PUBLIC WATER SUPPLIES IN PAKISTAN

Proceedings of a National Symposium held in November 1973

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

Proceedings of a

NATIONAL SYMPOSIUM ON PUBLIC WATER SUPPLIES IN PAKISTAN

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FOREWORD

The National Symposium on Public Water Supplies was organized by the Institute from 6 to 7 November 1973 at a time when expansion in the water industry was beginning to take place. As a result it served as an effective form for discussion and for focusing attention on problems relating to national planning. The subsequent years have witnessed a major breakthrough by way of establishment of Water and Sanitation Agencies for many Urban Cetres and greater investment for development of rural water supply schemes in the country. The Institute has been participating in the efforts in this field by offering necessary advisory services to the relevant agencies and by arranging in-service training courses and programmes such as Disinfection Practices in Public Water Supplies held in 1974, Bacteriological Quality Monitoring of Public Water Supplies held in 1976 and Planning and Preventive Maintenance of Water Distribution Systems held in 1978. Additionally studies relating to different aspects of drinking water supply were undertaken.

The Symposium Proceedings were first published in the begining of 1974. Like many of the Institute publications which have come in circulation at national and international levels the Symposium Proceedings have been in regular demand even to this day. The need therefore arose to reprint the proceedings resulting in the present volume. It includes two titles, one on national planning and second on Rural Water Supplies, which are in addition to those actually presented in the Symposium because both are considered to conform to the theme of the Symposium.

DR. MOHAMMAD NAWAZ TARIQ
Director and Professor of
Public Health Engineering

Lahore
2 October 1979

PROGRAMME

INAUGURAL SESSION

Tuesday 6 November 1973

0900 Registration of Delegates
0930 Arrival of the Chief Guest
0935 Recitation from Quran Majeed
0945 Address of Welcome
1000 Inaugural Address
1015 Keynote Address
1030 Break

TECHNICAL SESSION I

Chairman of Technical Session
M. H. Rahimtoola
Member (Technical)
Karachi Development Authority
Karachi

1100 National Policy on Public Water Supplies
1130 Discussion
1200 Urban Water Supply Systems
in Pakistan with particular reference
to Karachi
1215 Discussion
1245 Rural Water Supplies in
Pakistan with particular reference
to N.W.F.P.
1300 Discussion

TECHNICAL SESSION II

Wednesday 7 November 1973

Chairman of Technical Session
Brig. (Retd) Manzoor Ahmad Chaudry
Director General Health
Ministry of Health
Government of Pakistan
Islamabad

0905 Recitation from Quran Majeed
0915 Role of University in the Development of Public Water Supplies in Pakistan
0930 Discussion

1000 Management & Financing of Public Water Supplies in Pakistan
1015 Discussion
1045 Break

TECHNICAL SESSION III

Chairman of Technical Session
Dr. Israr ul Haque
Vice-Chancellor
Agriculture University
Faisalabad

1100 Nuclear Desalination and its Prospects in Pakistan
1115 Discussion
1145 A Review of the Water Supply Position in Developing Countries
1200 Discussion
1230 Surveillance of Water Quality
1245 Discussion
1900 Dinner

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MESSAGE

GHULAM MUSTAFA KHAR
Governor of the Punjab

It is a matter of great pleasure for me to know that Institute of Public Health Engineering and Research of West Pakistan University of Engineering and Technology Lahore is holding the first National Symposium on Public Water Supplies in Pakistan.

All over the world the demand for water supplies is increasing due to rapid increase in population and industrialization. In Pakistan most of the rural and urban communities still do not have an access to safe drinking water supplies. As a result of this, a large segment of our society suffers from great many water-borne diseases which result in debility and death. The importance of clean and wholesome water supplies in the context of socio-economic development of our country can therefore, hardly be overemphasized. The people's Government recognises the need of safe water supplies as a pre-requisite to healthy living and economic progress and is undertaking many public water supply projects in both our rural and urban areas.

The Symposium I hope, will provide an opportunity to consolidate information in this area, to define major problems and to recommed ways in which requisite water quality for drinking purposes can be maintained. I wish all success to the organisers of the Symposium.

MESSAGE

DR. A. H. TABA M.D.
Regional Director
WHO EMRO
Aleandria

It gives me great pleasure to send this message on the occasion of the Inaugural Session of the Symposium on Public Water Supplies in Pakistan.

The provision of safe and adequate water supplies is essential for the improvement of public health, particularly environmental health, and is a pre-requisite for economic and social advancement. Recognizing this, the World Health Assembly has, in the past years, passed a number of resolutions urging the Governments to place priority on the development of community water supply programmes in their countries. Multi-lateral and bilateral assistance has also become increasingy available for such undertakings.

The water supply situation in the Region is somewhat diversified : whilst for some countries almost the entire population is served or has reasonable access to water supplies, a large number of the population in others will still have to travel long distances to fetch water for domestic uses. Apparently, the problem in the former is a matter of maintaining a high water quality standard and in the later the urgent action required is the construction of more water supplies so that more people will benefit. It is therefore important for the Governments to identify their specific needs and to formulate plans for meeting the needs, utilizing their resources and external assistance as available. The Organization will of course continue to assist the Member Governments in the development of their national community water supply programmes.

The National Symposium on Public Water Supplies in Pakistan being organized by the Institute of Public Health Engineering and Research is indeed a timely and commendable effort to stimulate interest in such an important activity. I am confident it will result in promoting an accelerated development of water supplies in Pakistan.

I wish you every success in your deliberations.

WELCOME ADDRESS

PROF. DR. M. ISLAM SHEIKH
Vice Chancellor
University of Engineering and Technology
Lahore

It is a matter of great honour and privilege for me to extend, on behalf of the University, a very warm welcome to you all. We feel particularly indebted to you, Dr. Tabibzadeh, for having very kindly accepted our invitation in spite of your multifarious engagements, to inaugurate the National symposium on Public Water Supplies in Pakistan. Your contribution to the cause of public health and your services in this regard in Pakistan are very well known to us all. You have contributed very significantly as representative of the World Health Organization in many ways and this, I assure you, Sir shall always be remembered with appreciation and gratitude. WHO through your good offices has been materially assisting this University for the past 5 rears to set up modern Public Health Engineering Laboratories thus enabling us to produce better trained man-power in the extremely important field of engineering. Through your interest and association, Dr. Tabibzadeh a full fledged Institute of Public Health Engineering and Research has now been established at this University. We expect that major financial and technical assistance will be forthcoming from UNDP and WHO in the very near future for further strengthening these facilities.

Sir, the present era is an era of development, the whole world appears to be engaged in development. The essential purpose of development is to liberate man-kind from poverty, squalor, disease, ignorance and exploitation so as to permit the full evolution of human personality and dignity. This can be done as the human race now has the necessary knowledge and resources. What is needed is to mobilize our knowledge and resources for these purposes and to use these rightly. Modern concept development closely interrelate economic and social activities. They are regarded as in-separable and of equal importance. Social development deals with education, health, welfare, Public utilities etc. Community health is one of the sectors which should receive close attention and should be given a very high priority in any development programme. Provision of safe water supplies is one of the important factors which guarantee a healthy community. If the water is not of an adequate quantity and of a safe quality, its use causes serious diseases such as Cholera, Typhoid, Dysentery, infectious hepatitis and many more. It is, therefore, correct to say that a community with restricted water supply is a community with restricted growth. The economics of water supply often constitutes a decisive influence on the size of human habitation. In economic and social planning, therefore, the development of water resources need to be given a very high priority.

Let us for a moment look at the man's enormous demands on water and comparable availability of supplies. More than 99 per cent of world's water is in the salty oceans i.e. less than 1 per cent of earth water is inuseable. More than 13/rd of this available fresh water is in countries which have relatively thin population densities. The porblem of availability of this vital liquid is further aggravated due to very high demand on it by the industry. In a developed country, the industry uses about 6000 liters of water a day to produce the goods and service for only one person. To keep up with the accelerated demand, man is increasingly drawing on fresh water from the underground reservoir considering perhaps that this is an unlimited resource. While the demand for water continues to increase due to rise in standard of living of the people, the population wanting to make use of this precious commodity also continues to increase. For example, it took several million years for the world to reach a population figure of 2 Billion-1930 was the year. The second 2 Billions will be the year 1975. The world population is expected to touch the staggering figure of 6 billion in the year 200 . The problem is further compounded by the increased population being concentrated in urban areas. This clearly points out to the impending World-wide water shortage crisis.

In Pakistan, the position of water supplies is not quite unsatisfactory either. The result has been that the infant mortality rate is Pakistan due to water-borne diseases is one of the highest in the world. 136 per thousand live births as against 19 in U. K. and 26 in U. S.S. R. In large urban areas where 33 percent of the population has access to piped water supplies, only 7% enjoy this facility in their houses and the rest are dependent on public stand posts. In rural areas, only 235 rural water supply schemes have so far been completed thus serving a population of about 2 million persons as against a rural population of 40 million. It has been estimated that the capital out-lay for providing water supplies and drainage services to the population in Pakistan which does not have this facility would be around Rs. 3000 million (300 crors). This is truely a tremendous task and a great challenge to economists, planners, administrators and the public health engineers. This country particularly looks to the public health engineers for evolving a water supply technology which is in consonance with the resources and needs of people. We must devise methods which make maximum use of the locally available techniques and skills in the design, construction and operation of water supply systems. This would require local investigation and research even innovation. The public health planners would do a trememdous service if they set—side even a fraction of the capital project expenditure on research and development. If we can evolve methods which might save only 13 of the expenditure which we must make to provide water supply facilities to our population, the total saving in money can be of the tune ot about Rs. 3 crors. The expenditure in research, therefore, is a worth while investment.

I would like, Sir, to say a word to our planners also. While formulating policies and procedures for control of water-borne diseases, our planners must give greater recognition to the fact that provisions of water supplies are essentially preventive measures and that economic considerations should not be allowed to obstruct measures designed to save human lives. The prevention of disability, morbidity and mortality from water-borne diseases should be a sufficient justification in itself for the provision of safe water supplies. Preventive public health engineering measures, in the long run, are at least three times cheaper than the curative medical means.

Before I conclude, I wish to once again thank you most sincerely, Sir for sparing time to be with us this morning. I thank you all.

INAUGURAL ADDRESS

DR. A. TABIBZADEH
WHO Representative
Islamabad

Mr. Chairman, Honoured Guests

I consider it a great honour for myself and the World Health Organization to be inivted to inaugurate this National Symposium on Public Water Supplies in Pakistan.

The shortage of good drinking-water has become a worldwide problem. WHO is assisting many countries in order to improve the water supply situation.

Only when health is assured can the other requirements of a satisfactory humant existance such as education and wealth materialize. Throughout the history of mankind we should take particular note that for any people to blossom forth as a highly developed nation a necessary pre-requisite was a proper water supply and sanitation to communities.

The Holy Quran recognized these facts and we may read how much importance is attached to the protection of water resources used for drinking purposes. The constan pollution of rivers, streams and underground sources are against these principles and it will continue to cost mankind very highly to correct.

In addition, I would refer to the UN charter of human rights in which it is stated that all mankind should have "equal rights of men" also to promote social progress and better standards of life".

With these objectives in mind we must plan our resources and manpower to improve the human environment which includes water supply and waste disposal not only to our larger cities but also to the semi urban communities, villages and even the smallest hamlets of a few persons.

All citizens of this great nation, as we see, are treated alike. The Government have requested 100,000 hand pumps to be installed for our unfortunate retheren who have suffered in the recent floods. Perhaps this facility can be extended to all other small communities in Pakistan wherever possible.

Not only must water supplies be provided but in accordance with the objectives of improving "the standard of life" the water supplies must be pure and wholesome that is particularly free from disease carrying parasites, also it should be abundantly available with a constant supply. Only then can we have satisfied the requirement that the supply shall be for "the comfort and convenience" of our citizens.

How inconvenient it is for instance to awake in the night feeling thirsty and find the tap dry and nothing to drink in the house.

Dr. A. H. Taba, Director, World Health Organization, Eastern Mediterranean Region, in his message has referred to the need to identify specific needs and organize our resources. Pakistan is gifted with plentiful natural resources for the production of pipes and building materials, pipes can be made from natural gas or from the very minerals from the mother earth itself with certain imported materials. Bricks and cement are plentifully available. Manpower is freely available and the technological expertise requirement is rapidly being fulfilled from this institution of learning.

I am pleased to say that the UNDP have made provision to assist in the development of the Institute of Public Health Engineering as both a training and applied researc establishment so that all people may benefit. This is a very large and project UNDP have earmarked a sum of US S 433,000.

With these words, Mr. Chairman, I have great pleasure in inaugurating this first symposium on the PublicWater Supplies which I hope will be followed by many others.

KEYNOTE ADDRESS

DR. M. NAWAZ TARIQ
Director and Professor
Institute of Public Health Engineering and Research
University of Engineering and Technology
Lahore

I have immense pleasure in welcoming you on behalf of the Institute. The Institute deems it a great privilege to be the host for the national sympoisum on Public Water Supplies in the country. We feel no less privileged and inspited by the presence with us, today of such a large number of eminent scientists, engineers, doctors, planners and administrators to exchange ideas on a national problem—a problem which is of great urgency in human terms as well as in terms of economic and industrial development. This concourse of distinguished men of science symbolises for us the fact that the discipline of public health engineering in the country has come of age, and has attained the recognition it deserves. We earnestly hope that the symposium proves a productive meeting of minds from the diverse fields which all have equally to contribute to the improvement of the environmental health of the nation.

It will not be out of place, I guess, to briefly introduce you, ladies and gentlemen, to the history of the evolution of the public health engineering as an academic discipline at this University. Back in I the 1950's, with the beginnings of the phenomenon of industrialization and urbanization, the need of establishing this discipline here was keenly felt. The awareness of this need materialized in the introduction of a postgraduate programme in public health engineering in 1961. Mention should herebe made of Dr. Mubashar Massan, Federal Minister for Finance, then Professor of Civil Engineering with us, who played a leading role in conceiving and organizing this programme.

Later, with accelerated pace of industrialization and urbanization it was increasingly realised that we need a national centre for this discipline which is adequately organized and equipped to deal with the diverse spheres of public health engineering in the country. Out of this realization grew the idea of establishing an institute of public health engineering, The idea was transformed into a reality in 1972; the Institute was then established, and it can rightly be described as a land-mark in this area of national endeavour. It will be an omission not to mention here the resolute and preservant efforts of Prof. Dr. M. Islam Sheikh, our present Vice Chancellor, to which, to a very great extent, the Institute owes its existance.

The Institute aspires to be the major national centre for the generation, accumulation and dissemination of knowledge in the field of public health engineering. Its aims extend to the establishment of programmes of education, applied research, and training of public health engineering personnel of diverse cadres. At present the Institute has two major academic programmes: it is conducting an M.Sc. Degree Course in Public Health

Engineering, and teaches undergraduates from departments of the University whose syllabi include Public Health Engineering as a major subject. Research projects are in progress at the Institute on topics such as Water Quality Management, Waste Water Disposal, and Air Pollution. In terms of facilities and wherewithal the Institute is still in the formative stage. Efforts are being made to develop and extend them so that its services and resources are commensurate with the national needs. At present the Institute is housed in a part of the University buildings. Work however is under-way to ensure that by the end of 1970 the Institute has its own buildings within the University Campus.

It should not be difficult to imagine why the first national-level symposium arranged by the Institute is on the topic of Public Water Supplies. Water, like air, is considered to be a free gift of nature. But we know that gifts are never free. Today great human ingenuity, technical know-how, and material investment are required to ensure the supply of wholesome water to millions of people. The problem is, as well all know, very acute in our country, both for the urban and rural areas. We engineers, scarecely have time, or temptation to read works of literature. But there is an interesting legend in Greek mythology which fits our circumstances. Tantalus, a king, was punnished by the gods in a strange way. He was plunged, so the legend runs, in a river up to chin, and yet he thirsted for water. Because the moment he stooped to drink, the water receded out of his reach. The story, I believe, describes very aptly the situation in Lahore, the venue of this symposium, because of the receding water-table here. Let us hope that the deliberations of the symposium increase our knowledge and ability to cure this Tantalus-like situation.

The problems of water supply in a developing country, according to a summing-up in a WHO publication, are compounded by two major factors. These factors are :

—insufficient allocation of finances ;

—shortage of skilled personel.

According to the same summing up some of the basic limitations of sanitation services in developing countries are as follows :

—absence of integrated national environmental health programmes within health ministries ;

—inadequate or no legislation, regulations, standards criteria or codes of practice relating to water supply ;

—shortages of competence as to administration and management of water supply programmes and facilities ;

—unsatisfactory and unsound fiscal structures for financing of water supply projects ;

—lack of information on water resources and existing water systems ;

—insufficient research and adaptation of technology to meet local difficulties and to maximize the utilization of available resources.

It is a matter of great satisfaction that the learned papers received for this symposium, by and large, cover these very areas.

While concluding it may be mentioned that here in the Institute we are mindful of the fact that the discipline of Public Health Engineering developed in the highly advanced countries. As a result, the existing body of knowledge in the field is predominantly, if not exclusively, oriented towards the peculiar needs and problems of the industrial-urban centres. In developing countries, like ours, predominant proportion of population lives, and will in foreseeable future continue to live, in rural agricultural set up. This, in our opinion, poses a big challenge for this young profession and discipline in Pakistan. We have to adopt and apply all the available knowledge and know-how to the problems of our rural areas and develop an indigenous philosophy and strategy of Public Health Engineering suited to our conditions. For this purpose, amongst other measures, the Institute plans, in course of time, to develop a systemativ body knowledge which would be integrated with the adult education programmes of the country, the agro-technical syllabi now being prepared at the national level for the school-stage, and which would be offered as an elective course in environmental sciences at the levl of the general B.Sc. degree of the national universities.

In the end I have to thank you once again ladies and gentlemen, for participating in this inaugural session of the symposium.

NATIONAL POLICY ON PUBLIC WATER SUPPLY

SHAMS UL MULK
Director
Water and Sewerage
Capital Development Authority
Islamabad

Summary

The formulation of a national policy is not the task of one profession and public water supplies are no exception. In this case, it is the combined task of the engineer, the economist, the financier, the lawyer and last, but by no means the least, the politician.

The availability of water is so fundamental to the human well-being that it is considered to be the nature's free gift and more often than not the idea of making payments for water supply is a very unpopular one. Except in the initial stages of development when water in its natural form is sufficient to meet with demands a stage does arise when the non-availability of purified water can hinder the economic growth of a country.

Pakistan has entered upon a stage of planned development and it is time that consideration is given to the formulation of a national policy on public water supplies in Pakistan. The requirements of rapid growth of the economy as a whole at the macro-level and the well-being of groups of population at micro-level cannot be allowed to be hindered by insufficiency of water, either as a commodity or as an essential need for human consumption.

A policy in essence is a compromise of the various conflicting demands on a resource. In case of water such demands are for irrigation, hydro-power. Reclamation, recreation facilities, industrial use as well as human and live stock consumption. In the context of historical development of water resources, irrigation received the exclusive priority on the use of water resources. Hydro-power and reclamation followed, as an important component of water resources development. Public water supplies as a demande on surface flows is of recent origin in Pakistan. However, these are isolated cases and even till-today public water supplies find little, if any mention, in tne various plans of water resources development in Pakistan. The first goal of a National Policy should be to rectify this situation and to make public water supplies and its projected requirements upto a foreseeable future as an inherent component in the water resource development plans.

Economic evaluation is another factor that requires consideration. Water is not a commodity except when used as a resource in-put in agriculture or in industry. The concepts of welfare economics are more relevant to the public water supplies and it is in such context that the economic evaluation of each project be carried out. The national policy

should, therefore, include the above suggestion, and prescribe justfication of water supplies not in monetary returns but as a goal for the welfare of the society and the population as a whole.

No policy can succeed without the availability of adequate finances, commensurate with the goals and targets set therein. Pakistan has limited financial resources and therefore, the greatest difficulty is faced when it comes to allocation of financial resources for public water supplies. It is in this context, that consideration be given to the economies of this sector and the reduction of diseconomies of the other more productive sectors, by investment in public water supplies.

The national policy on public water supplies would be incomplete without considering the legal aspects. The existing laws and rights pertaining to the ownership of water and its development need examination. Since this resource is limited and no wastage what-so-ever can be allowed in its use, the concept of most beneficial use would, in the legal sense, be a goal of the national policy. Anti-pollution laws should be framed by learning from the experiences elsewhere. Laws, legislative or administrative, must in each case conform to these concepts.

The National Policy should include a programme of covering a fixed minimum group of population with potable water supplies in a certain period. It is admitted that such a statement and a goal is easily stated but its attainment is dependent upon so many factors, the foremost being the availability of finances, that this aspect of the policy should be flexible and may even be reviewed every five years depending upon the previous achievement and the expected availability of resources in the coming years. Nevertheless th,s goal is important enough to be set notwithstanding all the inherent flexibilities involved in it.

