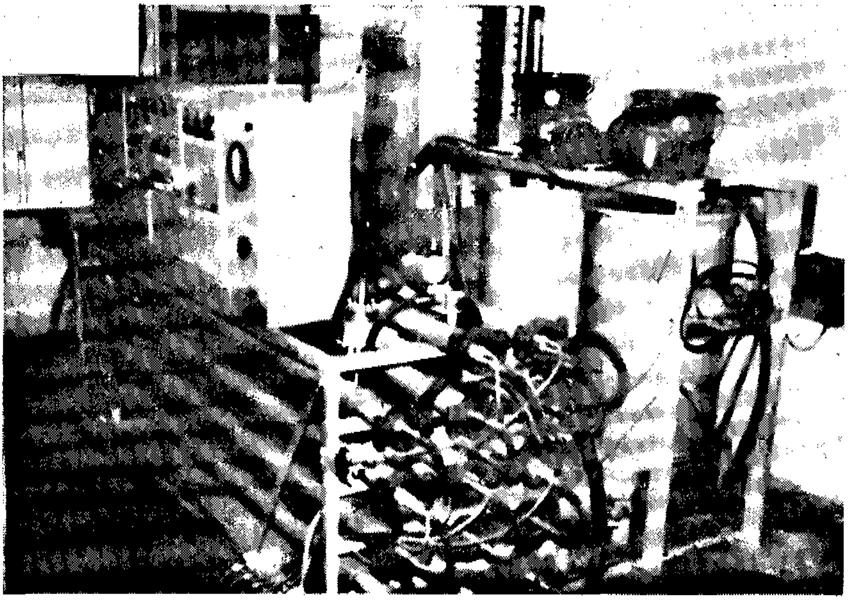
SHUBHRA CHAKRAVARTY



DRINKING WATER AND SCIENCE

(An Indian Experiment)

Water is an essential ingrediant for human life recognised since the Vedic ages when the Supply of drinking water was classified as a religious act. In present days also, top priority has been assigned by Government of India in Drinking Water Supply, particularly in villages. This is a major component of the programme related to rural development. For further emphasis on this, a National Technology Mission has been formed which will provide a source in almost all problem villages during the current plan period.

A large part of national resources are spent for providing the basic infrastructure at the village level. However, due to non scientific handling and lack of maintenance these are often deteriorated and not in a position to provide the desired services. The wide spread knowledge of scientific practices among the common people and village level functionaries also help in preventing such wastage. The present publication will provide interesting reading in practical experience about adoption of scientific methods and technological services in solving the problems of people at the most hardest state of social and economic living.

In this Technical Approach the areas covered by major programme of rural water supply have been taken up to describe the practical experience of the author enumerating the ways and means of application of technological solutions and their outcome. Vital benefit such as supply of clean potable water on a sustained basis has been made possible in drought prone areas. With the application of Science, it is possible to optimise the utilisation of both ground and surface water in a manner so as to make it available in desired time and space avoiding wastage and making it cost effective in the long run. The quality of water is a very important criteria for its appropriate end use. The scientific method for quality assessment and necessary improvement in quality have been discussed in simple language for understanding by persons not practising science.

This book is a must for all concerned with Drinking Water. The policy makers and those in functional authority will find it inspiring for

(Continued on back flap)

Rs. 175

DRINKING WATER AND SCIENCE

(*An Indian Experiment*)

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BATRA BOOK SERVICE

Batra Book Service
1/5, Bhagat Singh Lane
Gole Market, New Delhi-1
Tele : 310129, 350417

First Edition 1990

Printed by :
Lohia Composing Agency
at Sunil Printers
C.B.-386, Naraina
New Delhi-110028

In memory of my Mother
who is always remembered

Preface

Water has been considered to be a perennial bliss of mother nature. But repeatitive flood and drought make us to think about the sensuality of this resource which can be more economically and optimally utilised with application of scientific methods like other critical resources.

All the people handling and using water should be fully concerned about its inherent nature and criteria involved with it. This is possible when all the dimensions of science is explained in a simple language with an analytical approach. The losses due to water borne diseases which are predominent in our rural an semi urban sectors, can also be reduced to a great extent with large scale awareness generation on the subject. The infrastructure created for water supply is often not used to the fullest extent and the downtime adds on to avoidable wastage. A self sustaining System maintained by the local users would provide an ideal solution in this situation.

In this collection of essays Titled "Drinking Water and Science An Indian Experiment", an attempt has been made to analyse in one place all the related aspects of specific input required for both quantitative and qualitative management for for sustained supply of potable water to the people all over the country. The language is simple so as to make it readable for both technical and non technical personnel, who may be interested in knowing the state of art of Indian Water with special emphasis on drinking water.

As has been highlighted by the National Mission on Drinking Water, the generation of Awareness and involvement of the public is the key to the successful outcome of the programme undertaken by the Central and State Government. I have no doubt that the publications of this nature will be of great help in this regard.

Shubhra Chakravarty

Acknowledgement

I am deeply indebted to Director General, CSIR and to the CSIR laboratories whose achievement I have freely highlighted in this book, to provide me the opportunity of work and acquintance in the related field. I must place in record the guidance provided by Dr. Ram K. Iyengar, Additional Director General, CSIR for the article titled Cost effective Technology for potable water in villages and the assistance by Mrs. Rekha Sharma, Scientist for the articles viz. Mission Approach in Accelerated Development of weaker Section and Technology for Safe Drinking Water.

My secretary Mrs. Pratibha has patiently typed all the modified versions of the manuscript.

Inspite of all, the production of this book would not have been possible without the support and enthusiasm of Mr. J C. Batra of Batra Book Service who is equal claimant of reader's reaction. I expect all persons interested in water will find it useful.

Contents

1

Mission Approach in Accelerated Development of Weaker Section*

In developing countries large amount of resource is spent towards welfare and development of the weaker section of people, who are not in a position to derive direct benefits from the economic activities of the country. In a situation of growing resources gap, it is important to design the programme of development in such a manner so as to reach the target group of beneficiaries without lapses in between.

In India, a recent experiment involving application of Science and Technology to a number of Societal Missions in the field of Immunisation, Literacy, Drinking Water, Oil Seeds, Dairy Development etc. have been taken up for achieving the individual sector target without lagging in the implementation of the programme laid for Seventh Five Year Plan.

In the first few years' progress of the Societal Missions, a considerable operational changes have been experienced specially due to the involvement of the workers and beneficiaries at the grass root level. This paper deals in both qualitative and quantitative aspects of the various programme undertaken by the Societal Missions, their success and particular reference to the involvement of women.

The plan outlay in a developing country contains a great degree of deficit in budget which is mainly due to compartment-

* Reprinted from *Yojana*.

alisation of the input and output of individual sectors and a large section of the population continuously remaining outside the range of economic planning, which makes an increasing demand on health and welfare budget and subsidies, such as in food and fertilisers. In India, almost 60 per cent of the population comprising of women and backward classes, still have little involvement and awareness about the overall progress of the country or the fellow citizen. The day-to-day drudgery including poverty, health and sanitation problem, drinking water, food and fodder and fuel are the foremost challenges of their life. Statistical relation has been drawn between illiteracy and higher child and pregnancy death as well as number of children in a family and other such backwardness.

The 20 point programme of Govt. of India is the cutting edge of the plan for poor and has been restructured in the light of achievements and experience and the objectives in the Seventh Plan. The restructured programme renews the commitment to eradicating poverty, raising productivity, reducing income irregularities removing social and economic desparities and improving the quality of life. This include :

Attack on rural poverty	Justice to Scheduled Caste and Tribes
Strategy to rainfed agriculture	Equality for women
Better use of irrigation water	New opportunities for youth
Bigger storage panels	Housing for the people
Enforcement of land reforms	Improvement of slums
Special programme for rural labour clean drinking water	New strategy for forestry
Health for all by 2000 AD	Protection of the Environment for the consumer.
Two child norm	Energy for the village
Expansion of Education	A responsive Administration

The nation is spending increasing amount of resources in Health and Family Welfare, Integrated Rural Development, Rural Water Supply etc. without achieving the total coverage of the population desired. In view of this diversity of situation a number of Societal Missions were formulated during the current plan period, with time targetted objective based on results attainable through application of Technology.

In words of National Leader, "High technology should be applied in a simple manner to every day objects that are needed in our rural areas and the Technology Missions will stretch from laboratories to the people".

The Missions were launched to give a new focus to development in which we shift from directing people to empowering people. The concept was to replicate our success stories from other areas to meet basic needs. The Mission approach was required to create a sense of urgency and to provide management focus, increase communication, organise information, improve centre state coordination and substantially improve the participation of the people. However, in order to maintain the working environment in the long run, a number of other facilities are required such as regeneration of existing institutions, administrative reforms, decentralised planning, openness and accountability which should be inbuilt in the system. The present Missions and their targets are described below :

Literacy	Impart functional literacy to 80 million illiterate persons in 15-35 age group by 1995. 30 million by 1990 and another 40 million by 1995.
Drinking Water	Supply 40 litres per capita per day in all areas for human and 30 litre per capita per day in desert areas for cattle, by 1990.
Immunization	Reduce mortality due to Diphtheria Pertussis, Tetanus, Poliomyelitis, Tuberculosis, Measles among children, and pregnant women. Achieve self sufficiency in vaccine production (BCG, DPT, TT).

Oil Seeds	Production of 16 to 18 million tonnes oil seeds per year by 1990. 26 million tonnes seeds and 8 million tonnes oil by 2000.
Telecommunication	To bring up the call completion rate 98 per cent for local calls, 94 per cent for junction calls and 80 per cent for STD calls, reduce the fault rate to 10 per 100 station both for telephones and telexes, increase the efficiency of normal trunk call to 80 per cent by 1990. Improve the Directory enquiry and billing services.
Dairy Development	150,000 village cooperative in 275 districts. Increase milk production to 700 lakh metric tons and per capita availability to 196 gms per day. Productivity 640 liter per cow and 1020 liter per buffalo per annum by 1995.

The Baseline Scenario

The development strategy of VII plan aims at direct attack on problems of poverty, unemployment and regional imbalance.s Around the year 1985 the country had 360 million women, 110 million SC and 60 million ST and 270 million below poverty level *i.e.* with monthly income less than Rs. 150/-. These comprise of the weaker section, to whom the welfare programme of the country is directed. The outlay of Seventh Five Year Plan for public sector was about Rs. 1,80,000 crores out of which Rs. 9000 crores was allocated for Rural Development, Rs. 29000 crores for social services and Rs. 3000 crores for Special Areas Programme.

The beneficiaries of the welfare programme comprise of 40 per cent SC/ST. In addition various special programmes for upliftment of the backward community were activated with outlay of Rs. 280 crores in Central Sector and Rs. 12,000 crores in the State Sector. A number of Scheduled Caste Development

Corporations were set up in the states for implementing welfare programme including distribution of bank loan and allocation of surplus lands and creation of job opportunities etc. Integrated Tribal Development Projects were set up in addition to IRDP (Integrated Rural Development Programme), Drought Prone Area Programme, RLEGP (Rural Landless Employment Programmes). This is further supported by SCP (Special Component Programme), MNP (Minimum Need Programme) and Tribal sub plan drawn at state level.

Under IRDP, 254 lakh families have so for been assisted with total investment of Rs. 8413 crores, about 20 per cent of these are headed by women. In addition, a number of schemes were taken up to benefit women in need. 3000 women were trained and provided employment in training cum production centres. Primary education and vocational training were organised by Voluntary Organisations for about 1,11,000 women, 3589 units were assisted under socio-economic programme to provide a coverage for 47011 women. A summary of the programme operated for benefit of weaker section is presented in Table 1, in Annexure I.

The Plan Achievement and Mission Approach

The Seventh Plan target was to bring 75 per cent of the country's population above the poverty line and provide 37 per cent with literacy. The total plan outlay was at the level of Rs. 350,000 Crore including a deficit financing of Rs. 15,000 Crore. In order to provide for the success of the plan implementation the country needs substantial improvement and economy in use of resources. This is possible only through accelerated development and use of domestic capabilities and total involvement of people or beneficiaries.

As a close observer of progress of India, UNICEF has observed that a continuing gap exists in India's otherwise impressive profile of progress, which is a gap in developing the full potential of basic human capability through increasingly equal opportunity to all of its 800 million people. The inability of a large cross section of people to share the fruits of prosperity of the country arises mainly from illiteracy, dietary deficiencies, communicable diseases, unsafe drinking water and isolation caused by lack of communication. The approach towards the rapid changing scene of the developmental map of India is basically to link the available scientific solutions to the needs of the Society by matching the managerial skill with the political will. The Missions seek to achieve to build and facilitate purposeful use of the vast servicing infrastructure into an open and wholistic orientation for a given task.

Although the National Societal Missions which are popularly called the Technology Missions, cover widely diverse fields namely drinking water, immunization, adult literacy, oilseeds, dairy development and telecommunications, they are identifiable by common features namely mutual linkages pointing to an integrated strategy, district level planning and decentralisation of authority and responsibility, active involvement of grass root level organisations including NGO's, careful use of simple and sophisticated technology and basic theme of motivation and mobilization of all the partners involved, including the planners and benefactors. In words of one partner of the Technology Missions, the technology missions are important management innovation in the Govt. whereby many agencies have been able to come together and work in matrix type organisations without losing their individual autonomy and characterstic. A new culture of cooperation and understanding each others problems and to pool the resources towards the common objective have helped in reduction of the implementation gap.

TECHNOLOGY MISSION HIGH LIGHTS

Oilseeds Mission

The Technology Mission on Oilseeds launched in May 1986, has the immediate objective of producing 160 to 180 lakh tonnes of oilseeds and between 40 to 50 lakh tonnes of edible oil by 1990. In the short and medium term, the approach is to improve use of available technologies and experiment with high-yielding imported seeds. In the long term, the objective is to develop indigenous seeds, improve their yields, decrease crop duration and increase oil content.

India imported 18 lakhs tonnes of edible oil in 1987-88. In 1988-89 the imports are expected to be of 8 lakh tonnes only. The production of oil seeds within the country during 2 years are given in Table II.

TABLE II

Production of Oilseeds : 1987-88 and 1988-89

(*Lakh tonnes*)

Oilseeds	1987-88 (Official estimates)	1988-89 (CMIE estimates)	Change %
Groundnut	56.7	74.0	30.5
Rapeseed and mustard	33.7	36.0	6.8
soyabean	9.8	13.5	37.8
Sesamum	5.6	6.5	16.1
sunflower	6.1	6.5	6.6
safflower	4.5	6.0	33.0
Niger seed	1.8	2.0	11.1
Linseed	3.7	5.5	48.6
Castor seed	1.8	4.5	150.0
Total nine oilseeds	123.7	154.5	24.9

The Mission has developed a new integrated policy on oilseeds for accelerating the move towards self-reliance by boosting domestic production of oilseeds through improved technology incentive prices to farmers, with suitable subsidy if needed for holding price line within specified limits :

(*a*) Support to farmers with technology inputs to raise the output.

(*b*) Review of the prices of edible oils distributed through the public distribution system.

(*c*) Prescription of a price band for range of variation,

(*d*) Procurement of domestically produced oilseeds and edible oils by the designated authority namely National Dairy Development Board for building a buffer stock.

(*e*) Constitution of empowered committee headed by the Cabinet Secretary to supervise the implementation of the policy.

Telecommunication Mission

The first telephone line in India was opened in 1881 and telegraph line in 1851. At the time of independence there were only 321 telephone exchanges and 82000 working connections. By 1987, this was increased to above 12000 exchanges and 40 lakh lines (35 lakh working connections). This covers 216 cities, 3029 towns and 8877 villages including 44,248 public call offices. There are 36000 long distance public telephone and telegraph offices.

The Telecommunication Mission was established in 1986 with the following broad objective :

— improve quality of service through staff commitment.

— selected use of new technology in net work upgradation and special inputs in selected areas of net work to achieve net work customers satisfaction.

— improvement in the delivery of telegrams within 12 hrs. from present level of 30 per cent to 99 per cent by replacement of mechanical teleprinters with electronic ones.

— Reduction in fault rate of telephones from present level of 35 per cent to 20 per cent by replacing old telephone instrument drop wires, fault prone overhead lines and cables by introduction of computerised subscribers line testing.

— 6,00,000 PCO by 2000 A.D.

— Provide Telex Facility on demand.

— Improve call success rate.

From 91 per cent to 99 per cent for local calls.

From 70 per cent to 98 per cent for junction calls.

From 20 per cent to 90 per cent for STD calls.

Through the induction of PCM Systems and optical fibres in junction net work, induction of digital microwave and digital TAXS in addition to commissioning of computerised trunk exchanges in big cities and by induction of SFK system for manual trunk exchanges.

Drinking Water Mission

The Technology Mission on Drinking Water in Villages and Related Water Management has the following objectives :

* Cover all problem villages by 1990.

* Supply of potable water at 40 litres per capita/day.

* Supply 70 litres per capita/day in desert areas.

* — 40 litres for human beings.

* — 30 litres for cattle.

* Evolve cost effective technology mix to achieve these objectives.

* Take conservation measures for sustained supply of water.

Of the 5.75 lakh villages in the country about 1.62 lakh problem villages have been identified. A problem village has been defined as :

* No source of water.

* Water source at more than

  — 1.6 km distance

  — 15 meters depth

  — 100 meters elevation difference

* Biological contamination

* Chemical contamination

The Technology Mission on Drinking Water aims at a scientific study and evolving cost-effective solutions by mobilising and pooling the resources of various agencies viz. Space, Atomic Energy, CSIR, Central Ground Water Board (CGWB), etc.

Research and development has been carried out in vitally important areas such as finding sources of water, treatment of water and identifying the water-related health hazards. Applications of such findings have not percolated down to the rural areas. It is being increasingly realised that integrated application of science and technology is necessary for solution to the water-related problems in rural India, on a long term basis.

The strategy for accomplishment of the total coverage adopted by the Mission are as follows :

* For visible results focus on submissions (country wide) Eradication of Guinea worm—9920 villages by 1989.

  Control of Fluorosis—8700 villages by 1988.

  Control of Brackishness—17,500 villages by 1990.

  Removal of Excess Iron—2900 villages by 1988.

  To focus on 50 Projects Areas (Mini Missions).

  To evolve new cost effective S & T techniques.

* To replicate and simultaneously apply these techniques for the rest of problem villages.

* Integrated approach for water conservation.

Literacy Mission

Till Sixth plan, education was taken to be a social service rather than an input in the development programme of the country. A change in emphasis started during sixth plan period wherein human resource development has been considered to be pivotal in the social and economic development of the country. A new National Education Policy was approved by the Parliament in May 1986, which envisages universalisation of primary education and adult literacy by 1990.

According to the 1981 census, the literacy rate increased from 16.67 per cent in 1951 to 36.23 per cent in 1981. Of the total 412 districts in the country, 343 had a literacy level below national average, inclusive of the 193 districts where the female literacy rate is below 20 per cent (1981).

Inspite of the apparent increase there is a significant increase in actual number of illiterate persons over this period. The plan expenditure almost doubled from Rs. 2524 Crores in Sixth Plan to Rs. 6383 Crore in the Seventh Plan. However, the literacy rate among male is around 47 per cent, among female is 25 per cent and 16 per cent among Scheduled Castes and Tribes.

To accelerate the coverage of this gap, the literacy Mission was created integrating few of the existing programme of state and central level and strengthening them with suitable technological input and services input of voluntary teachers from the public, teachers and students at large. The programme includes :

Participation of a *million* student volunteers apart from NCC, National Service Scheme, Nehru Yuvak Kendras, Bharat

Scouts and Guides. The student volunteers will be supplied with free Literacy kit—and 10000 youth activities will be trained.

Setting up of "Jana Shiksha Nilayam" at the rate of one Nilayam for four or five villages with a population of about 5000, for continuing education has been taken up in addition to strengthening the extension facilities at employers, trade union, universities, colleges and polytechniques.

Modernisation in teaching will be introduced through improved aids, such as new types slates, globes, maps, models, radios, cassettes slides, film strips, T.V. etc.

Adult Education Centres will be set up at village level under supervision of Jana Shiksha Nilayam.

Techno pedagogic input in literacy will be provided in 40 selected districts in the first place.

Shramik Vidya Peeth to be set up to provide literacy to working class, upto Dec. 1988 they covered 90,797 beneficiaries in 1987-88.

300 voluntary agencies in 1987-88 and 1000 in 1989-90 will be identified for imparting 3 weeks training each year to 50-75 persons, in addition to universities, trade unions, Nehru Yuvak Kendras and social and labour research institutes

Village Education Committee and jathas or cultural caravan students, teachers and artists will tour places making people aware of the importance of literacy and there own rights.

Immunization Mission

In the middle of Seventh Plan, the general death rate is one per cent and life expectancy at birth is 55 years. The infant mortality is controlled at less than 10 per cent. In rural areas there are 14,145 primary health centres and 98,987 subcentres. The 20 point programme lays special emphasis on improving the health status of the people. According to the programme, it is proposed to promote family planning on a voluntary basis as a people's movement, substantially augment universal primary health facilities and control leprosy, tuberculosis and blindness, accelerate programme of welfare for women and children and nutrition programme for pregnant women, nursing mothers and children in tribal, hilly and backward areas. The emphasis is on preventive and promotive aspects.

Immunization is a low cost efficient technology for child survival and prevention of disabilities. The Expanded Programme on immunization was started in 1978 with the objective of reducing morbidity mortality and disabilities due to Diptheria, Hooping cough, Tetanus and Tuberculosis by making free vaccination services easily available to all eligible children and Expectant mothers. Polio and Typhoid vaccination were included in the programme in 1979-80, Tetanus Toxide (School Children) in 1980-81, BCG was brought under the purview of EPI in 1981-82 and Measles vaccine was initiated in 1985-86.

Universal Immunization Programme was started in the country in 1985-86 with the objective to immunise 85 per cent of eligible infants against six preventable disease and to cover 100 per cent pregnant women by 1990. The total number of infants was 822 lakh and women 925 lakh. In 1985-86, 30 selected districts were taken up, 62 were added in 1986-87 and 90 in 1987-88, 120 in 1988-89 and the remaining in 1989-90.

