Therefore almost all new big industrial complexes have 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.

YEMEN ARAB REPUBLIC

The country consists of three distinct regions, the central highlands, the coastal plains and the eastern plateau which has 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 not municipal sewer systems yet in operation in the Yemen Arab Republic.

Sana's 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, 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 colllection 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. 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 developing countries in particular feel the heavy economic burden associated with waste water treatment because it is in addition to many other costly development schemes that usually receive higher priority. Those directly involved with waste water treatment feel that resource 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 of the construction and operation of sanitary facilities.

In seeking suitable solutions, one needs also to bear in mind that water is scarce 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 by stabilization ponds or lagoons. A hot climate together with easy access to large areas of land makes this sollution attractive in many cases. 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. For financial and technical reasons, self-purifying or extensive systems are often preferred to 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.

ANNEX I

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