With the predominance of rural population in Pakistan, it is necessary that in areas where water available is unfit for human consumption with treatment, facilities of treatment are provided. Such facilities should not be costly either at the stage of capital investment or during maintenance and operation. Intensive research would therefore be necessary to determine the methods of water treatment and design of engineering works that are in accordance with these requirements. This is a challenging task for the scientist and the engineer. From this stand point, therefore, the national policy should facilitate intensive research in the development methods of treatment and design of works that achieve the above requirements.

If this paper sets no guidelines for the policy, it is because there are too many aspects of the national policy which cannot be looked in its entirety from one angle. This paper is however, presented with the hope that it will initiate discussion on all these aspects, leading to fruitful results in the shape of recommendations for policy makers.

NATIONAL POLICY ON PUBLIC WATER SUPPLY

MUHAMMAD FAZIL QURESHI
Chief Engineer
Public Health Engineering Department
Lahore

Water has great importance in the life of living organizms including human beings. Its importance cannot be further emphasised than as has been said in the Holy Quran :

It is He Who sends down Rain from the sky
From it ye drink, and out of it (grows)
The vegetation on which Ye feeds your cattle.

(Nahl XVI, 10)

In the modern developing world economy revolves around the availability of consumable water for use in technological advanced production processes leaving aside the domestic demand. The earth has 2/3rd of the surface covered with water yet hardly 2% of the entire quantity is useful and fit for human consumption. Therefore the planning and management of water supply sourse not only in Pakistan but in all other parts of the world has a big role to play in economic development and control over the hazards. In the past the public had not realized the fact that water directly and indirectly affects the health of the people who are the back-bone in building up the economy of any country. In Pakistan the sector of public water systems had been mostly neglected upto the year 1961 when Public Health Engineering Department was created in West Pakistan to streamline the policies of the Government towards the implementation of the master plan for providing water supply to the people. The policies started taking shape with the help of foreign experts, WHO adviser and UNICEF.

The local engineers having some experience in sanitary works, foreign training and qualifications in the specialized subjects of Public Health Engineering were pooled in the newly created department. The following major steps were taoen by the department for breaking through the existing systems for providing properly planned and scientifically designed water supply systems :

—a library was formed containing the technical books on the subject ;

—the research laboratories were set up to start chemical and bacteriological survey of water sources to be tapped for water supply systems and to have quality control of the existing systems

—A Directorate of Survey, Planning and Design was created for collection of data, plans and other information for preparation of master plans and estimates of large urban cities and small rural communities ;

—Standards and Specifications were drafted keeping in view the local requirements for keeping the cost of the system most economically ;

—Technical memos were prepared for guiding the young Engineers in the preparation and execution of water supply systems after due investigation of source ;

I—Urban Water Supply Schemes

—Since according to the Municipal Rules the responsibility for providing hygienically fit water for domestic use is that of the local body, it was decided by the Government that Municipal Committee, may be given financial help to implement the costly water supply schemes according to the following formula :—

—*Municipal Committees with annual budget of less than Rs. 10 lacs.*

—2/3rd of the estimated cost to be given as grant-in-aid by the Government.

—2/3rd of the estimated cost of the scheme to be given as loan to the Municipal Committee to be repaid in 10 years at normal rate of interest and two years grace period.

—1/5th of the cost to be loaned by the M. C. from their own sources.

—*Municipal Committees with an annual budget between 10 lacs and 100 lacs.*

—1/3rd of the estimated cost of the scheme to be given as free aid by the Government ;

—1/3rd of the estimated cost of the schemes to be given as loan by the Government to be repaid by the local body in 10 years with the normal rate of interest and 2 years grace period ;

—1/3rd of the estimated cost of the scheme to be borne by the Municipal Committee from their own resources ;

—*Municipal Committees with annual budget of more than 100 lacs.*

No free aid, but loan can be sanctioned by the Government to any extent.

II—Rural Water Supply Schemes

As regards rural water supply schemes it was decided that the capital cost of the scheme is to be borne by the Government and the recurring operation and maintenance cost to be met by the local body. Subsequently, however, further concession has been granted to the extent that for the first two years, the maintenance cost will also be borne by the Government.

To supplement the resources for financing the rural water supply schemes UNICEF came forward and supplied PVC pipes, A. C. pipes and specials for implementation of water supply schemes for rural population. Also they supplied the laboratory equipments. Still the agency is anxous to supplement the programmes for water supply systems specially for small communities where the people cannot afford to bear any portion of the cost and had been ignored so far.

Since there was great shortage of public health engineers a programme was chalked out by the Government for sending some abroad on fellowships for training in specialised fields of sanitary engineering as under :—

—Design and construction of community water supply systems ;

—Operation and maintenance for water supply system ;

—Engineering management of water supply system ;

—Chemical and bacteriological examination of water samples in the laboratory and in the field ;

—Execution of the schemes ;

—Development of ground water and source of water resources ;

—Construction of treatment works.

Health Education

A communication programme has been started by the Public Health Engineering Department to make the rural population to understand the harmfulness and usefulness of different waters available in a village for human consumption. It has been established that properly installed hand pump water is better than open well water and of course nothing is better than dis-infected water from pumped and piped water system.

Further recommendations could be :—

—Greater emphasis should be laid on the implementation of water supply schemes being the basic necessity.

—The financing of schemes has to be on the subsidized basis. For larger projects the rate of interest should be low and period of repayment large, with sufficient grace period.

—Research should be encouraged to find the economical solut on of the treatment problems and the designs.

—Local materials such as pipes, pumps, motors, engines of international quality be developed for execution of schemes.

—The mechanics and operators be taught and trained specially for running the systems Casual on the job-training is not sufficient.

—Institutional set is necessary for preservation of stream pollution. Legal backing is a so required for this purpose.

—Mass education for prevention of waste is needed.

—In 1962-63 Government decided to start post-graduate class inWest Pakistan Engineering University at Lahore so that the need of Public Health Engineers could be met.

—Recently University of Engineering and Technology, Lahore, has set up an Institute of

Public Health Engineering Research so that the scientific solution of the sanitation problems under the local conditions could be found out.

All this has resulted in the building up of a big reservior of teachnical know-how In addition to the foreigontraining young engineers were also trained according to the policy of the Government for the local requirements and problems. This was arranged by engagements of foreign and local consultants on the following 5-major water supply proiects with different water sources :—

(1) Gujranwala Water Supply Project

(2) Sheikhupura Water Supply Project.

(3) Multan Water Supply Project.

(4) Nawabshah Water Supply Project.

(5) Hyderabad Water Supply Project.

This process has benefitted the country to a great extent. Local manuals for maintenance and operation have also been prepared. The public heatlh engineers have raised their standards considerly and this department is now in a position to prepare major water supply projects.

The present Government has enlarged the activities in this sector very effectively with the result that in the current year 45 rural water supply schemes are being executed for the province of Punjab against 102 completed during 10 years from 1961 to 1971. In the next annual development programme it is expected that about 350 rural water supply schemes shall be taken in hand. The peoples' Government is laying greater emphasis on the rural development programmes. The policy of the Government is to make available hygienically fit drinking water to one and all, whether he lives in large city or in a small village situated in a remote corner of the country in the shortest possible period.

At present hardly 35% of the urban population has access to the public water supply system and in rural areas it is less than 6%. It is a big task to provide good water to the rapidly growing population of the country. Previously in the budget allocations, the priority to the sanitary works was very low but now this sector is being given top most priority knowing well that unless the basic sanitary problems are solved the health of the people cannot be improved and a break-through for economic development cannot be achieved. The amount allocated for water supply and sewerage projects was only 1.5% which is required to be increased to meet the existing and the growing needs in this sector. The future financial requirements for water supply and sewerage systems have been roughly worked out as under :—

Description		Year 1975—80	Year 1980—85	Year 1985—90	Total
Urban Water Supply	..	170.00	230.00	272.00	672.00
Rural Water Supply	..	200.00	300.00	392.00	892.00

Stream Pollution and Protection of Water Sources

With the rapid industrialization other problems are creeping up. The trade effluents are being discharged into the streams without any pretreatment and the streams are being polluted. It is becoming difficult to use the natural water for drinking or for irrigation of crops at some places. Realizing the problem the Provincial and Central Governments are thinking for setting up an organization to control the trade waste disposal, stream pollution and air pollution etc. Unless the pre-treatment of effluents is done properly, it will become difficult for the growing population to have suitable drinking water without spending huge amounts, even though at present we are thinking that it is in abundance and can meet any of the future requirements.

Discussion

Both presentations on national policy were followed by discussion. The questions and comments mainly related to absence of legislative framework and a co-ordinating agency of the national level. The need for concrete efforts to provide them was highlighted.

WATER SUPPLY AND SEWERAGE PROBLEMS POLICIES AND PROSPECTS

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Introduction

An increase in urbanization and lack of sanitation in rural communities has coused widespread drinking water pollution and aggravated the existing unsatisfactory environment. Many of the diseases are transmitted by water and poor sanitation which deplete human energy and result in death for thousand annually. Statistics of water borne disease are generally incomplete and unreliable but there is no doubt that contaminated drinking water is one of the principal agents of disease and death in Pakistan. It is estimated that around 30 per cent of all reported diseases are waterborne and that 40 per cent of all deaths are due to waterborne diseases. The protection measures against waterborne disease consist, besides laxying of water pipes, of sanitary control of water resources, meticulous water works operation and supervision, continuous water treatment and disinfection, safe excreta disposal, etc. Thus, with a programme of proper sanitation, the incidence of disease can be appreciably reduced. Consequently the rest and foremost measure needed to be taken for improving the environment is to provide hygienically good water in sufficient quantity to the people and to safely drain off the wastewater. Similarly, the solution of sophisticated sanitation problems especally due to industrialization needs to be given serious thought before these become chronic.

Current Access to Services

Out of a total urban population of approximately 20.70 million in 1970, 12.6 million or 61.1% are served with safe drinking water supply and 7.2 million or 34.8 with sewerage and drainage facilities. In the rural areas only 7.66 million out of a population of 54.92 million or 14.0% are served with potable water whereas sanitation facilities are virtually non existent.

In addition to the above coverage a large number of privately installed hand pumps are in operation in the rural areas. The balance of the rural population fetches its water from rivers, canals, dugwells and ponds ; all of which are as a rule bacteriologically polluted.

Problems and Constraints

Most local authorities are unable to collect sufficient revenue to cover the expenses for operation and maintenance of water supplies. The water charges are normally at a flat monthly rate which varies with the size of connection. Metering is not practiced except in Islamabad and parts of Lahore and Karachi. In this connection, the various problems andconstraints which have been indentified in the provision of community services may be briefly summed up as follows :

The water tariffs in most of the urban areas have not been increased for a considerapel period of time while inflation has been very high over the past few years and the construction price index has increased manifold. In many cases the revenue collection is not even enough to cover the operating cost of the facilities. The water rates have ranged from Rs. 1 per 1,000 gallons to Rs. 3 per 1000 gallons against an average cost of more than Rs. 5 per 1000 gallons. For example, in Islamabad, the annual operating cost of the facilities is about Rs. 6 5 million whereas the estimated revenue collection for 1975-76 was only Rs. 2.4 million. Although all connections are metered the domestic tariff Rs. 1.5 per thousand gallons which is very low compared to the costs. In Karachi and other major cities, the local authorities are incurring heavy losses on supply of water. There has also been considerable pressure on local authorities against increasing the water rate and disconnection of non-paying consumers.

In the past, the development of water supplies for local authorities classified as urban were financed through one third cost from the authority, one third loan and one third grant from the Provincial Government. This policy has not been feasible to follow in receot years as the local authorities do not generate sufficieot revenues from the consumers to operate and maintain the water supply facilities or to service the loans and are unable to subsidize the sector from other sources of income.

Most of the rural water supples are operated at a loss. In Punjab and Sind, the local bodies make up the deficits from other sources of revenues. In Taluchistan and N.W.F.P , most of the rural supplies are operated by the Irrigation Department and Public Health Engineering Department respectively, and expenses are charged to the revenue budget. While no revenue is collected, recurrent expenditure is rapidly increasing with the installation of new supplies.

The cost of providing modern water borne sewerdge system is very high particularly with respect to the paying capacity of low income group. There is, therefore, an urgent need for developing indigenous low cost solutions for disposal of solid and liquid wastes.

There is enormous waste of water in all major cities. The proportion of water which is wasted due to leakage or which remains un-accounted for is very high compared to the international standards.

Maximum benefits from the water supplies cannot be reached with the intermittent service which is typical of the water systems in Pakistan. During periods of negative pressure impurities infiltrate into the systems. The situation is particularly serious where sewer systems are inadequate or do not exist, so that the ground water is likely to be heavily polluted.

There is no Federal Government agency specifically charged with the responsibility for the water supply and sewerage sector. There is need for making a separate Federal Division directly responsible for this sub-sector at the Federal level. Communication and coordination between the provinces in the past also remained extremely restricted.

The production capacity of asbestos cement pipe within the country has remained insufficient to meet the demands as a result of which the progress of work has suffered.

Public Health education regarding the benefits of drinking uncontaminated water is minimal, only being carried out in a limited way by the Public Health Engineering Department of Punjab.

There is no organized training available for the operating staff. This results in a major constraint in absorbing untrained personnel to properly operate and maintain new systems.

Strategy and Policies

In order to minimize the constraints outlined above so that a large development programme can be executed and the service situation improved, the following strategy and policies need to be pursued in the next few years.

Financial Aspects

The provision of safe water to rural and urban areas, with related sewerage facilities, cannot be carried out without a fundamental change in water pricing policies. The Government should aim at financial viability for urban systems i.e. revenue collected should cover the cost of operation and maintenance as well as cost of capital. In other words' as a matter of policy, the water supply and sewerage facilities should be provided on no profit no loss basis and measures be adopted to recover the total cost of the projects from the beneficiaries. The level of charges for water and sewerage services should be part of the loan agreement with local authorities in order to remove the pressure for unduly low rates. For rural supplies, the target should be to recover at least the cost of operation and maintenance.

As part of the drive to conserve water and to raise more resources, more extensive use of water meters should be considered. It is proposed that all water connections to industries, shops and other institutions and domestic consumers in high class residential areas be metered. Block tariffs should be used for metered connections with small quantities available at low rates and large volumes at increasing unit costs. In this connection, the possibility of setting up of a factory for producing water meters within the country could be examined. The basic aim of the tariff policy should be to encourage conservation, generate adequate revenues and to apportion charges in a way which brings the basic quantities of safe water to everyone at prices they can afford. This will help limit the waste and excess consumption and hence defer the need for expensive new sources of supply.

Connections to unmetered low cost housing areas should be provided with modules to limit the water consumption. Unmetered connections should be charged at a flat monthly rate based on connection size, number of taps in the house and rental value of the property.

The financial condition of local authorities has deteriorated in recent years, as their main sources of revenues are not responsible to price increases and as procedures for increasing them are very lengthy. A major tax reform would be required to improve the financial condition of local authorities. The present system of taxing incoming trade based on weights (octroi) is out-dated. A revision of the system will take several years and it is unlikely that the majority of urban communities will be able to contribute their one-third share of development cost in the foreseeable future. It is, therefore, necessary that the present policy be reconsidered and the loan portion to urban authorities be increased in order to reduce their cash contribution.

Institutional Aspects

The responsibility for coordination of provincial programmes of water supply, sewerage and drainage should be given to the Environment and Urban Affairs Division at the Federal level. Their responsibilities should include legislation, training, guidelines on design criteria, information systems, development targets and negotiations with external agencies for financial and technical assistance. For this purpose, the capacity of the Environment and Urban Affairs Division should be strengthened.

The Institute of Public Health Engineering and Research Lahore should be able to play an important role in the dissemination of technology know-how from one province to the other after it has been designated as a National Institute in Environmental Health Engineering.

It is essential that management of revenue collection is improved. Lessons learnt from the cities receiving external finance, for which management assistance is likely to be forthcoming, should be transferred to other cities. A pilot exercise may also be carried out by contracting the revenue collection for water supply service to a private firm along the same lines as octroi (trade tax) has been contracted by a number of local authorities to see whether an improvement in revenues was possible through this system.

Arrangements for operation and maintenance of water supply and sewerage schemes are not satisfactory particularly where systems have been handed over to local authorities with insufficient technical know-how and funds. The policy is that the supplies are handed over to local authorities for operation and maintenance, two years after construction. In most cases, the Public Health Engineering Departments continue to operate them when local authorities do not have competence. There are cases, where local authorities have insisted on taking over plants too soon resulting in deterioration of services.

For major cities, water and sewerage authorities should be established for proper provision, operation, maintenance and management of the systems. In the long run, such authorities could become financially viable, but would require initial subsidies as the present level of service is too low to permit significant increase in charges.

For urban areas of small size, it is recommended that the systems, as a rule, be operated by the Public Health Engineering Department and the cost charged to the local authorities. If a local authority desires to take over the operation, it should engage technical staff to work with and be trained by the Public Health Engineering Department staff on site for a period of at least two years before handing over. After handing over, the Public Health Engineering Department should continue to monitor the operations. Procedures for handing over and responsibility and authority of Public Health Engineering Department should form part of the loan agreement between the Government and the local authority.

For rural supplies, it is necessary that the local bodies should engage operating staff to work in association with the Public Health Engineering Department staff during the first two years after construction. Then, the major maintenance and repairs should be carried out by mobile Public Health Engineering Department maintenance teams.

In order to maintain and operate rural supplies without loss, it is recommended that village water committees be established before selection of projects. Prior to the execution of a scheme, the committee should be made aware of the estimated cost of operating and maintaining the supply and the system of recovering the cost from the beneficiaries should be established. It is also proposed that the programme of rural water supply and sanitation should be coordinated with programmes such as the establishment of primary health centres, rural electrification, village planning and rural housing programmes.

Technical Aspects

A 24-hour supply requires control of demand which can normally be achieved by effective metering, billing and collection in the case of house connections and by control of standpipe use. Previous experience in Pakistan, however, indicates that the wastages increase considerably if the water is supplied on a continuous basis. In view of the large problem of areas which have not yet been supplied with water at all, it appears that during the next few years, the intermittent system of service will generally have to be continued and continuous 24-hour service will not be possible.

Feasibility studies for the augmentation of existing supplies should be carried out which should include an assessment of the unaccounted for water and recommendations for reduction of waste and leakages.

It is essential that the water supply design criteria developed by the General Advisory Service Unit in Lahore upto 1968 should be updated and a suitable design criteria and guidelines for sewerage and drainage works should be evolved.

Research needs to be carried out to develop low cost solution for disposal of solid and liquid wastes. As the cost of water-borne sewerage is high, the system of septic tanks and latrines will have to supplement the programme of coverage through water-borne sewerage during the next few years.

Manpower and Training

Training of water operators, including training in methods of reducing water waste needs to be improved and expanded. Specific training programmes need to be developed for water operators in each province with proper development of curricula and training aids.

Information Systems

The data base for future planning is inadequate and unreliable. Information on unit costs for development and for operation and maintenance has not been compiled systemetically and information on the status of systems that have been handed over to the local authorities is inadequate. Proper information systems for future planning of sector development in all the provinces need to be set up.

Rural Areas

Handpumps being cheaper than piped water supply system in rural areas, emphasis needs to be placed on the coverage of rural areas through handpumps programme wherever they are technically feasible. Research also needs to be carried out to determine the most suitable design for handpumps.

It is also recommended that for the rural areas, use of existing irrigation tubewells, both in the Public and Private sector may be made for water supplies wherever technically and economically, feasible.

In the provision of water supply to rural areas, the following selection criteria could be considered for adoption : (1) Distance and difficulty of access from the existing source (area facing greatest problem). (2) High rate of water-borne disease. (3) Willingness of the local body/community : (a) to pay the capital cost. (b) to pay the operation and maintenance (c) to make available suitable personnel for training in operation and maintenance of handpumps and piped water supply (4) In villages where basic health unit exists and in Integrated Rural Development Programme project areas etc. (this will partly solve the problem of operation and maintenance as an official of the above organization could also be made responsible for looking after the water su ply scheme). (5) Availability of low cost reliable source of supply (6) Unit cost per capita. (7) Size of the village.

Health education programme in Punjab needs to be expanded and similar programmes need to be carried out in all the other provinces.

Fifth Plan Programme

The fifth plan (1978—83) places a major emphasis on the provision of water supply in both the urban and rural areas and it is felt that potable water supply should be available to everyone in the country. If a target of 100 per cent coverage of urban and rural population by the end of Fifth Plan is to be achieved, an additional population of 13.01 million in the urban areas and 53.58 million in the rural areas would have to be provided with potable water facilities. This will require an investment of Rs. 8,112 million. The availability of adequate finances is however not the only constraint in the provision of water supply facilities in the urban and rural areas. It has also to be kept in mind that we are starting from very low benchmarks, especially in the case of rural areas. The government departments and development authorities can increase their capacity only gradually in order to cope with a large programme of water supply coverage. Another vital factor would be the availability of adequate materials, more specifically, the pipes and handpumps required for the programme. In the case of rural areas, the programme of coverage of entire rural areas during the Fifth Plan would require a very large programme of piped water supply. In addition, it would require installation of about 40,000 handpumps per annum in Punjab and 20,000 handpumps per annum in Sind. Against this requirement, the installation capacity in Punjab and Sind at present is not more than 15,000 handpumps and 10,000 handpumps, respectively.