This programme was further strengthened by setting up of Immunization Mission in 1986, which had specific programme for vaccination for specified disease and indigenous production of vaccines as well as their preservation by cold chain equipment and intensive health education and training for lasting impact.

Progress level and outlook for future

In an attempt to quantify the outcome of the Mission Approach, achievements of previous plans *vis-a-vis* the current programme have been summarised in Table III in Annexure 2.

However, it needs a very detailed survey to establish the fact whether an increasing number of the members of the target group are feeling communicated or participated in the long run. But presently it is worthwhile to take a short term evaluation of the organised methodology for continued impetus and expectations therefrom.

It may be worth while to mention that in the year 1987 the country faced a calamatious drought, but a positive growth rate of 3.6 per cent was maintained. Oilseeds production reached a new high along with record harvest of kharif crop and also good rabi crop and substantial reduction in oil import was achieved as compared to the previous years by 50 per cent. 1986-87 production was 11 million tonnes with 60 per cent rainfall and that is 1987-88 with 25 million tonnes with 40 per cent rainfall. The production is expected to reach 155 lakh tonnes in 1988-89. This is possible by demonstration of improved technology along with coordinated input of fertilizers, pesticides, seeds, irrigation facilities etc. as well as economic support prices for the farmer. Under the Mission Programme 40 new varieties of groundnut, mustard and sunflower have been released with average yields thrice as high as that of present breeds. New policy concensus has been derived for production, distribution, import and pricing to balance the interest of farmers, consumers as well as the economy as a whole.

The Water Mission has already provided 65,000 problem villages with at least one source of water, 32,000 water harvesting structures have been created and new sources have been found in 3,985 villages and hydrogeo-morphological maps have been completed for 25 States/U.T.s. The number of guinea-worm affected villages has been reduced from about 8,000 to 3,111. A number of technology for improving water quality to potable level have been demonstrated in over 30 villages, which included removal of dissolved salts, flourides iron etc. Elaborate steps have been taken to ensure testing of quality of water at sources including training of local persons. More than 5,000 people have been trained at different levels, by various national institutions in order to make large number of functionaries conversant with appropriate scientific activity. Standardisation of existing technologies and equipments have been taken up for making them cost effective and widely available to common people.

The Immunisation Mission looks forward to cover whole of the country by vaccination by the end of 7th Plan as well as to take necessery measures for production, preservation and testing of vaccines indigenously in a large number of centres throughout the country. As such the backlog is expected to be cleared and modernised facilities be established for improved health programme for the coming years. Indigenous production of few vaccines and cold chain equipments will emerge as a part of the Mission activities.

In the field of telecommunication, rapid strides have been made both in rural and urban sectors. Eleven digital exchanges and 2,000 long distance public telephones have been installed in rural areas in 1987-88. 278 district headquarters have been connected by STD and 3,300 public telephones have been installed in urban areas. 70 per cent telegrams are being delivered within 12 hours and trunk call completion rates have increased from 70 per cent to 84 per cent. Other measures for improvement in equipments and services are under implementation.

In spreading of literacy, the contribution of student volunteers and other voluntary agencies have been greatly increased since the commencement of the Literacy Mission. Improved prototypes of black boards, slates, dustless chalks and lanterns have been developed and field tested.

The key lessons already derived from the Mission activities appear to be as follows :

(*a*) Mission concept should be used selectively and on going programmes should not be merely redesignated as Technology Mission.

(*b*) Priority should be given to specific activities in specific regions, such as desalination of water in brackish water zone and intervention of technology should be clearly explicit within its own limits.

(*c*) Concerned agencies and voluntary groups should be involved from the very beginning and all their resources be pooled and integrated for common aims.

(*d*) The action points and policy should be clearly specified in written document for total understanding among all concerned.

(*e*) Standardisation, Monitoring and Evaluation should be taken up as essential tasks rather than a subsidiary system. The ultimate and intermediate goals should be set up for monitoring.

(*f*) It is necessary to deemphasise hierarchy and emphasise egalitarianism. Teamwork and integration will have to be ensured to eliminate wastage and duplication in delivery of services.

(*g*) The target group should be made aware that the Missions are interested in eleminating their problems. So that they come forward to take over from the functional authorities the ownership and responsibility for maintenance and replication of the facilities created on assembled by the Mission.

(*h*) Lastly, the spirit should continue and transform the general way of work in the long run.

The rural women who have accepted the role of second fiddle in all walks of life, may now find their own role in nation building after achieving the basic needs such as health, drinking water and literacy.

ANNEXURE 1

TABLE I

Socio-Economic Programme for Weaker Section

Name of Programme	Objective	Outlay (Rs. Crore)	Target
1	2	3	4
Integrated Rural Development Programme (IRDP).	Alleviation of Rural poverty through creation of assets/ financial assistance in the form of subsidy by the Government.	2,352	To reduce the population effected by poverty below 20 per cent. The poverty line income is Rs. 6,400 per year for rural areas. 20 million people are expected to be benefitted under the programme. It is provided that 30 per cent of assisted families should be from SC/ST and 30 per cent of the assisted should be women.

(Contd.)

Annexure 1 (*Contd.*)

1	2	3	4
National Rural Employment Programme (NREP).	Creation of employment and also durable assets for economic growth and rise in income at a steady rate including improvement in nutrition and living standard of rural poor.	2,488	1,455 million mandays are to be generated.
Rural Landless Employment Guarantee (RLEGP)	To provide employment to atleast one member of every landless house hold for 100 mandays.		1,013 million mandays are to be generated.
Training of Rural Youth for Self-Employment (TRYSEM)	To train youth women, SC/ST with productive, technical and managerial skills with which they can set up their own self-employed ventures. Financial Assistance and infra-structural assistance for production and marketing of such goods is provided.	150	The target group for rural youth is between 18-35 years drawn from the families having income less than Rs. 4,800. Atleast 33 per cent SC/ST youth are benifitted.

Process-cum-Product Development Centres (PPDC).	PPDC will take up special programme at a substantially increased level.		
Development of Women and Children in Rural Areas (DWCRA).	To provide support to enable women to generate income generating activities through child care activities providing health care, security and nursing of children at the NREP work sites,	48	To assist the women of IRDP families through financial grant of Rs. 15,000 to a group of 15 to 20 women and train them through TRYSEM facilities and provide with basic facilities for production and sale of their products.
Integrated Child Development Services (ICDS).	To reduce childhood mortality, morbidity malnutrition by supplying health, education, nutrition as non-formal education to children below 6 years of age and pregnant and nursing mothers of rural and backward areas as slum.	75	Implement 1,738 Integrated Child Development Services Project in most backward areas covering most of tribal places with more than 30 per cent ST population and urban slum.
Minimum needs Programme (MNP).	To develop human resources and infrastructure in villages through elementary education, Adult education, rural	10,000 in State Sector 1,464 in Central Sector	To integrate the programme with other Development programme and anti-poverty programme so as to create neces-

(Contd.)

Annexure 1 (*Contd.*)

1	2	3	4
	health, rural water supply, rural electrification, rural Road, rural housing environmental improvment of urban slums and nutrition,		sary linkages in the delivery services.
			Education : 25 million children for formal education and 25 million children for non-formal education. Health : Establish 54,000 health centres. Water supply : cover all remaining problem village, 39,000. Roads : To cover 20,487 villages. Electrification : To cover minimum 65 per cent villages in all States/UTs. Rural Housing : To cover 0.27

			million house-holds foı allocation of sites and 2.7 million families for construction. Environment : 9 millions slum dwellers to be provided with improved living condition. Nutrition : Continued support to 7 million eligible persons.
Special Component Assistance for SC/ST.		930	
(i) Tribal Subplan Socio-economic development of tribal areas and families.	(*a*) To arrange bank loan etc. for tribal families for setting up small scale industries.	173	
(ii) Scheduled Caste Development *Corporation*	(*b*) To distribute surplus land among SC/ST *families.*		
(*iii*) Integrated Vribal Development project.	Development of primitive tribes in segregated tribal areas.		

(*Contd.*)

ANNEXURE 2

TABLE III

Comparative Statement of Mission Progress/Achievement and Ongoing Rural Development Programme

Programme	Coverage				Use of New/ Existing Technology	Remark
	1985-86	1986-87	1987-88	1988-89		
1	2	3	4	5	6	7
ARWSP	50,000 villages 250 lakh (population)		90903 villages			
Drinking Water Mission		500 lakh (Population)	800 lakh (Population)	251 lakh (Population)	32,000 Rain Water Harvesting structures created.	For first time ear-marking of funds for water conservation under DPAP.
		90,000 villages	1,05,000 villages	52,000 villages	Guineaworm affected villages reduced from	Ground Water potential map now available

8,000 odd to 3,111.	for 46 districts important for source finding.
100 Desalination plants to be set up 1988-89. (7 Mobile desalination plants supplied to states).	85 Water Quality testing laboratories are to be set up at district level.
130-Defluoridation plants being set up in 1988-89.	200 Solar pumping System in villages.
3,000-Iron Removal plants being set up.	For first time quality standards for tubewells formulated and prescribed. Step-well conversion into sanitary wells.

(*Contd.*)

Annexure 2 *(Contd.)*

1	2	3	4	5	6	7
Oil Seed Production						
Groundnut	1,762.4	2,900 qtns				
Soyabeen	852.8	1,535 qtns				
Rape-seed/ Mustard	38.4	35 qtns				
Sunflower	35	35 qtns				
Safflower	21.8	40 qtns				
Oilseeds Mission		110 lakh Tonnes	123 iakh Tonnes	155 lakh Tonnes	New Technology for sunflower processing demonstrated. 70 new varieties for groundnut, mustard and sunflower released for first time with average yield 3 times higher. Modern expeller	

					prototype demonstrated. 5,000 expellers to be modernised. In-expensive rice bran stabiliser demonstrated, Polypack oil pouches introduced.	
Adult Education Programme	6.3 Mill	8.6 Mill	9.1 Mill	10 Mill (target)		
Literacy Mission			—80 Mill—		Improved prototypes of blackboards, slates, dustless chalks and lanterns have been developed and field tested.	Ex-service men have been drawn into Mission from 25 Districts.

(*Contd.*)

Annexure 2 *(Contd.)*

1	2	3	4	5	6	7
						Mass mobilisation of students volunteers was done in summer of 1988, 6 lakh students to reach out to 10 lakh illiterates. Action plan for 1 lakh illiterate Prison inmates finalised. Nehru Yuvak Kendras involved in 27 Districts.
Ongoing Telecommunication Programme	44,000 (local calls) 1,500 Trunk Calls 700 STD (Target) Cummulative					

Telecommunication Mission		2,000 long distances public telephones installed in rural public areas 3,300 public telephones installed in urban areas. Public telephones to be provided 61,000 for local calls. 35,000 for Trunk Calls 7,000 for STD Calls		11 Rural Exchanges installed Prototypes for reliable public telephones are on trial electronic key board to replace the conventional Morse Code System for transmitting telegrams is being used for trials.	7 out of 10 telegrams now delivered within 12 hours and efficiency of manual trunks has increased from 70 to 84 per cent.
Call Success					
STD	20	45	70		
Junction Call	70	72	80		
Local Calls	90	95	98		

(Contd.)

Annexure 2 *(Contd.)*

1	2	3	4	5	6	7
Primary and Community Health Centres	1,829 111	1,747 343	328 40	3,151 (Target) 312		
Immunisation Mission	30 Districts	62 Ditricts	90 Districts	(Target) 120 Districts	Plans for indigenous production of polio, measles Vaccine by 1991 finalised.	
					Indigenisation of cold chain equipment *initiated.*	40 Districts to use Indian made equipment in 1988-89.
Pregnant Women	3 Mill (Target)	12 Mill (Target)	15 Mill (Target)	20 Mill (Target)	Testing facilities to be promoted.	11 Vaccine testing Centre to becreated by mid-89.

					At present only 2 are available (Haffkine and Pasteurs). Modernisation of above two started.
Children	2 Mill (Target)	8 Mill (Target)	12 Mill (Target)	15 Mill (Target)	

2

Cost Effective Technology for Potable Water in Villages*

The benefit of Science & Technology have been concentrated in the urban section, while the rural population have not developed full conciousness of the impact S&T can have in human life. Scientists have carried out research and development in vitally important areas essential for human life such as finding of sources of water, treatment of water to potable quality and identifying the water related health hazards. Application of such finding have been taken up in a sporadic manner until recently. It is being increasingly realised that integrated application of Science & Technology is necessary for permanent solution of the water related problems in rural India.

The Technology Mission for Drinking Water and related Water Management have taken up problems-wise approach in its action plan and has developed five sub-Missions for scientific source finding, eradication of guineaworm, control of fluororis, removal of excess iron and control of brackishness. A concerned scientific organisation has been nominated as the nodal agency for achieving the targets set in each of the sub-Missions.

Since water is closely linked with the people, the Mission envisages complete involvement of people to carry it forward after the initial establishment and commissioning of the technologies by the Government agencies. As such the awareness

* Presented in NMDW Seminar at CSMCRI, Bhavnagar.

generation and location specific cost effective solutions have been made an integral part of the Mission.

It has been experienced that as high as 40 per cent of the available capital remains dormant due to the high down-time of equipments. Standardisation and proper maintenance can solve 80 per cent to 90 per cent of this problem. This would involve proper application of existing norms as well as evolution of better norms for maintenance, materials and designs.

It has to be borne in mind that the new S&T inputs are not altogether alien to the water supply system in villages and the scientists in the laboratory as well as the water supply authorities in villages can both gain from each others experience in furthering their respective field of work. A continuous dialouge can establish the optimum norms of practices for continuous running of water supply schemes with routine check up and maintenance, which will lead to minimisation of down time.

Scientific Approach of the Sub-Missionn

(*i*) *Scientific Source Finding* : As high as 68 per cent of the problems of target villages are associated with lack of adequate water sources. This means non-availability of surface and ground water sources within 1.6 km. distance and/or higher than 15 meters depth, or 100 meters elevation difference. To find water resources use of satellite imageries, geophysical resistivity sounding and geohydrological studies need to be undertaken for locations of possible water bearing zone or aquifers. This will be followed by drilling and installation of hand pumps etc.

Figure 1 shows the programme of action required in this regard. As per present practice, the success rate of completion of drilling is not more than 10 per cent the rate of completion of the location studies. This makes it more important to avoid drilling failures by adopting scietific source finding methods for a particular location. This will also reduce the total cost since the cost of drilling is 8 to 10 times higher than that of source finding studies.

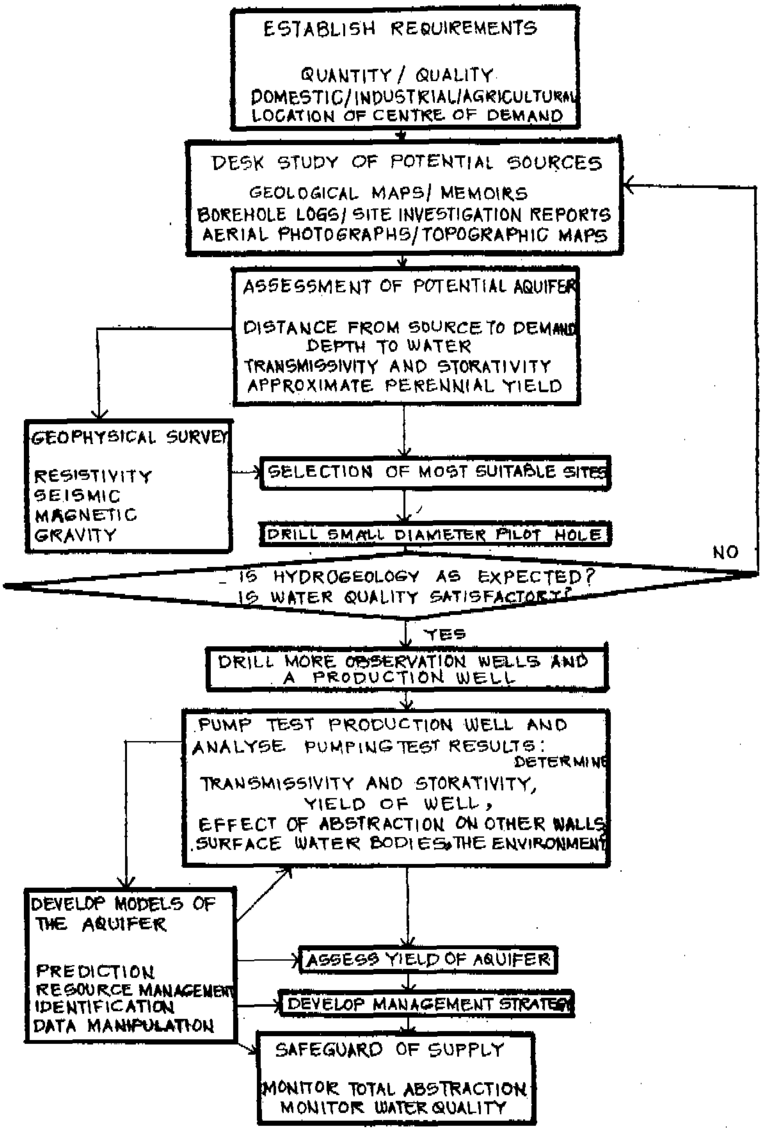


Fig. 1. Stages in the assessment, development and management of an aquifer (after Hamill and Bell. 1986).

(*ii*) *Eradication of fluorosis* : Fluoride in ground water occurs in a region bearing granite rock (Ca F_2), Lime stone etc. It is difficult to draw any definite relationship between the rock types, the nature and origin of ground water and flouride distribution in sub-terrainean waters. Presence of fluoride in India has been initially detected through mottling of teeth and deformation of bone structure. So far 13 States have been reported to be effected by high flouride levels in ground water in peninsular Indian region.

Solubility of fluoride in water depends on presence of other electrolytes and pH of water. Fluoride ion can be removed from water by suitable ion exchange resins or chemical precipitation and coagulation. NEERI has used various methods namely, anion exchange resins, cation exchange resins, saw dust carbon, Defluoron-1 and Defluoron-2, activated magnesia etc. for removal of fluoride ions. The Nalgonda technique uses commercial calcined magnesite as the precipitating agent. The treated water flows by gravity through wiremesh filter into a carbon-dioxide reaction chamber where excess alkalinity is removed by carbon dioxide treatment. After detailed studies including use of various reagents the Nalgonda technique was developed which involved adding in sequence an alkali, chlorine and aluminium sulphate followed by flocculation, sedimentation and filtration.

The solubility of Al F_3 in presence of $Al(OH)_3$ is guided by the following relation,

$$\text{Concentration of } (OH^-) = \frac{1}{6.918 \times 10^8} \times \text{Concentration of } (F^-)$$

As such, when the water sample contains hydroxide and fluoride ions and alum solution is added to it, Al (OH_3) will be precipitated until the OH^- ions are removed, in order to increase the concentration of fluoride ions to the desired level. Henceforth aluminium fluoride will coprecipitate alongwith trace of aluminium hydroxide, as long as the ratio of concentration is maintained in supernatant liquid. Experiments have confirmed that the above concentration also help (F^-) removal with the floc during flocculation and sedimentation. It was

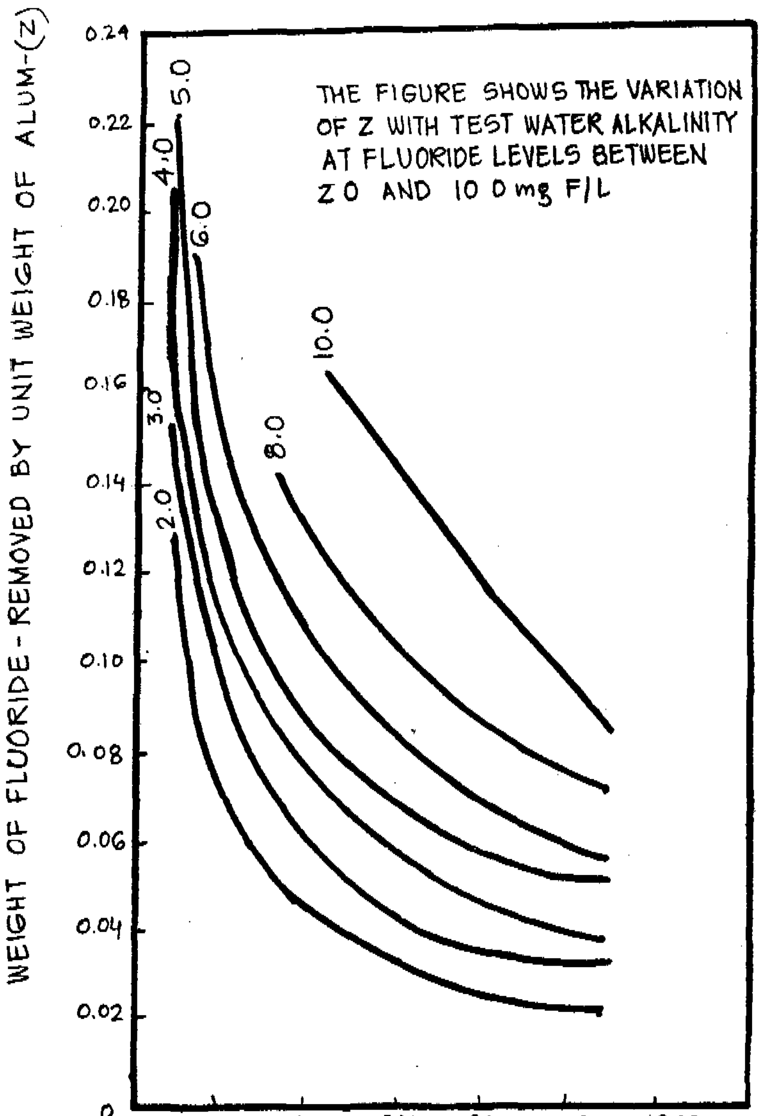


Fig. 2. Relationship between Test Water Alkalinity and the Fluorides Removed by Unit Quantity of Alum.

also established that presence of poly phosphates, nitrates and organic matter has no adverse effect on defluoridation.

The dosage requirement for lime and alum is calculated as per laboratory experiments conducted with raw water from the source. The typical results are presented in Figure 2.

The Nalgonda process for treatment of water for removal of fluoride, developed by NEERI, includes channel mixer, pebble bed flocculator, sedimentation tanks and sand filters. The entire system is gravity operated except the filling of overhead storage tank and delivery from treated water tank. The use of channel mixer for mixing lime and alum and pebble bed flocculator in place of conventional flocculator make the system less dependent on power supply fluctuations. The raw water tank can be filled with minimum of 2 hours of power supply. The design of the plant is available in 40, 80, 160 and 380 cubic meter per day capacities. The running cost of such plants reduce substantially with increase in design capacity, in the following order:

Capital Cost $= 0.33$ (flow rate) 0.36

Running Cost $= 2.9 \times 10^{4} \times$ (flow rate) -0.62

The sequence of operation is shown in Figure 3.

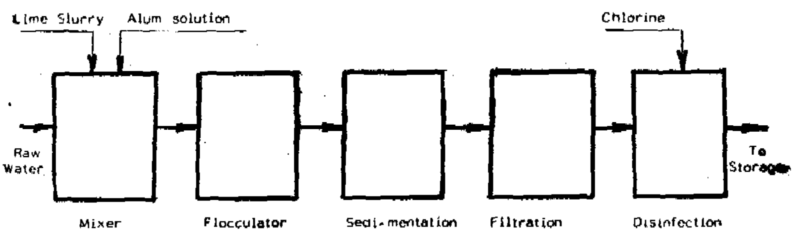


Fig. 3. Flow diagram of Defluoridation Process

(*iii*) *Removal of excess iron* : The problem of excess iron in ground water is usually associated with the presence of excess manganese which occur in shale, sand stone and other rocks. The minerals are dissolved by ground water containing carbon-dioxide in absence of oxygen. The insoluble oxides are reduced and transformed to soluble bicarbonates. The same reactions also occur in the lower portion of deep reservoirs that flood iron and manganese bearing soils and rocks.

The presence of iron and manganese in water is objectionable as they stain clothing and plumbing fixtures and detract from the appearance of water. The maximum permissible limit of iron in water is 1 ppm, and that of Manganese is 0.5 ppm.

For removal of these impurities, aeration method is extensively used. Ferrous bicarbonate is precipitated by aeration which causes removal of carbondioxide. The pH of water is also required to be adjusted for facilitating precipitation of iron. The following stages are involved in iron removal :

Aeration : Dissolution of oxygen in water containing dissolved iron, helps in stripping of CO_2 to oxidize ferrous iron to ferric state as shown in the following equations :

$$4Fe^{2+}+O_2+8OH^-+2H^-{}_2O=4Fe(OH)_3$$

$$-\frac{d(Fe^{2+})}{dt} = K.(Fe^{2+}).\ pO_2.\ (OH^-)^2$$

Increase in pH and dissolved oxygen results in accelerated iron removal. Iron is removed in the form of Fe $(OH)_3$ which precipitated.

Settling : Chemical addition followed by clarification is necessary, if iron is accompanied by colour, turbidity and organic matter. Alum with or without prechlorination is used.

Filtration : The precipitated iron hydroxide flocs are removed by sand filtration. The filtered water will meet the drinking water quality standards.

Oxidation : Stoichiometrically 0.14 mg oxygen is required to oxidise 1 mg of iron. Oxidation can be accelerated by raising the pH and saturation by dissolved oxygen.

CO_2 removal : It has been seen that 80 per CO_2 removal is achieved, if a drop of water is exposed to air for 3-5 seconds. Removal of CO_2 results in formation of microflocs of $Fe(OH)_3$ which settle in a settling tank or separated by floatation. Escaping microflocs are absorbed on the gravel in the sand bed of the iron removal unit. Absorbed $Fe(OH)_3$ enhances filter efficiency.

Higher concentration of iron (more than 6 mg/l) results in heavy sludge which is removed by coagulation.

The flow diagram of an iron removal unit is given in Figure 4.

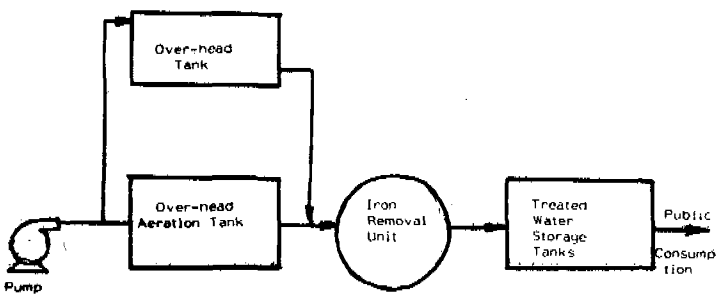


Fig. 4. Flow Diagram for Iron Removal Unit.

The number of trays and number and size of holes and the layer of filtration bed comprising of sand and coal and gravel is calculated on the basis of the capacity of source of the water. The cost of a 8 cubic meter per day plant is around Rs. 40,000 to Rs. 50,000 which can be run by a 1 HP pump.

(*iv*) *Control of Brackishness* : The presence of total dissolved solids in excess of 1500 ppm in water and render the water non-potable. About 12 states in India are affected by presence of high dissolved solids in water and require control of brackishness and salinity for providing potable water.

The dissolved solids content in water is measured by electrical conductivity methods. Dissolved solids can be removed by Reverse Osmosis (RO) and Electro Dialysis (ED) process for control of brackishness.

The RO process involves application of high pressure to cause solvent (water) to flow across the selective membrane which does not allow dissolved solids to permeate. The rejection of individual ions depend on the size of the ion and the combination of other ions present in dissolved state. The major parameter of RO process is the characteristic of the membrane and its configuration.

CSMCRI Bhavnagar has developed secondary and substituted cellulose acetate membrane with cellulose acetate mixed esters. Poly acrylonitrile poly methyl methacrylate and acrylonitrile methacrylate copolymer etc., various other polymers have also been tried at bench scale level for development of high salt rejection membrane.

The tubular configuration of RO plant has achieved 94-95 per cent of salt rejection when operated at pressure of 600 psig. Presently spiral configuration of RO module have been developed which provided higher area/volume ratio, lower capital and operating cost and better flexibility for replacement of membrane.

The RO process has been applied for desalination of water and ten plants based on CSMCRI technology are operating in Tamil Nadu, Rajasthan and Andhra Pradesh. Two plants have been gifted to Thailand.

The flow diagrams of RO plants are given in Figure 5. The operating features of RO plants are given as follows :

pH of feed water—9.4—5.1

Operating Voltage—Higher than 400 volts

Plant capacity—50,000 litres per day

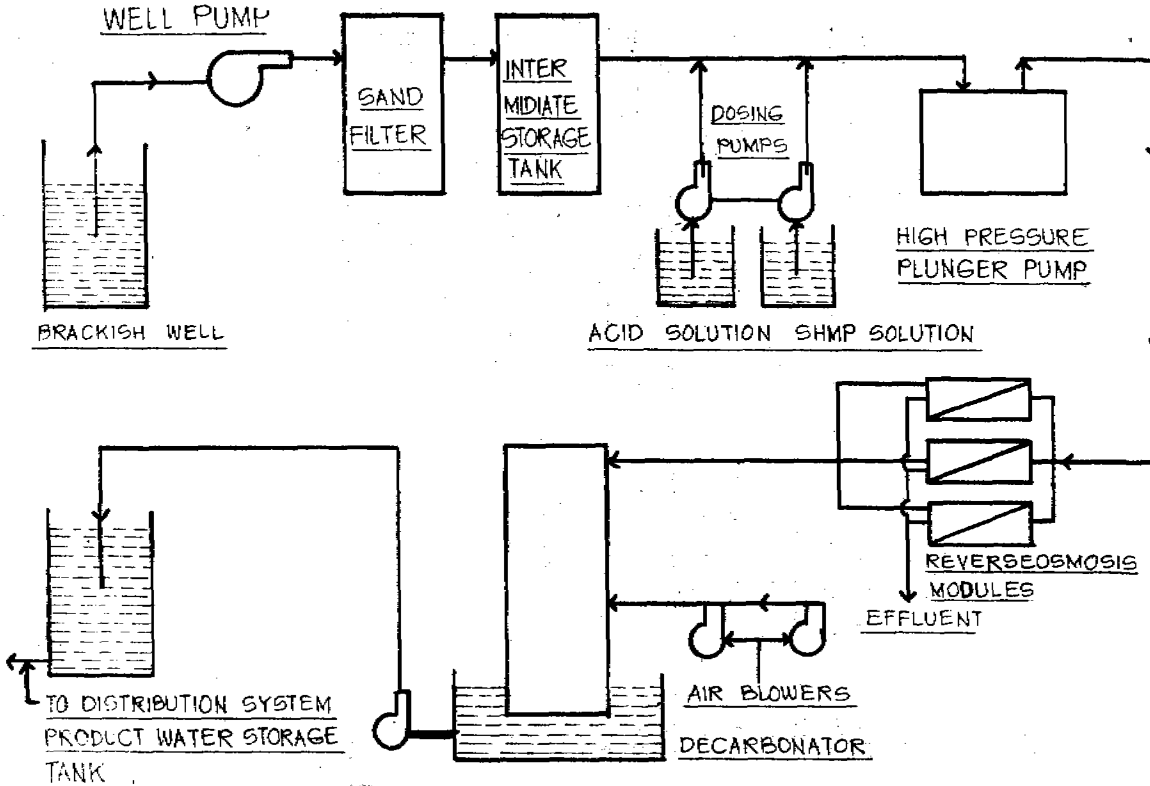


Fig. 5. RO Plant Flow Diagram.

Operating Pressure—600 psig

Salt rejection—Higher than 80 per cent

Electrodialysis

Electrodialysis process for desalination of brackish water involves separation of dissolved cations and anions by the use of ion exchange membranes. Ion exchange membranes are thin films which are largely impervious to water but contain electrically charged groups set in a gel structure which allows the ions of salts to pass through under the application of direct electric current. Anion exchange membrane contains electro positive groups which attracts, by coulombic interaction, such negatively charged ions as chlorides and sulphates and allow them to pass through. The positive charged ions such as sodium and calcium are prevented and are exclusively passed through cation membranes in the reverse direction.

In an electrodialysis apparatus, the anion exchange and cation exchange membranes are arranged alternatively into an assembly of cells of about 1-2 mm thickness with suitable gaskets and spacers to create ion traps into which the ionised salts are made to migrate by applying an electric potential through suitable electrodes at the ends. The cells are assembled into stacks of $60 \times 30 \times 75$ cm size which comprises as many as 200 membranes.

The membranes are made out of interpolymers of polyethylene and vinyl monomers like styrene and divinyl benzene to which cation exchange property is added by sulphonation and anion exchange property is added by chloromethylation followed by amination.

In electrodialysis process the energy consumed is directly proportional to the salinity hence it becomes uneconomic beyond 5000 ppm of dissolved solids in feed water. Feed water is first treated for removal of hardness by ion exchange and is split into 2 streams and fed into alternate set of compartments in the stack. The electrode chambers are separately flushed with the feed water. When direct current is passed through this unit, the ions migrate towards the respective electrodes of opposite charges but due to the presence of membrane the alternate chambers get depleted in salt content while the remaining chambers get concentrated. The process can operate continuously if the concentrated and dilute solutions are

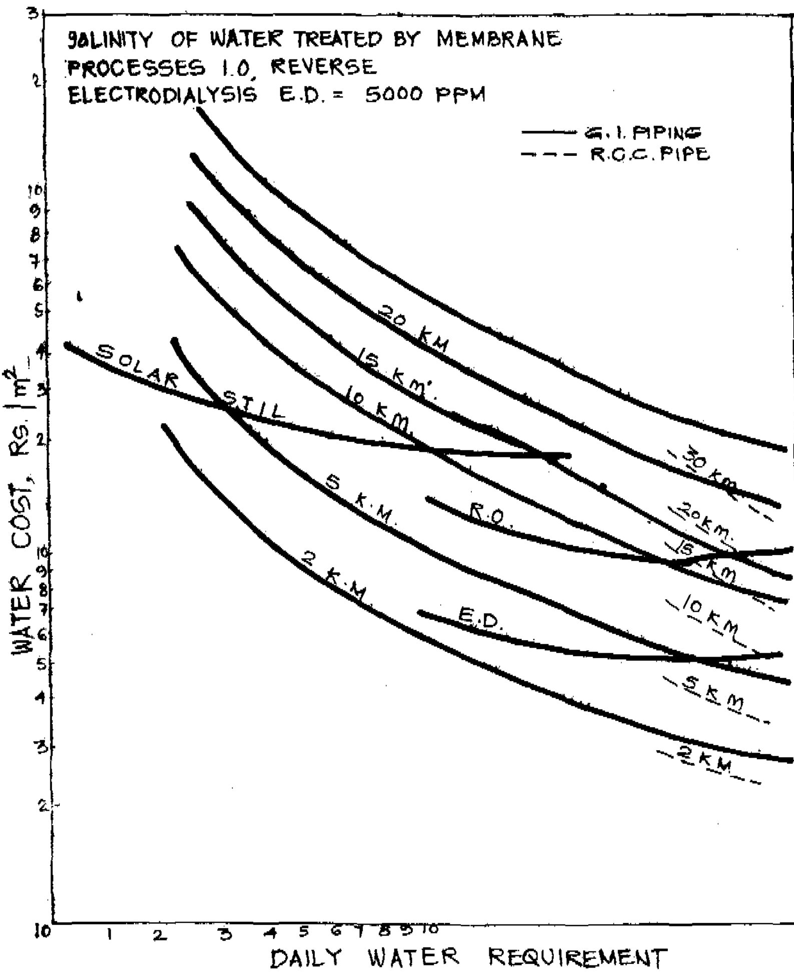


Fig. 6. Comparison of Cost of Water Supplied by Disalination Techniques with Water Pipelines.

continuously withdrawn from the respective chambers. The salinity of product water can be adjusted by flowrate and current input.

Cost of product water by RO/ED plants vary from Rs. 4 to Rs. 10 per 1000 litre. 7 ED plants have been installed in Gujarat, Rajasthan, West Bengal and Diu. The comparison of RO/ED plants with piped water supply are given in figure 6.

Cost effective solutions

The water supply units which can be run by human power and has a life of 15-20 years with annual maintenance of 2 to 3 per cent of the capital cost, can be cost effective. To this yard stick, the social cost of available mandays due to good health may be added wherever maintenance of units for water quality is concerned. The water supply facilities which are installed with welfare fund or interest-free grants from Govt. should not be subjected to interest charges for costing. The depreciation charges also should not be calculated at more than those for normal water works equipments. Basically the life of the technological plants can be extended to the same extent, by proper maintenance. As such the maximum depreciation charges should not be more than 5 to 7 per cent of the capital cost.

The evaluation of proformance of RO/ED plants have shown that the cost component of depreciation charges are almost 50 per cent of the total running cost while the direct cost including chemicals, power, and man-power is 30 to 40 per cent on the basis of 8 hours running of plants. As such, it can be seen that the continuous running of plants on 3 shift basis and standardisation of depreciation charges can bring down the cost per cubic meter of treated water by 50 per cent of the present cost. For example, the cost of treated water for 10 cubic meter per day (8 hours) plant including depreciation, chemical and power and man power and interest charges is Rs. 38.47 per cubic meter while the cost of the treatment with only membrane, chemical power and man power charges comes to Rs. 13.9 per cubic meter. This plant has worked on an average for 2.5 hours only per day as compared to the rated 8 hours per day. The common experience of reduction of share of fixed cost by increasing the output should be adopted by the authorities responsible for operation of such plants.

The reference to RO and ED plants have been made because their capital cost is highest among all treatment plants for improvement in water quality. The RO/ED plants can also effect the removal of other ions such as fluoride and Nitrates to some extent. The treatment methods specific for removal of fluoride and ion will also fall within the standard to be applied for RO/ED plants.

Better management practices normally applied to all process plants such as formulation of reliable data base, prescheduled routine maintenance and improvement in design and materials, would also apply to these plants. However, these can be further improved by innovative measures in the basic design, material improvement or operation and maintenance norms of such units. Reduction of time taken in installation, by development of standard modules, can also result in achieving cost reduction.

Simultaneous action have been started towards achieving multidimentional goals and the Technology Advisory Groups are pursuing the possible measures in these directions. All the known source of expertise are being brought within the network of the agencies involved with the Mission. It is expected that by the end of the first phase of the demonstrative mini-missions, a comprehensive data base will be generated which will optimise the activities in the consequent phases.

3

Water Resources and Their Development in a Tropical System

The principal water resources for human use are :

(*i*) Surface resources through rivers and streams. and

(*ii*) ground water.

The current estimation of annual flow of all river systems in India is of the order of 2,000,000 million cubic meter. The correct and scientific assessment of all the ground water potential of the country which is under progress over last 2 decades, is yet to be finalised.

The development of water resources in India is linked with non-availability of water, quality assessement for potability, location, distribution and variation, climatic condition including rain-fall, nature of soil and terrain, cropping pattern etc. Dealing with all these diversified field for conjunctive use of water calls for a comprehensive integrated strategy for the conservation and development of water resources. The integrated policy for rational development for water resources needs due attention to irrigation, drainage, navigation, flood control, hydro-electric power generation, supply and disposal of water for industrial and domestic use, reclaimation of land including afforestation, control of pollution from point and non point sources, pisciculture, animal husbandry, recreation, ground water recharge etc. The water resources being limited, increasing competition between agriculture, industry and other users is envisaged. Keeping this in view, the national policy of water has been worked out giving highest priority to safe drinking water, to which the irrigation water comes next.

Other policy measures under consideration include introduction of legislative measure for systematic water management, setting of national agencies such as National Water Board for specific tasks, reservation of water for drinking purposes in all irrigation projects, compulsory prescribed geophysical survey before drilling deep tube wells, banning of cultivation of water intensive crops in water scarcity areas.

Role of Hydrology in Water Resources Development and Utilisation

Hydrology is the earth science which deals with availability of water resources and their variability in space and time. Hydrological investigation and analysis constitute basic requirement in the effective utilization of water resources, their developments and coordination as well as mitigation of disasters caused by extreme events like floods, droughts, etc. The hydrological analysis is mainly related to the assessment of water yields, estimation of flood for design of structures and such other analysis as would be required for flood control, reservoir operation and water resources managment. Besides basic and fundamental research in scientific hydrology, it is necessary to identify and develop appropriate technologies for dealing with practical fields problems with typical environmental, physiographic and climatic conditions. Hydrology as an inter-disciplinary science has grown considerably after the launching of International Hydrological Decade. Recent developments in this field include use of mathematical and conceptual models with high speed digital computers, systems techniques, remote sensing and nuclear technique.

The important areas of study/research in the field of Hydrology are listed below :

1. Assessment of Water Resources

2. Floods
3. Design Flood including Design Storm
4. Surface Water Yield
5. Ground Water Yield
6. Inter Basin Transfer
7. Water Logging, Drainage and Salinity
8. Water Quality and Waste Disposal
9. Water Availability from Lakes (Natural and man made)
10. Water Management including Erosion and sedimentation
11. Drought and its causes and cure
12. Arid Zone Hydrology
13. Conjunctive use of Surface and Ground Water
14. Information System, Data Storage and Processing
15. Hydrological Investigation
16. Hydrology of Mountaineous areas.
17. Hydrological Problems of Forests and Agricultural Lands
18. Man's Influence on Water Regime and Availability
19. Hydrological and Environmental Factors for Water Resources Projects
20. Integrated Planning of Surface Water Resources
21. Water Use Management

22. Water Availability Studies in Hard Rock Areas

23. Hydrology of Coastal Areas, Esturaries and Deltas

24. Hydrology of Islands.

25. Man Power Development

26. Water Laws

27. Nuclear Applications

28. Remote Sensing

29. Instrumentation

The Steps Involved in Water Management

A graphical correlation of components involved in total water management is shown in Fig. 1. The scientific methods involved in ground water exploration are described below :

(*i*) *Hydrological Exploration*

The key for successful ground-water programme lies in obtaining essential information on Geology and Hydrology of a terrain. Knowledge of Hydrology is needed to determine the the sources of supply and discharge of groundwater. Precipitation (ultimate supply source) may infiltrate to groundwater directly or it may go as run off and stream flow which infiltrates in part. Excess water supplied to the land for irrigation purposes, could sink partly underground and contribute significantly to the ground water reservoir. Quantitative evaluation of all these items are essential for a proper understanding of groundwater occurence and availability. The second essential item is precise information on geological formation such as (*i*) sedimentation framework, (*ii*) structural framework, (*iii*) thick-ness of various geological units acting as aquifers, and (*iv*) permeability and storage characters.