Coverage of entire population by water supply during the Fifth Plan will also not be desirable from another point of view. The development of water supplies has to go hand in hand with that of sewerage, drainage and sanitation. As already pointed out. there is already a large gap between water supply and sanitation coverage in both the urban and the rural areas. It is, therefore, proposed to adopt an integrated approach during the Fifth Plan for the development of water supply, sewerage, drainage and sanitation facilities and the programme is so conceived that total coverage by water supply would be available for both the urban and rural areas in the late eighties, i.e. towards the end of Sixth Plan period.

In line with the above long-term objectives, the following specific targets have been fixed for the Fifth Plan period : (a) The population served by water supply in urban areas will increase from 61.01 per cent in 1978 to 81.5 per cent in 1983. (b) The population served by water supply in rural areas will be increased from 14.0 per cent in 1978 to 35.8 per cent in 1983. (c) The population served by sewerage and sanitation in urban areas will increase from 34.80 per cent in 1978 to 50.90 per cent in 1983. (*d*) Rural sanitation cover will increase from 0.25 per cent in 1978 to 3.5 per cent by 1983.

The above mentioned targets in terms of additional population to be served during the Fifth plan work out as follows :

Urban Water Supply	..	8.25 million
Urban Sewerage and Drainage	..	5.86 million
Rural Water Supply	..	14.25 million
Rural Sanitation	..	2.00 million

The physical targets mentioned above include population which will benefit from services available from urban plot development projects. However, while the ultimate population to be served by the plot development programme will be 3.5 million, allowance has been made for water supply benefits for only 2.11 million. The difference is due to the time lag between plot development and house construction (and habitation). The coverage of additional population through the specific water supply and sewerage programme, included in the Fifth Plan, is as follows :

Urban Water Supply	..	6.15 million
Urban Sewerage and Drainage	..	3.76 million
Rural Water Supply	..	14.25 million
Rural Sanitation	..	2.00 million

In view of resource limitations and to cover type maximum population, rigid adherence to high and sophisticated standards has been avoided. Both conventional and modern methods would be used. Water supply coverage will be provided both through house connections and through standposts in the urban areas. Handpumps will be used extensively in the rural areas. In the case of piped water supply schemes priority will be given to villages where the source of water is more than two miles from the village.

URBAN WATER SUPPLY SYSTEMS IN PAKISTAN WITH PARTICULAR REFERENCE TO KARACHI

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General Arrangements of Water Supply in Pakistan

As in other parts of the world, public water supply in Pakistan has previously been obtained from the ground water sources or from the surface water sources where ground water was difficult to obtain. In most of the towns and cities in Pakistan, the growth of population has occurred on the basis of the availability of water either from ground water source or from surface water available in the vicinity. The deviation from this basis has happened in a few towns and cities which became important on account of various factors such as Headquarters of Central or Provincial Governments, Industrialisation, Trading, Port Development etc. There has generally been no difficulty in obtaining adequate supplies by sinking shallow wells and installing pumps or providing Tube wells or arranging water supplies from the rivers or from the cannal net works.

In case of ground water supplies, since water passes through course ground it gets completely relieved of the suspended matter and, therefore, no arrangement of large storage or filteration etc., are necessary but in places where the ground water source was considered inadequate and where surface water was available in the vicinity, works necessary for conveyance of water from distances and providing storage at high levels in the neighbourhood of the towns for distribution to the public became necessary. In other towns where ground water was difficult to be exploited, it was possible to provide low dams or a series of dams over rivers or their tributories to provide adequate storage so as to enable regular supply throughout the year.

In the growing cities of Pakistan, modern methods of conveying, storing, filteration and distribution to the consumers within their premises, etc, are being adopted for supply of water for public use. The study of water supply to different towns and cities of Pakistan is a wide field and therefore, for this reason I would restrict myself to the study of the water supply to Karachi only.

Brief Description of Karachi and its Water Supply Arrangement Prior to Independence

Karachi was originally a small fishermen's town which developed on the left bank of Lyari River. This river remains dry throughout the year except for the duration of the rains when water is drained out from the city through this river. Shallow wells dug out on the bank and inside the bed of the river provided water for the residents for quite sometime. Development of the town, however, was affected when the Karachi port was developed bringing Karachi into prominence. The Development of the city was, therefore, planned and a public municipality was formed. Arrangements for public water supply was thereafter, made the responsibilities of the Karachi municipality. In the year 1883, the first major water supply scheme was drawn up and a series of wells were dug on the banks of Malir river at Dumlottee about 20 miles from the town. Water was brought to Karachi through a stone masonry covered conduit having a rectangular section with arch top with a capacity of 5 MGD terminating at Temple and Currie reservoirs which had 5.5 MGD capacity for storage with full supply level at 65 feet above the sea level. House to house supply was arranged through pipelines. Later on more wells were constructed and another underground reservoir with a full supply level at RL 75 having a capacity of 6 MG by the name of Sydenham reservoir was brought into commission in the year 1923. Another big addition was made to the existing water supply system when another conduit of 16 MGD capacity was laid from Dumlottee to Karachi and a storage reservoir with full supply level at 98 now called the Low Service Reservoir was constructed in 1942. With the addition of this conduit and reservoir system it was expected that the water from Dumlottee well source would be sufficient to meet the water requirements upto 20 MGD, but the record indicates that the supply went up to 15 MGD, only from this source during the World War-II, when it was felt that the position of Karacni was such that the demand of water was expected to rise beyond 15 MGD and also that the yield of Malir and Lyari wells was not expected to suffice for the needs of this growing town. It was also found that during dry years, supply from this source was only 5 to 6MGD. It was, therefore, considered necessary to tap some other source of water.

Studies were made in this respect and 2 possible sources were investigated, the nearest being the Hub river valley and the other one was the Indus river. Hub river was about 20 miles from Karachi whereas the Indus was about 70 miles away from Karachi. The difficulty with the Hub river source was that although the river was to some extent perennial, the rain fall in the catchment was scantry and the river's discharge during the period of low rainfall reduced to a great extent and therefore, a reliable water supply to the extent of 20 MGD could not be ensured. There had been previous observations that there had been as many as 6 drought years and as such it was not considered feasible that Hub could serve as a reliable water supply sourse. Quality of water deteriorated during the period of low flows and the salt contents rose far beyond the tolerable limits. The other source, although at a long distance was considered as a reliable source and, therefore, the next scheme for water supply was prepared in 1941, known as the Haleji scheme for providing immediately 10 MGD water (ultimately 20 MGD) from Indus river. In order to achieve this result a system consisting of an inundation Canal from river Indus upto Haleji a place about 50 miles from Karachi was designed and at this place an artificial lake was formed by an earthen bund, having an area of about 11 sq. miles for a capacity of 3000 acre ft. From Haleji lake, an underground masonry conduit of 20 MGD capacity was constructed to Gharo where a pumping station raised water by 150 ft. to Gharo Hills where Sedimentation tanks and a Paterson Felter plant of 10 MGD capacity were constructed. From Gharo to Karachi a RCC pipe conduit was laid to supply water by gravity to a place about 6 miles from the city where another pumping station of 10 MGD capacity was installed to raise water for a 2nd lift of 150 ft. The Rising Mains both at Gharo and at Karachi were of C. I. Pipes with varying diameters from 30 to 39 . This system terminated at a high point where a High Level Service Reservoir was constructed having a full supply level of 150 ft. above the sea level with a capacity of 20 M.G. This reservoir is called the *high service reservoir* or the *stadium reservoir* on account of its proximity to the national stadium.

Position At The Time of Independence

At the time of Independence, the water supply to Karachi was being made througn these 2 sources i.e. (1) DumlotteeWell & (2) Indus-Haleji source. Average supply was about 16 MGD and another 10 MGD was available. Due to the influx of population into Karachi due to partition, the position of Karachi as the interim capital of Pakistan and growth of industries as it was the only port town of the country, the rate of growth of population was beyond all expectations and the entire available supply was found inadequate by the year 1950 necessitating immediate arrangement for augmentation of water supply. The step taken at this juncture was immediate duplication of pumping stations at Gharo and Karachi and the installation of filteration facilities at Gharo raising the capacity by another 10 MGD. The reservoir system as well as the distribution mains which had hitherto been sufficient were also found to be inadequate. Moreover, the sewers which had been laid for an ultimate population of 5 lacs (as was the case with water distribution system) could not keep pace with the addition of the water supply without augmentation to the Sewerage system. Water started flowing in the streets, creating health hazard, untidy conditions and foul smells.

Master Plan for Greater Karachi and Planning of Water Supply and Ancilliary Schemes

The Government of Pakistan therefore, arranged for the preparation of a Master Plan for greater Karachi through a foreign consulting Firm (M.R.V.P.) in 1951 on the basis of which the Central Government authorised K.J.W.B. (Karachi Joint Water Board) now Karachi Development Authority to prepare a comprehensive scheme for providing water supply. Sewerage and sewage disposal as well as water distribution facilities for greater Karachi. The planning of the ancilliary scheme for providing sewerage and sewage disposal facilities was undertaken by the Central Engineering Authority. All the three projects were submitted in 1952. The Government of Pakistan approved all the schemes in 1953 and Karachi Joint Water Board was authorised to execute all the 3 schemes. These schemes are known as the *Greater Water Supply* and *Ancilliary Schemes*. These schemes were based on a target population of 30 Lacs persons by the year 2000 with an ultimate per capita consumption of 75 gallons per day.

Topography

The natural lay out of the Karachi city is such that the lower areas are situated near the harbour, therefore, the earlier population occupied the lower areas whereas the growth of population continued to higher areas having ground levels upto 60 ft. approximately ; in the early stages of development and beyond 60 ft. upto 90 in the post-independence period. According to the Master Plan, immediate growth of population was expected to extend to RL—120 and beyond it in the subsequent years.

The Dumlottee system of supply could provide water on its way to some high level consumers as well as to the low level consumers. The Haleji system was, however, laid in such a way that no intermediate supply was envisaged and the entire supply was to be provided to consumers in Karachi area below level of 100 ft. The Dumlottee supply was already catering for the needs of consumers along the conduit and those living in lower areas of the old town. Most of the new development was expected in the high level areas between RL 100 to 200 and as such the water supply system had to be designed in such a way that normally water could be made available upto 4 storied buildings with 80 ft. residual pressure.

Economics

The 2nd aspect was the economics. The supply was to be arranged in such a way that there may be no shortage of water for the existing consumers but they should not be burdened by providing facilities for future generations as a bigger system could not be utilised fully for a number of years. It was, therefore, decided that the water trunk mains and the trunk sewers for the areas having 120 as the highest contour may be provided for the ultimate capacity whereas the higher areas may be left out for development in the future and service facilities be provided as required. Hence the water supply scheme known as the *Bulk Water Supply Scheme* had to be planned for execution in phases. The ultimate water requirement of the city was worked out at 312 million gallons, out of which 12 MGD were to be provided by the Dumlottee system and 20 million gallons were to be available from the Haleji system. The net deficiency was worked out at 280 MGD. It was planned to bring this water in 4 phases ; 1st phase was to be completed in 1956, the 2nd Phase in 1960, 3rd Phase in 1975 and the fourth phase in 1985.

Each phase was to add 70 MGD for the needs of the additional population and development of industry etc.

First Phase of the Project

The population growth was tremendous and demanded immediate implementation of the first phase of the project. The work was started in 1954, but the task was gigantic and was originally expected to cost rupees 7 crores and about 4 years to complete. Similarly, the water distribution project was also taken in hand and this project was to cost 3.37 crores while the sewerage and sewage disposal project was estimated to cost Rs. 5 crores. The initial designing detailing invitation of the tenders etc., took about one year and the work was actually started in 1955.

Source of Supply

The main aspect of this additional supply was exploitation of the Indus source of supply. Karachi city was fortunate that it could get a perennial supply from Indus river through the lower Sind barrage system under which a canal known as Kalri Bagar Feeder was taken from the right bank of the river Indus upstream of the barrage at Jamshoro a place 5 miles upstream of Kotri. This feeder supplies water for irrigation to areas on the right bank of Indus up to Jhimpir. The canal at its tail end was connected to an artificial lake known as Kalri lake which included a natural lake, named Keenjhar lake.

It was expected that water supply at the rate of 280 MGD could be made available to Karachi throughout the year from this lake through lower Kalri canal and it's Jam branch upto Gujjo upto which the irrigation system was perennial.

The point of supply from the new source was at Gujjo where head works nad to be constructed and an independent canal (with RCC lining) 10.6 miles long upto Gharo Creak was designed for 280 MGD supply. From the Canal a low level conduit with 280 MGD capacity was to be built in plain cement concrete upto Dhabeji where the pumping station was sited. The capacity of the pumping station was 70 MGD for the first phase with 2 lines of 72 dia. rising mains for pumping water against a head of about 220 ft. (one line was a standby. The rising mains were about 3 miles long. These pipes were manufactured by the department in a new prestressed pipe factory erected and installed with the assistance of the Australian Government provided as a Colombo Plan Aid. The next part of this project was to lay a high level gravity conduit from Dhabeji hills down to Karachi. This conduit was 38 miles long and a part of this conduit i.e. from Dhabeji to

Pipri Hills was designed for supplying 280 MGD water, whereas, the remaining portion from Pipri Hills to Karachi was of 140 MGD. At Pirpi a tunnel 7000 ft. long had to be bored through the hills and this tunnel was also designed for supplying 280 MGD. In order to cross the streams, nallahs and low lying portions (near Karachi) prestressed pipe syphons of 84" dia. to pass 70 MGD water were constructed for the first phase. Water had to be processed through a 70 MGD filteration plant located at COD hills before being supplied to the city through a Balancing Reservoir of 10 MG Capacity also at COD hills. For construction of such large work and for making arrangements for connecting the new system with the existing water supply system, a large machinery pool organisation and a big workshop had also to be added to the set up, since large quantities of excavations and transportation of pipes, machinery and other materials had to be undertaken. There was needed a change in the organisational set up as well. The K.J.W.B. which has till then had been a small Organization, had to be developed into a full scale engineering department for planning, construction and maintenance of the entire water supply system of the city. This project was completed in 1962 as against the target of 1956. The Government of Pakistan with the assistance of the U.S. AID arranged for loans in foreign and local currency to the extent of rupees 32 crores required for the completion of the bulk water supply distribution and sewerage and sewage disposal projects for the first phase only, as against the original estimated cost of Rs. 15.7 crores. Foreign currency was arranged through D.L.F. directly for the project but machinery procured by the authority through U. K. Government Credit was also utilised on the works. Although the work was taken up at the planned rate of progress and all items of work continued in the normal method but the tunnel became a bottleneck and a problem as Shale rock and similar rocks were encountered and a sub-soil water reservoir was also met with, which hampered the progress badly. In order to relieve the city from the difficult situation due to shortage of water, it was arranged that 10 MGD water supply be given by relay pumping over the top of the hills. Thus in August, 1959, 10 MGD were supplied through the new system. The remaining works including the tunnel were completed in 1962. Simultaneously work proceeded on the trunk sewers and the sewage treatment plants. Two plants each with a capacity of 20 MGD have been completed. Design of the plants provides for 100% expansion. The plants have been handed over to the K.M.C. for running and maintenance.

Second Phase

With the augmented supply by 70 MGD through the first phase of the project, the position of demand and supply was favourable but the reserves were being utilised quickly. Hence it was necessary that the 2nd phase of water supply should be taken in hand so that Karachi may not be faced with acute shortage of water supply as had been the case between 1956—62. The project for the 2nd phase of water wupply was submitted in 1965, sanctioned in 1967-68 and the implementation took 1¾ years from June, 1969 to March, 1971 (as against 3 years period foreseen earlier). Foreign exchange was released in April/May, 1969. This boost in construction progress was achieved by giving bonus facilities to the contractors for supplying and erecting the filteration plants and pumping equipments ahead of schedule etc. The Government of Pakistan arranged for a 12 million French franc's credit to meet the foreign exchange needs and the remaining amount was loaned by the Government of Pakistan as rupees component for local expenditure. This phase of the project consisting of a duplicate pumping station with pumping capacity of 70 MGD at Dhabeji (financed from a German loan), laying the second line of syphons 84" dia. and adding a filteration plant of 25 MGD capacity at Pipri together with the connected pump house as well as a 10 M.G.D. Reservoir from where the trunk main varying 72" to 84" dia. was laid upto Landhi, Korangi area where the residential and industrial development was taking place. Another filteration plant of 45 MGD was added at COD hills ; also a 10 MG reservoir was added at the COD Hills, thus raising the pumping and filteration capacity of the

Bulk Water Supply System to 140 MGD in addition to the supply through other sources which is about 25.0 MGD.

The storage capacity which at the time of partition was 42 MG, was raised by another 10 MG in the first phase and 20 MG in the second phase. In addition to these schemes a steel rising main at Dhabeji, a 6 MGD reservoir at Orangi hills and trunkmains were also added to arrange an efficient water supply system. Full fledged laboratories are being maintained for quality control, where chemical and bacteriological analysis of raw water, purified water and water obtained from consumers premises are analysed constantly to ensure efficiency of the systems. As a further precaution, the authority is getting independent checks analysis carried out by the University of Karachi. Between 100 to 200 samples are being collected by the University every month for the purpose.

Present Position

The yield of the Dumlottee wells is getting reduced day by day because of 3 consecutive dry years and due to the growth of farms along the Malir river valley where private individuals have utilised practically the entire water conserving capacity of the river bed. The Dumlottee system (at the present) only provides approximately 2.6 to 2.7 million gallons a day as against the anticipation of procuring 20 MGD as assessed prior to independence and 12 MGD assessed in 1951. Similarly due to the division of water sources of the Indus valley between India and Pakistan the Indus river, during most of the year, goes dry below lower Sind Barrage at Jamshoro with the result that the irrigation has been suffering due to the artificial drought and with the "Grow More Food Compaign" it was necessary that Indus water was provided for irrigation along the River. It is also hardly possible to supply water to Karachi at the present rate of supply through Kalri lake. It was, therefore, necessary that quantity of Indus water being the only dependable source at the present, may be reserved for supply to Karachi. Request has already been made for reservation of 3,500 cusecs for Karachi.

Tarbela Dam

With the construction of Tarbela Dam it is anticipated that the round the year supply to the Karachi for the entire needs of the Metropolitan city would be assured. There are, however, other aspects of the water supply to Karachi, which have to be looked into.

The Dumlotee system being no more a supply source to be relied on, there was only one source i.e. Indus source for which there are the 2 systems of water supply namely:

(1) 20 MGD Haleji system.

(2) 280 MGD G.K.B.W. system.

are available at present. The bigger system through which at present 140 MGD is being procured for the use of Karachi, if temporarily rendered out of commission, becomes a point of big worry not only to KDA but to the entire population, as only to KDA but to the entire population, as only 20 MGD supply cannot serve even the bare minimum requirements of the population and dire consequences would result due to failure of the supply of water through the Greater Karachi water supply system ; it was, therefore, considered desireable to tap water from another source ie. the Hub river source.

Hub Dam Source

WAPDA have prepared a scheme for supplying water to Karachi for drinking purposes as well as for catering to the needs of the hitherto under-developed areas of Lasbela Distt. of Baluchistan province and to provide potable water for the needs of the steel mills which was being planned to be located within the Hub river valley. Originally a multipurpose dam was conceived to provide water as well as electricity, by constructing the dam in the hill range at a gorge near Thana Bola Khan about 27 miles from Karachi. This project has now been sanctioned and is being executed in a modified form for supplying water for irrigation in the Lasbela Distt. and arranging about 70 MGD of water for the citizens of Karachi, in addition to the 20 MGD needed for the steel mill. Lately the steel mill site is to be shifted from Buleji to Pipri and, therefore, it was expected that water to the extent of 90 MGD would be made available for Karachi, through this source. This will, therefore, be not only a second source of supply, but it would serve as an alternate arrangement in case of repairs and unforeseen break-downs to either system.

The growth of population in Karachi has, however, been going on un-checked with the result that the population target of 3.0 million expected in the year 2000 has been reached in the year 1965 and the present day population of Karachi is estimated at 4.0 millions (un-confirmed, census figures of 1972 not yet available) and therefore, as a matter of fact the per capita supply that should have been @ 75 gallons could not be increased beyond 30 to 35 gallons and in some areas the supply is as low as 15 to 20 gallons per head. This heavy influx of population attracted by the temperate climate of Karachi, establishment of large scale industries, low cost housing and above all facilities for work, have been the factors which could not be curbed and the population growth, is expected to continue further.