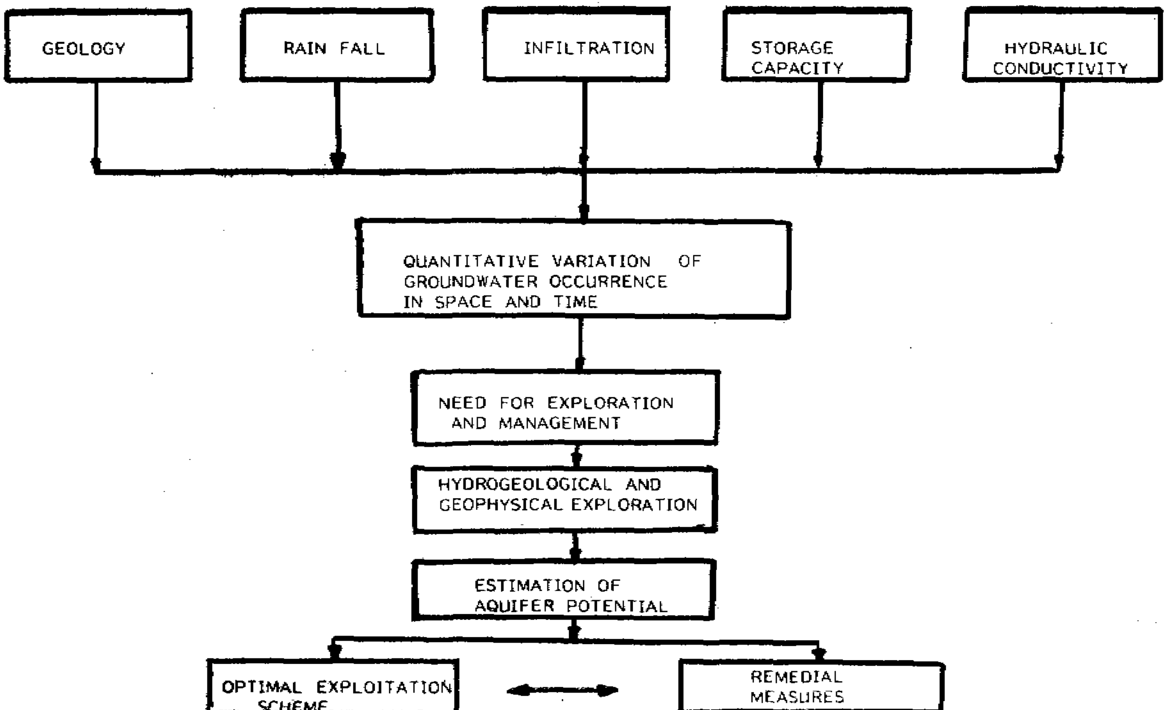

GEOLOGY
RAIN FALL
INFILTRATION
STORAGE CAPACITY
HYDRAULIC CONDUCTIVITY
QUANTITATIVE VARIATION OF GROUNDWATER OCCURRENCE IN SPACE AND TIME
NEED FOR EXPLORATION AND MANAGEMENT
HYDROGEOLOGICAL AND GEOPHYSICAL EXPLORATION
ESTIMATION OF AQUIFER POTENTIAL
OPTIMAL EXPLOITATION SCHEME
REMEDIAL MEASURES

Fig. 1

The hydrological and geological features when combined together would lead towards understanding the hydrological system/or a unit. It could be a major unit (macro basin) or a micro unit (micro basin). Each of the basin or a sub-basin would have surface hydrological boundaries and a sub-surface system with certain degree of transmissivity and storage. One must analyse these boundaries and parameters as accurately as possible before any system is subjected to development programmes and management practices.

A rapid inexpensive reconnaissance survey over a region could be conducted in unexplored regions through quick field traverses and by collecting all relevant geological and hydrolocal features. Interpretations of ERTS images combined with field checks should become a part of these rapid studies.

All available hydrological data such as water levels spring discharges, yield characters of well structures and water quality parameters when properly evaluated over a geological terrain would facilitate preparation of a preliminary hydrological map.

The above studies could further be intensified to map the terrain in detail and estimate the micro-level changes in the flow patterns, velocity potentials, yield characters and chemical quality variations. These detailed studies could be taken up over a period to time — say one hydrological cycle or two hydrological cycles depending upon the logistics. Detailed hydrological and hydrochemical maps could consequently be prepared which could serue as potential tools for development of ground water either for drinking or irrigation. The above studies would in general help to evolve the following hydrological information.

(*a*) Primary and secondary porosity and permeability characteristic of the materials.

(*b*) Aquifer boundaries.

(*c*) Depth of water table and probable saturated thickness of aquifers.

(*d*) Relationship between topography, geology and hydrology.

(*e*) Identification of recharge and discharge areas ; relationships between surface and ground waters.

(*f*) Estimates of productive areas for ground water development and design of well fields.

(g) Estimates of groud water quality ; fresh or saline.

(*ii*) **Hydrological Test Analysis-Yield Characters Equipment-Interpretation Techniques**

In a ground water system, if its flow properties and yield characters are to be properly evaluated, a proper hydrological testing design should be framed and short and long duration hydrological tests should be carried out depending upon the details of the parameters we are looking for. A number of methods/techniques are available to evaluate the hydrological parameters. One should be careful in adopting right method of approach taking into consideration the well structural design and the ground water system. One should not use methods available for a confined system to an unconfined system etc.

A mobile generator and necessary pumping equipment and and assemblies are used to test wells in both hard rocks and sedimentaries. The equipment could be moved from place to place with the help of a jeep and tractor. Hydrological tests should be carried out even in remote places where electricity is not available. Ascertaining the yield characters is a must for any ground water development programme whether it is for drinking or irrigation. The above procedure when followed would yield the following information:

(*a*) Yield characterstics and potentials of a well.

(*b*) Efficiency of the well performance.

(*c*) Confirmation of the hydrological nature of the aquifer.

(*d*) Determination of the hydraulic properties of the aquifer system.

(*e*) Production of the effect(s) of present or future pumping from the ground water system.

Simulation of Aquifer Parameter

The purpose of a simulation model is the following :

(*a*) To synthesize past hydrologic events.

(*b*) To predict furture hydrologic events and to evaluate, for designing purposes and computation of hydraulic events occuring rarely in nature.

(*c*) To evaluate the effects of artificial charges imposed by man on the hydrologic regime.

(*d*) To provide a means of research for improving the understanding of hydrology including the run off process.

Aquifer parameters are obtained by pumping tests at several points and are estimated for the areas in between. In practice, three types of models are used namely.

(*a*) Resistor-Capacitor model (R-C Model).

(*b*) Digital models

(*c*) Hybrid models

(*d*) Analog model

With the help of analog models, the physical condition of the system can be measured at each point of the model but the parameters can be varied only in a limited manner. In case of digital and R-C models the aquifer has to be sub-divided into a large number of sub-areas and the parameters can be varied in wide range. But the response of the model is only available in a sub-area.

A very rough view of prices of hydraulic modelling is presented in Figure II.

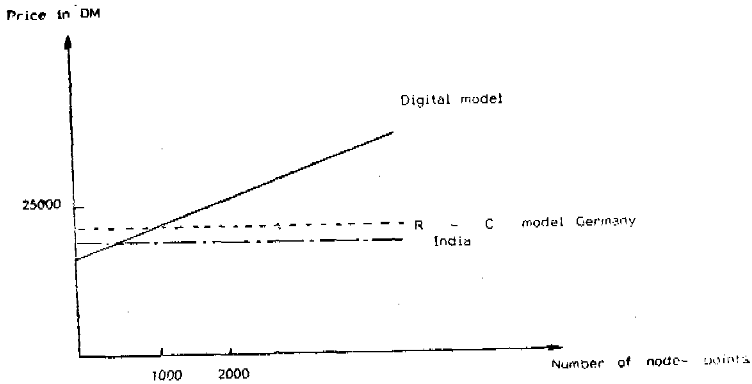


Fig. II

It can be seen that for less than 1000-2000 node points the digital model will be less expensive than the RC model. For a higher number of node points the price of a digital model is is higher than the RC model.

The basic data on aquifer system is obtained by geophysical investigation, This is to be combined with bore hole measurements in existing wells or some additional wells if necessary and pumping tests for the evaluation of the aquifer parameters. As such the geohydrologists and the hydrologists who will build up the simulation model, should plan together the first model of the system. The surface data and Hydrological data together will simplify the model. The first rough model may not simulate the prototype in its most accurate form but the models' results will bring up questions to hydrologists who are to conduct further field studies, with the result of which the model can be refined further.

Different simulation technique is best suited for specific type of aquifers. If the aquifer system is very simple, analog models as an electrolytic through or a conducting paper model will be sufficient. For more complex system, RC analog, digital or hybrid models are more useful. The kind of simulation model which will be most suitable depends on the availability of man power and price of diverse techniques. If the aquifer parameters are changing with time, the application of techniques becomes more complicated and capital intensive.

Hydrochemistry of Ground Water

A major part of the ground water infiltrates through the soil and therefore, it acquires the mineral composition and characterstic of the soil. Many of the process involved in weathering of rocks which give rise to soil formation result in dissolution of minerals by leaching by water. Decomposition of organic water by micro organisms results in presence of soluble bicarbonates in water.

The chemical composition of water in a basin can be used to understand the flow and mixing patterns of water of different origins. The geochemistry of confined and unconfined aquifer and river water clearly distinguish between recharge, transition and discharge zones. In practical experience it has been found that the radioistopic tracer studies and studies of chemical characterstic are in conformity with each other, in determining the specific hydraulic zones.

In order to ascertain accurate hydrochemical characterstic, it is necessary to adopt spot sampling and anlaysis by mobile laboratory. It is also necessary to design and fabricate monitoring gadgets to continuously measure the level of contaminants at identified locations.

Organisation and Programme in India

As many as sixty organisations are working in the field related to hydrological investigation inclusive of the international hydrological programme sponsored by UNESCO. The phase III of the programme which is under implementation during the current years, cover the following :

1. Investigation of elements of the hydrological cycle and determination of water balances.

2. Methods for the investigation of surface and ground water regimes and for the determination of hydrological parameters for water projects.

3. Interaction between climatic variability and change and hydrological processes.

4. Hydrology of particular regions and land areas.

5. Application of special technologies for the study of water resources.

6. Methods for assessing the charges in the hydrological regime due to man's influence.

7. Environmental impact studies of water projects.

8. Specific influence of man on the hydrological regime.

9. Methodologies for water resources assessment.

10. Methodologies for integrated planning and management of water resources.

11. Systems management for reduction of negative side effects of water resources development.

12. Development presentation of information for planners and and decision makers concerning the implications of modern water resources planning and management approaches.

13. Promotion of education and training in the fields of water resources.

14. Preparation of guidance material to be used for the establishment of training courses in hydrology and water resources management, addressed to various categories of a personnel.

15. Improvement of teaching methods in hydrology and water resources nabagenebt.

16. Comparative methodologies for public information and the promotion of public participation in the proper utilization, protection and conservation of water resources.

17. Scientific information systems : to facilitate the flow and utilization of scientific and technical information in the field of water resources.

18. Methods for the effective transfer of knowledge and technology related to water resoruces, and for the evaluation of their impacts in developing countires.

About eighty scientific organisations including Central. State and Universities educational bodies are engaged within the the country in various tasks involved in the above programme.

The Technology Mission for Drinking Water in Villages and Related Water Management

During the tenure of 7th plan, period, about 1.5 lac villages have been identified where new potable sources of water is required to be created. A Central Technology Advisory Group has been formed which shall attempt precise indentification of dependable sources and prepare plans for development of ground water sources and disseminate ground water data to the user agencies for follow up action; develop and suggest areas for augmentation of the existing ground water resources through micro level ecological planning and make recommendations for conjunctive use of ground and surface water resources.

At the state level there are source finding committees which will take care of the details of conservation, recharge, quality monitoring and exploration for water. Hydrogeomorphological and lineament maps on 1:250,000 scale have been prepared for about six districts in the north and most of the southern part of the country. Potential features around the villages with water scarcity in selected districts have been plotted on the 1:50,000 topographical maps. In order to cover the entire county under this activity, extensive man power development programme has been taken up by central agencies for placement of property qualified personnel at the state level for collection and interpretation of satellite data and geohydrological data, and preparation of maps etc.

The Technology Mission has taken up 50 districts in the first place, for systematic demonstration of application of scientific techniques in reduction of time and cost in creation of new potable water sources and their maintenance. Central Scientific agencies namely Central Groundwater Board, National Gaophysical Research Institute, Space Application Centre, National Remote Sensing Agency will help the state Govts. in providing adequate scientific input for source location and development in these districts. About 25,000 villages are likely to be covered under this demonstration programme.

The demonstration of technology in the 50 pilot districts is expected to bring out various locations specific combinations. The examination of data on development of water source in these districts could generate the pattern which should be adopted in similar locations for application of technology.

During last few months about 25 districts have been extensively covered by scientific source finding techniques and as many as 1500 locations have been indicated, The drilling failure in these locations is significantly lower than those locations which are drilled without adequate scientific studies.

4

Integrated Approach for Ground Water Management in India

The requirement of drinking water for the present population in India at the rate of 40 lpcd is about 1.1 mil. hm.

The average annual rainfall is .about 400 mil. hm. which provides potential for 60-65 mil. hm. of surface water and 25-40 mil. hm. of ground water. However, about 300 million people remain affected by lack of supply of potable water till the 7th Five Year Plan Period.

One of the main difficulties in making water available at time and place of need is the highly non-uniform spatio-temporal distribution of the various utilisable components of the hydrological cycle of rainfall, surface water and ground water. The variation of rainfall throughout the country ranges from 10 cm to 1070 cm per year. The occurance of surface and ground water also has very wide spatio-temporal variation due to diverse topological, hydrological, hydrometeorological and soil conditions. In such a situation the problem of drinking water cannot be solved on a permanent basis without resorting to scientific management of this resource.

Programme of integrated Water Management in general involves (*i*) quantitative assessment of the utilizable components of the dynamic water system,

(*ii*) quantification of interlinkages between these components,

(*iii*) maximization of the utilizable water through proper manipulation of these interlinkages,

(*iv*) maintenance of desired quality of water for specific and uses.

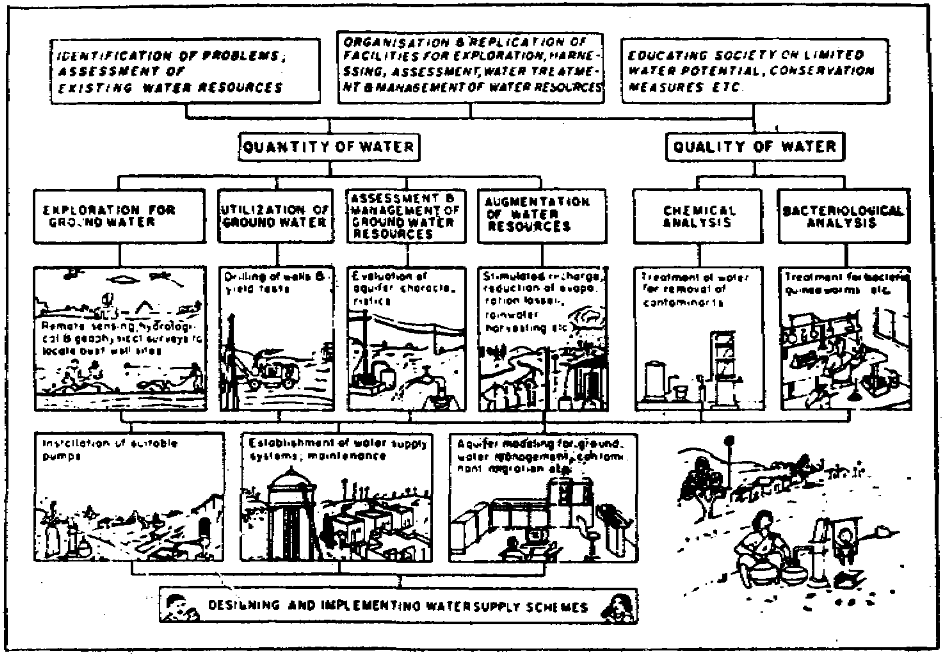
A graphical presentation of suggested procedure for design and implementation of water supply scheme for sustained supply of potable water is given at page 59.

India experiences an average annual rain fall of about 1200 mm which is significantly higher as compared to that in United States which is about 200 mm per year. The quantity of precipitation received every year is about 400 mham which is distributed in 3 basic ways :

Evaporation loss	—	70 mham
Surface run off	—	115 mham
Percolation into soil	—	215 mham

This creates annual renewable resources of ground water of about 40 mham.

The demand of water in India is mainly for irrigation which consists of more than 90 per cent of the total demand. Domestic and Industrial uses accounts for the remaining. Drinking water comprises very small part of the total consumption and is not more than 1-2 mham per year. However, the latter involves specific quality requirement in order to provide appropriate health and welfare for the community. The total water consumptian does not exceed 150 mham per year in our country, which can be met out of the renewable water sources, simultaneously maintaining the ground water sources.



IDENTIFICATION OF PROBLEMS; ASSESSMENT OF EXISTING WATER RESOURCES
ORGANISATION & REPLICATION OF FACILITIES FOR EXPLORATION, HARNESSING, ASSESSMENT, WATER TREATMENT & MANAGEMENT OF WATER RESOURCES
EDUCATING SOCIETY ON LIMITED WATER POTENTIAL, CONSERVATION MEASURES ETC.
QUANTITY OF WATER
QUALITY OF WATER
EXPLORATION FOR GROUND WATER
UTILIZATION OF GROUND WATER
ASSESSMENT & MANAGEMENT OF GROUND WATER RESOURCES
AUGMENTATION OF WATER RESOURCES
CHEMICAL ANALYSIS
BACTERIOLOGICAL ANALYSIS
Remote sensing, hydrological & geophysical surveys to locate best well sites
Drilling of wells & yield tests
Evaluation of aquifer characteristics
Stimulated recharge, reduction of evaporation losses, rainwater harvesting etc.
Treatment of water for removal of contaminants
Treatment for bacteria, guinea worms etc.
Installation of suitable pumps
Establishment of water supply systems; maintenance
Aquifer modeling for ground water management, contaminant migration etc.
DESIGNING AND IMPLEMENTING WATERSUPPLY SCHEMES

Fig. 1

Inspite of the above situation we are faced with severe water shortage in various parts of our country and are not in a position to make available required quantity water at times and places of need. This situation occurs mainly due to high regional variation in rain fall, from 100 mm in Rajasthan deserts to 11,000 mm at Cherapunji, also high non-uniform spatio temporal distribution of ground water, great diversity in topological, hydrological, hydrometeorological and soil condition in various parts of the country. It is primarily because of these variations in availability of water, the related problems cannot be solved on a permanent basis without resorting to scientific management of the dynamic resource.

Suggested Steps in Scientific Water Management

The objective of water management is to increase the residence time of water on land by efficient and cost effective storage during and places of abundance for being used at time of scarcity. Similar objective is also applicable for ground water which is to be used as complement and supplement to the water available on the surface.

The collection and study of existing regional data on topography, geology, geomorphology would give the basic understanding about the watershed area. Hydrology, rain fall, evaporation rate, surface hydrology and potential of water source will indicate the total resource available at time and place. Use pattern and water collection status including the requirements of water for specific end uses and indicated short fall, identifying the requirement of further action to be undertaken with respect to the exploitation of various sources, should be verified as primary measure.

The exploration of ground water should be carried out after studying the land-sat imagery of the region, Ground check and geological traversing data will indicate the location of the aquifer. The well inventory should be verified by geo-electrical profiling and sounding along with geophysical logging. Hydrological maps should be prepared after study of the forgoing data, in order to indicate the possible location to be tapped for adequate ground water resource.

Dug wells and bore wells are next to be drilled in the more suitable points identified by geoelectrical sounding and ground water draft is assessed before installing the stand post or public supply points.

The ground water should be suitably supplemented by use of surface water in order to preserve the latter for more difficult times. Surface water can last longer provided adequate steps are taken for control of evaporation and seepage. Modern technologies for evaporation/seepage control by use of polymeric chemicals and films have been extensively used in other countries. In addition, efficient water harvesting system should be identified and installed for cost effective storage at the points of collection of rain water,

The quality of the ground and surface water which has been made available at particular place should be assessed for its acceptability particularly for the purpose of drinking. The parameters may be broadly underlined as under:

Physical	:	colour, turbidity, temperature, taste, odour.
Chemical	:	pH, conductivity, Alkalinity, hardness, chlorides sulphates, fluorides, nitrates, iron, manganese, CO_2.
Bactereological	:	MPN Test/rapid test
Biological	:	Guinea worm vector

After identification of water problems one has to assess the appropriate type of treatment technology to be adopted for the particular source. In some cases the source can be abandoned and there may not be need for treatment, as water may be available from another nearby source of good quality. However, in many cases it has been experienced that concept of treatment of water at the source points, may avoid need for laying long drawn distribution lines and its maintenance. It may be possible to develop a method of involving the community in installation and maintenance of the treatment facility installed for a community, by the community itself. This concept is propagating in various developing countries at a satisfactory rate.

In case of installation of treatment plant, it is necessary to adopt a suitable design which is specific for the location. The operation and maintenance and evaluation of the plant including its acceptance should always form an essential part of such plants. Efforts should be made for ensuring that the community is involved from the begining for installation, operation, maintenance and evaluation particularly for a subject like water which has lasting effect on humanity and environment.

Guidelines for environmental impact assessment for use and disposal of water should be derived and followed for preservation of both surface and ground water. Disposal of highly polluted water in surface or on the ground will change the nature of the regional water shed to an irrepairable extent.

Infrastructure Requirement

It is essential to have adequate infrastructural supports to facilitate adoption of scientific management system for utilisation and preservation of water resources. Trained man power is one of the greatest constraint in furthering scientific practices and adopting an integrated approach. It is necessary to organise specially designed training programme to train a good number of scientists/technicians in the integrated approach. These people can further replicate such training in their individual region. Engineers, Geologists, Geohydrologists can be selected for such training. Operational part of the system can further be taken up by science graduate and technicians in the field.

It is necessary to install rain-gauging stations, stream-gauging stations in strategic locations for assessment of surface water flow over the years. Comprehensive multiparameter hydro-meterological stations should also be installed for collection of hydrological information.

Adequate facility for drilling of exploratory bore wells for assessing the availability of ground water in various places in the country should be provided. Present facilities are not in a position to cover more than 1000 such wells a year. Assessment of well potential is to be carried out simultaneously by pumping/recuperation test to estimate hydrological parameters of the aquifer.

In most of the places in the country the quality of water is not tested in absence of appropriate facilities. Since the drinking water is more linked with human health, it is necessary to assess its quality by testing laboratories, which should be instituted at the district level and state headquarters level and provided with instruments which should give preliminary and detailed information about water quality in order to indicate the need for treatment of water.

Design and installation of the water treatment system should be undertaken after assessing the most cost effective measures along with simultaneous operation and maintenanee.

Intensive health education for public through all the established and other possible means should be developed in order to maintain the awareness regarding appropriate use of water from individual water sources.

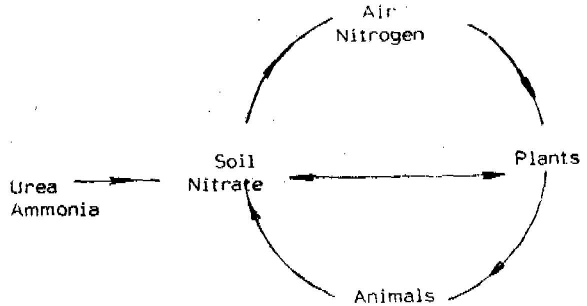
It is not possible to develop such huge infrastructure under supervision of the Government alone. It is necessary that all organisations engaged in development and utilisation of water should do their own bit in regard to development of such a system. It is more important that the system should be maintained after it has been installed and provide necessary data for monitoring of the quantity and quality of the water sources. A base has been prepared with the help of national and international bodies concerned in development and use of water. which should be further widened for broad basing as well as for micro level operation.

5

Nitrates in Ground Water

Origin of Nitrate

A newly emerging problem in the field of ground water quality is in the form of excessive nitrates arising out of increased use of nitrogen fertilisers. The current consumption of nitrogen fertilisers in the country is of the order of 10 mil. tons which is likely to increase to 15 mil. tons by the end of the century. This fortifies the global nitrogen cycle as indicated below:



The nitrate compouds present in soil helps the plants in the synthesis of their substance. It is the nitrogen compound with highest stage of oxidation. It occurs due to mineralisation of organic manure and subsequent bacterial nitrification. discharge also occurs during thunderstorm by means of electric Nitrate in the atmosphere, which is the largest reservoir of nitrogen.

Nitrate in ground water is usually derived from,

— Nitrate from the geochemical composition of ground water

— Nitrate from thunderstorm

— Nitrate from manure

— Nitrate from the organic pool of the soil

— Nitrate from the infiltration of surface runoff.

Sodium nitrate and calcium nitrate are often found in minerals occuring in arid zones and are highly soluble in water. Ammonium is bound on the lattice of silicates in a non-exchangeable form and is released only if the rock gets decayed. The nitrogen compounds go into surface waters mainly through the introduction of the communal, agricultural and industrial waste waters, through the rain water and through the washing away of agriculturally used surface and built areas. Average distribution of contamination from each source may be represented as under :

Commercial fertilisers	31%
Manure	19%
Soil nitrogen	46%
Rains	4%

Presently the specified limit of nitrates in drinking water has been set at 50 mg NO_3 per litre.

Effect of Nitrate

The nitrate itself has no effect on health. But nitrate gets reduced to nitrite, which has a definite toxic effect at the concentration of 0.1 mg/l. The nitrite oxidises the red colouring matter (hemoglobin) of blood to methemoglobin, in which case the blood colouring matter is not in a position to transport oxygen. In case large rates of conversions are involved, inner suffocation may occur which can be recognised by the grey-blue colouring of skin and mucous membrane. In case of infants the convertion of hemoglobin can occur at double speed, as such they are more susceptible to methemoglobinemia. Such cases were reported more frequently when the limiting nitrate concentration was laid as 90 mg/l.

Besides methemoglobinemia, which is characterised as secondary toxicity, there is possibility of tertiary toxicity due to formation of nitrosamines. Nitrosamine occurs due to the reaction of nitrate with amines which are essential constituent of human food. Nitrosamines are reported to be very strong cancer producing agents.

The nitrates can be reduced to nitrite with the help of bacteria

- in water distributing lines
- by means of reduction of bacteria in foodstuffs and drinks
- in the stomach and small intestine
- in dental cavities.

Measures For Reducing Nitrates

In India, in a recent survey, 1290 ground water samples from 11 states were found to be having nitrate content more than 45 mg/lit. Most of them are also found to have high dissolved solids content. Necessary steps should be taken to supply nitrate free water in these regions viz. Rajasthan, Gujarat, Tamil Nadu, Andhra Pradesh, Haryana, Karnataka, Lakhshadweep, Madhya Pradesh, Bihar, Maharastra, Orissa etc. Various methods adopted and suggested in other countries are indicated below for information and perusal.

It has to be kept in view that the cost of such solution varies from one possibility to another depending on the place, hydrogeological conditions and agricultural conditions. Dilution by mixing with nitrate free water is often recommended in this regards, if possible. As nitrates are often associated with high TDS (total dissolved Solids), the standard technologies applied for. desalination viz reverse osmosis and electrodialysis can also achieve the removal of nitrates, as is the case for fluorides and other undesirable salts.

The method of natural decomposition of nitrates by bacteria can be sucessfully applied for removal of nitrates. The pre-requisite for the course of denitrification are the partly oxidised conditions, optimum pH-value and temperature and sufficient supply of reduction agent for the micro-organism. Depending on the type of micro-organism used, either hydrogen (Autotrophic becteria) or an organic carbon compound (heterotrophic bacteria) are added as reduction agent. For denitrification within a short time, highly concentrated bacteria on a suitable carrier is used. As an after treatment aeration for enriching oxygen, active coal-filtration for the removing the residue substrate and disinfection of the nitrate-free water is carried out.

The advantage of this method is that only nitrate compounds are converted to nitrogen gas, keeping the other properties of water unaltered. No separation nor pre-treatment are required. But for disadvantage, the carbonate hardness of water is increased and extensive checking for complete removal of nitrate is required.

For supply of water with reduced nitrate content for drinking purposes the following alternative measures can be adopted : —

Source Development

* Procurement of water from other sources totally or partially.

* New tapping of ground water with low-nitrate content by constructing new wells in nitrate free zone, widening of flat wells or tapping of water from higher depth.

* Selective aquifer management with known nitrate profiles.

Hydro-Technical Methods

* Physico-chemical methods such as reverse osmosis, ion-exchange (pure anionexchange and partial desalting) electrodialysis.

* Biological methods including autotrophic denitrification with hydrogen and heterotrophic denitrification with organic substrate.

* Subsoil denitrification.

* Elimination by high nitrate consuming vegetation,

The selection of any of these measures should depend on the location of the concerned water works with respect to the vicinity of source of supply, existing piping system including long distance water supply, hydrogeological factors, conditions within catchment area.

However, for each individual hydrotechnicol method, additional expeniture for pretreatment of raw water and the subsequent post treatment of the treated water and that for removal of waste water should be taken into consideration. It is necessary to apply all these methods in such a way that they conform to the standard concept of seepage/drainage removal.

In the biological method, installation of plant for post treatment by aeration etc. can be avoided by allowing a sufficiently long aerobic passage (canal) to be attached to the denitrification platform. The capacity of subsoil for aerobic self purification may be used as a basis for design of this canal. The nitrate removal plants should be designed and laid in such a manner that even during the peak operation the limiting values of nitrates, 50 mg/l, should never be exceeded.

The cost of treatment by these methods may vary between Rs. 3 to Rs. 8 per cubic mtr, of treated water and is quite uneconomic for small water works below 30 cubic mtrs. per hour capacity, praticularly when the raw water is strongly loaded with nitrate. As such, one must generally proceed on the basis of the assumption that treatment should be taken up as a last resort. In many cases a combination of instantly implemented hydrological measures and a packet of agricultural measures adopted to local condition would be most suitable way to solve the problem of nitrate load. In this respect a close collaboration between the water supplying and the agricultural sectors with in the affected catchment areas is necessary.

6

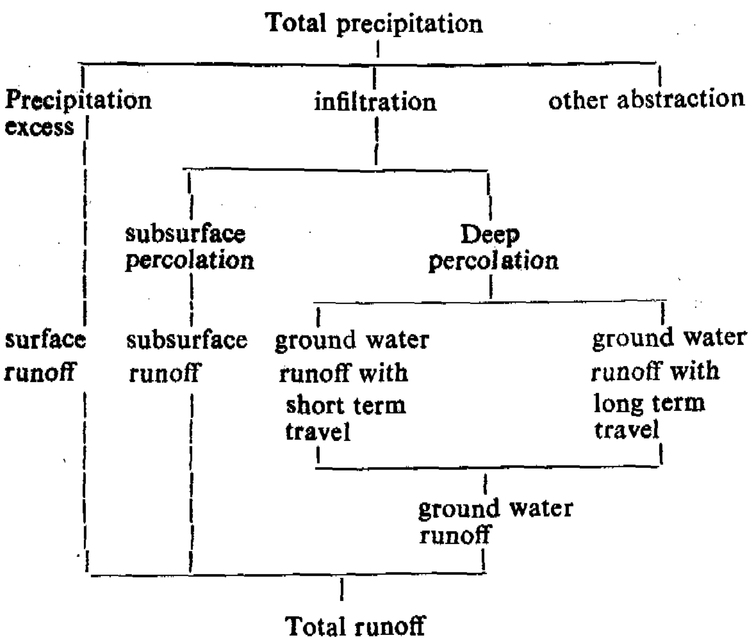
Surface Water Potential and Its Utilisation in India

The World Waters

The global Water Resources are estimated at the rate of 1.5×10^9 cu k.m. of which ocean waters are 98%, and the other surface waters including lakes, rivers, soil moistures and biological waters are not more than 1% of the remaining 2%. The evaporation from ocean and other surface waters provide about 110,000 cu k.m. water every year, but most of this amount goes to the ocean leaving only 25 per cent for replenishing the land based water system. The polar ice caps and glaciers form a major source of fresh water. At present glaciers cover 16.2 mil k.m.^{2} or about 11 per cent of land surface. 99 per cent of the total glacial ice on earth, estimated to be 27 mil. k.m.^{3}, is concentrated in Antarctica and Greenland. The rest can be considered for supplementing the surface water sources through natural and artificial melting processes. Many river discharges are supplemented by seasonal melting of glaciers, however, consolidated man made effort in this direction should be supported by adequate environmental impact studies.

Runoff is major factor affecting the water available on ground. This is often associated with runout of the neigbhouring ground water components. The length of total shoreline is about 370000 k.m. and the discharges of 304 major rivers in about 661,960m^3 per sec. The drainage area of these rivers is about 61930 $km^2 \times 10^{-3}$. These comprise of about 60 per cent of total world runoff.

Precipitation supplements the land based water sytsems *including runoff as indicated* below :



This can be summarised by the equation

$$P = R + E + \Delta s$$

P is precipitation

R is run off

E is evaporation

Δs is storage change which can be positive or negative

There is a sharp asymmetry in the quantitative distribution and dynamical significance among the elements of global water system. The basic features of the surface water systems and those of the streamflow regime are specified by the climatical conditions. Under the given climatical conditions the amount and time variation of baseflow are controlled by geohydrological characterstics. From the hydrological point of view the present decade represent a transient period from natural regime into man controlled or influenced regime. This will be achieved by extending water resources planning and operation activity to more areas.

In particular the surface water reacts sensitively to all man-induced changes within drainage area. The subsurface camponent of river runoff formed by underground runoff of different types from aquifers, drained by hydrographic network provides the genetic and quantitative index of relation between surface runoff and under ground runoff. Subsurface flow represents one of the main components of the water cycle during the formation of water regime of river basins. Quantitative estimation of subsurface flow provides a quantitative coordination of precipitation, river runoff and ground water to characterise the relations between the main sources of ground water recharge, and would help in estimating direct underground discharge into seas and oceans. Estimation of basins by hydrologic-hydrogeological method for the preparation of river runoff hydrographs would also give an indication of the parameters of subsurface inflow into rivers from the permanent aquifers. This will develop methods for the forecast of seasonal variation of discharge of river basins. Information on hydrology and physics of soils, hydrochemistry, hydrodynamics, geomorphology and other related seiences, are required for reliable estimation of the water resources at a given time and space.

Surface Water In India

The Indian subcontinent has an unique geographic position.

In the north the Himalayas, snow capped ranges feed the great Himalayan rivers, one fifth of their flow being snowmelt. To the South spread the tropical seas between 10° N and 10° S latitudes which is the generation zone of tropical cumulus clouds. The rainfall during June-September from the South-West monsoon and November-February from the North East monsoon comes to an average 105 cms.

India has fourteen major rivers, fortyfour medium rivers and a great number of minor streams with a total annual runoff of 1645 thousand million cubic meter (TMC). The annual rainfall is estimated to be contributing about 3816 TMC. There are abaut 1500 glaciers in the Himalayan region with total volume of ice of the order of 1400 k.m. There are a few large natural lakes like Dal and Wullar in Jammu and Kashmir, Kolleru in Andhra Pradesh, Chilka in Orissa, Pulikat in Tamil Nadu etc. The potential of these lakes have not yet been scientifically studied. About 2.8 m.k.m. of Indian territory is reported to be ground water worthy and 30 per cent of the total ground water is generally used for water supply net work.

In India 90 per cent of the water required is used for irrigation, but only 50 per cent of the net sown area may be brought under irrigation till the end of the century, by implementing the ultimate potential of major medium and minor surface water and ground water based irrigation projects. This will cover about 113 m.ha of agriculture area and about 60 per cent of agriculture will continue to be rainfed.

The anticipated need of water for population of 900 mil is estimated to be about 850 TMC. The surface water sources alone can provide 1440 mil acre feet, which is same as in USA. But in USA, its utilisation is five times of that in India. The storage capacity in India will not exceed 200 mil acre feet by 2000 A.D. which will be affected by heavy silting by that time. Already one third of the country is drought prone and about 40 mil ha land is affected by flood annually. An efficient system of water management alone can help in meeting the agriculture target as well as avoid the natural calamities and associated losses.

Some preliminary studies indicate, by making optimum use of water resources through construction of storages in the head reaches of the rivers and by interlinking the river systems as well as by effecting economics in water use on the existing irrigation systems, the ultimate irrigation potential in the country may be increased to 140-145 m.ha.

Presently the efficiency in water usage for irrigation i.e. the ratio of water requirement of crop to the water delivered, is not more than 30-40 per cent. It is hampered by the inappropriate field channels, inadequate preparation of land and lack of consolidation of land holdings. Marginal and small farmers holding less than 2 ha land each have 70 per cent of their lands irrigated by small tanks and stored rain water.

Another major aspect to be considered for efficient water management is development of waste lands. These are caused due to factors such as water logging due to restriction of flow of water by the construction of roads, rail tracks, canals; obstruction of natural drainage by culverts and bridges; seepage from canal systems including water courses and field channels, deep percolation in canal irrigation areas, often as a result of over irrigation and heavy rainfall and floods. Alkalinity and salinity are caused due to lack of leaching and drainage in particular areas.

It is desired therefore that construction of irrigation projects are not undertaken in isolation without simultaneous command area development and watershed management. These activities along with engineering works should be brought under same authority for Development of surface water resources.

Scientific Water Management

The economic effects of the way runoff moves through the watershed are determined by the state of simultaneous watershed economic development. Flood Plain Development, the extent of available uses for fresh water, and the number of participants in agricultural activities translate the sequence of physical flow events into a lime pattern of derived economic value. Structures are used to alter the physical system and thereby the time and space pattern of flows and storage within the watershed. If the resulting increase in derived economic value or system utility exceeds the cost of structure, their installation is justified.

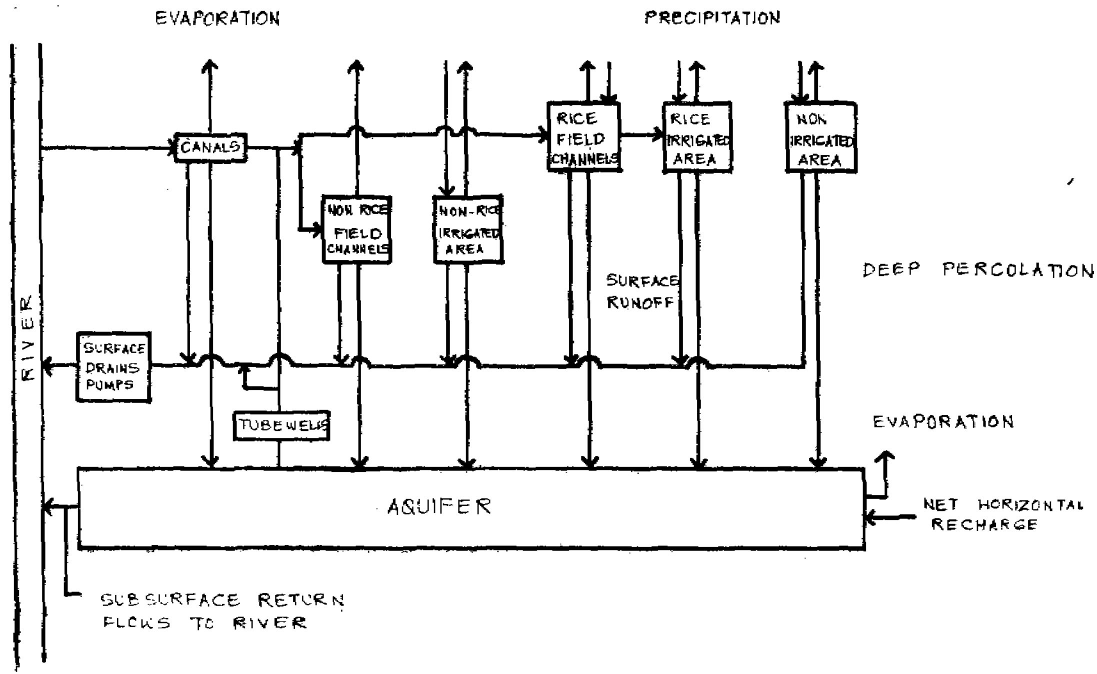
The interdependence of surface and ground waters in India may be represented at page 76.

The river water supply being seasonal, thus need to be stored or supplemented by ground water to meet the multiple cropping demand and other deficit areas.

In designing the systems appropriate cropping pattern and water losses criteria has to be taken into consideration along with the distribution and accessibility to farmers. The cost of irrigation projects may be around Rs. 20000 per ha and the economic return can be improved by improving performance capability and operating characterstics. Existing systems can be modernised by changing the cross section of major canals, building parallel canals, canal lining, increasing control structures changing design of gates, constructing a higher proportion of the distribution system to reach closer to the farmer, conjunctive use of groundwater and many other changes. Modernisation can yield quite high rates of return by overcoming constraints to reliable and efficient water distribution.

Conceptual Model in Water Resources Planning

For the conceptual model of water resources planning, the major dimensions to be kept in view are space, time, economic value, the three hydraulic dimensions of flow, chemical and biological quality as well as political and public support. The resources geometry operates with four basic interconnected vectors, resources, demand, pollution and upgrading. The effect of unpredictable climatic (stochastic) factors on the resources can be derived from pattern of data available for the past.


EVAPORATION
PRECIPITATION
RIVER
CANALS
NON RICE FIELD CHANNELS
NON-RICE IRRIGATED AREA
RICE FIELD CHANNELS
RICE IRRIGATED AREA
NON IRRIGATED AREA
SURFACE RUNOFF
DEEP PERCOLATION
SURFACE DRAINS PUMPS
TUBEWELLS
EVAPORATION
AQUIFER
NET HORIZONTAL RECHARGE
SUBSURFACE RETURN FLOWS TO RIVER

The basic operational policy of the resources geometry is to optimise application of intervention vector upon the resources vectors so as to comply with the requirements of the demand vector and the systems target. The probabilistic nature of the resources can be overcome by supplementary provisions, in long term planning, as man made water will prevail upon the natural water sources, at a specified cost. As such, the limitation imposed by natural resources on the model, will be of economic nature (Richardian). When the proportion of costly man made fresh water to cheaper natural water become substantial, the economic efficiency of prevailing water applications will have to be revaluated and the present uses of water for low value production will have to be reconsidered.

To put it in a more general form, the system space of planning will have to be expanded from the limited contents of new water and demand streams to include both introduction of new water application techniques and reallocation of existing water uses. For achieving such higher level system approach, the area of analysis for long term planning has to include following manipulative patterns :

(a) Selection of management patterns for the natural water resources and the over-all water resulting optimal water yields and qualities.

(b) Technological intervention into natural water cycle that will within economic limits improve the yields and quality of the natural water resources.

(c) Shifting of water allocations in keeping with anticipated rising water costs.

(d) Adjusting and changing water utilisation technology, so as to adapt it to anticipated higher cost of man-made water.

The unit of management of water supply system should be a hydrological basin rather than fargmented for individual communities within basin, as this will provide realistic basin data on flow pattern, spell of dry season, maximum flood flow, average flow on a long term basis, as well as the extent of urbanisation, industrialisation and number of housing units planned for the region. This will also help in integration of available manpower and better distribution of water between upstream and downstream users.

Upgrading of Resources

Upgrading of water resources in arid countries like India comprise of six complexes :

(a) The water supply function conceived within the framework of the hydrological cycle.

(b) Possible modification of the hydrological cycle by human intervention.

(c) The composition of the resource base of production complexes and services into which water enters as a substantial input.

(d) Man made water.

(e) Resources pollutlon.

(f) Political and institutional implications.

Upgrading the quantity of water by applying measures related to complexes a, b and d and improving its quality by applying measures related to complex e will have to complete with measures related to modification of the resources base (complex c), while complex f (politico institutional) will usually be treated as a constraint. The optimum solution will select the lowest cost measures and modifications of the resources base that will make it possible to maintain the desired and economically justifiable scope of production of commodities and services.

Various appropriate technologies have been developed and demonstrated for augmentation of surface water both by quantitative and qualitative measures which should be propagated through socio-political will for benefit of population suffering with scarcity. The important ones which have been accepted in general in India, are described below :

Seasonal water may be channelised from the slopes, especially in hilly terrains with the help of mini chek dams in lined ponds or closed tanks. Thin walled tanks consuming substantially less cement can be constructed locally by laying iron wiremesh within the building material using special moulds and techniques. A capacity range from 600 lit to 20000 lit has been achieved by application of this technique. It is normally recommendable to build the storage facility for individual household or small communities residing in far off places in desert-affected areas. When single pipeline supply has been arranged, ferrocement structures for storage can be gainfully utilised. In some cases the rain water falling on the roof top of a house is channelised to a storage tank to supplement the water requirement of the family. The demand of water and number of rainy days including the magnitude of rainfall should be taken into consideration while designing the storage capacity.