A recent study by the Master Plan Deptt. of the KDA, who have been charged with the responsibilities of preparing a new master plan for the city of Karachi, has revealed that the population of Karachi will be 12 to 15 millions by the year 2000 and the target per capita supply is proposed to be 70 gallons/ capita. Karachi city will, therefore, face a big problem in respect of water supply in the years to come, because of the scarcity of potential sources of potable water supply and secondly because of the enormous expenditure that has to be incurred for arranging, covering storage, filteration, distribution and quality control for such a big water supply system in a short span of 25 to 30 years. This is a big challenge and great responsibility for the engineers of the K.D.A. and to meet this challenge necessary planning has been started for getting reservation of water from the Indus valley storage (2) Hub Dam source (3) By Desalination of sea water. Regarding the use of the 3rd source (sea water), which is available in abundance in the vicinity of Karachi, exploitation on the commercial lines is a big problem. With the energy provided by an atomic energy power plant, constructed last year by the Atomic Energy Commission of Pakistan, it appears to be physically feasible that desalination plant could be installed near the coast and it was possible that with the passage of time this may be the main source of supply for Karachi. Initially the Atomic Energy Commission have offered to investigate, plan and provide a desalination plant of a capacity of about 100 MGD by the year 1985. The biggest problem is the high cost of water obtained through desalination.

In addition to this Bulk Water Supply arrangement, additional distribution facilities, storage and balancing reservoirs as well as sewerage and sewage disposal facilities have to be made available in accordance with the enhancement in supply of water.

Programme of Water Supply Third Phase

Having been charged with the responsibilities of runing the water supply system of Karachi, the authority took all steps to prepare the project for the 3rd phase of the Bulk Scheme. The P.C.I. forms were submitted in May 71 to the Government for sanction and implementation without delay and it is expected that another 25 MGD shall be added by the end of the year 1975. Duplication of 25 MGD Plant at Pipri and addition of another 20 MGD on the other side of the Pipri hills towards Karachi are expected to be carried out by the year 1978. In the meantime Hub-Dam and its canals are to be completed (at present expected by 1976). The fourth phase of water supply shall be embarked upon immediately thereafter. Planning for the 5th phase and subsequent phases shall, however, be continued by the authority. I hope that the problem of water supply for Karachi will be satisfactorily solved and the works carried out at Karachi will give a fillip to the projects for water supply and sewer systems in other cities of Pakistan.

P. C. I forms are under preparation for the provision of trunk sewers and sewage treatment plants to cater for the water used from the 3rd phase of the Bulk Water-supply Project.

In the discussion which followed the presentation by Rahimtoola questions were asked concerning chlorination, legislative basis for KDA operation, gpcd figure adopted for design and radiological and virological contamination of drinking water supplies.

In reply the speaker said that 0.1 ppm of residual chlorine is being maintained in the system. The Bombay Municipal Act, as amended, forms the legislative basis for KDA operation involving fixation of rates and responsibility for bulk water supply in Karachi. Arrangements do not exist regarding safeguards against radiological and virological contamination. However KDA is trying to collaborate with Karachi University and Pakistan Atomic Energy Commission to start testing of water supplies in this regard.

KDA had worked out the requirement of water per capita on the basis of income grouping and availability or otherwise of a sewerage system. The basis of calculation used to determine the gpcd figure are given as follow :

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Table income Distribution and water demand. For the purposes of developing any arrangement let us assume that water consumption breaks down into the following categories. (Figures in gallons per capita per day).

Categories		Percent	Income group Rs. 299	Rs. 300—499	Rs. 500—999	Rs. 1000—1999	Above 2000
Domestic	..	50	8.0	15.0	25.0	30.0	45.0
Small Community	..	2	0.3	0.6	1.0	1.2	1.8
Education & Health	..	2	0.3	0.6	1.0	1.2	1.8
Large Community	..	5	0.8	1.5	2.5	3.0	4.5
Large Industry	..	20	3.2	6.0	10.0	12.0	18.0
Small Industry	..	5	0.8	1.5	2.5	3.0	4.5
Agriculture	..	1	0.2	0.3	0.5	0.6	0.9
Technical	..	5	0.8	1.5	2.5	3.0	4.5
Losses	..	10	1.6	3.0	5.0	6.0	9.0
Total	..	100	16.0	30.0	50.0	60.0	90.0

RURAL WATER SUPPLIES IN PAKISTAN WITH PARTICULAR REFERENCE TO N.-W.F.P.

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Summary

Historically the progress of rural water supplies in Pakistan can be divided into three phases. Before 1957, from 1957 to 1970 and the third phase which started after the dismemberment of West Pakistan. Prior to 1957 almost as a rule the Government did not spend any money on providing water supplies in the rural areas. The people had to depend on the time old tanks, ponds, open wells and springs for all their water supply needs, and where no source existed the villagers had to trek for miles in search of drinking water. There were of course, few exceptions to this general policy, for example in the N.-W.F.P. we had few open wells three small capacity tube wells and another three small schemes based on infilteration galleries which were constructed out of the Provincial Government funds. The situation in the other part of the country was not very different. In the southern districts of N.W.F.P. walking five to 10 miles for a pitcher of water was not unusual.

The second phase started in 1957 with the programme of construction of Rural Health Centres. It was a first significant step in the field of public health in this country. This scheme envisaged that in every village where a health centre is built the community is to be supplied with safe water. These health centres were planned to be the nucleus of good health and hygiene from where knowledge and result of successful experience would disseminate into the surrounding rural areas and help alleviate dirt, squalor and disease. How for this programme has been successful is a different question but for the first time the Government associated itself with the rural water supplies and a fairly big size programme of construction was launched. Over 235 rural communities in West Pakistan were provided with water supplies at a cost of 7.4 crores rupees. To this if we add the water supply schemes which were executed under the Rural Works Programme the number of the project executed during this period, would be over 300. This programme was generously assisted by WHO and UNICEF. To under take this programme an independent Public Health Engineering Department was established in the West Pakistan, engineers were trained in the field of sanitary engineering. On job training was arranged in planning, design, and construction under a U.S. AID loan with the help of foreign consultants. Thus by 1970 West Pakistan had an organization which could plan, construct and operate Public Health Engineering Project in the country, but soon we were to loose this organizational arrangement.

The third phase started with the dismemberment of West Pakistan. The cader of West Pakistan Public Health Engineering Department was also bifurcated. In the Punjab it is still a separate department but in the other provinces it has been merged with the Public Works Departments. For the small provinces it will be a fairly difficult task to muster the expertise needed for continued development. In the N.-.W.F.P. although we have organizational problem but the programme of rural water supplies is steadily growing.

Magnitude of the Problem

The 1971 rural population of the N.-.W.F.P. including the tribal areas is estimated 1.2 crores of this not more than 5% is served by community water supplies. To provide the balance of the rural population with water supply would cost the Provincial Government nearly 70 crorres of rupees. Obviously this is for the time being beyond the capacity of the Government and it will be unrealistic to plan on a universal coverage. The unpleasant fact is that apparently it is out of our reach even to keep pace with the population growth. To make up for the past neglect would indeed be a formidable task. This means, that inspite of the new facilities that we are adding, every year there are more people without safe water.

Need of Planning

The difference between the needs of the sector and the financial resources which are at present available for its implementation is so big that unless the programme is very carefully planned it will be difficult to make any headway. Unfortunately inspite of this definite need a comprehensive plan has never been prepared. The schemes are usually selected on yearly basis for inclusion in the annual development programme and do not form part of a comprehensive master plan.

During 1972 recommendations were submitted to the Government for the preparation of a master plan for providing rural water supplies facilities in the N.-.W.F.P. this work has not been started so far. A decision problem can be visualized as follows. The rural areas of the Province can be broadly divided into two categories. (1 Rural area where surface, spring or ground water is available within reasonable distance of the habitations. 27 Rural areas where population exclusively depends upon stored rain and flood water. To this we can apply another decision parameter. There are certain areas where irrigation facilities are proposed to be extended in the near future and there are others for which there is no such programme. This gives us four basic categories. Obviously the sub-category "no water and no irrigation in the near future" should get the first priority. I admit it will be unwise to attempt to define a single index for the broad objectives but the point is that we must develop some strategy for the implementations of the rural water supply schemes and the whole programme should be carried out within a well planned frame work which should take care of the economic constraints, public health and the human aspects of the problem.

Public Health Aspect

Form a public health point of view, the essential requirements of a community water supply are safety, adequacy, convenience, and continuity. These have been generally our design parameters but in actual implementation of the programme we had various degree of success at various places.

With our rural population "Convenience" ranks very high in the order of priority. They might pay for a service connection because it is more convenient to have a tap in the house and not because the community supply is safe. If there is a hand pump in the house or the irrigation ditch is flowing close by, chances are they will use this water than walk 100 yards to a community stand post. Safe supplies which are not convenient are not easily acceptable.

During 1957—70 phase we provided water supplies in certain villages where they had available to them open wells or irrigation ditches. Our objective was to supply the community with safe water. Utilization of the facilities in some such communities has been very low. Now we are facing criticism from the people and the Government for providing water supply facilities to a community which had available to them water, whether safe or unsafe and not investing this money in an area where the people did not have any water. There is a certain degree of merit in this criticism. When the economic pie is limited, universal coverage is out of our reach and then if the choice is between a community which has water available to them irrespective of its quality and a village from where people walk for miles for drinking water obviously the choice should be for the later.

The capital investment in the N.-W.F.P. for many years to come in the field of the rural water supplies would mostly be limited to the areas where people exclusively depend upon stored rain water and in the summers when this dries up, they have to leave their home and hearth with their cattles in search of water. But can we completely neglect the communities who have access to drinking water but which is not safe ? If we cannot do capital investment in better facilities we must initiate a programme of health education. The people on self help basis should be motivated to protect and improve the existing sources. There is a great deal that can be done without big capital investments provided we have people who can work with will, zeal and determination and educate the masses in the basic principles of health and hygiene and convince them of the relation between diseases and unsafe water.

Economic and Finance

When the programme of rural water supplies was started in 1957 the West Pakistan Government established a financial pattern under which the capital cost of the scheme was paid by the Provincial Government. The community itself was expected to give land free of cost for the project and give an undertaking to pay for the maintenance and operation of the scheme.

In the N.-W.F.P. except for village Lachi and Khanpur no other community has been able to pay for the maintenance and operational cost. For some time the District Councils have been paying this cost but this money also inturn came from the Provincial exchequer under the Rural Works Programme. This arrangement did not work and ultimately the Provincial Government has now decided to pay for the maintenance. It is very much with in reach of many communities to pay for the maintenance and operation of their water supply facilities provided there is an institutional frame work at every village level to take up this responsibility. Promotion of community interest and participation is essential for the success of any such programme. Eventually the communities must take over this burden if the programme is to be made viable. Further more we must not totally exclude the possibility of "bankable" projects in rural sector. The project that can be financed from the consumer charges, the concept is long over due in this country. The undertaking would be difficult but is certainly not impossible.

Operation and Survillance

Most of the rural water supplies in West Pakistan were constructed by the Public Health Engineering Department. This department, unfortunately never full identified itself with the maintenance and operation. New construction was considered to be the prime function and the desired attention was not given to maintenance and operation. The result is that very few facilities could be considered as well as managed from operational, sanitary and financial point of view.

As a first step we must train staff on the operation side. Managerial competence is vital to water supply schemes. We may develop a cadre of junior managers to operate rural water supplies. They should be trained in financial economic and operational procedures. With the present system of a sub-divisional officer, operating a rural water supply through an illitrate plumber would not lead us very far. There is a very big need for a training institute at national level to impart training and to develop expertise in this field. As a first step few pilot maintenance and operation projects may be started.

From the Public Health point of view survellance of the utilities is an important need. Very little work has been done in this field. Although it will be desirable to decentralize management and operation and make the community responsible for it but on other hand public health survellance should be organized at provincial and national level. Survellance is a function of the Health Department but so far even a start has not been made.

Research and Development

We should have a central organization where all the activities in this field could be co-ordinated. There is a need for improving a whole range of technology. Material and methods must be developed to suit the specific needs of the rural areas. Standardization should be promoted to reduce the first cost and make the operation easy. The local industry still needs a great deal of help and guidance. Cast iron fittings sluice valves and hand pumps are seldom upto the standard. A very good beginning was made during the execution of a pilot water supplies projects in West Pakistan but this work has not continued. Continuous work is needed at the national level on data collection, dissimination of technical information, development of design guide lines and criteria applicable to rural water supplies.

Discussion

The participants evinced keen interest in the proposals for the design of a community stand-post which would appropriately meet the needs and at the same time avoid wastage of water. The speaker agreed that the improvement in the water supply facilities in a community accentuates the problem of waste water disposal unless it is accompanied by a parallel development of the sewerage facilities. He stressed the need for a greater co-operation between the Public Health Engineering and the Health Departments in the country for a coordinated effort in improving the environment.

RURAL WATER QUALITY STUDY*

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Background and Purpose

Several issues concerning the bacteriological quality of water available in rural areas in the country need to be addressed. They include the following : (*a*)What levels of bacteriological quality are achievable in rural Pakistan ? How do these levels compare with recognized international standards ? (*b*) How does the bacteriological quality of water vary among sources ? (*c*)What is the magnitude of the change in water quality that could be expected through the introduction of an improved water source ? (*d*) What are the important determinants of water quality in Pakistan ?

With a view to pursue them a study was conducted with focus on handpumps although some piped water systems were also included in the samples. In addition to identifying the potential improvements in water quality, it was hoped that the study would indicate which factors are most important in determining water quality. The objective was to identify these so that an effort could be made at the national planning stage to focus on those features.

Because of our interest in determining what levels of water quality are 'feasible', we did not include treated sources in the sample (with the exception of a few piped systems). This is based on the fact that most efforts to institute even simple water treatment programmes in rural areas have not proved successful.

Study Design

The study was designed by staff from USAID and the Institute of Public Health Engineering and Research (IPHER) in Lahore. The field work, including the collection and analysis of water samples and the administration of questionnaire, was done by IPHER. Logistical support and assistance in identifying the sources to be sampled was provided by

Reproduced from *Public Health Engineer* Journal of Pakistan Society of Public Health Engineers Vol. 6 No. 1.

the Punjab Peoples works Programme (PWP). Following fieldwork, the completed questionnaire and tables summarizing the data were prepared by IPHER and submitted to UNICEF (the project sponsor) and USAID for analysis. IPHER also undertook analysis of the data summarizing some of the major findings now available as one of its publications. More detailed statistical analysis of the data was undertaken by USAID, with assistance from a foreign consultant and staff at the Computer Centre at the Quaid-i-Azam University in Islamabad.

Sample Procedure

Although unprotected sources (e.g. open wells, canals, etc.) and some piped systems were included in the sample for rough comparative purposes, the number of sources sampled limited (29 and 10 respectively) the kinds of satistical analysis that could be done. The primary focus, therefore, was on handpumps. An effort was made to obtain an equal number of private and public handpumps so that they could be compared in terms of water quality, pump and installation characteristics, maintenance, and location.

The selection of the sources to be sampled was accomplished by first startifying the sample to obtain a sample of pumps representing the varied geographical features of the rural Punjab. The samples area was restricted of course to those areas where it was known that handpumps could be found. A cluster sampling technique was then used to identify the specific pumps (and other sources) to be sampled. Using a list of public handpumps provided by the PWP 30 pumps were selected at random. These pumps then became the nucleus for each cluster of sources to be sampled. Each cluster of ten sources was completed by sampling the four public pumps closest to each of the identified public pumps. One unprotected source was sampled for each cluster and rural piped systems whenever such systems were found.

Questionnaire

The purpose of the questionnaire was to collect information on the most likely determinants of water quality in rural Pakistan. These variables included soil characteristics, groundwater level and depth the pipe (used to calculate an index of penetration), and several installation and maintenance factors felt to be important (e.g., presence of drainage channel, cement platform, space around the pipe, leakage into pipe, need to prime pump, etc.) An assessment was also made of various other potential sources of contamination in the immediate vicinity, including the distance of these potential sources from the water source. A few questions regarding maintenance, such as the age of the pump, and filter, and the number of months since last repairs were made, were also included.

Water Sampling and Testing Procedure

Two collections were made at each source. One collection was used to determine the number of coliforms and the other to assess the number offaecal coliforms (E. Coli). Millipore Field Monitors and the Millipore Portable Water Testing Kit were used for the coliform test (enabling incubation to begin immediately while in the field),while the tests for faecal coliforms were made back in the laboratory. The water samples for the faecal coliform tests were kept cold to prevent deterioration and incubation was begun immediately upon returning from the field.

It should be noted that both of the organisms referred to above are indicators of the presence of pathogens, but are not pathogens themselves. The basis for using coliforms, both as an indicator of faceal contamination and the presence of pathogenic organisms is the following (*a*) coliforms are numerous in faeces but not other materials ; (*b*) they can be counted by means of simple, reliable tests ; (*c*) they are more resistant than pathogens to physical and chemical inactivating agents ; (*d*) they are unable to grow in conditions outisde the intestine.

In recent years, however, there has been a move away from the use of coliforms as an indicator of the possible presence of pathogens. The fact that certain physiological changes occur to the organism in hot climates and that several species of the coliform groups regularly occur in non-contaminated soils has caused faecal coliform (E. Coli) to all but replace the coliform test as an indicator of contamination. For the purpose of this study, the coliform test can be viewed as a less precise indicator of contamination and assuming that there should be a high correlation between E. Coli and faecal coliform levels, as a check on the validity of the data.

Analysis of the Data

The purpose of the analysis was to determine the level of contamination, in both absolute and relative terms, and then to determine which factors seem to explain the observed variation in water quality. The measures of water quality become the dependent variables and the independent variables are those hypothesized casual factors that have been identified in the questionnaire.

After coding, punching, and checking the data, a set of descriptive tables summarizing the data on both water quality and source characteristics was prepared. A simple regression was then performed to determine whether the observed differences in quality could be explained by any of the suspected casual variables. A more sophisticated analysis of this data was then done using multiple regression analysis, enabling us to assess which variables appear to be most important when considered together. In this way, we control for the fact that certain variables are likely to be highly intercorrelated.

A description of some of these data and the major findings of the analysis are given below.

Findings

Water Quality

The study revealed that protected sources, particularly handpumps, do have much better water quality than un-protected sources. The findings also show that 28 percent of the handpumps sampled met WHO standards (zero E. Coli and not more than 10 coliforms per 100 ml) for non-piped systems.

As indicated in Table I, public handpumps had significantly better guality water than the private pumps. It should be noted, however, that most of the private pumps are considerably older than the public ones, many of Which were installed under the Flood Rehabilitation Programme less than two years ago. Nevertheless, the data in Table 2 clearly indicates that the public pumps are better installed and at least thus far are in better condition than the private pumps. The small number of piped systems included in the sample fared badly, with only 2 out of 10 systems meeting WHO standards.

It is obvious, given the number of handpumps that met WHO standards of potability and the mean number of coliforms and E. Coli presented in Table I, that there is a great deal of variation in water quality among the handpumps sampled. The standard deviation for coliforms and faecal coliform levels are high, 17% of the handpumps were found to be free of coliforms and 38% were free of E. Coli.

Description of Handpump Sources

The data in Table 3 indicates the difference in age and time since last maintenance of private and public handpumps. As indicated above, this is primarily a function of the fact that most of the public pumps were installed recently.

TABLE 1

Bacteriological Quality of Water

Type of Source	No. of Sources Tested	No. of Coliforms (Mean)	No. of Faecal Coliforms E. Coli (Mean)	Remarks
Handpumps (private)	158	1135	132	Only 2 piped sources met WHO Standards.
Handpumps (public)	133	257	19	
Open Wells ..	29	4446	466	
Piped Systems ..	10			

TABLE 2

Characteristics of Handpumps Surveyed

Characteristics	Public	Per cent of Total	Private	Percent of Total
Cement platform	115	80	121	70
Space around pipe	41	31	74	47
No need to prime	106	91	136	97
Drainage channel	106	80	127	80
(avg. length) 14' (pri) 18' (pub)				
Leakage around pipe	7	6	26	18

TABLE 3

Age/Maintenance of Private Versus Public Handpumps

Characteristics	Mean number of Months	
	Public	Private
Age of Pump	21	79
Age of filter	16	33
Last repairs	5	23

The mean groundwater depth in the survey area was 23.3 feet. The mean depth of the handpump pipe was 45.7 feet, yielding a mean "depth of penetration" of 22.6 feet. Drainage channels, on the average, were 16 feet long.

Determinants of Water Quality

The most interesting aspect of the study is the attempt to identify those factors which are the most important determinants of water quality. It was hoped that this information could be used to maximize water quality.

The results of both the simple and multiple regressions found that few variables were significant. Taking water quality as the dependent variable, only "leakage around the pipe" was found to be significant at the 0.05 level ($t=2.196$). Controlling for other variables, the multiple regression analysis found only the presence of a "drainage channel" and the "need to prime" to be significant variables when related to water quality.

An attempt was also made to develop an analytical model of the demand for water using "number of users" as the dependant variable and characteristics of the water, such as turbidity and taste (sweet or brackish), as the independent variables. However, after reviewing the data, it was felt that the definition "user" and estimates of the number of users were too inadequate to permit this analysis to be done.