Open tanks with shallow bottoms have been extensively used for harvesting rain water in the plains. These are prepared by raising side elevation by eight to ten feet. Use of impervious lining of bricks covered by polyethylene/PVC sheets help in longer retention of water. Evaporation control with long chain ether based composites layers spread over water surfaces has been able to control upto 80 per cent loss by evaporation at a nominal cost upto wind velocity of 40 miles per hour. With increasing cost of other opportunities, these techniques are expected to become more widely accepted.

Another area of technical approach is to increase the efficiency of water use by crops. Water retention polymers have been used by cash crops, orchard and other crops with average increase of 30 to 80 per cent in yield. Large scale manufacture of these polymers have been taken up by indigenous industries and widespread consumption practice is expected to follow.

Some of the more traditional methods adopted in rain water harvesting, surface water proofing and runoff farming may not be out of place to be mentioned here. Few tested surface impervious covers are soil bentonite, soil cement, mud pluster (mixture of soil, wheat husk and cow dung) use of oil emulsion with soil and tank silt, mechanical stablilisation, sodium carbonate spray and grass (lasirus sindicus) cover at 25 cms $\times$ 25 cms spacing. Among these methods, oil emulsion has been found most effecitve in improving the runoff of the catchment area.

Higher crop yield have been found in farms of arid zones like Rajasthan by recycling the runoff, use of micro catchment with moisture barrier of bentonite clay and 40 cms furrow and 60 cms ridge method of planting. It has been found that furrows are more effective in conserving moisture upto 30 cm depth. Contourtrenching conserve moisture from 28 per cent to 46 per cent, contour bunds conserve from 29 per cent to 44 percent and contour furrowing 51 per cent to 109 per cent under variable rainfall conditions. Many village households in arid North West India have successfully harvested rain water from roof top and collected in ground tanks. This is used for cattle as well as domestic uses other than cooking and drinking.

In use of surface water great deal vigilance is required to be practiced with respect to its bacteriological nature. Presence of turbidity and coliforms are essentially found in water flowing or accumulated on the surface. In addition, there is presence of dissolved salts, pesticides etc occuring on account of characterstics of the land and its use. Accordingly the available water may be required to be treated chemically, physically or biologically for making it suitable for the end use.

Biological upgradation is usually carried by application of chlorine or other oxidizing agent in a suitable form, for removal of faecal coliform from drinking water. Chlorine tablet, slow sand filtration, pot chlorination are few among the methods used for village water supply in India. Yet another biological water-borne menace for human health predominent in half a dozen states are guinea worm vector cyclops which are propagated through human contact with water bodies. These are controlled by separation as well as use of pesticides. Superior methods are under advanced stage of demonstration, which incorporate use of plastic dispensors as well as nontoxic chemicals.

The physical upgradation is carried out by removal of suspended impurities and colloidal matters. For this purpose traditional coagulation and filtration techniques are still found most suitable. Mixing of various grades of water may be a futuristic approach in cases where such opportunities are possible to be derived.

Chemical upgradation involves removal of undesirable chemical ingradients with the help of physicochemical actions. Membrane separation processes with the application of high perssure or electromotive forces are widely applicable for water pretrearted for removal of biological and physical impurities. Polymeric membranes have been used for reduction of dissolved solids by reverse osmosis and electrodialysis methods. The cost of such treatment is dependent upon the quality of input and output water, the nature of membrane and the rate of power available. A large number of such plants have been installed through out the world including India. These processes are possible to be used for desalinating sea water and highly brackish water in the coastal region.

It is necessary for men to be fully conversant with the nature of water which is going to be consumed for various purposes, in order to take optimised steps for its supply. The quality assessment is an essential step in this direction. There is a tendancy to take the available water for granted and accept it by physical appearance and taste which often create health and other hazards. Many water supply stations distribute their water without minimum basic tests for presence of bacteria or residual chlorine. The toxic ingradients and dissolved impurities are hardly estimated even at state headquarters level.

The government of India has taken up the training of manpower and establishment of analytical facilities at state and district level in order to catalyse widespread common practices for water quality assessment.

7

Mission Approach for Quality Management of Drinking Water

The problem of water supply has been traditionally linked with distance of source, both horizontal and vertical, and its quantity in terms of per capita consumption requirement of human and cattle population. However, after the enactment of legislation regarding water pollution control, increasing attention has been given to the quality of water. The Decade Programme on Drinking Water Supply and Sanitation has been instrumental in on formulating specific schemes related to maintenance of quality of potable water. The major contaminants in surface and ground water sources, which have been established to be harmful for human health are bacteria, guineaworm and faecal choliforms, excess dissolved solids in particular, fluoride and iron salts apart from hardness metal/salts and turbidity. The quality of ground water although guided by the nature of rock strata, is also affected by the drawal rate, seepage, use of fertilisers, pesticides etc.

The policy concept for disbursement of water gives highest priority to the drinking water supply in the irrigation schemes. Nevertheless, the major sources of water such as great river like Ganga, are also not free from harmful pollutants.

Steps have been initiated to monitor the quality of water of rivers such as Ganga and Yamuna on one hand, and on the other hand to establish water treatment plants for removal or dissolved solids, fluoride, iron Guineaworm, faecal coliform etc.

In addition, the sources of pollutants are also being treated to reduce the effluent BOD at less than 20 mg per litre and suspended solids less than 20 mg per litre. These levels are more stringtent than develop countries where BOD is permitted at 30 mg per litre and suspended solids at 50 mg per litre.

Cleaning of River

The immediate reduction of pollution load (leading eventually to tatal prevention) on the river and the establishment of self sustaining treatment plant systems thus emerge as the two objectives of the Action Plan in the first phase. Accordingly, the following can be identified as the components of the Action Plan.

Renovation (cleaning/desilting/repairing) of existing trunks sewers and outfalls to prevent the overflow of sewage into river.

Construction of interceptors to divert flow of sewage and other liquid wastes into river.

Renovation of existing sewage pumping stations and sewage treatment plants and installation of new sewage treatment plants to recover the maximum possible resources, specially energy, to operate the pumping and treatment plants and drive the maximum possible revenue to cover at least the operation and maintenance cost of these plants.

Arrangements for bringing human and animal wastes from locations proximate to the sewage/sullage digesters for sanitary disposal, production of energy and manure.

Providing sullage of sewage pumping stations at the outfall points of open drains, to divert the discharge from the river into the nearest sewers and treatment plants.

Alternative arrangements to prevent discharge of animal and human wastes from cattle sheds located on the river banks.

Low cost sanitation schemes in area adjoining the river to reduce or prevent the flow of human wastes into the river.

Biological conservation measures based on proven techniques for purification of streams.

Pilot projects to establish cost effective systems for diversion of wastes now flowing into the river, their treatment and resources recovery.

Pilot projects to establish feasibility of technology applications in the treatment of wastes and resources/energy recovery.

Depending on feasibility, circumstances and availability of funds certain other components will need to be taken up in phases, such as the following :

Extending the existing sewerage systems in the towns to cover the unsewered areas.

Construction of large cattle sheds in the fringe of urban areas to facilitate collection of animal and human waste at suitable places and generating biogas (energy) and manurial matter at these points. This will also prevent the rainfall run-off from the urban area washing and bringing all the muck to the river during the rainy season and grossly polluting it. Keeping the cattle at such sheds instead of built up areas will also improve the urban environment.

Prevention of throwing of dead bodies in river.

Regulation of the use of pesticides and insecticides for agriculture in such a way that surface run-off from the cultivated areas does not carry excessive quantities of these materials to the rivers.

This includes treatment of sewage in 27 Class I cities and

23 Class II cities along the bank of the rivers. In addition, 28 sampling locations are situated along the course of the river for monitoring of the quality of water with respect to presence of metallic compound such as Iron, Arsenic, Chromium, Lead, Cadmium, Manganese, Copper, Nickel, Zinc and Mercury and pesticides commonly used in agriculture.

Utilisation of Sewage

Stoppage of discharge of sewage/sullage into the river should reduce the pollution level by almost 75 per cent. Fortunately, in most of the major urban settlements on the banks of the main rivers trunk-sewers have already been laid along the riverside to intercept the drains/sewers coming from the inhabited areas. Most of the dry-weather discharge of sewage/sullage (which at times also contains liquid wastes of minor industrial units) can be intercepted and carried by these sewers to such downstream plants where sewage can be pumped above the ground level and applied on land for cultivation. But often the pumping plants installed for this purpose are not properly operated and maintained, with the result that sewage overflows from the sewers and finds its way to the river. The problem has to be solved and it should be possible to do it in the following manner.

Sewage is a very rich source of energy (through the production of biogas) and manurial matter. Utilisation of this manurial matter can increase the crop yield substantially. On the basis of Nitrogen, Phosphorous, and Potassium content (NPK), the per capita contribution of manurial matter can be taken as almost Rs. 3 per year. As regards energy, the per capita contribution of biogas (in terms of equivalent energy from kerosene oil) can be taken as Rs. 2 per year. The production of energy from sewage will also ensure a regular supply of power to run the sewage pumping and treatment plants. In view of scarcity of power, the provision of energy atleast for operating the treatment plant by such recycling should be a critical consideration. In some cases some surplus power may still be available for other uses. Ways and means for an optimum use of this power can be worked out after considering the local condition at each place.

As regards the best utilisation of the rich manurial components of sewage *i.e.* the disgested sluge and effluent produced by the sewage treatment plants, it should be recognised that these are marketable products and the authorities should be able to arrange for their sale at reasonable rates on the basis of NPK contents.

At present, raw sewage is generally allowed to be used by farmers at very low prices that have no bearing on the manurial value sewage. The use of untreated sewage for irrigation is also inadvisable because its handling by the farmers and eating of the produce from these farms pose serious health hazards.

A noconventional sewage treatment plant, much cheaper and compact than the conventional plants, is quite feasible. Raw sewage is led to a settling process where solids are separated from liquid. The solids go to disgester to produce methane gas and digested solid. The methane gas is fed to gas turbine to generate electrical power for running the factory as well as to sell the surplus to other consumers. The digested solid is sold as manure. The liquid from the settling process goes to biological aerator where more solids are produced and separated to be fed to digester. The liquid or water from the biological aerator is clean enough to be used for acquaculture where algae and fishes are grown. Algae is harvested as poultry feed and fishes are marketed. The water from aquaculture flows out as irrigation water. Thus, each sewage treatment plant functions as a resource recycling unit producing energy, manure, poultry feed, fish and irrigant. Hence efficient marketing of these products is also conceived as an integral part of resource recycling unit. A conceptual model based on the treatment plant developed by the National Botanical Research Institute, Lucknow, is presented in Figure 1.

Quality of Drinking Water

The desired level of contaminants in drinking water is given in Annexure I. In most water supply schemes, no analytical facility is included as an integral part so as to ascertain the monitoring of quality. As such, as a special consideration the

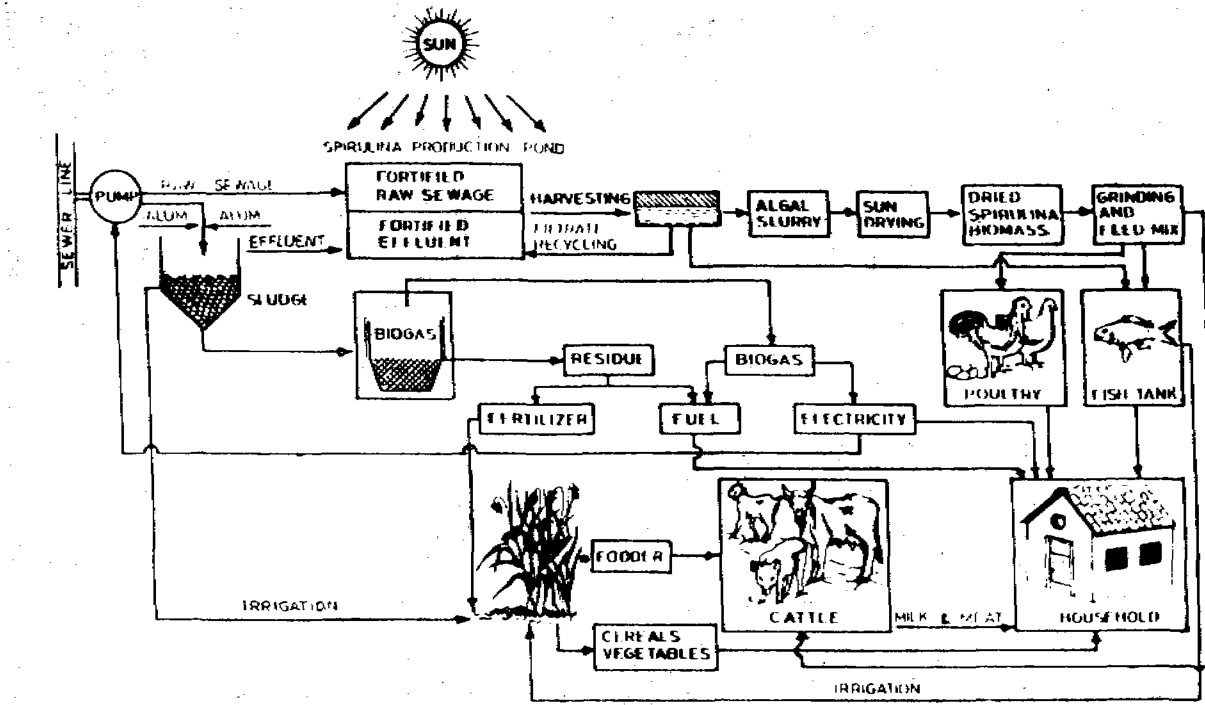


Fig. 1. Integrated Sewage Utilisatiyn System.

National laboratories took up the water quality assessment in about 2000 villages. The report of the systematic assessment along with recommendations were handed over to the local authorities for taking steps for installation of treatment plants for respective sources of water including ponds and streams, dug well bore well hand pump and piped water supply. In some instances where the land is in general over-irrigated with regular use of chemical fertilisers the piped water was found to contain more than the desired level of dissolved salts.

Simple technologies like air oxidation, chemical precipitation and selective membrane separation can be used for removal of harmful contaminants which are often found in water. But maintenance of such units in rural areas where simple hand-pump maintenance is also difficult to achieve, pose certain problem.

Several National laboratories with expertise in water quality assessment and technologies for rendering water potable, have been assigned to take up intensive training programme for regional functionaries, in order to enable them to continue these activities for sustained supply of potable water. Suitable packages for training, manpower, laboratory set up, operating manual for treatment plants are being developed and supplied to all the regional authorities in charge of water supply systems.

In brief, it can be stated that a massive programme for collation and dissemination of technology on a nation wide basis has been taken up. An indicative list of various technologies and equipments involved is given in Annexure II.

Integrated S & T Activities

A summary of Scientific and Technical activities are listed in Table I.

Potable water testing kits are being developed in order to facilitate standardisation of baseline data on quality of nation wide sources of water, as well as for water quality monitoring.

Improvement in design of check dams and rain water harvesting system and storages are being carried out for reducing the loss of rain water. Use of chemicals for surface evaporation control is also under consideration for this purpose. On the other hand, for combating the drought situations, scientific ground water exploration with compulsory geoelectric sounding is being adopted to minimise unsuccessful drilling of bore wells. Tubewell maintenance is being improved to bring down the failure rates from 30-40 per cent to less than 10 per cent by application of improved material and design as well as better systems of maintenance.

TABLE I

Summary of S & T Activities for Water Mission

Activity		1986-87	1987-88
1.	Water Samples Analysed	1253	1500
2.	New Sources Found	434	1000
3.	Awareness Generated	Seminars 2 Camps 2	Seminars 3 Camps 5
4.	Technology Demonstration Finalised	CSMCRI-5 NEERI-15 SERC-10 30	CSMCRI-10 NEERI-25 SERC-15 50
5.	R&D Projects Identified	16	16
6.	Persons Trained	243	500

CSMCRI—Central Salt and Marine Chemicals Research Institute, Bhavnagar.
NEERI—National Environmental Engineering Research Institute, Nagpur.
SERC—Structural Engineering Research Centre, Ghaziabad.

As long term measures for preserving the qualitative and quantitative nature of water sheds, related water management activities in representative areas have been taken up. This includes study of well behaviour, aquifer modelling, successful recharge and also ingress measurement through chemical hydrology. The main theme of all these activities remain to be the establishment of cost effectiveness in sustained supply of potable water. Preservation of water quality through environmental activities including sanitation and drainage, cultivation of water purifying herbs for biological control of contaminants, soil preservation through afforestation and other established method will continue to be adopted wherever applicable.

The human resource management and systems management programmes have been set up both with short term and long term targets. It is highly encouraging to watch that the functionaries beneficiaries as well as the NGO's, all have a great deal of interest in learning and adopting the scientific approach within the framework of their individual role related to water. For bridging the gaps in information and resources implementation of projects are being carried out by the scientific and administrative authorities in close coordination with each other.

ANNEXURE I

Substances and characteristic affecting the acceptability of water for domestic use

Substances of characteristics	Undesirable effect that may be produced	Highest desirable level	Maximum permissible level
1	2	3	4
Substances effecting the colour, TCU	Discolouration	5 units	25 units
Substances causing odours	Odours	Unobjectionable	Unobjectionable
Substances altering the taste	Taste	Unobjectionable	Unobjectionable
Turbidity JTU	Gastrointestinal irritation	5 units	25 units
Dissolved solids	Gastrointestinal irritation	500 mg/l	1500 mg/l
pH range	Taste, corrosion, scale formation	7.0 to 8.5	6.5 to 9.0
Total hardness	Taste, scale formation	300 mg $CaCO_3$/l	600 mg $CaCo_3$/l

(*Contd.*)

Annexure I (*Contd.*)

1	2	3	4
Calcium	Taste, scale formation	75 mg Ca/l	200 mg Ca/l
Magnesium	Taste, scale formation gastrointestinal irritation in presence of sulphates	Not more than 50 mg/l if there are SO_4 if there is less sulphate magnesium upto 100 mg/Mg may be allowed at the rate of 10 mg	100 mg/l 200 mg/l sulphate :
Copper	Astringent taste, discolouration, corrosion of pipes fittings utensils.	0.5 mg Cu/l	1.5 mg Cu/l
Iron	Astringent taste, discolouration,	0.1 mg Fe/l	1.0 mg Fe/l

	turbidity, deposits growth of iron bacteria in pipes.		
Chloride	Taste, corrosion in hot water system	200 mg Cl/l	1.0 mg C/L
Sulphates	Gastrointestinal irritation when combined with manganese of sodium	200 mg SO_4/l	400 mg SO_4/L
Nitrate	Danger of infantile methaemoglobinaemia, if the water is consumed by infants	20 mg/NO_3/l	
Fluoride	Fluorosis	1.0 mg F/l	1.5 mg F/l
Phenolic compounds	Taste particularly	0.0001 mg phenol/l	0.002 mg Phenol/l
Manganese	Astringent taste, discolouration, turbidity, deposits in pipes	0.1 mg/Mn/l	0.5 mg Mn/l

WHO guidelines values for health related organic contaminants

Contaminants	Guideline value (mg/litre)
Aldrin and dieldrin	0.03
Benzene	10
Benzo (α) pyrene	0.01
Chlordane (Total isomers)	0.3
Chloroform	30
2, 4-D	100
DDT (total isomers)	1
1, 2-Dichloroethane	10
1, 1-Dichloroethane	0.3
Heptachlor and heptachlor epoxide	0.1
Hexachlorobenzene	0.01
gamma-BHC (HCH lindane)	3
Methoxychlor	30
Pentachlorphenol	10
2, 4, 6-trichlorophenol	10

The guideline values for these substances were computed from a conservative, hypoth etical, mathematical model that cannot be experimentally verified and therefore, should be interpreted differently. Uncertainties involved are considerable and a variation of about two orders of magnitude (*i.e.* from 0.1 to 10 times the number) could exist.

ANNEXURE II

List of Technologies

Desalination by Reverse Osmosis

Desalination by Electrodialysis

Mobile Reverse Osmosis Plants

Solar Electrodialysis

Solar Stills—Domestic and Community Uses

Defluoridation by Nalgonda Technique

Muscle Powered Defluoridation Plants

Domestic Iron Removal Unit

Handpump Unit for Iron Removal

Potchlorinator

Chlorine Table t and Ampoules

Water Filter Candle

Slow Sand Filtration Unit

Package Water Treatment Plants

Deep Well Hand Pump

Shallow Well Hand Pump

Wind Mill

Water Testing Kits

Chloroscope

Aluminium Strip Turbidity Meter

PH Meter

Earth Resistivity Meter

Bore Hole Logger

Bacteriological Analysis Kit

Ferrocement Water Storage Tanks

Digital Turbity Meter

Refraction Seismic Timer

8

Technology for Safe Drinking Water*

The Seventh Five Year Plan (1985-1990) of the Government of India envisages the provision of safe drinking water to the entire rural population by the end of the plan period. This requires the development of sufficient water sources to maintain supply at the current level of 40 litres of water per person per day with an additional 30 l per day for each head of cattle in the desert areas. The problems existing in those areas such as excessive salinity, excessive fluoride and iron content, bacterial contamination, difficult terrain, difficulty in locating new sources of water and harvesting of rain water require scientific and technological attention.

The Government of India has set up a Technology Mission for Drinking Water in Villages and Related Water Management in the Department of Rural Development. The Technology Mission is a joint group of Central and State government departments responsible for water management as well as scientific agencies which have developed suitable technologies applicable for water resources development.

The Mission deals with specific problems of contamination including chemical, physical and bacteriological contamination; ground water management including application of scientific methods in assessing the availability of ground water as well as the permissible rate of withdrawal and recharge; integrated approach to conservation and augmentation of water sources; demonstrate new technologies and determine their cost

* Reprinted from Water Resources Journal, ESCAP.

effectiveness, and supervises the replication of those technologies by the local authorities. The objectives of the Mission are:

—to provide safe water to 98,746 residual problem villages by the end of 1990, the end of the International Drinking Water Supply and Sanitation Decade. A problem village is defined as a village with no source of water or a village with a water source of more than 1.6 kilometres away, 15 meters depth, 100 meters elevation difference or with biological or chemical contamination (guinea worm, cholera, typhoid, fluoride, brackishness, iron, etc);

—to supply 40 l of water per person a day. This amount is increased to 70 l per day in the desert area —40 l for man and 30 l per head of cattle;

—to evolve a cost effective technology mix to achieve the above objectives within the specified Five-Year Plan allocation; and

—to take conservation measures for a sustained water supply.

The Council of Scientific and Industrial Research (CSIR), as the agency responsible for co-ordinating the scientific and technological inputs for various activities undertaken by the Technology Mission has the following action plan (co-operating agencies are indicated in parenthesis) :

1. To act as the nodal agency to control fluorosis and the removal of excess iron (National Environmental Engineering Research Institute—NEERI) and control of brackishness (Central Salt and Marine Chemicals Research Institute—CSMCRI).

2. To provide training to the state government and voluntary agencies' representatives in :

   —geophsical exploration for ground water—(National Geophysical Research Institute—NGRI)

—water quality assessment (Industrial Toxicology Research Centre—ITRC/NEERI)

—operation of reverse osmosis and electrodialysis plant—(CSMCRI)

—defluoridation and iron removal—(NEERI)

—structures for rain water harvesting and storage—(Structural Engineering Research Centre—SERC, Ghaziabad).

3. To set up demonstration projects in selected mini missions in 55 districts with a view to evolve cost effective technology for sustained availability of water. The following aspects will be covered :

—scientific methods for source finding;

—improvement of traditional methods for water collection, storage and conservation;

—purification of water to potable quality;

—improvement of materials and designs of water supply systems;

—Technology transfer for sustained supply of plant, machinery and spare parts; and

—research and development for innovative solutions.

CSIR technologies in water supply

An attempt has been made to use the various technologies developed by CSIR laboratories in the assessment of water quality and water availability; treatment of water to free it from chemical, physical and bacteriological contaminants; and storage and distribution of water. Drawings and designs along with a technology package have been developed for most of the technologies many of which have also been manufactured in India. Demonstration of the technologies for solving specific problems have been carried out in mini missions in 55 districts throughout India. The list below provides in detail the technologies commissioned and tested by CSIR. For further information on each technology contact :

Water Mission Cell

Council of Scientific and Industrial Research
Anusandhan Bhawan, Rafi Marg,
New Delhi-110001
India

Technology transfer charges vary. However basis information is provided free.

Purification

1. Reverse osmosis (RO)—CSMCRI, Bhavnagar

   (*a*) Community use

Service

Control of brackishness up to 6000 parts per million (ppm) of total dissolved solids (TDS).

Description

Brackish water is passed under a pressure of 400-600 pounds per square inch (psi) through a spiral semi-permeable cellulose acetate membrane which is chemically coated. The membrane rejects 85-90 per cent of dissolved salts. The output of water ranges from 300 to 400 litres/square meter (m^2)/day. Plants with capacity to produce upto 50,000 litres of water per day cost about Rs. 8 lakh each.

Operating data

Plant capacity	—	10,000—50,000 litres/day of product water

Plant cost	—	Rs. 18,000—Rs. 25,000 per 1000 litres of product water depending on installed capacity of plant and salinity of feed water.
Cost of product water	—	Rs. 6—Rs. 15 per 1000 litres depending on the capacity of the plant and salinity of feed water.
Maintenance cost	—	2 per cent of capital cost.
Power consumption and cost	—	5 kilowatt hour (Kwh) per 1000 litres.

(*b*) Mobile Unit

Service

Control of brackishness up to 6000 ppm of TDS in more than one places.

Description

The small capacity plant fitted on passenger bus chassis can be taken to problem villages for treating water on the spot. The unit costs about Rs. 4.5 lakh (1986), of which Rs. 3 lakh is the cost of the bus.

Operating data

Plant capacity :	10,000 litres/day.
Fuel required :	Diesel oil
Manpower required :	One driver and one helper

2. Electrodialysis (ED)—CSMCRI, Bhavnagar

Service

Control of brackishness up to 5000 ppm of TDS.

Description

Electrodialysis (ED) plant consists of stacks of cation and anion exchange membrane packed alternately between two electrodes. Brackish water is split into two streams and passed through the alternate chambers in the stack. On passing electric current, the positive and negative ions travel towards opposite electrodes and thus the water become free from dissolved salts. Desalination process is continued by withdrawing salt free water continuously from the system. Salinity of product water is controlled by adjusting flow rate and current.

Operating data

	Input	*Output*
Capacity :	45,000 litres/day	30,000 litres/day
Total dissolved solids		
solids :	5,000 ppm	1,000 ppm
Input voltage :	220 volts per pair of cell	
Hardness :	200 ppm	40 ppm
Energy :	One kwh for removing 1 kilogram (kg) of dissolved salts	
Plant cost :	Rs. 10,000—15,000 per 1,000 litres per day depending on installed capacity.	
Cost of water treatment :	Rs. 3—Rs. 6 per 1,000 litres of product water in salinity range of 3,000—5,000 ppm TDS.	
Maintenance cost :	2 per cent of capital cost of plant.	

3. Solar stills—CSMCRI, Bhavnagar

(*a*) Community unit

Service

Removal of salinity (more than 10,000 ppm of TDS).

Description

Solar stills operate in batches. Stills are filled with raw water to a depth of 10 centimetres (cms) with about 100 litres of water/m^2 of *evaporating* area. When the level drops to 5 cm, brine is discharged and fresh raw water is fed. The average output of still ranges from 2.0 to 3.0 litres/m^2 of evaporating area per day. Solar stills are ideal for small and isolated communities where water is saltish and power is scarce. The treated water is potable and can be used for analytical and battery charging purposes. Construction materials for the solar stills are similar to those commonly used in building construction.

Operating data

Input	*Output*
Raw water with 10,000 ppm to	Product water contains
35,000 ppm of TDS	40 ppm TDS
Feed temp, 20°—30°C.	Temp of brine in still, 50°C.
Pressure	Atmospheric
Source of energy :	Solar

Plant cost : Rs. 1 lakh—Rs. 1.25 lakh per 1,000 litres of product water

Product water cost : Rs. 15—Rs. 20 per 1,000 litres depending on capacity.

(*b*) Household unit

Service

Removal of salinity, more than 10,000 ppm of TDS.

Technical features

Solar stills designed for household use provide output of desalinated water at the rate of about 2 to 3 $l/m^2/day$. Investment cost is about Rs. 120 per litre of product water.

4. Water Filter Candles—Central Glass and Ceramic Research Institute (CGCRI), Calcutta/Regional Research Laboratory (RRL), Jorhat.

(Household unit)

Service

Removal of Bacteriae.

Description

To remove suspended particles and bacteria from raw water, water is passed through filter candles fitted to domestic water containers, including earthen pitchers. One candle can meet daily requirements of drinking water of an average family. A candle costs about Rs. 14. The life of a candle is about 2-3 years.

Technical data

Input	*Output*
pH : 6.5—8	6.5—8
Conductivity : 1.6—3.75	1.6—3.75
Turbidity : 0.64—2.74 nephelometric turbidity unit (NTU)	Negligible
Bacteria coliform [Most Probable Number (MPN)] :	
Filtration rate	1—1.5 litres/hour

5. Low cost water filter. Central Food Technical Research Institute (CFTRI) Mysore.

Service

Removal of pesticides and contaminants.

Description

Raw water, contaminated with pesticides is passed through four clay pots of 20-40 litres capacity with perforated bottom and are placed one above the other on a wooden stand.

The second and third pot have an 8 cm thick adsorbent pack of specially processed carbon and an 8 cm thick layer of pure sand, respectively. Pure water free from pesticides and harmful microorganisms percolates though second and third pots and accumulates in the fourth container. Cost per litre of treated water is about 0.3 paise. The above materials can treat 400 litres of water.

6. Package water treatment plant—NEERI, Nagpur]

Service

Removes turbidity and other suspended impurities in surface waters.

Description

The package plants consists of simple innovative units for chemical coagulation sedimentation and filtration, all incorporated in a compact system. By treatment of water in this plant it is possible to reduce turbidity from 4000 to 2 NTU. This process is particularly suitable for small communities. The plant can be used for treating 3000—4000 litre/hour of water.

Specifications

Alum dosage — 7—200 milligram (mg)/litre

Power consumption — 1 kwh/1000 litres of treated water.

7. Water disinfection with chlorine tablets/ampoules—NEERI, Nagpur

(Household treatment)

Service

Removal of bacteria

Description

Safe water with a fixed range of chlorine, 2 mg/litre of water, can be obtained by disinfecting with chlorine tablets and ampoules. The treated water is stirred and allowed to stand for 30 minutes. A pack of 1000 tablets (2.5 gm each) cost Rs. 80; each tablet can disinfect about 250 litres of water. Tablets in other sizes are also available.

8. Double pot chlorination system for wells with 4000 litres capacity—NEERI, Nagpur.

Service

Removal of bacteriae, virus and protozoa.

Description

It consists of two cylindrical pots—one inside the other. The inner pot is fitted with a moist mixture of 1 kg of bleaching powder, 2 kg of sand and is placed in the other. A hole of 1 cm diameter is provided in the inner pot. A similar hole is to be made 3-4 cm above the bottom of the outer pot. The mouth of both the pots are tied with polythene sheets. The chlorinator is left in a wire cage and lowered by rope in the well below water surface for 2-3 weeks. The unit costs about Rs. 30 (1986).

9. Single pot chlorinator system—NEERI, Nagpur
(for wells of 9,000—13000 litres capacity)

Service

Removal of bacteriae, virus and protozoa in drinking water.

Description

It consists of a plastic pot of 5-litre capacity with a cover filled with gravel of 2.0—2.5 cm size to a height of 5 cm from bottom. A mixture of bleaching powder and coarse sand (1 : 3 by weight) is placed on the top of the gravel to about an equal height. Two half centimetre diameter holes are made in the cover of the pot, which is placed in a wire-cage and hung at the centre of the well to be disinfected. The position of pot is adjusted so that it remains submerged in water under a depth of about 1 metre. The chlorine from the bleaching powder in the pot oozes out slowly and maintains a residual concentration of about 0.5—0.2 mg per litre for 5 days (when the draw off rate of water from the well is about 1,200 litres per day).

Technical data

One pot costing about Rs. 40 (1986) is sufficient for a community well (9,000—13000 litres capacity) where 900—1,300 litres water are drawn per day. It gives adequate chlorination for 5—7 days. Residual chlorine in the water is negligible (0.5—0.2 mg/litre).

10. Slow sand filtration—NEERI, Nagpur
(*a*) For small communities in rural areas

Service

Removal of impurities such as organic matter, disease carrying organisms and turbidity in surface water.

Description

Slow-sand filtration is most suitable for purifying polluted surface waters for rural and small community water supplies. Surface water of turbidity level up to 20 NTU can be treated by slow-sand filters to produce a filtrate with turbidity of less than 1 NTU.

For 100 per cent safety, chlorination with bleaching powder is necessary. Treatment cost ranges from Re. 0.5—Re. 1 per 1,000 litres of treated water. The process has several advantages :

— Improves simultaneously physical, chemical and bacteriological quality of raw water.

– Provides a single-step treatment for surface waters of low turbidity (20 NTU)

— Simple to construct, easy to operate and maintain. Hence it is manageable with local skill and resources.

— Operating cost is quite low, because it is based on labour rather than energy or chemical inputs.

For surface waters of high turbidity a suitable pretreatment step such as an infiltration system, sedimentation tanks, horizontal flow roughing filtration etc. is necessary.

Raw water from the nearby river is drawn through an infiltration gallery to reduce suspended impurities and then filtered through slow-sand filter to produce clean and safe water for drinking. The technology is most suited for populations of up to 100,000. Its cost ranges from 50 paise to Re. 1.00 per litre of water treated.

Operating data

	Input	*Output*
Capacity	57,000 litres/hour	57,000 litres/hour

Turbidity – 20 NTU	1 NTU
Chemical oxygen demand—20 mg/litre	3 mg/litre
Dissolved solids—500 ppm	500 ppm

(b) Domestic Water Filter

Service

Removal of impurities in surface water.

Description

The unit consists of a 120-litre capacity steel or ferrocement drum (40 cm diametre, 100 cm depth). It is filled with a layer of 0.7 mm—1.4 mm size coarse sand and 3 mm—6 mm size gravel, each layer of 5 cm thick and overlaid by 40 cm of 0.2 mm—0.3 mm size sand. The rate of filtration is slow and the unit gives about 50 litres of purified water in 10-12 hours.

11. Defluoridation of Water—NEERI, Nagpur.

(a) Nalgonda technique
(Community level)

Service

Removal of Fluoride

Description

The plant consists of flash mix unit, flocculator, settling tank, rapid gravity sand filter and disinfection unit.

Alum, lime and bleaching powder in prescribed quantities are added to water, followed by flocculation, sedimentation, and filtration. The defluoridated water is distributed through public stand posts. The per capita cost of the plant to supply 40 litres per head per day ranges from Rs. 40 for a population of 875 to Rs. 90 for a population of 1750 persons. The cost of treatment varies from Rs. 1.3 to Rs. 1.6/1000 litres depending upon the raw water quality.

Operating data

Input	*Output*
Fluoride content 4 mg/litre	1 mg/litre

(b) Household techniques

Service

Removal of Fluoride

Description

Excess fluoride at household level can be removed by repeating the Nalgonda process in a container of capacity 20-50 litres wherein prescribed chemicals are added, stirred for 10 minutes and allowed to settle for one hour.

Supernatant water is tapped for drinking purposes.

The cost of treatment depends only on cost of chemicals used. For treating 1000 litres of water the cost is about 0.80 paise.

11. Chloroscope — NEERI, Nagpur

Service

Estimation of residual chlorine in-drinking water.

Description

The instrument makes use of orthotoluidine dihydrochloride reagent for development of colour with residual chlorine in water. The developed colour is visually matched with the standard colour discs calibrated for residual chlorine level of 0.1, 0.2, 0.5 and 1 mg/litre. Two glass sample tubes with marking are placed at a specified level in the instrument and a glass dropper adding the reagent is also supplied.

12. Iron and manganese removal — NEERI, Nagpur
    (a) Large unit of 400 litre/hour capacity

Service

Removal of iron and mgananese

Description

Iron (Fe) Manganese (Mn) in drinking water are identified by the reddish brown precipitate and metallic taste. Permissible limits of Fe and Mn are 0.3 and 2.1 mg/litre respectively. NEERI's process for removal of soluble iron and maganese involves aeration over a series of coke beds followed by sand filtration. The proeess reduces the iron/manganese content in affected water to a neglible and safe level. Fabrication cost of plant without reinforced concrete cement/brick work is estimated at Rs. 50,000 (1986) for 400 litres/hour capacity.

Technical Data

Pump : Centrifugal multistage pump for a flow of 400 litres/hour/head.

Aeration tank : 2×40 litres/hour aeration trays (three water storage tanks, capacity 1,600 litres each)

(b) Domestic Unit

Service

Removal of Iron and Manganese

Description

A domestic iron and manganese removal unit can be installed on wells with handpumps. A 200 litre/hour capacity unit would cost about Rs. 700 (1986).

Water Analysis

1. Water analysis kit

(a) Central Scientific Instrument Organization (CSIO), Chandigarh.

Service

Assessment of chemical contaminants in water.

Description

The water analysis kit incorporates a pH meter, a dissolved oxygen analyzer with an electronic thermometer and a conductivity meter. All these units are designed in modular form to enable easy replacement of component parts and serviceability. In addition the kit has been designed to operate on available batteries so that it can be taken easily to the actual spots where measurements are to be carried out.

Specifications

— pH meter	
Range	0-7; 7-14
Accuracy	± 0.1 pH
Millivolts	0 to 1000 mV, either polarity
Temperature compensation	Manual 20° to 80°C
— dissolve oxygen analyser	
Range	0.20 ppm oxygen
Accuracy	±3% (with Winkler's method)
Temperature compensation	Manual 0—50°C
— Conductivity bridge	
Range	1K, 10K 1000K and 1 Mega ohms
Accuracy	±2%

(b) Industrial Toxicology Research Centre, Lucknow

Service

Assessment of bacteriological contaminants in water.

Description

The water analysis kit consists of a small incubator for carrying out bacteriological analysis and chlorometre used for determining chloride, nitrate and fluoride levels by standard methods. The kit can run on generator or electricity mains.

A simple membrane filtration assembly comprising plexi glass filter holder with rubber washers held together by butterfly screws, is attached to a syringe. The syringe filled with the water to be tested is then slowly pushed through the filter. The microbial content of test samples of water will be measured by MPN tests which is to be followed by colony count of faecal and non faecal coliforms.

Specifications

Dimensions	20×14×11 inches
Weights	20 kgs
Incubator	9 square inches

2. Turbidity meter-CSIO, Chandigarh

(a) Digital

Service

Determination of turbidity of drinking water.

Descripstion

The instrument incorporates, among other important circuit elements, a pre-amplifier, a linear amplifier, a precision AC/DC converter and ADC digital display. The instrument is insensitive to any general white light background. A sensitive silicon photodiode has been used of as a light sensor. The instrument can be used for estimating the efficiency of municipal water treatment plants by measuring the turbidity of inflowing raw water.

Specifications

The turbidity meter operates over a single range of 0 to 1000 JTU (Jackson Turbidity Unit) with an accuracy of better than 2 per cent and a resolution of 1 JTU.

(b) Aluminium strip turbidity metre.

Service

Measurement of turbidity of surface water sources,

Description

A simple device called Aluminium Strip Turbidity Metre has been designed and developed at CSIO to obtain approximate values of turbidity by simple visual inspection. The device actually consists of an aluminium strip about 20 cms and has a platinum needle attached with a screw to one end of the strip. A 1.5 metre non-wettable cloth tape is attached to the other end of the strip which is immersed in water to a depth where the needle just disappearas visually. At this depth, the level of water on the tape is measured. This indicates the turbidity. The strip turbidity metre is a handy, inexpensive and extremely simple device to measure the turbidity of water sources like revers, canals, lakes, ponds, etc.

Supply and Water Storage

1. Ferrocement (FC) water storage tanks—Structural Engineering Research Centre (SERC), Ghaziabad

Service

Storage of water

Description

Ferrocement is a highly versatile form of reinforced cement mortar, reinforced with closely packed layers of steel wire-meshes. It is possible to castferrocement elements with thickness as small as 10 mm. Ferrocement possesses high resistance to cracking and unlike steel structures has high corrosion resistance. It is an ideal material of constrution for water tanks. SERC Ghaziabad has developed two techniques for producing cylindrical ferrocement concrete tanks suitable for storing drinking water. In the semi-mechanised process, ferrocement walls are produced using a simple process equipment in which the steel wire-mesh layers are plastered with cement by hand in stretched condition over a rotating mould. Tanks are assembled using precast reinforced cement concrete base, ferrocement wall, roof and lid. In the second process, ferrocement segmental shell elements are cast in segments of a cylinder over masonary or wooden moulds. The cylindrical wall of the tanks are assembled using these precast segments. Tanks from 200 to 20,000 litre capacities can be constructed using the above two processes. Ferrocement tanks are lighter in weight than reinforced cement concrete/masonary tanks and cost effective in comparison with plastic tank (33 per cent), steel tank (50 per cent) and reinforced cement concrete (25 per cent). The casting skills can be easily acquired by rural labourers and damage can be easily repaired at the site itself.

Specifications

Capacity	6000-2500 litres
Diameter	900-1200 mm
Thickness of wall	10 mm
Wire-mesh	240+1/2 for surfaces 3 mm wire ring for top and bottom.

Plasticizing chemicals are added to mortar to make it impervious for water.

2. Rainwater harvesting system—SERC Ghaziabod

Service

Collection of drinking water.

Description

SERC, Ghaziabad has modified the traditional rain water collection system for making it more safe and hygienic by introducing the catchment, inflow and storage components. A by pass system has been developed for removing wash out during first rain. A filtering system has also been introduced along with strainers at various water entry points.

3. Windmill Samira—National Aeronautical Laboratory (NAL), Bangalore

Service

Lifting of water from shallow wells up to 7 metres depth.

Description

The windmill "SAMIRA" is designed to have a 7.5 metre rotor which comprises of 3 blades. The rotor drives a centrifugal pump of 2 hp rating. It is superior in design due to rotary transmission and noval spoiler arrangement as against the furling of the head used in conventional multivative designs. It costs about Rs. 25,000 and is at par with imported wind mills at 2 hp rating in 25 km/hour wind speed.

Specifications

Starting wind speed 13 km/hour; peak output, 20,000 litres/hour in 25 km/hour winds.

4. Deep Well Hand Pump

Service

Pumping of ground water

Description

This pump can draw ground water from a depth of 30-40 metres below ground level. It was primarily meant to segment safe drinking water facility in water scarce and drought stricken places. It is an improved design and adopted by UNICEF for their water supply programme for the villages. The pump includes the following major components :

— pump head together with the handle and pump stand,

— riser main, the pipe that carries the water from the source to the surface via cylinder valve assembly, and

— connecting rod which connects the piston in cylinder valve assembly to the handle.

Special features :

— elimination of costly non-ferrous parts,

— use of non-metallic parts to minimise corrosion,

— effort reducer incorporated for easy manual operation, and

— minimum cost of maintenance.

Sperifications

Depth	50 m
Overall height of the pump	1,457 mm
Height from the ground level	1,060 mm
Maximum stroke angle	40°
Output	9-13 litres/minute
Spout (dia)	32 mm
Leverage	1,070 mm
Pump Head	Fabricated
Platform	1.8 mm dia

Prospecting

1. D.C. Earth Resistivity Metre—NGRI, Hyderabad

Service

Data of earth resistivity and spontaneous polarisation potential are needed in prospecting for water by the electrical method. Changes in electrical resistivity either in the vertical or lateral direction can be interpreted in terms of geology and mineralogy and natural earth potentials associated with sulphide mineralisation. This instrument is a combined resistivity and self-potential meter. It is useful for :

— locating probable aquifers

— determining depth to bed rock

— prospecting for conductive ore bodies e.g. metallic sulphides, graphite etc.