Water Use

The mean number of handpump "users" was 171 per day per pump. Roughly 77% of the drinking water sources sampled were "sweet" ($n=224$) and the remaining were judged to be "brackish". The mean turbidity level was 8.3.

Several questions regarding water use patterns were also included in the questionnaire. About 70% ($n=113$) of those interviewed (primarily handpump owners) reported that they share their water with others. About 65% of those interviewed said that they had an alternate source of water. 95% of them named handpumps as the source.

Methodological Problems

The main weakness in the study design was the procedure used to determine water quality. The specific tests used are considered acceptable, but multiple samples of each source over an extended period of time need be taken. This would enable seasonal differences and minor variations in the administration of the test itself to be taken into account. A more conclusive statement about the level of contamination could then be made.

The second set of problems concerns the questionnaire. Although it is believed that the important variables were included, more additional steps like training of interviews to insure an acceptable level of uniformity would be desirable. Several of the questions could also have been stated in more precise terms.

Efforts to compare private and public pumps was confounded by the fact that most of the public pumps were recently installed. In order to compare the conditions and quality of pump maintenance, it is necessary to control for age—there were not enough older public pumps to be done.

Conclusions

The study indicates that the introduction of a protected source can lead to a substantial reduction in the level of contamination. The findings also show, however, that it is not easy to achieve a level of water quality that meets established international standards.

The data also indicate the public handpumps, although newer, tend to have been better installed and are generally in better condition. Even so, there are a number of relatively small improvements in the siting and installation of the pumps that could lead to further reductions in contamination. The findings of the multiple regression analysis are not conclusive, but they do seem to indicate that opportunities for surface contamination, including priming, can seriously affect water quality. The depth of the water table, depth of the pipe, and the depth of pipe penetration into the water table, were not found to be important determinants of water quality. In sum, however, it is believed that final conclusions regarding these issues should not be drawn without further study taking into account the methodological problems mentioned above.

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ROLE OF UNIVERSITY IN THE DEVELOPMENT OF PUBLIC WATER SUPPLIES

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Introduction

The university has an obligation to be sensitive to national, regional and local problems. The provision of efficient and safe water supplies is one such problem. It is often one of the most urgent needs in a developing country like Pakistan. This is particularly true in Pakistan in view of the endemic occurrences of water-borne diseases such as cholera and typhoid and the numerous cases of dysentry in areas not served by safe water supplies. The Government of Pakistan has rightly considered the provision of safe water as one of the major steps for the improvement of the health of the nation in the proposed national health policy. More new public water supply systems will have to be constructed if this proposed policy is to be implemented.

Problems of Water Supply and Water Treatment

At present only about 30% of total population enjoys piped water supply. In addition, there is also an increasing demand for expanding and improving existing urban water supplies to cope with rapid urbanization and industrialization, a common phenomenon for developing countries. Sound planning and design are vital to ensure that these new or expanded systems are going to serve their purposes.

With the ever-increasing demand for domestic and industrial supplies as well as for agricultural irrigation, it is often harder to obtain adequate sources of high raw water quality for public water supplies. Stream pollution has contributed its share to render raw water more difficult to treat. Residual insecticides viruses from human wastes and industrial pollutants such as mercury are a few of the cases in point. The general awareness of the importance of preserving our environment has put another constraint on the design of water systems. For instance, the discharge of wastewater from water treatment plants such as settling sludge and filter backwash water into drainage systems or natural streams without treatment was taken as granted in the past. Quite a few countries are

*The views expressed in this paper are of the author and not necessarily represent those of WHO.

now promulgating stern legislations to restrict or prohibit such discharges. In Pakistan, the old practice is probably still in use. But time will come that pollution from this source is no longer tolerable in the overall picture of environmental protection.

Until now, most installations for water supply in Pakistan have been based upon criteria for design and operation patterned after those used in Europe and the United States of America. Although the general principles of design, construction and operation of such facilities are universally applicable. adaptation of methods of construction and treatment to local conditions such as water characteristics, prevailing environmental factors and readily available materials is necessary for the achievement of maximum efficiency and economy . Moreover methods of treatment less costly than the conventional ones may have particular advantages in Pakistan with its warm sunny climate, compared with regions of the world for which the traditional methods were developed.

Even a minor percentage reduction in the costs of satisfactory treatment and distribution of water would be of great assistance to Pakistan's development programme. Not only would the total funds required for the solution of current problems of water supply be reduced, but lower unit costs would promote rapid attainments to this essential target of an urbanised, industrialised society.

The Challenge

Community water supply schemes present one of the greatest tasks as well as opportunity for public health engineering in Pakistan at this time. Rapid industrialisation in parts of Pakistan is, however, introducing problems of water pollution by industry which already call for attention. The brief discussion presented here indicates two very significant points. First, because of either the need of utilizing sources of poor quality or the deterioration of water quality due to pollution, the technology of water treatment for maintaining the desired drinking water standards is getting moresophisticated and complicated. New products, equipments and processes are being developed to meet this challenge on our ability to cope with the newly arising difficult situation. Process design for coagulation using polymers, mixed media rapid filtration, and elimination of taste and odor of industrial or plankton origin usually calls for advanced knowledge in water chemistry, aquatic biology and surface and colloidal chemistry, Second, the necessity of providing adequate means for water treatment plant wastewater disposal adds a new dimension to water supply engineering. Practice used in sewage or industrial waste treatment may not be necessarily applicable because of the differences in wastewater characteristics. To find the most economical method for water treatment plant wastewater disposal is now a hot subject in many countries. Processes such as lagooning, pressing, freezing and dewatering by disk-nozle centrifuges are being studied in this respect.

New Concepts of Development

The field of public water supply is no exception to this age of technological explosion. Without constantly keeping in touch with new developments, a professional specialist may find himself out-of-step with modern technology. One example is the application of digital computers in engineering. Computer technology is such that an average size company is now able to acquire or rent a computer for use in its own office. Structural design by computer is becoming standard routine in consulting offices. For sanitary engineers, items in our arsenal of software include programme for hydraulic analysis of networks involving multiple sources, several pumping stations and different pressure zones. A more complicated sewer design programme can optimize the cost of a sewer line with respect to materials, labour and other relevant items and actually plot the sewer line profile in a finished form. In one instance, a sewer system requiring six full-time engineers to do the design in three months was completed in three days with a computer programme. The saving in time cannot be measured in terms of money alone. This popular acceptance of computer applications has put many engineers of the older generation in a very difficult position. Most of them choose to return to the classroom. There are many similar cases in technical as well as in management fields. The term continuing education specifically applies to the provision of opportunities for professionals working in the field to fresh up their knowledge and understanding of new concepts and developments which may have made their previous education obsolete.

Need for Trained Personnel

It is generally recognized that the proper operation of a water supply system is at least as important as its design. There are many cases where well-design treatment plants are operated below standards. Many instruments are out-of-order without getting proper attention. This is especially true in developing countries because of lack of qualified personnel. Unaccounted for water in certain cities in Pakistan is said to be as high as 30 to 40 percent of the total supply. This provides a good indication of the need of improvement of system management and operation. Usually high loss of water from a system is not the foremost significant consideration in the operation of the system. The paramount importance is that the water supplied to the consumers must be safe and wholesome. The operator of a water treatment plant must be constantly on the alert for any abnormal raw water quality variations and be able to take appropriate measures whenever such emergency occurs. He must be aware of the seriousness of his business in maintaining health and welfare of the people. He should have adequate technical background to appreciate the various processes used and the working and control of these processes to achieve optimum results.

There are therefore three major areas pertaining to the training and education of personnel for the development of public water supplies in a country :

(1) High level advanced training to provide key engineers, scientists and executives for planning, design and management of public water supply systems as well as competent researchers for conducting applied and basic research for solutions to practical problems and for the development of new processes.

(2) Continuing education in the form of refresher courses and seminars for professional already working in the field with the purpose of keeping them abreast with new concepts and developments in water supply technology and management.

(3) Training classes for water treatment plants operators and water supply system maintenance personnel to improve the technical level of the working of the systems.

Role of the University

Here the University can play its role in all these areas. As the seat of higher learning, advanced education for high level personnel is one of its supreme responsibilities to the community. Since the facilities and staff for training are available, it is logical to have refresher courses, seminars and training classes also in the University. This is particularly desirable in a developing country where the available resources in terms of providing competent staff and adequate facilities are very limited. There are sometimes complaints that university teachers tend to be too academically minded with little interest in practical aspects of technology. This has actually developed into a controversy in the United States where university professors are often criticized for their publishing papers for the sake of publishing without due regard to their practical value at all. A well-known foundation has tried to initiate a programme to encourage university teachers in water supply engineering and related subjects to spend a period of one year or more with consulting firms to gain experience in practical design and to learn the problems actually facing the profession. There are so far very little discernible results. However, one should not lose sight of the fact that many professors are active consultant in the field and a large number of excellent refresher courses are being offered by universities all over the world. There is another aspect which is sometimes overlooked. This is that, in conducting refresher courses, seminars and operator training courses, the University can always invite outside consultants, field engineers and other experts as instructors. The quality of the existing staff is not necessarily the sole yardstick for measuring the potential of such programmes.

One advantage for a university to handle all aspects of training is that modern water supply technology has become so involved that many of its problems need an interdisciplinary approach for their proper solution. Fluid mechanics, bacteriology chemistry, biology, computer programming, and systems analysis are examples of the major fieds with significant contributions in public water supply developments. With its multiple departments of various specialities, the University is probably the only place with staff and facilities available for such varieties of learning.

The working together of academic teachers and practicing professionals could also achieve the desirable effect of cross-fertilization. At least in one country, some universities have adopted the so-called CO-OP system under which a university and a consulting firm work together for undergraduate programmes. The student is required to tudy and work in alternate periods. It may take longer to complete the degree but a student benefits much more by learning practical aspects in parallel with his academic study. In addition, he can usually pay his own way since he is paid for the time working for the firm. This system may not he suitable for Pakistan. But government agencies and private firms concerned with the development of public water supplies should be encouraged to send their technical staff members for advanced studies with pay to achieve the same benefit. Under this arrangement, the person selected is not necessarily the sole beneficiary. The agency gets improved technical services as well as the leverage of giving incentive to staff who want to improve himself. The teaching staff members normally get as much out of students with practical experience as these students get from them.

University Research

Research is an area where the University can and should play an important role. A university teacher normally has the obligation to be involved in research either in connection with his teaching programmes such as student thesis work or as his own contribution to the profession. He also learns a lot through his research work. In some countries, there are criticisms to the effect that university professors are spending too much time on research resulting in the neglect of teaching. This of course does not mean that a professor not engaged in research is always giving his full attention to teaching. There are large number of professors neglecting both research and teaching. Hence the problem is largely a matter of personal attitude. One significant point worth special attention is the quality of the research being undertaken. The science policy in Pakistan has correctly set up the criterion that research should always be directed to the problems confronting the nation. This criterion should be universally applicable at least in countries such as Pakistan with definite priorities and limited resources. One ideal arrangement seems to encourage joint research projects between the University and agencies responsible for the execution of development programmes of public water supplies. For instance, in Pakistan, there is the problem of high hardness in groundwater sources. No body seems to have made any economical assessment of the situation. Development of processes using local materials and equipment is another potential field of joint research activities.

Advisory and other Services by the University

The University is also suited to play a role in the following matters in Pakistan :

(1) Establishment of a technical information Centre to provide latest technical publications in various aspects of public water supplies for use as references in the country.

(2) Testing and examination of water samples and materials used in water supply engineering.

(3) Advisory services in the form of pilot studies, digital computer applications and engineering investigations.

(4) Organization of conferences and symposia in topics with special interest to personnel concerned with public water supplies.

(5) Publication of research papers and other technical literature.

(6) Consultation to the Government regarding the setting up of water quality standards and other relevant regulations.

The University is one segment of the community and belongs to everybody in the community. The efficient utilization of its laboratories, teaching facilities, library and staff is in the interest of the community as a whole. From the point of view of the University, to serve the community should be its highest aim. A University irrelevant to what is going on in the community is a tragedy of infinite magnitude. On the other hand, the under-estimate of the potential of the University for the development of public water supplies in the nation, the ignorance of the dynamical nature of technology necessitating practicing professionals to keep abreast of new concepts and developments in the field and the denial of the opportunity of technical improvements to the staff members working in practical fields resulting in substandard planning, design and operation of public water supply systems are inexcusable on the part of the authorities responsible for the overall development of public water supplies in the country.

MANAGEMENT AND FINANCING OF PUBLIC WATER SUPPLIES

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The water-supply and sewerage projects require much greater time and effort in their preparation, financial justification, planning, supervision, execution as well as operation.

Essentially, such a project has to be handled as an industry and not as a Government Department. The management problems in such service organizations are very complex, even more complex than many industrial units. There is a long chain of events and steps that are required to be followed in most chronological order, in order to successfully produce potable drinking water and transport it to the consumer's door, recover its cost and plough back the money into operations and renewals, as well as, to arrange satisfactory disposal of the waste water. All this requires adequate manpower of the required education and training.

Quality of the management as well as the staff at all levels, in such an organization, is always closely related to the salaries, salary incentives and the job securities. Public enterprises can seldom compete with salaries in private industry and thus job security is their main attraction. However, in sem-autonomous bodies like the Lahore Improvement Trust, the misfortune has been that there is neither the security of the Government jor nor the attraction of the salary of the private industry. The result is that people recruited by this organization, after receiving sufficient training achieve good market value and whenever they have a more secure job with the Government or a luring offer from any private firm, they keep leaving the project. Thus we have to continuously run a training course without being sure that we will ever be able to develop our own expertise. The idea has been all along to train people, develop expertise in our organization so that we can shed our dependability on foreign assistance and be able to generate a pool of expertise which would then be available for use else-where. The Greater Lahore Water Supply, Sewerage and Drainage Project can be defined as a pilot project of its own nature in this country. The project was started in 1967 from scratch and in this period of 6 years, has developed its own systems, management, expertise and skill with the result that we are, to a reasonable extent running our show independently without the assistance of any foreign consultants.

In addition to the staffing problem narrated above, there is problem with the systems also. As I have said earlier this organization is neither the Government Department nor a private industrial unit and, therefore, we are not free to choose our own accounting system, rules and procedures as is done by the private industry, neither does the Government system suit or requirements. The result is that we have to cook our own system mostly based on commercial system yet trying to keep the Government audit as well as financial rules fully satisfied. This is not a very workable solution and is bound to create complications and delays, which factors are very much there.

All this is enough deterrent for any qualified person to come near such projects and if a Government employee is deputed to such an organization he is more likely to consider it a demotion than a possibility to expand his experience. There is no denying the fact that there is quite a dearth of qualified public health engineers and managers and managers with sufficient experience and expertise in the specific technical aspects of water-supply and sewerage services. Nevertheless the water wing of the Lahore Improvement Trust has been continuously making efforts to create its own pool of expertise by engaging qualified persons, training them on the job as well as in the class rooms, also arranging foreign trainings to some of them for higher knowledge. Courses of management are also arranged for them through N.I.P.A. and P.I.D.C. etc. All these efforts are being put into create a pool of experts not only to cater for water-supply and sewerage project of Lahore but to provide nucleus for smaller cities where the local authorities cannot provide the support of personnel.

The organizational structure of water-supply and sewerage services, have to be functional and should clearly define lines of responsibility in such a manner that the management can effectively delegate authority without losing control over the operations. This requires the installation of effective management reporting system and general communication system within the organization, which is a common feature with all the commercial firms. However, the principle of operating revenue earning public-enterprises in a business-like manner, is at-least developed at the municipal level and in turn, seldom adopted for water-supply and sewerage services. In order, therefore, to facilitate the handling of these services in a more business-like manner it is essential to have an independent autonomous organization, to operate it as a revenue earning utility, separated from normal Government bureaucracy and unaffected by political interference in its normal affairs. It should be able to independently set its own water rates in accordance with the sound financial criterion and within the general conditions of the people in the country. Such an authority could of course have full representation on its board, of the city fathers.

On the financial side one of the elements on which the economic apparisal of a water-supply and sewerage project is based, are the demand projections which should be as possible. This should include projected population growth, increase in per capita demand, requirements and consumption patterns of different consumer groups, elasticity of water demands effected by prices and rate structure etc. There are no set rules available in the books, which can provide this information. This has to be collected from the field by actual data collection and then processed for the purpose of calculating the various factors which will produce the demand projections. From economic point of view the merits of the project can be evaluated by preparing cost benefit analysis, internal rate of return calculations, discounted cash now, present worth analysis etc. Extreme care is very essential before investing in the water-supply and sewerage projects which have an economic return below the respective opportunity cost of capital. The cost of the project is always higher than the return and no body would borrow money unless he expects to earn from investing it more than the amount needed to service his debts. Accordingly the main factor in analysing the economic viability of any of water-supply and sewerage project, is the measurement of cost and benefit in economic and not financial terms which also includes social benefits which are over and above those realised by individual consumers. Such benefits can be divided into two categories. The first is related to the collective nature of water use like street cleaning, public gardens watering etc ; which contributes to the aesthetics of urban life and second is the eradication of water borne diseases resulting in reduced disability, morbidity and death rates. In addition, reduction in fire losses could yet be another benefit. As a matter of fact it is rather difficult to fully quantify these social benefits. Rather, some people feel that some of the results of these benefits may tend to create more problems like population growth and accelerated migration into uroan areas. The truth is however, somewhere in between the two extremes. On the one hand there are no doubt intangible benefits of water-supply which cannot be quantified but are important for the improvement of human life and of living conditions. On the other hand admittedly, a social infrastructure is not a means by itself, but its development should be programmed in balance with other basic investments in the economy.

With all such extra benefits which cannot be quantified, there is no escape from making the projects financially viable in order to successfully operate the same. More often it becomes more difficult to finance the operational part of the project compared to the construction phase. The system must generate enough money not only to meet the operational cost, depreciation charges and the debt service but also to net some net income too. The ratio of this net income to the net fixed assets, gives us the rate of return which is, for such schemes, recommended to be 8 to 10%. Unless this is achieved the project cannot progress satisfactorily. The no profit no loss concept, simply does not work. here. The cash requirement thus has a direct bearing on the charges which have to be levied on the water and sewerage customers and it is here that the economic and financial theory ends and where practical, pragmatic and political considerations begin. In case certain types of consumers are required to be given water "free", the cost of supply of such water must be borne by the Government or the municipality to subsidise payment for water consumption by such sections, which they wish to assist.

The Greater Lahore Water Supply Sewerage and Drainage Project has been working in the light of these internationally accepted princples for financing its project but there have been tremendous practical difficulties in achieving the objective. In obtaining a reasonable rate of return, revision of present water rate of structure is very much called for. Subsidy for water being supplied to poorer community through P.S.Ps. remains uncovered from the L.M.C. as well as the Government. The people are not prepared to bear any new taxes for sewerage system. The L.M.C. is not prepared to part with the house tax collected by it, and the Government is finding its own hands too tight to give anything from the property tax. These are problems of serious nature and are today receiving attention at the highest provincial level and we hope to find a solution to all these problems in the near future, in an effort to make this project a successful going concern and to set it as an example for more similar projects in other towns of the country.

Discussion

In the prolonged discussion which followed the presentation by Mazhar Haq questions were asked on different aspects of management and financing of public water supplies. In reply to a question regarding jobs and pay incentives it was stated that accelerated promotions are given to the serving personnel of L.I.T. (Water Wing). However, employees tend to leave for better prospects as this organisation is still to be put on a firm footing. Regarding metering system and payment by the consumers, the speaker replied that there are about 85,000 connections which are being billed quarterly. Future planning to streamline the system includes dividing Greater Lahore into 63 sectors. Such an arrangement will also help guard against unauthorized connections Government grants and loans are sources of finance for the L.I.T. (Water Wing). These in part are paid back by means of water rates.

He spoke of the idea of setting up of regional boards and a national organization dealing with public water supplies as being thought-provoking and suggested that it needed detailed consideration. Regarding the wastage and leakage in Lahore, he replied that L.I.T. (Water Wing) have not yet been able to start any rigorous programme. However a watch is always kept for apparent leakages and corrective measures enforced. He stated that the water quality in Lahore is generally of a satisfactory standard.

NUCLEAR DESALINATION & ITS PROSPECTS IN PAKISTAN

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Abstract

Where conventional sources of water supply have been exhausted or are difficult to develop, desalination offers a new source of fresh water. Important desalination methods and the two common schemes of coupling the two plants in a dual-purpose power desalination plant are described. Argument is advanced in favour of nuclear desalination for Pakistan. It is observed that Karachi Metropolitan area would experience water shortage by mid 1980's and that there are only two real alternatives to meet the supplemental demand : (a) Storage of Indus flood water, and (b) Nuclear Desalination. Pakistan Atomic Energy Commission (PAEC) plans to undertake preliminary technical and economic feasibility study of the two alternatives.

Introduction

Availability ot fresh water has always had a decisive effect on the pattern of human development. In many places around the World, water shortage has become acute and existing supplies are proving inadequate. This is occasioned by increasing demand for industrialisation as well as continuous growth in population and rising living standard, all of which increase consumption of water. The increasing complexity of urban life has put a heavy strain on the existing water resources. Secondly, about 60% of land on our Earth is classified either extremely arid or semi-arid. Rack of fresh water has been a major factor in retarding the industrial and social development of such areas. Increasing emphasis on industrialisation and sharply growing population have made it imperative for developing and developed countries alike to increase the productivity of these areas. Adequate supplies of water must be ensured if a decent standard of living is to be provided/ maintained or if the present need of bringing the arid areas under cultivation is to be met.

In such areas of water shortage where there is easy access to sea or brackish water, desalination can enable man to manufacture fresh water when he needs it, on the reliable basis in the volume he requires, and, hopefully at a price he can afford.

Desalination Technology

There are numerous methods of desalination all of which require energy either thermal, mechanical electrical or solar. Distillation methods requiring thermal energy account for over 98% of the desalination plants capacity around the World. The remaining 2% capacity is of the membrane and crystalisation type. In the following are discussed some of the more important desalination processes.

Distillation (Evaporation Type) Process

Multi-Stage-Flash (MSF) Distillation

Most of the water desalting plants have used MSF process and consequently this is the most proven of all the desalination methods. The essential features of an MSF plant are shown in Fig. 1. The process begins with the chlorination, chemical treatment and deaeration of raw sea water. Chemical treatment is essential to prevent build-up of scale on the inside of the overhead tubing in the recovery section of the plant. The objective of the deaeration is too be eliminate non-condensables which are corrosive in nature and also result in reducing the heat-transfer efficiency. Upon leaving the deaerator, the processed sea water is mixed with a portion of the highly concentrated recycling brine leaving the last stage of the reject section. The recycle brine is then pumped to the tubes of the last stage of the recovery section and travels through the entire length of the tubes, receiving, on its way to the brine heater, heat from the condensing product water and reflashing distillate. The pre-heated feed then enters the brine heater where it is finally heated to the maximum temperature (usually 250°F) with the process steam in the case of single-purpose desalination plant, and saturated exhaust steam from the turbine in the case of a dual-purpose desalination plant.

The hot sea water then enters the first stage which is maintained at a lower pressure than the vapour pressure of the heated sea water. As a result, a portion of sea water flashes into vapour which condenses on the overhead tube bundle and is collected in trays under the bundle. The flashing process continues at progressively lower temperature until the concentrated brine leaves the last stage. The distillate also travels from stage to stage in the direction of descreasing pressure and, as it proceeds, a part of it flashes and is condensed by sea water flowing in the tube. This also helps to cool the product which is finally pumped to the desired location.

Other Distillation Type Processes

Another Distillation Type Process is the *Multi-Effect* Evaporation in which steam is used to vaporise some of the sea water in the first evaporator (called first effect). Unvaporised sea water flows to the second effect which is operated at a lower pressure than the first. The vapour generated in the first effect is used as the heating medium in the second effect. This way there may be as many as 12 effects. In the 1950s, most of the commercial Multi-Effect-Plants were sub-merged tube type in which the steam is inside the tubes which are submerged in sea water. This highly inefficient variant of ME has entirely been replaced by the MSF process. Since early 1960s, when the MSF was introduced, most of the distillation plants are based on MSF.

Vertical Tube Evaporator (VTE) Process

Another variant of ME shown in fig. 2 is the Vertical Tube Evaporator (VTE) process in which evaporation occurs as hot sea water travels downwards in forced flow inside the long vertical tube bundles surrounded by steam. At the moment there is only one commercial plant and one demonstration plant each 1 million gallons per day (MGD) capacity based on VTE process. However, owing to much higher thermal efficiency than the submerged tube type. VTE plants hold great promise in reducing the cost of fresh water produced. The formation of scale within the tubes is the more serious problem

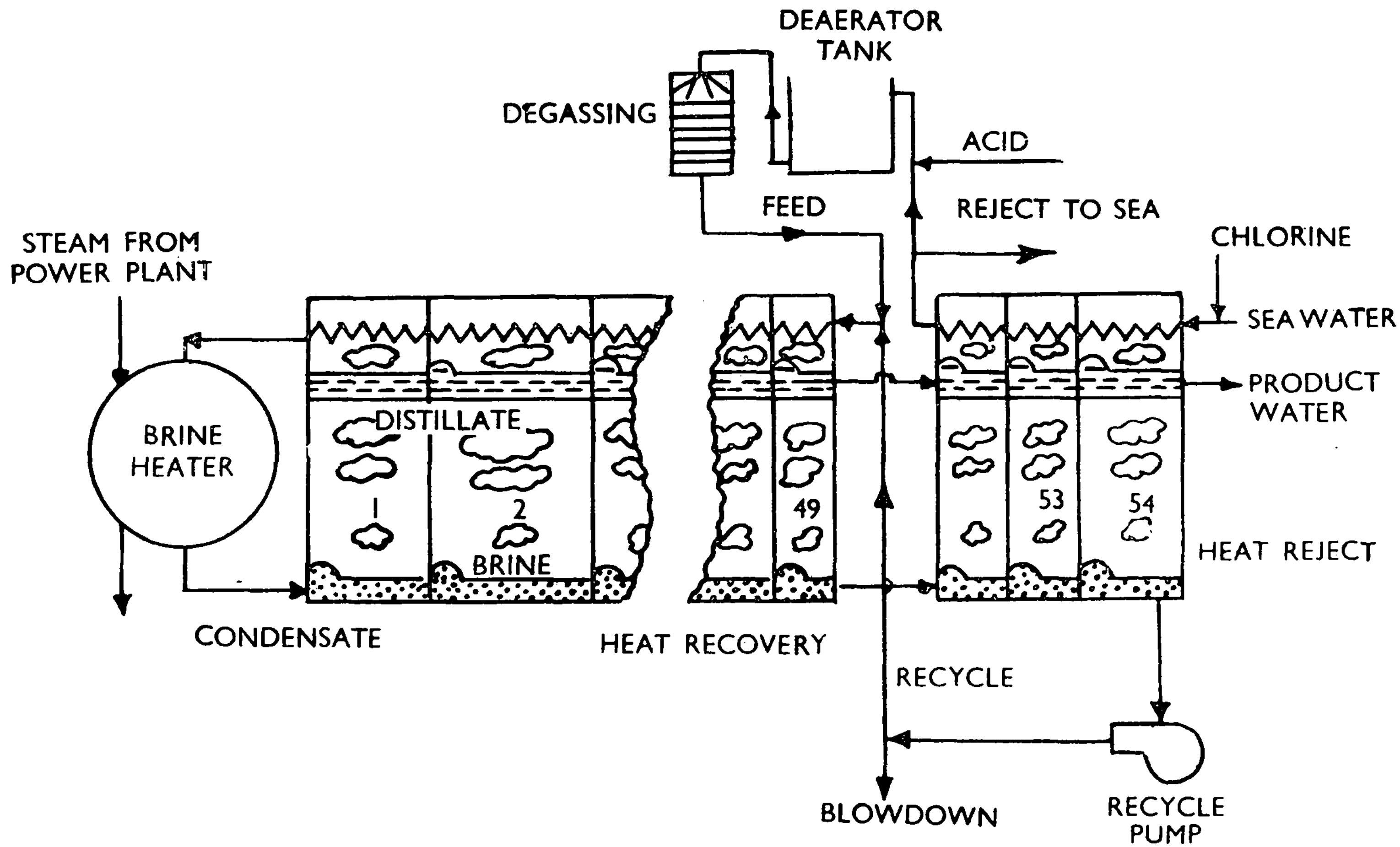


FIGURE 1.

MULTISTAGE FLASH DISTILLATION

than in the stages of MSF evaporator. But improvements in anti-scaling have demonstrated that scaling is not a serious handicaptor this process to compete with the MSF process. Some designers in recent conceptual design studies are suggesting a combination of MSF—VTE Processes for the large desalination plants to further reduce the cost of fresh water produced.

Vapor Compression (VC) Distillation

In vapour compression (VC) distillation, steam produced from the boiling brine inside the tube is pressurised and heated with mechanical compressor and then condensed on the outside of the vertical tubes, thereby boiling more brine and producing fresh water. This process has been used extensively for small capacity plants on board the marine ships.

Examples of Distillation Type Desalination Plants

Commercial Distillation Type Plants of 1—3 MGD capacity have been producing fresh water in the general cost range of $ 1.00 per 1,000 gallons. Studies of large nuclear power Dual Purpose Plants (50 MGD and above) indicate that cost of $ 2.20 to $0.40 per 1,000 gallons may be achieved in the 1980s.

Desalination plants based on MSF concept are operating throughout the World. A number of MSF plants are listed below :—

	Location and country			*Capacity*
1.	Key, Florida (USA)	..	..	2.4
2.	Tijuana, Mexico	..	..	7.5
3.	Eilat, Israel	..	..	1.0
4.	Sinai, Egypt	..	..	0.6
5.	Doha, Qatar	..	..	1.8
6.	Shuwaikh, Kuwait	..	..	2.52
7.	Shuaiba, Kuwait	..	..	6 0
8.	Shuaiba, Kuwait	..	..	30 0
9.	Kharak is., Iran	..	..	0.3

The Key West Plant has been producing fresh water since 1969 for a reported S0.85 per gallons. The Mexican plant produces water for $0.75 per 1,000 gallons. In the Middle Eastern countries, where oil is readily available at low cost, the production cost attributable to water production is about $0.55 per 1,000 gallons.

A 12-effect, VTE plant of 1 MGD rated capacity has been operating at Freeport, Texas for many years. This plant, which can produce water for 11 per 1,000 gallons is used primarily for research and development of VTE concept. A commercial plant of 1 MGD capacity has been installed at St. Croix, Virgin Islands.

Saudi Arabia has a VC-type desalination plant, 0.2 MGD capacity, at Dhahran. The VC plant, located at Roswell, New Mexico (USA), is the biggest of its kind and is used mainly as a research tool.

MEMBRANE POCESSES

Electrodialysis (ED)

The basic principle of this salt removing process is shown in Fig. 3. It uses perme-

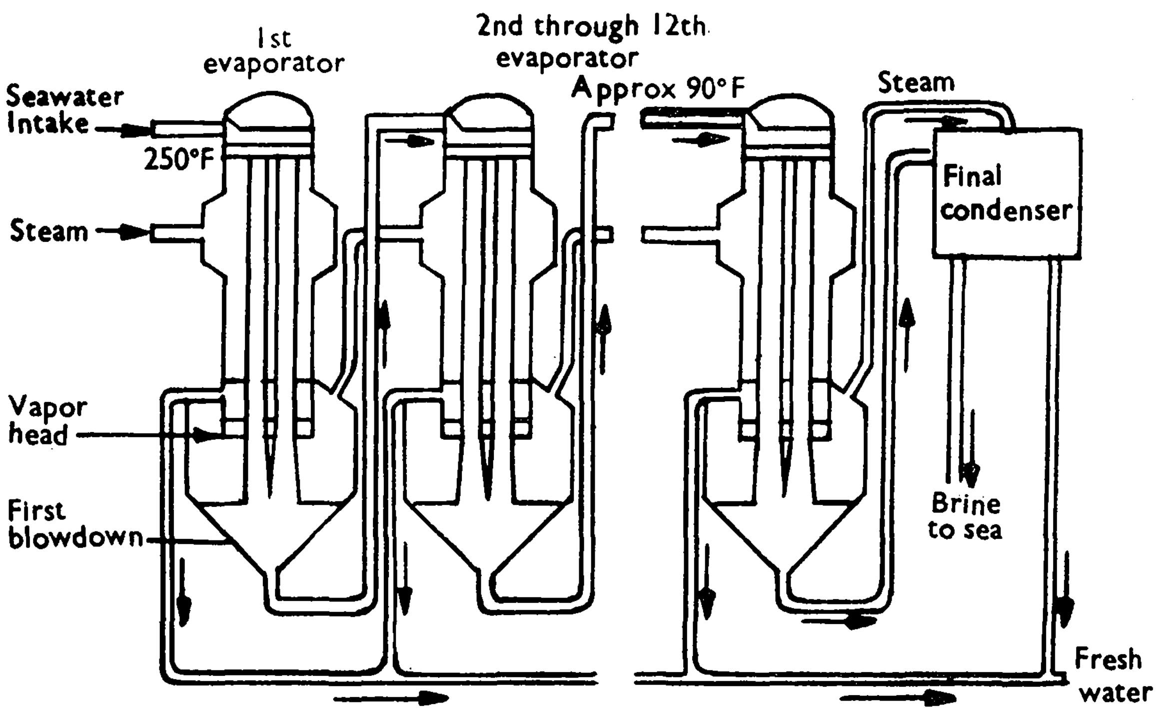


FIGURE 2.

VERTICAL-TUBE EVAPORATOR PROCESS

able membranes that allow ions to pass in one direction only. The C-type-Membrane is permeable only to positive ions, while A-type Membrane is permeable only to negative ions. These membranes are stalked between the anode and cathode. When saline feed is pumped in the compartments and a direct current potential applied across the ancde and cathode, the positive ions in the soluticn pass towards the cathode. These ions pass easily through the C-type membranes, but are stopped by an A-type membrane. Similarly, negative ions, while migrating towards the anode, pass through the A-type membrane and are stopped by a C-type membrane. The ion concentration increases in alternate compartments. Simultaneously, the other compartment become depleted of ions.

ED plant uses a series of such stages to reduce the salinity to the desired level. The pre-treatment consists of screening for trash removal, chlorination to retard the growth of algae, coagulation, rapid and filteration and chemical treatment, if necessary. From the pre-treatment plant the feed water is pumped simultaneously to all the stages. Also, product from first stage is pumped as feed to the second stage and so on, whereas brine from all stages is usually discharged. Product water from the last stage is either pumped directly into the water supply system or into storage tanks.

There is a large number of Ed plants in the Middle East and elsewhere with a total installed capacity around 5 MGD. The cost of fresh water produced by this method is attractive. The power requirement for the ED process is about 5 Kwh/1000 gallons product per 1000 ppm reduction in salinity. Typical pumping power requirements are about 3 Kwh/1000 gallons of products. However, ED is limited to use for brackish water with total salt concentration below 5000 ppm. Also, the product water is less pure (about 5C0 ppm. TDS) than that from distillation processes and organic impurities generally remain in the product. Other than MSF, ED is the chief process extensively used for commercial, land-based application.

Reverse Osmosis (RO)

This process depends on certain semi-permeable membrane which allow certain components of a solution to pass through, while one or more of other components are retained. Cellulose acetate is one such material that possesses the property of semi-permeability. If relatively pure water contained on one side of semi-permeable and a salt solution on the other side, water, under normal conditions, will flow through the membrane and enter into the salt solution. This phenomenon is known as Osmosis, and the driving potential for the flow of pure water is known as Osmotic pressure. If an external pressure greater than the osmotic pressure is applied on the salt solution, a reversal of flow will occur, thereby further concentrating the salt solution and producing pure water.

The RO process, shown in Fig. 4, is conceptually very simple ; all it requires is fluid containment, semi-permeable membrane, and high pressure process pump to pressurize the saline feed stream. In the so-called tabular membrane configuration, the membrane is supported by a porous backing material such as nylon, plastic sheet, and fiber glass re-inforced epary tubes.

Saline feed at a suitable pressure (between 600 and 1000 psi) is pumped through a tube and product water is collected in inexpensive plastic containers.

Pre-treatment of feed, like ED, is necessary to prevent calcium sulphate scale formation on the RO membrane.

There is, as yet, no large scale commercial plant in operation. However, this process has progressed rapidly and, due to its simplicity and low energy cost, is considered

LEGEND

C = MEMBRANE PERMEABLE TO POSITIVE IONS ONLY

A = MEMBRANE PERMEABLE TO NEGATIVE IONS ONLY

⊕ = ANY POSITIVE ION SUCH AS Na^+

⊖ = ANY NEGATIVE ION SUCH AS Cl^-

FIGURE 3.

ELECTODIALYSIS PROCESS

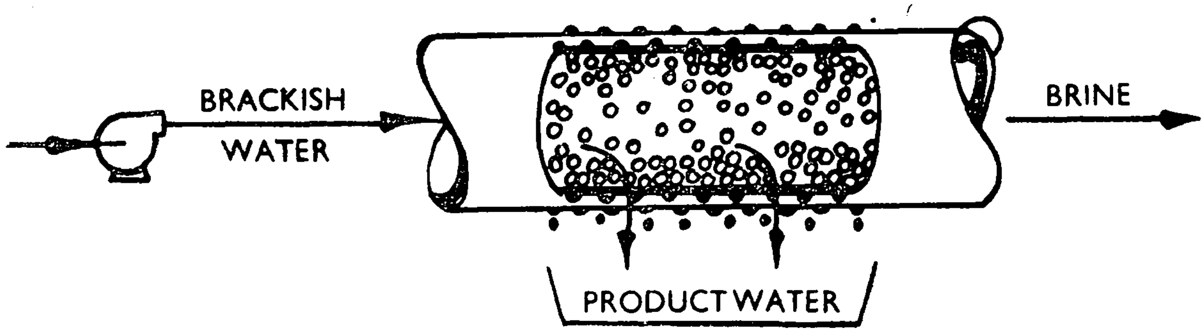
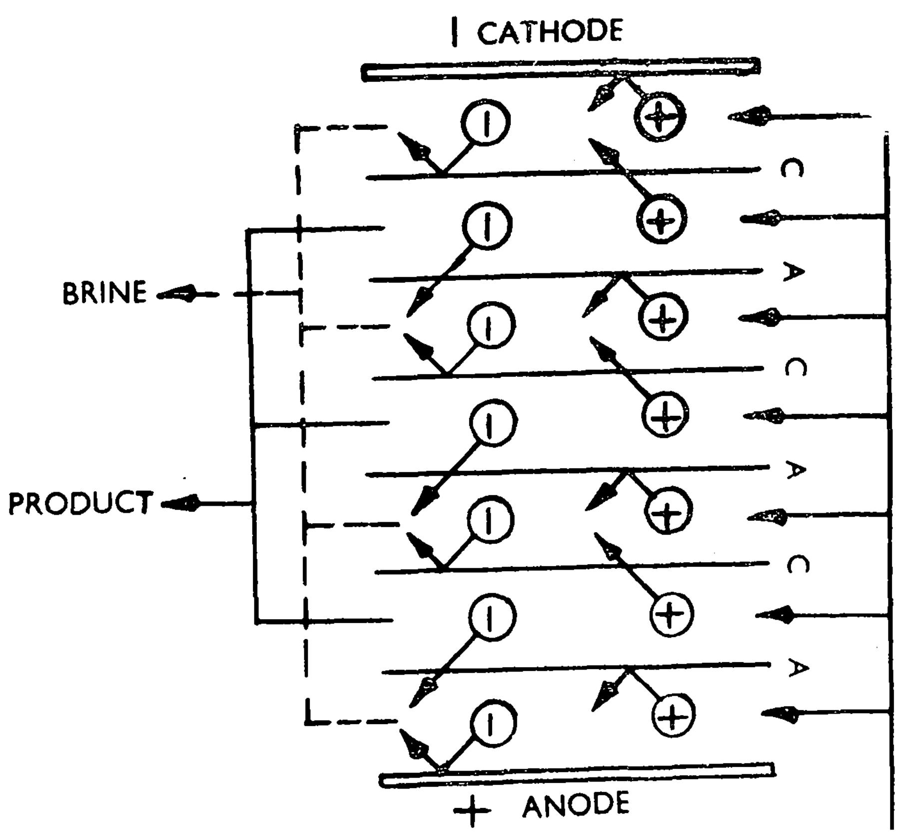


FIGURE 4.

REVERSE OSMOSIS PROCESS



to be a practical alternative for the desalting of brackish waters with salinities upto 10,000 ppm TDS.

Examples of Membrane Type Desalination Plants

Desalination plants based on ED are numerous. Bahrain, Saudi Arabia, Libya, Kuwait have, among others, ED plants, of 0.1, 0.1152, 0 1152, 0.24 MGD capacity respectively. The largest ED plant (1.2 MGD) located at Siesta Key, Florida (USA) has been producing water since 1969 at $0.35 per 1,000 gallons. A 0 65 MGD capacity plant at Buckeye, Arizona (USA) has produced water at $0.65 per 1,000 gallons for several years.

A 0.1 MGD RO plant was built at Plains, Texas (USA) in 1969 to meet the municipal requirements of the town.

Solar Desalination

In this process, the heat energy for desalination is provided by direct solar radiation. The solar energy is directly absorbed in the saline water or on an adjacent surface and the evaporation of a portion of water takes place in an enclosed air space. This evaporation occurs at a temperature substantially below the normal boiling point, about 20 to 30°F above the atmospheric temperature. The pure water vapour is usually condensed in the same enclosure on cool surface.

The plant consists of a horizontal basin to which saline water is supplied continuously or intermittently to depths ranging from an inch to a foot. The drain is provided for continuous or intermittent discard of concentrated brine. The bottom of the pool is a black surface (asphalt sheets, butyl rubber etc.) which absorbs bulk of the incident radiation energy. Heat is conducted from the bottom surface into the saline water, thereby raising its temperature and vapour pressure. Above the basin, a transparent cover of glass sheet or plastic film, arranged at an angle so that the vapour condensing on the underside of it, drains into gutters or troughs underneath. The fresh water from the troughs is piped to storage.

It is apparent from the above description that the solar distillation process and apparatus are extremely simple. There are no pumps involved, and the plant is practically self-operating. But solar stills are suited only to regions of sunny climates. Another characteristic of the solar stills is that they occupy large areas. Therefore, in the multi-million-gallon category, they cannot complete with the methods using conventional energy sources. Small solar stills upto a few thousand gallons per day capacity have been quite successful.

Today's large solar stills are located in Australia, Greece and Spain etc. Perhaps the largest commercial solar plant is located on the island of Patmos, Greece, with total capacity of 10,000 gallons per day (GPD). The cost of fresh water produced by solar plants can be as high as $5.0 per 1000 gallons or higher.

Dual-Purpose Desalination

In a desalination plant based on distillation process, the maximum operating temperature is limited by alkaline and calcium sulphate scale formation. At present, the acid treatment of feed permits a maximum temperature of 250°F. In general, it would be uneconomic to raise steam at this low temperature (250°F, 30 psi) purely for the purpose of heating the brine ; it does not cost all that much more to raise the same amount of steam

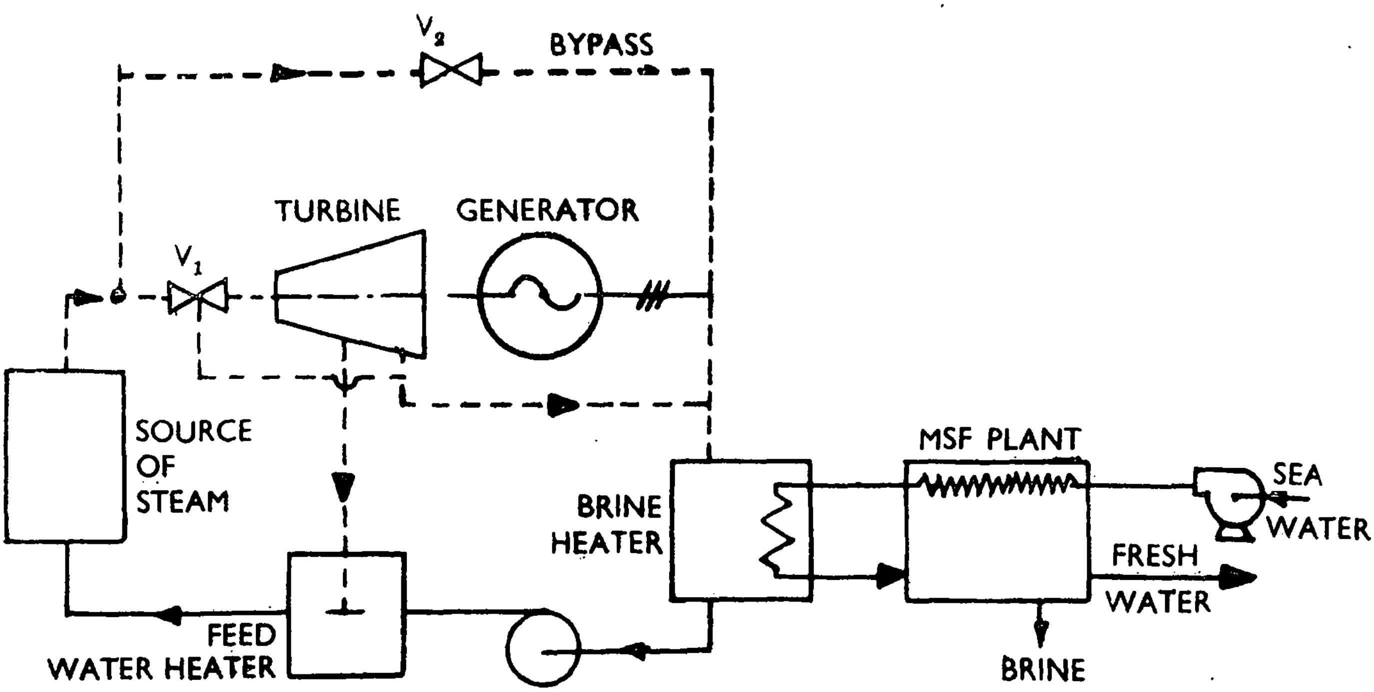


FIGURE 5

DUAL—PURPOSE PLANT, BACK PRESSURE CYCLE

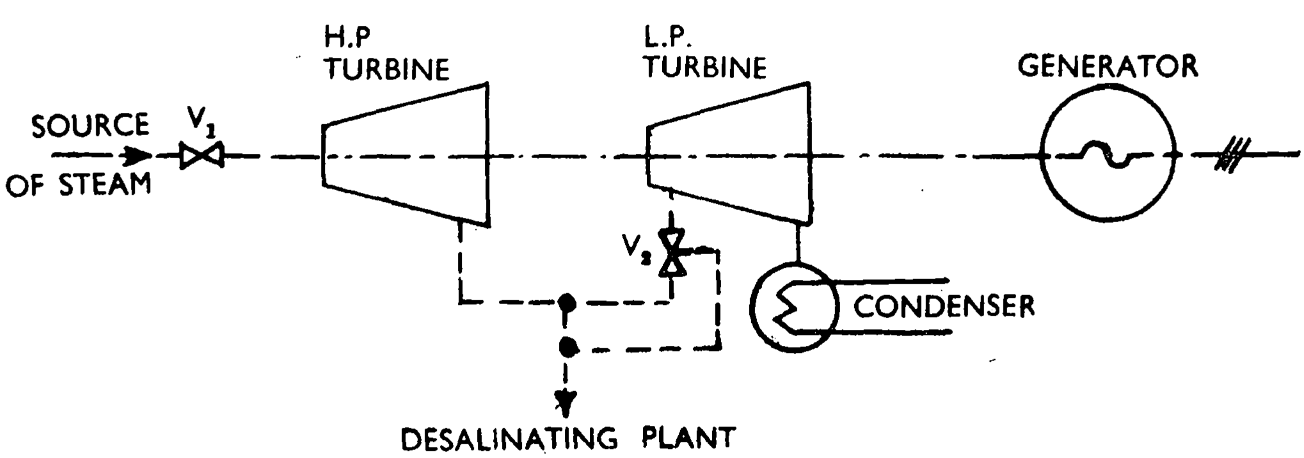


FIGURE 6.

DUAL—PURPOSE PLANT, EXTRACTION CYCLE

at high temperature and pressure required for a modern power station. The obvious method to supply low grade steam for a desalination plant is, therefore, to generate steam at high temperature and pressure, extract a substantial amount of the available energy from the steam for driving the turbo-generator and, after the steam has been dropped to the appropriate temperature and pressure, condense it in the brine heater of the desalination plant. This, then, is the principle of a Dual-Purpose Power Desalination Plant. Depending upon plant size and fuel costs etc., a general value for exhaust steam equal to about half the cost of prime steam is obtained in a Dual-Purpose Plant, while there appears to be a saving of about 15% in the cost of desalted water compared with the Single-Purpose Plant.

There are two basic schemes of hooking up the two plants. (1) Back-Pressure-Scheme and (2) Extraction Scheme. The type of power plant scheme to be used in a Dual-Purpose Plant is dependent primarily upon the so-called power/water ratio, that is, the ratio of the net power production in MWe to net water production of MGD. The Back-Pressure Scheme is suitable for the lowest ratio while the Extraction Scheme is appropriate for the highest power/water ratio.

Back-Pressure Scheme

In the Back-Pressure Scheme, shown in Fig. 5, all the steam produced in the boiler is expanded in the turbine and then condensed in the brine heater to raise the brine temperature to about 250°F. The by-pass steam line shown in the figure, serves to control the turbine exhaust pressure as well as provides a means to run the Desalination Plant at a maximum capacity during period of low paper demand. This provides some flexibility though at the cost of efficiency, since the steam throttled through the by-pass valve produces no power and the resultant water produced is, thus, relatively more expensive.

This scheme has relatively low investment cost and is suitable for Dual-purpose Plant whose prime product is deslated water (power/water ratios between 1.5 and 8).

Extraction Scheme

In this scheme, shown in Fig. 6 all of the steam produced in the boiler first passes through a high pressure turbine after which it splits ; part of it going to the brine heater of the desalination plant and the rest being expanded in the low pressure turbine. The valve V_2 serves to control the pressure of the heating steam and provides a greater flexibility in adjusting the power/water ratio.

This scheme has relatively investment cost and is suited to dual-purpose-plants which low water production and high power demand (power/water ratio 25 and above).

Development Status of Nuclear Desalination

There is, at present, only one dual purpose nuclear desalination plant reportedly in operation in the Russian port city of Schevchenko on the Capsain Sea. The desalination plant of 1.3 MGD capacity is reportedly of VTE type. Another dual purpose plant is planned for the western coast of California, USA. This plant, which is expected to go into operation by 1978, will be hooked up with the nuclear power plant already under construction on Diablo Canyon site. The plant will employ Multi-Stage-Flash (MSF) process and will produce 40 MGD of fresh water. The desalination plant alone is expected to cost \$ 66.2 million, and the conveyance system another \$ 30.8 million. Water cost, including conveyance would be about \$ 0.92 per 1000 gallons, or \$ 300.00 per acre foot. Kuwait

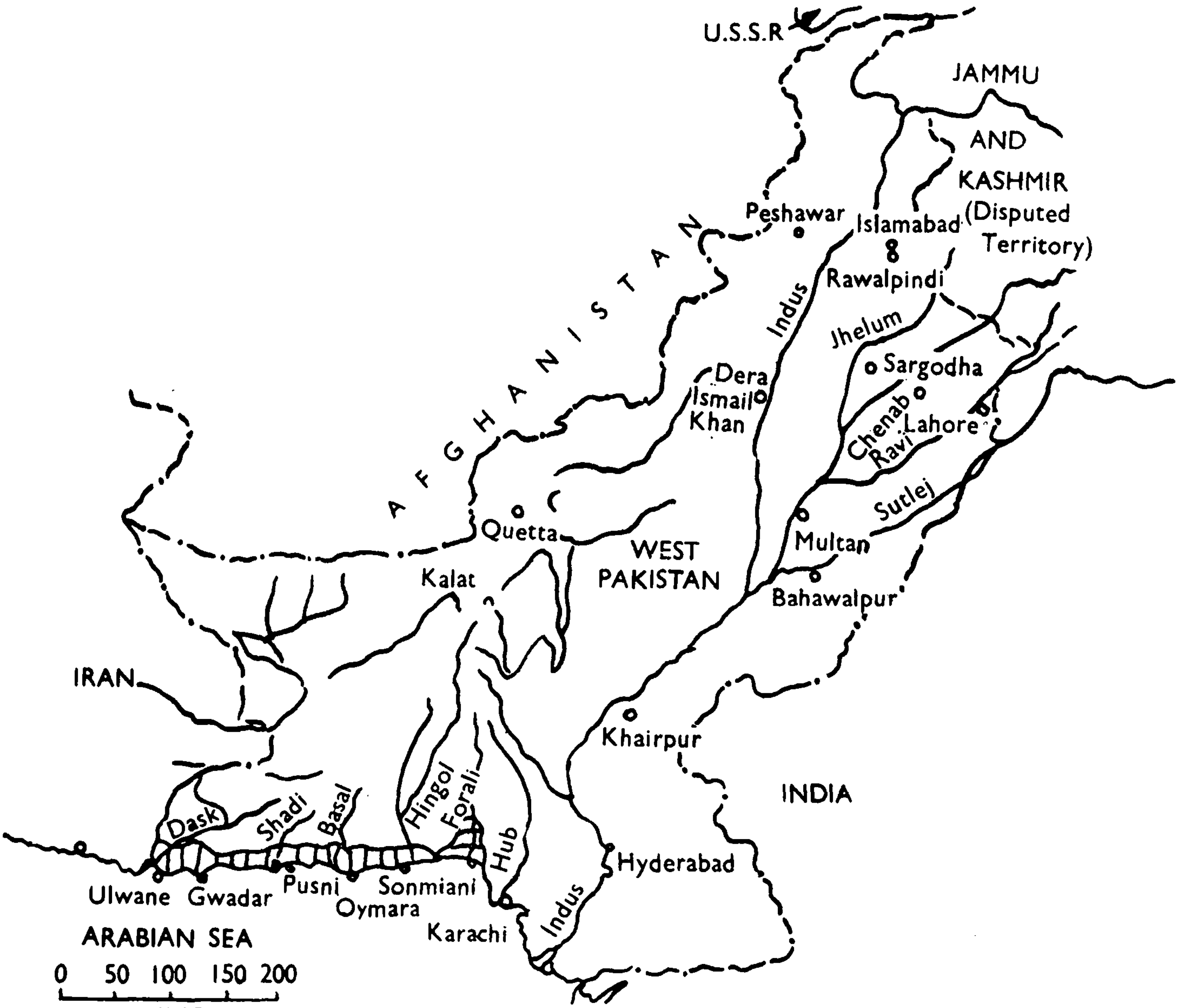


FIGURE 7.

MAP OF PAKISTAN

and Saudi Arabia also have dual purpose plants in which the source of steam is the conventional oil-fired boilers. The 30 MGD Kuwaiti plant, the largest in the World, employees the MSF concept and is linked with two electrical power plants located at Shuaiba. The desalination plant was completed at a total cost of $ 20.8 million and produces fresh water at a cost of about S 0.30 per 1000 gallons. The Saudi Arabian dual purpose plant, built in 1971 at a total cost (both for power as well as desalination plant) of $ 23.00 million, produces 50 MWe of electrical power and 5 MGD of desalted water at the part city of Jeddah.

PAEC NUCLEAR DESALINATION PROGRAMME

Interest of PAEC in the Dual Purpose Power Desalination dates back to 1965. It was realised at that time that the 300 miles long arid coastal zone of Mekran (Fig. 7) offered bright prospects of agricultural and industrial development provided the three basic requirements for development, namely, power, water and communication were made available. Since PAEC, by setting up a dual purpose nuclear desalination plant, was in a position to provide two of the basic facilities, it was decided to conduct the survey of the area with regard to its power and water resources and requirements. The study, however, revealed that the high capital and operational cost of a Nuclear Desalination Plant in MWe and Multi-Million Gallon Per Day range would not be feasible for the poor and sparsely populated communities of the Mekran Coast. In the absence of a guaranteed market to absorb large blocks of power and huge quantities of water, PAEC restricted its activities to setting up a 7200 GPD Solar Desalination Plant for Gawadar, one of the coastal towns on the Makran coast. The plant was completed in two years in October 1972 at a cost of Rs. 17.5 lacs. Since then the inhabitants of Gawadar, who used to pay Rs. 120/1000 gallons for brackish and unhygienic water have been getting their drinking water supply free of charge.

The PAEC then focussed its attention on setting up a dual-purpose nuclear desalination plant at Sonmiani, a small coastal settlement some 50 miles to the West of Karachi, which is located on the mouth of Miani Hor Lagoon. The arguments in favour of its selection as a candidate site were that

(*a*) Sonmiani was likely to develop as one of the Satellite Towns of Karachi Metropolitan area so that its water and power requirements would grow along with the pattern of Karachi.

(*b*) Sonmiani was a likely choice for the second port for Weat Pakistan.

The PAEC prepared a preliminary report on the feasibility of a dual purpose nuclear desalination plant for Karachi—Sonmiani area. A Nuclear Desalination Expert from the International Atomic Energy Agency (IAEA) was invited to review the desalination programme of PAEC. It was jointly recognised by the IAEA Expert and PAEC that, independent of the location of the new port, there was a need for water for the Greater Karachi Metropolitan Area.

Water Situation of Metropolitan Karachi

Karachi has been getting its water supply for several years mainly from Indus River under the Greater Karachi Bulk Water Supply Scheme which was designed for an ultimate capacity of 280 MGD in four phases of 70 MGD each. This water was to be obtained from Kotri Barrage (Fig. 8) at Indus River, nearly a 100-miles away, and conveyed through Kalri Lake to Metropolitan Karachi. Phases I and II, finished in 1962 and 1971 respectively, resulted in a total supply of 160 MGD as against a demand of 136 MGD and Phase III, scheduled for completion in 1977-78, will supply another 70 MGD. Additional 70 MGD have been

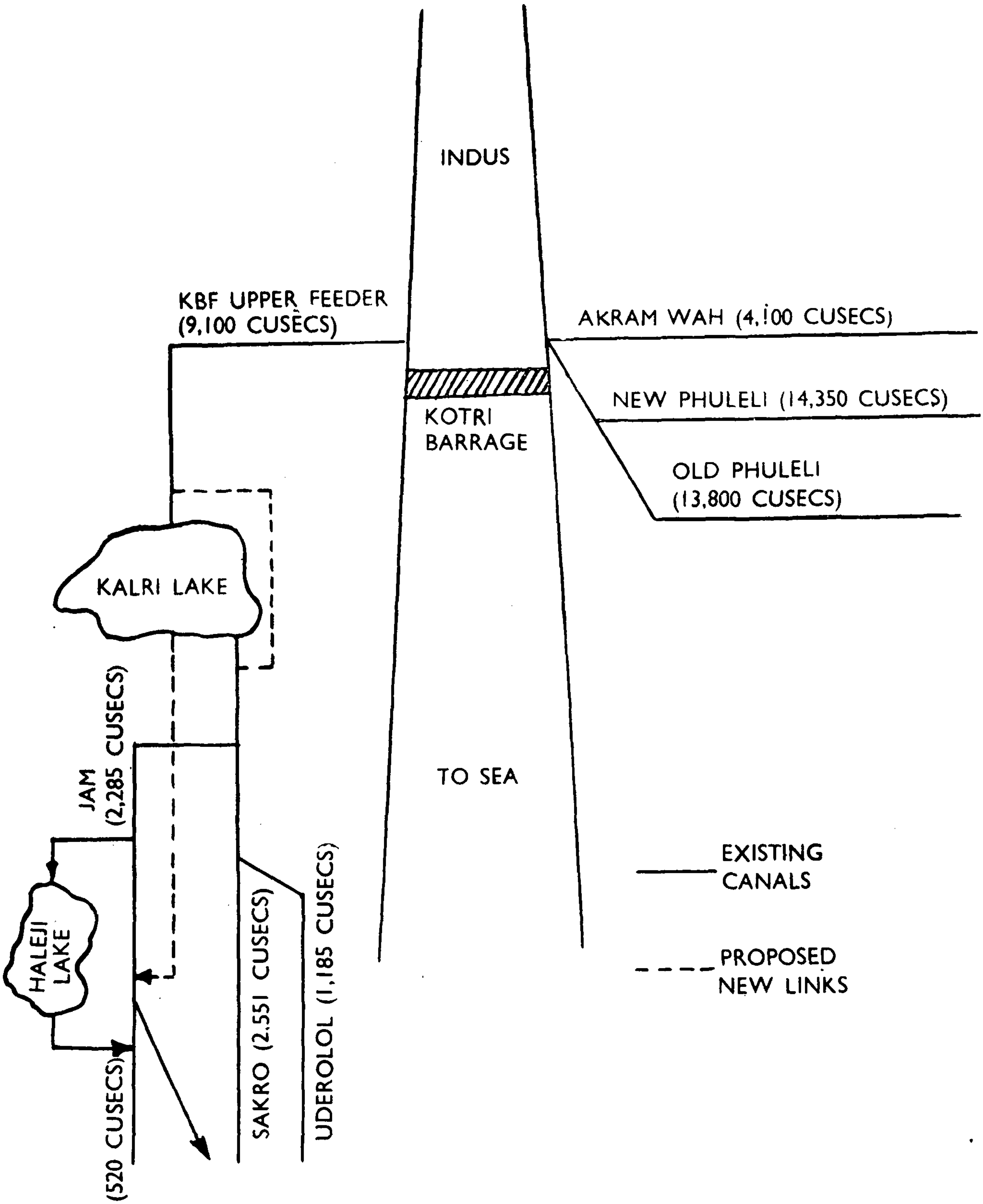


FIGURE 8

WATER DELIVERY SYSTEM FOR KOTRI BARRAGE
AGRICULTURAL PROJECT AND KARACHI WATER SUPPLY

allocated to Karachi from the HUB Dam Project which was originally meant to provide all of its supplies for irrigation to virgin lands in the Lasbela and Karachi districts. Phase IV will most likely be completed by mid 1980s, making the total supply from the scheme, of 350 MGD for Metropolitan Karachi. The estimated water demand will rise to 401 MGD by 1986 and 550 MGD by 1990. Obviously there is a serious threat of water shortage in the mid 1980s unless alternative sources of water are identified and developed in the meantime.

Power Situation

In view of the expected steady growth in the population and industry of Metropolitan Karachi the gross-maximum demand for power will rise from about 350 MWe in 1973 to about 1500 MWe by 1985. The contingency plans must, therefore, be made to meet the expected demand through the 1980s. However, the indigenous fuel for thermal power is in short supply. The hydro-power, mostly located in the North, will be unavailable to the Karachi grid in the foreseeable future. In view of this the alternative left with the planners of the Karachi Zone are imported oil-fired and/or nuclear power plants. Whereas in terms of capital cost the nuclear reactors are much more expensive than the conventional power plants (though in the bigger size range, 400 MWe and above they appear to be competitive), their fuel cost per KW, however, is much lower. Since it is reasonable to believe that the prices of nuclear fuel will fall further while those of the conventional fuels will go up with time, nuclear reactors become a particularly attractive choice for power production in the Karachi Zone. PAEC's Nuclear Power Plant, KANUPP of 137 MWe gross capacity, has been supplying power to the Karachi grid since 1972.

Alternatives to Augment Water Supply of Metropolitan Karachi

In the opinion of PAEC, there are only two real alternatives for augmenting the water supply of Metropolitan Karachi beyond the mid 1980s ;

(*a*) Storage of Indus Flood Water, and

(*b*) Nuclear Desalination.

During summer months of June-September, large quantities of Indus flood water flow down and are lost to the sea. This excess water could be impounded to provide an additional supply of water for Karachi. It was learnt from the Irrigation authorities that, whereas no site existed where water could be stored by gravity, there are several possible sites for building a storage area to which flood water could be pumped. It was also found that if the present embankments of Kalri lake (which is a part of Greater Karachi Bulk Water Supply Scheme and has a maximum capacity of 300 MGD) were raised by about 6 feet, the increased capacity would be sufficient to store the Indus flood water to supply an additional 150 MGD to Metropolitan Karachi. A feasibility study of such a scheme needs to be undertaken. In view of its background, WAPDA is being requested to undertake the study. PAEC will, most likely be responsible for the preliminary engineering feasibility study of a Dual Purpose Nuclear Desalination Plant of roughly 300 MWe and 150 MGD capacity. Preliminary data on five candidate sites namely, Sonmiani, Cape Monz—West, Cape Monz—Buleji, Bundal island, and Pipri/Gharo area have already been collected.

Both the studies are proposed to be conducted under the same ground rules so that the results form the basis for the appropriate decision.

Discussion

The discussion included questions on the necessity of such plants, their relative cost, disposal of concentrated residues and planning aspects for setting up of such plants. Dr. F. H. Butt stated that alternate sources of fresh water if available in places like Karachi were always to be preferred over sea water in meeting the requirements for public water supplies. He was of the view that the cost of desalination is not a function of salinity of raw water when distillation types of methods are used. In dealing with the problems of waste disposal the salt sometimes is reclaimed, discharging the waste water back into the sea. In any case the effect of such discharges on marine life deserves careful study.

-A REVIEW OF WATER SUPPLY POSITION IN DEVELOPING COUNTRIES

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It has been said that if one can define the problem one half-way to solving it ; in most developing countries the problem of community water supplies has still to be properly defined, without exception each country knows it has this problem but its precise magnitude is yet to be assessed ; let me add that the so-called more developed or developed countries have similar problems.

Broadly the broblem can be divided into two sectors viz. the urban communities and the rural areas. We immediately run into a definition problem with these sectors if we wish to compose one country with another as "urban" has a different meaning the different countries :W.H.O. generally would consider a minimum population of 5000 people as urban but we accept that this may not be the pattern in many countries and we do not suggest that national definitions be changed.

For urban communities, whatever the definition, most developing countries have made considerable headway in the provision of public water supplies, however it is unfortunately true that these installations are now inadequate ; too frequently they have intermittent supplies, with resultant health hazards ; they suffer from low pressure denying water to other than ground-level taps ; they lack surveillance to ensure safe water of acceptable quality ; and their financial management is weak, often resulting in annual expenditure for outstripping revenue even in locations where the wealth of the community is such that the water utility should be financially self-supporting.

Politicians and planners tend to overlook the fact that the demand for water rises each year, not only is there the urban population growth, invariably higher than the national growth rate, but there is the ever increasing per capita/day demand growth arising from higher living standards plus the accelerating non-domestic demand of trade and industry not to mention the fire service requirements.

For rural communities, whose needs have only in more recent years been recognised, programmes to provide safe water are almost universal but very few countries have a clear idea of the magnitude of the problem or of the resources such as time, finance and manpower necessary for its solution. New problems facing rural areas include population growth, contamination of traditional sources due to industrialization up-stream of the intake, salt water intrusion due to overdrawing from wells and the depletion of sources due to the construction of dams etc.

* The views expressed in this paper are of the author and do not necessarily represent those of WHO.

These problems listed above are not all inclusive but are typical of those I have met in recent years during my various assignments with WHO which have covered four WHO Regions and a spell at Headquarters in Geneva. Later in this paper I will briefly discuss how some countries are tackling these various problems frequently with WHO &/or UNDP assistance, material aid from UNICEF, World Bank/IDA loans, bilateral aid etc. Whatever this assistance it can only be marginal and the major input and effort must be internal.

During 1972 WHO HQ in Geneva, with the assistance of all its Regional Offices collected a lot of information on the community water supply situation in many developing countries ; specifically it was desired to ascertain changes between the years 1960 & 1970 and to define targets for the period through to 1980. In 1960 W.H.O. had undertaken a global assessment of community water supplies and publish a report based on details supplied by 75 developing countries, the present review cover some 90 countries and later this year the results of the latest survey will be published.

At the 25th World Health Assembly the Director-General of WHO presented a progress report on the "Community Water Supply Programme" and I will now touch on certain high-lights from this report.

The report is primarily concerned with 90 developing countries whose population in 1970 was 1,627 million, for the decade 1970—1980 their population is expected to grow by 32%, that is an increase of 523 million to a total of 2,150 million.

Breaking these figures down into rural and urban communities the 1970 populations were respectively 1,162 million & 461 million ; by 1980 the rural growth, estimated at 23% will result in an increase of 272 million people while the urban areas will have a higher growth rate of 54% giving a numerical growth of 251 million to 712 million.

In this paper we are only considering the implication of this in relation to water supplies but you can see the problems facing governments are formidable these hundreds of millions of people will need homes, hospitals, schools etc.

To assess the water supply problem WHO collected data on the 1970 situation to determine shortfalls in existing supplies, this indicated that at that date 50% of the urban population was not adequately served & 88% of the rural population was in a similar plight. If the population growths through to 1980 are added then at that terminal date the population not served or inadequately served would be 68% urban and 90% rural, the total population so affected being 1,781 million.

It is unrealistic to imagine this situation can be rectified to give all people a safe and adequate water supply by 1980, the resources are just now available ; however the great importance of such facilities in socioeconomic development and the proven benefits to national health indicate that targets for the decade must be ambitious but realistic.

Targets have been set as follows :

Urban : All urban dwellers should have access to safe water, 60% to be served by private house connections & 40% to be served by private standposts.

Rural : 25% of the 1980 rural population to have reasonable access to safe water.

To summarise what this means in urban areas is that 198 million additional people are to be served by private connections ; 193 million additional people are to be served by public standposts : at an average per head cost of US $ 38 for the first group and US $ 15 for the latter, this implies an investment of US $ 10,400 million.

For the rural communities an additional 217 million persons are to be served and at an average cost of US $ 13 per head the necessary investment is US $ 2,800 million.

In the view of WHO these targets are attainable if the respective countries make the requisite efforts, it will be easier for some than for others. Based on reports from Member States to WHO constraints seen to successful programme implementation are lack of internal finance, lack of trained personnel ; inappropriate administrative structure, insufficient external financing, inappropriate financial framework, insufficient production of local materials and inadequate or outmoded legal framework. While the order of priority was not exactly the same in each country the order given is the most typical.

If we can now go back and consider progress in the decade 196C—1970, the global position of community water supplies in developing countries was as follows :—for urban communities in 1952 approximately 33% of the population was served by private connections and by 1970 this had risen to 50 ; approximately 26% of the population had access to standpost water in 1962 and this fell to 20% by 1970 thus while in 1962 59% of the population had access to water either by means of private connections or through public standposts by 1970 this had risen to 70%.

For rural areas less than 10% had access to safe water in 1962 while by 1970 this had risen to 12%.

These changes become more meaningful if put into actual figures, very approximately, almost 20 million persons per year were added to the population with access to safe water.

The investment to achieve these successes has been considerable and an appreciable contribution has come from external sources ; WHO has estimated that loans totalling US $ 269 million were made 1958—1969 and US $ 159 million in 1970 alone.

For rural water supplies WHQ has been able to assist countries to obtain UNICEF assistance which is primarily in the form of materials ; for the 5 year periods 1961—65 and 1966—70 this assistance was US $ 10-9 million and US $ 11.3 million and commitments for 1971 amount to a further US $ 4.5 million.

It's hoped I have not overloaded this paper with statistics (WHO has a lot more), but it is only by quoting figures and percentages that the extent of the problems, now and in the future, and progress made in the past and which should be made in the future, can be visualised.

Based on my own experience the following impressions have been gained on certain aspects of water supplies in some developing countrier. —

Organization

In recent years many countries have come round to the view that central or regional organizations need to be set up to deal with public water supplies ; municipal autho-

The World Bank affiliate (IDA) International Development Association, makes interest-free loans to countries for up to 50 years with a 3/4 of 1% service charges, however IDA expects Governments to reload such funds at ruling interest rates.

Many countries have benefitted from UNICEF assistance in the development of their rural supplies, here the assistance is in materials such as pumps, pipes etc. local people make their own contribution in cash or, more frequently labour and local. materials such as sand, bricks, etc.

Conclusion

This paper is in somewhat general terms but it is hoped it has given the broad picture of what has been achieved and what future goals are in the developing countries. Much has been done but much remains to be done. If the goals set out by WHO are achieved this decade the benefits to health and national economic during development will amply repay the effort and investments involved.

SURVEILLANCE OF WATER QUALITY

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Introduction

The importance of a sanitary survey of sources of water cannot be over-emphasized. No bacteriological or chemical examination, however careful, can take the place of a complete knowledge of the conditions at the source of supply and throughout the distribution system. Every supply should be regularly inspected from source to outlet by experts, and samplying particularly for purposes of bacteriological examination should be repeated under varying climatic conditions, especially after heavy rainfall and after major repair or construction work. It should be emphasized that when sanitary inspection shows that a water as distributed, is liable to pollution, it should be condemned irrespective of the results of chemical or bacteriological examination. Contamination is often intermittent and may not be revealed by the chemical or bacteriological examination of a single sample, which can provide information only on the conditions prevailing at the moment of sampling; a satisfactory result cannot guarantee that the conditions found will persist in the future.

With a new supply, the sanitary survey should be carried out in conjunction with the collection of initial engineering data on the suitability of a particular source and its capacity to meet existing and future demands. The sanitary survey should include the detection of all potential sources of pollution of the supply and assessment of their present and future importance. In the case of an existing supply, a sanitary survey should be carried out as often as required for the control of pollution hazards and the maintenance of the quality of the water.

Chemical Examination

In Pakistan there appears to be a great fear of being poisoned by chemicals in water while the much greater risk of contamination by bacteria and virues is often overlooked.

The chemical quality of water in any natural form does not change much over the years so complete chemical analysis of public supply needs not to be carried out as frequently as the bacteriological examination.

Most likely sources of chemical poisons are :

(1) Toxic substances leached from mineral formations.

(2) Phytotoxins manufactured by some rare algae.

(3) Minerals leached from badly manufactured copper and PVC pipes.

(4) Pesticides and other industrial pollutants reaching natural waters.

The regular-say six monthly-complete chemical analysis of water is recommended. however for the purposes of providing advanced warning of a decline in quality. The graphical extrapolation of results will rapidly show any deterioration in quality-such as the increase of chloride or sulphate content in underground waters or sulphates from agricultural fertilizer in rivers.

The recommended limits of chemical substances for drinking water are given in the WHO International Standards for Drinking Water Quality. The latest edition is 1971.

In the past waters containing a higher proportion of chlorides or total solids have been classified as 'Unfit' for human consumption. However we should endeavour to qualify such broad statements since in many cases there is no alternative source of water available.

Bacteriological Examination

The highest importance should be attached to the frequent and regular bacteriological examination of water for public supplies.

The frequency of examination, the locations of sampling points at pumping stations, treatment plants, reservoirs and throughout the distribution system should all be carefully arranged to provide a total coverage of the system and ensure a safe water supply reaching the customers connected to the system.

The greatest danger is from recent contamination from sewage or human excrement. If such contamination has occurred sufficiently recently the water may contain the living pathogens of such diseases as dysentry, enteric fever, typhoid and cholera. The drinking of such water will result in fresh cases of the disease concerned.

Chlorine has two beneficial effects when added in quantities sufficient to maintain a residual concentration. The first is that the residual may afford some protection against subsequent contamination of the treated water within the distribution system ; normal concentrations, of the order of 0.2 mg/l are too low to have much of an effect of this kind, but larger doses, such as those given in an emergency, can provide some protection, though not against a massive instruction of pollution. The second is the possibility of supplementing bacteriological testing with the much simpler colorimetric test for free and combined residual chlorine. Disappearance of the residual chlorine is an immediate indicator of the entry of oxidizable matter, or of a malfunctioning of the treatment process that should have removed it before chlorination.

As chlorine residual tests can be carried out in minutes (compared with the hours required for bacteriological examinations) and by unskilled staff without laboratory facilities, it is recommended that maximum use should be made of the potentialities of such tests as a supplement to, though not as a substiture for, the bacteriological testing programme.

Organisms Indicative of Faecal Pollution

All the members of the coliform group may be of faecal origin, and the worst possible interpretation should therefore be attached to their presence in water ; thus, from a practical point of view, it should be assumed that they are all of faecal origin unless a non-faecal origin can be proved.

The finding of faecal streptococci is important confirmatory evidence of the faecal nature of the pollution.

Methods of Detection

Multiple Tube Method

Measured volumes of water are added to tubes of a culture medium and these are then incubated for a period of time after which they are examined for signs of reaction given by the growth of coliform organisms.

By a count of the numbers of tubes showing a positive reaction an estimate of the "Most Probable Number" of coliforms present can be made.

The following table shows the Most Probable Number of organisms present in 100 ml of the water, if five 10 ml volumes were examined.

Number of Tubes giving positive reaction out of 5 of 10 ml each	*MPN in 100 ml*
0	0
1	2.2
2	5.1
2	9.3
4	16.0
5	INFINITE

The advantage of this system is that these presumptive tests give results after 48 hours allowing for early remedial measures to be taken in the case of positive results. So immediate notification to the manager in charge of the system showing positive reaction must be given so that he may take steps to halt the pollution. Notification should be of a helpful nature giving exact location of sampling point, the extent of pollution, and proposed remedical measures such as chlorination of reservoirs or searching for underground breakage of mains near a sewer.

Presumptive tests are followed by confirmatory tests and complete conformation may be determined by culture on a plate of solid medium where actual colonies developing may be counted.

Membrane Method

In this method a measured quantity of the water is passed through a membrane of porous cellulose. The bacteria are retained on the surface and by incubating with a suitable media at the appropriate temperature a direct count of the number of coliforms present in the water can be obtained by counting the number of colonies developed from each bacteria.

Counts on membrane are, however ; subject to statistical variations and may not give consistent results in replicate tests of the same water sample. However this method has great scope for use in countries where bacteriological laboratories are widely spaced necessitating journeys of over one day between the sampling point and laboratory as in Pakistan. Specially designed mobile laboratories are not desirable, as ordinary vehicles can be adopted for this use.

Full information of the use of these methods are given in theWHO publication "International Standards for Drinking Water".

Interpretation of Results and Remedial Measures

Chlorinated or otherwise disinfected supplies

Efficient treatment, culminating in chlorination should yield a water free from any coliform organisms, however polluted the original raw water may have been. It should not be possible to demonstrate the presence of coliform organisms in any sample of 100 ml.

A sample of the water entering the distribution system that does not confirm to this standard calls for an immediate investigation into both the efficiency of the purification process and the method of sampling. It is important, however, in testing chlorinated water, that presumptive positive tubes should always be subject to appropriate confirmatory tests.

Non-disinfected supplies

No water enterning the distribution system should be considered satisfactory if it yields *E. coli* in 100 ml. If *E. coli* is absent, the presence of not more than 3 coliform organisms per 100 ml may be tolerated in occasional samples from established non-disinfected piped supplies, provided that they have been regularly and frequently tested and that the catchment area and storage conditions are found to be satisfactory. If repeated samples show the presence of coliform organisms steps should then be taken to discover and, if possible remove the source of the pollution. If the number of coliform organisms increases to more than 3 per 100 ml, the supply should be considered unsuitable for use without disinfection.

Water in the Distribution System

If any coliform or anisms are found the minimum action required is immediate re-sampling. The repeated findings of I to 10 coliform organisms in 100 ml or the appearance of higher numbers in individual samoles suggests that undesirable material is gaining access to the water and measures should at once be taken to discover and remove the source of the pollution.

The presence of any coliform organisms in a piped supply should always give rise to concern, but the measures-apart from the taking of further samples that may be considered advisable in order to safeguard the purity of the water supplied to consumers will depend on local conditions.

The degree of contamination may be so great that action should be taken without delay, even before the result of the examination of a repeated sample is known. This is a matter for decision by those who know the local circumstances and who are responsible for safeguarding the health of the community.

Sources of Pollution

Water may be polluted in the distribution system from the following causes :

(*a*) Cross connections to polluted water systems.

(*b*) Back-syphonage from tanks and open cattle throughs etc.

(*c*) Defective service reservoirs including Over Head Tanks.

(*d*) Defective fittings washouts, hydrants, valves etc.

(*e*) Defective domestic plumbing systems.

Pollution from outside to the distribution system is much more dangerous than pollution of the raw or untreated water.

In any well controlled water supply the raw water should be regularly monitored at least once per week and any sudden increase in the bacteriological colony count should be treated as an alarm signal indicating a deterioration of the raw water quality. Any deterioration of raw water quality may require greater surveillance of the purification process to obtain a pure and wholesome supply.

Tubewell Sources

In Pakistan we are indeed fortunate in that, bacteriologically pure water is usually available, from deep tubewells tapping underground waters purified by the natural seepage of water through the soil. It is only from tubewells penetrating fissured rocks or coarse pebble or boulder deposite that bacteriological pollution may occur. Treatment of these should be appropriate to the degree of pollution.

River & Canal Sources

These sources are usually heavily polluted with alluvial matter and turbidity necessitating full treatment by conventional methods including sedimentation and filtration. If properly maintained these works will give a high standard of water and chlorination will ensure the bacteriological purity. However in badly maintained works it has been found that this standard is not obtained.

Virological Examination

Enterovirus, neovirus and advenovirus have been found in water and the first named being most resistant to chlorination. None of the generally accepted sewage treatment methods yield virus free effluents.

The method used to inactivate virus in water closely follows that of reduction of bacteria. Tubewell waters are generally free of virus but the normal method of purification of canal or river waters will remove most of the virus before chlorination. In practice 0.5 mg/l of free chlorine for one hour is sufficient to inactivate virus, and 0.4 mg/l of free ozone for 4 minutes has been found to inactivate some virus strains but the resistance of hepatitis virus to ozons is unknown.

Radiological Examination

In the past radiological examination of water supplies have not been carried out since it was thought that there was little radioactivity in the country. However nuclear power generators have been set up and a search for naturally occuring radioactive substances has begun.

A careful watch should be kept on these activities and consideration may be given to the establishment of a national centre where simple radiological examinations of water can be undertaken.

In view of inadequacy of water quality surveillance programmes in this country, the presentation of this paper gave rise to lengthy discussion which included questions on WHO standards, national surveillance agencies, types of disinfectants, use of A. C. pipes for drinking water supply systems.

Discussion

In reply the speaker was of the view that this country should adopt WHO International Standards which have particularly been responsible for developing standard suitable for general use. He assumed that European countries will adopt these standards in time. In view of the non-availability of funds he stated that the work of water quality surveillance is not being done on regular basis. He was of the opinion that Public Health Engineering Departments in the respective provinces should be provided with funds so that surveillance programmes can be implemented. He stated that other disinfecting agents than chlorine can be used for water supplies such as iodine, ultraviolet light, and several others. However, it is not possible to utilize any of these methods without a large measure of skilled labour. The use of carefully regulated doses of iodine can be beneficial, but excessive dose can cause diseases similar to iodine deficiences. Regarding A. C. pipes the speaker said that it has been discovered that certain tumors formed round nucleus of asbestos cement fibre. This had led to the question of risk in the use of A. C. pipes for drinking water supply. However if pipes are properly washed out and cleared after laying, there should be no such risk. In fact the cases of tumors already discovered have been associated with the inhalation of asbestos cement dust particles during manufacturing process or otherwise under circumstances which have no relevance to the use of A. C. pipes in water supply systems.