Working principle

The instrument incorporates rugged transistorised DC potentiometer for voltage measurement across potential electrodes and an accurate current meter for measuring the DC excitation current that is sent into the ground through current electrodes. From the knowledge of the electrodes separation and the voltage and current involved, it is possible to calculate the value of apparent resistivity.

Specfiication

Potential	0—1.018 mV DC
Current transfer	10—2,000 A.D.C. in eight ranges
Accuracy of measurement	+ 1%
Read Out	Potential off two dials and current off a meter

Null Indication	Centre Zero, Transistorised micro voltmeter
Operating temperature	5—50°
Size	Potentiometer Unit : 46cm × 33cm × 16.5cm
Power supply	For the potentiometer unit and 90 volt packs for DC excitation.

The instrument is transistorised and portable.

2. Refraction Seismic Timer—NGRI, Hyderabad

Service

Quantitative assessment of aquifer

Travel time of seismic waves is raw data that are required for seismic studies of the sub-surface. The timer measures the shortest travel time of seismic waves between any two given locations. The time versus distance information can be interpreted in terms of geology. This instrument is useful for :

— locating probable aquifer

— determining the depth of the bed rock in engineering application.

Working principle

The seismic shock wave generated by a hammer stroke on a steel stake is received by an electromagnetic geophone placed at a known distance from the hammer (shot point). The elapsed time, between shock generation and its reception is recorded by an electronic stopwatch. The clock is set on at the instant of generation of the shock wave (the striking of the hammer on the stake) and put 'off' at the time of its arrival at the receiving point. The time is read off a digital indicator.

Specifications

Range of measurement	999 milly/seconds without recycling.
Accuracy of measurement	± 1 count
Read out	Digital indication of a three digit count on a single moving coil meter, obtained sequentially by pressing switches.
Operating temperature	10—45°C
Size	27.5cm × 28cm × 16cm
Weight	5.7 kg
Power supply	Built in source of 12 volts DC composed pack of 1.5 volt flash light cells.
Shock Sensor	Electrodynamic geophone. Natural frequency : 4 Hz Sensitivity : 1 Volt cm/sec. Damping : Less than critical.

The instrument is fully transistorised and portable.

3. Borehole Logger—NGRI, Hyderabad,

Service

Measurement of two electrical properties in the borehola potential and resistivity can be used :

— for stratiographic investigations in general and identification/correlation of geological markers like faults,

— mineral prospecting,

— groundwater investigations.

Description

The system consists of a sonde (down hole electrodes) logging cable, winch, measuring sheave ground electrode, cable motion sensing system depth indicator, strip chart recorder, square wave constant current generator and self potential and resistivity separation module. An inverter drives the chart recorder and also supplies power to all other electronic circuits. The cable winch is capable of accommodating 1,000 feet (300 metres) of four conductor cable.

The design differs from the conventional electrical logging equipment. The recording chart paper drive is coupled to the motion of logging electrode electrically. A square wave constant current is driven into the impedance between a surface reference point and the down hole electrode. The voltage across a second reference point on the surface and the down hole electrode is sampled a short while prior to every current switching. The samples are held separately during the positive and negative half cycles. The sum of these held-values gives a voltage proportional to S.P. while the difference is a voltage proportional to the resistance.

Specification

Integrated Circuits (ICS)

Digital
(7 types)

Seven segment display Linear
(35 types)

Transistors
(9 types)

Diodes
(3 types)

SCR's
(3 types)

Proset Potentiometers
(3 types)

Capacitors
(14 types)

9

Training of Professional Engineers for Multi Disciplinary Approach in Water Supply Management

The development and maintenance of water sourcesbegin with the Satelite imagery for regional outlook, pin pointing of sources by ground survey, assessment of aquifer to determine the potential and nature of the sources, quality assessment, treatment, as well as the rational use pattern for avoiding possibilities of imbalance or adverse environmental effects. A Mission approach for solving the perennial problem of water shortage or lack of rational utilisation, include emphasis on providing multi-disciplinary training and demonstration to the engineers concerned with various aspects of water supply. The Council of Scientific and Industrial Research has organised few such training programme over the last two years which have helped in broadening the outlook of the water supply authorities, enabling them to look into the associated problems for exploitation of a particular source for a short-term objective.

The vastness of the problem cannot be handled by a single organisation and poses a need for multi-plier effect for dissemination of knowledge through the persons trained at various level.

Need of Training

Water occupies a very competitive position specially in an expanding economy in a developing country like India. The objective of water resources systems management is largely political but can be described as a spectrum of goals :

To control or otherwise manage the fresh water resources of the cognizant geographic or political subdivision so as to provide for protection against injurious consequences of excessess or deficiencies in quality.

To provide or maintain water in such places and times and in adequate quantity and quality for human or animal consumptions, wild life (including native plants), food production and processing, industrial production including energy, commerce and for the recreational, aesthetic and conservation purposes.

Accomplish all these with a minimum cost of physical, economic and human resources.

It needs a multidisciplinary approach to keep in view all the related aspects, when taking practical steps regarding water resources management. The Water Resources Engineering is not exclusively related to huge dams, reservoirs or long winding aquaducts as all water problems cannot or should not be solved by such systems. Water Resources Planner should be in a position to give consideration to all the important alternatives which can be made available such as ground water development, weather modification, watershed management and water harvesting, desalination, waste water reclamation, economic allocation or political allocation.

Economic analysis of water management system has to assign a special price on health recreational and other values. For industrial usage cost of water treatment in relation to the raw water quality can be easily calculated. Cost functions can be developed to evaluate losses to a region by deterioration in its water quality with regard to industrial usage. The application of systems analysis methods can make it possible to take into account a large number of variables and determine the optimum alternative.

These broad aspects need to be imbited in all training programme for Water Management.

Philosophy of Training

Since water is the forre-unner of development, all human activities pre-suppose the availability of sufficient and reliable supplies of water of good quality. As such, training for water development should be given a high priority rating in the allocations of national resources for development. This multidisciplinary dynamic subject matter include the following :

Both surface and ground water resources are to be developed.

Investigations for the availability and location of water sources.

Assessment of water quantity and quality.

Planning and design of water treatment and supply projects.

Construction of water schemes.

Operation and maintenance of completed water supply schemes.

The key technical skills involved are civil, electrical, mechanical, environmental and sanitary engineering. Scientific skills are required in Chemistry, biology, hydrology, geology. The support of general services in accounting, personnel and supplies and the skills of economists, sociologists, demographers and systems analysts are also required.

All these skills are required at various levels of specialisation *i.e.* professional, subprofessional, technician and craftsman. It is important that skill levels be advanced on all fronts so that progress in one sphere is not negated by the liability of other spheres to adapt their activities to changed conditions. The needs of organisations change as new technologies are applied. In this process, training must be a continuous activity lasting an entire career starting with induction, continue with on-the-job instruction and should from time to time include specifically designed courses to meet increased responsibility for adaptation to new technologies.

A line about the cost of application of new technologies may be event to be mentioned here in relation to the accured benefit. Theoritically, this may be presented as in figure 1. The

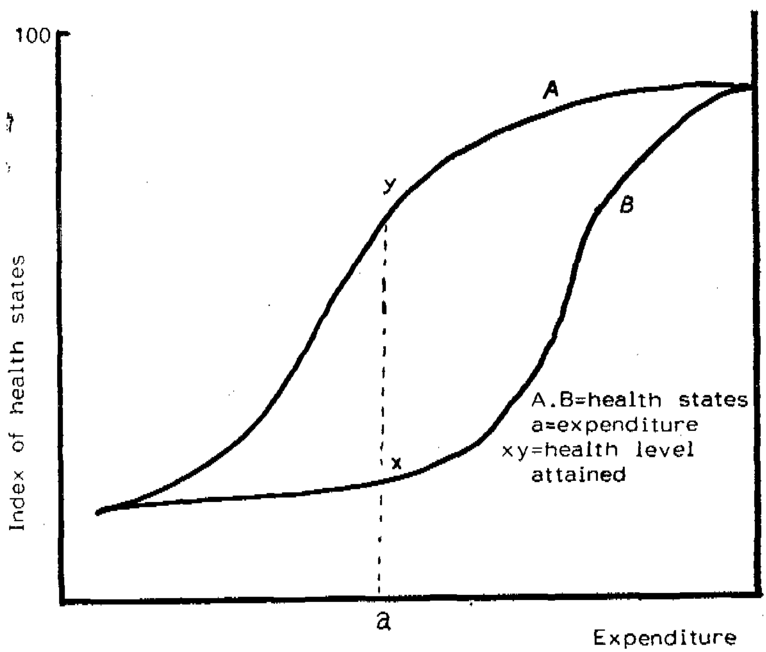


Fig. 1. Hypothetical Relations between Village Health and Costs of Water Supply Project.

actual per capita cost can be calculated and compared with per capita cost of health maintenance and productive man hour availability which are vital components in the development of the country.

Training Objectives and Staff Development for Drinking Water in Villages

The training objectives should reflect the basic established policy *i.e.* to provide the total rural population with potable water. Such training should be geared towards learning the principles that will enhance the desired goal. The training of engineers should satisfy the following broad objectives :

* At the end of the course, the trainees should be able to apply the principles related to water supply with the appropriate technology to suit a particular environment.

* They should be able to plan, manage and liaise with staff at the junior level and with the users for care and maintenance of the water supply system.

The concept of applying principles learnt in one subject area to new situation implies that the subjects taught to technical officers should be broad in nature. The guidelines for appropriate technology may be used as under :

The choice of technology should be one that would facilitate a significant improvement in the quantity of potable water supply to villages.

The technology should be as low as possible in cost without jeopardizing the effectiveness of the improvements sought.

The technology should facilitate operation and maintenance by users without demanding a high level of technical skill.

The technology should make as much use as possible of locally available materials, there by decreasing reliance upon imported materials.

Where possible, the technology should encourage the growth of local manufacturing of necessary equipments and parts.

The technology should be compatible with local users, values, attitudes and preferences.

The technology should encourage and facilitate community involvement and participation.

Suggested Curriculum for Various Levels of Training
Engineer Level

Detection and maintenance of water sources. Water related diseases/water quality analysis. Social organisation and management economics and planning low cost sanitation methods as alternative to traditional sewage treatment. Updating of technology through continuous research.

Total Water Management System.

Technician Level

Water hygiene and water borne diseases

Political Science.

General studies and management (for social, cultural and economic factors in the life of consumers).

Safety precautions during construction maintenance and operation.

Technical Assistant Level (for individual area)

Drilling	Drilling techniques, geological formations, administration.
Shallow wells	Well siting, geological formations, well construction, pump installation, community participation, administration well hydraulic.
Pump attendant	Pump operations, full identification and repair, preventive maintenance.
Gravity Fed schemes	Pumping, construction work, welding, water treatment, community, organisation, hydraulics, map reading, leveling tools.
Treatment plants	Plumbing, mechanical work installation techniques, tools, welding and soldering.
Electrician	Installation of electric pumps, welding, plumbing, tools, fault identification and repair.

Liaison Officer	Health aspects, simple water technology, community development, extension and communication.

CSIR Training Programme Undertaken for Water Technology Mission

The Council of Scientific and Industrial Research has developed specific expertise in various fields related to water management. In 1986, CSIR entered into a Memorandum of Understanding with Ministry of Agriculture for providing training to the recommended personnel in CSIR technologies. A number of Training Programme organised by various national laboratories are listed in Table 1. These courses were based on the experience of the laboratories in the respective fields and subsequently enriched and modified with suggestions of the participants to make them more suitable for the field conditions. In general, each programme was formulated to demonstrate each technological method with introduction to the theoretical principal involved.

Geophysical Exploration

Theory of geological formation and their magnetic properties; instruments to be used for water exploration ; steps involved in selection of region and in pin pointing the sources; practical demonstration of methods and instruments in locating the water sources by field survey.

Water Quality Assessment

Theory of water contaminants, their origin and effect on health is given to the participants to form the background. The principle of analysis for each contaminents along with use of equipment, reagents and procedure involved ; make and supplies of instruments and approximate cost; sampling procedure and instruction for storage and handling of samples; setting up and maintenance of modular laboratory for Water Quality Analysis.

Rain Water Harvesting

Scope of harvesting of rain water as related to rain fall and other sources in the region ; Design and materials for appropriate strucuures ; Description properties and application of ferrocement structures; selection of local material and construction of F.C. Structures ; Development of local masons for commercial services.

Treatment of Water (Desalination, Defluoridation, Iron Removal)

Basic principle such as reaction, input/output conditions, critical considerations, cost and operational aspects were explained briefly. The participants were helped to operate these plants to note and handle each step themselves. Intensive question answer sessions and audiovisuals are provided in addition to written course material to make the points reach home.

The Effects of Training

There was an initial lukewarm response to the programme and many States could not find appropriate persons to be nominated for the training programmes which were designed for working officials, with a duration of maximum 10 days (except the course on Geophysical exploration which has a duration of one month due to field survey and data interpretation being involved). However, in successive programmes greater interest was expressed and in few cases the trained persons were engaged in implementation of projects based on these technologies. However, in a greater number of cases, trained persons were not utilised to cary out jobs based on the subject of training. Many States could not nominate participants due to lack of clarity on the need of training for appropriate persons.

However, the programme helped on creating an interest awareness among all concerned about the need and ways for application of technology for various water supply system. Many States are forward with request for exclusive field demonstration of selected technology in their premises which expedited their activities in providing coverage to the problem areas.

The requirement of personnel to be trained in different areas were sought from all States for the year 1988-89. A few only has responded so far, which are presented in Table 2.

This shows a large number of States still are indicisive with respect to the training needs or have already got adequately trained personnel to perform the induction of new technologies.

For greater involvement, the central technical agencies are undertaking wider demonstration of technologies related to source finding and development, quantity assessment and setting up of treatment plants in association with the State Governments on "doing together" basis.

An integrated approach for total water management including rense of water is being considered to be taken up in cooperation with respective state authorities in selected states for demonstrating the inter related aspects of management, control ana monitoring. This is essentially to carry out the integral aspects of the erstwhile training programme in the field alongwith long term implication in sustained water supply. The experience and findings of the state authorities, backed by the scientific studies of the central agencies can bring out undisputed facts to specify the guidelines to be adopted in supply and maintenance of water for a region.

TABLE 1

Technology Mission on Safe Drinking Water in Villages Training Programme by CSIR for 1986-87

Course Title	Organised by	Organised at	Date	Participants States/ (V.A.)
1	2	3	4	5
Rain Water Harvesting	SERC (G)	SERC (G)	Jan. 5, 87 (5 days)	16
Rain Water Harvesting	SERC (G)	SERC (G)	Mar. 30, 87 (12 days)	14
Geophysical Survey G.W. Exploration	NGRI (Hyd.)	NGRI (Hyd.)	Mar. 11, 87 (4 Weeks)	9
Geophysical Survey G.W. Exploration	NGRI (Hyd.)	NGRI (Hyd.)	July 1, 87 (4 Weeks)	25
Geophysical Survey G.W. Exploration	NGRI (Hyd.)	NGRI (Hyd.)	May-June, 88 (6 Weeks)	21
Desalination, R.O.E.D.	CSMCRI, Bhavnagar	CSMCRI, Bhavnagar	Mar. 17, 87 (1 Week)	19

Defluoridation	NEERI, Nagpur	AMRELI, Gujarat	April 20, 87 (1 Week)	28
Qlty. Anlalysis Water and Waste Water	ITRC, Lucknow	ITRC, Lucknow	May 18, (10 Days)	40
Qlty. Analysis Water and Waste Water	NEERI, Nagpur	NEERI, Nagpur	June 9, 87 (16 Days)	40
Qlty. Analysis Water and Waste Water	NEERI, Nagpur	NEERI, Nagpur	July 6, 87 (5 Days)	35
Qlty. Analysis Water and Waste Water	RRL (JT.)	RRL (JT.)	Jan. 88	9
Iron Removal	NEERI, Nagpur	Agartala	July 14, 87 (5 Days)	45
Iron Removal	NEERI, Nagpur	Gangtok, Sikkim	Oct. 7, 87 (5 Days)	32
Iron Removal	NEERI, Nagpur	Mirzapur, UP	Nov. 7, 87 (3 Days)	18
Defluoridation	NEERI, Nagpur	Mehasana, Gujarat	Dec. 87 (4 Days)	22
Defluoridation	NEERI, Nagpur	Palakudoddi, AP	Dec. 87 (2 Days)	79
Desalination RO, ED	CSMCRI, Bhavnagar	CSMCRI	Oct. 12, 87 (5 Days)	7
Desalination RO, ED	CSMCRI, Bhavnagar	CSMCRI	Feb. 24, 88 (3 Days)	6

(*Contd.*)

Table 1 *(Contd.)*

1	2	3	4	5
Rain Water Harvesting	SERC (G)	Manipur	Nov. 9, 87 (22 Days)	26
Rain Water Harvesting	SERC (G)	SERC (G)	Oct. 28, 87 (10 Days)	11
Rain Water Harvesting	SERC (G)	Bhopal	Jan. 11, 88 (6 Days)	40
Quality Analysis Water and Waste Water	NEERI (Nagpur)	NEERI (Nagpur)	Sept. 87 (2 Days)	20
Quality Analysis Water and Waste Water	NEERI (Nagpur)	NEERI (Nagpur)	Nov. 87 (5 Days)	22
Quality Analysis Water and Waste Water	NEERI (Nagpur)	NEERI (Nagpur)	Nov. 87 (2 Days)	21
Quality Analysis Water and Waste Water	NEERI (Nagpur)	NEERI (Nagpur)	Jan. 88 (2 Days)	22
Quality Analysis Water and Waste Water	NEERI (Nagpur)	NEERI (Nagpur)	March 88 (2 Days)	20
Total				647

TABLE 2

Exploration Assessment of Ground Water Resources

State	No. of Districts	No. of Hydro-geologist Available	No. of Geo-Physists Available	No. of Teams Proposed/to be Organised	Persons in Service	Persons Req. (Fresh) M.Sc./B.E.	Technicians Req. B.Sc./Dip in Engg.
Maharashtra	29	261	9	9	200	0	30
Meghalaya	0	0	0	2	0	2	2
Manipur	8	0	0	8	3	2	4
Gujarat	19	19	13	49	20	11	2
Madhya Pradesh	45	10	0	25	10	0	0
Kashmir	8	0	0	6	3	3	12
West Bengal	16	0	0	18	36	72	54
Sikkim	4	0	0	1	0	1	2
Jammu	6	0	0	7	0	7	14
Lakshdeep	1	0	0	0	0	0	0
Tamilnadu	18	75	0	0	50	0	0
Total	154	365	22	125	322	98	120

Water Quality Testing (WQT)

State	No. of Districts	Existing Labs. for WQT	Identified Problem Villages	Additional Labs. Required Fullfledge	Mobile	Qualified and Trained persons in WQT	Additional persons to be Trained
Maharashtra	29	27	0	6	6	0	29
Meghalaya	0	0	4727	1	1	0	4
Gujarat	19	3	14288	3	3	20	17
Manipur	8	1	1749	0	8	2	21
Madhya Pradesh	10	0	0	0	1	9	33
Kashmir	8	0	3178	8	14	0	64
West Bengal	16	0	25243	18	18	26	90
Sikkim	4	0	440	1	1	0	5
Jammu	6	0	3398	6	21	0	66
Lakashdeep	0	0	10	9	0	0	9
Tamil Nadu	20	5	963	6	0	24	12
Total	120	37	53996	58	73	81	350

Water Treatment

States	No. of districts	No. of treatment plants already set up	No. of treatment plants to be set up	No. of persons already trained	No. of persons to be trained
1	2	3	4	5	6
Maharashtra	0	0	2 RO	0	4 DEF, 4 DES
Meghalaya	0	2 Iron	0	0	10 Iron
Gujarat	7	7 DES, IDEF	3 DEF, 13 DES	4 DEF, 3 DES	9 DEF, 26 DES
Madhya Pradesh	0	0	9 RO	0	0
Lakshadweep	0	0	9 RO	0	9 DES
Jammu	6	0	30 DISIN	0	30 DISIN
Sikkim	4	180 DISIN	1990 DISIN	0	440 DISIN
West Bengal	16	120 IR, 249 DISIN	251 IR, 8 DES	36 IR, 2 DES, 24 DISIN	118 IR, 3 DES, 58 DISIN
Kashmir	8	0	0	0	0

(*Contd.*)

Table 2 (*Contd.*)

1	2	3	4	5	6
Manipur	8	0	0	2 IR, 1 DEF, 1 DES, 10 DISIN	8 IRON, 2 DEF, 10 DISIN
Tamil Nadu	2	3 DES RO, DES RO, DES ED	0	3	0
Total	52				

DES=Desalination DISIN=Disinfection DEF=Defl Uoridation IR=Iron Removal

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Support Services from International Agencies

Among the international agencies, many of the constituent bodies of United Nations such as UNESCO, WHO, UNICEF have extended great deal of assistance in Resource Survey, Research Training and Educational Programme and specific exploratory studies on assessment of the nature of resources and special problem areas. UNDP assistance have been provided for creation of infrastructure for aquisition of hydrological data and study centres including National Institute of Hydrology. UNICEF spends about $70 m for water supply and sanitation annually for all countries.

World Meteorological Organisation and World Bank have assisted in setting up of meteorological studies and irrigation projects respectively. In addition, a number of policy papers have been prepared by such agencies for guiding the utilisation of water resources in India, with a satisfactory degree of optimisation. Experts services have been made available by WHO, UNICEF, UNDP for providing alternative solutions for regional problems and setting up of information net work.

Apart from United Nations, a number of individual countries have taken keen interest in development of the water resources of India. Development agencies in Sewden, Denmark, FRG, UK and other European countries have participated in projects of hydrological studies in difficult terrains and underground water flow characterstics. In addition, a large number of ground water mining and distribution projects are also supported including supply of rigs. The total assistance would run into thousands of crores of rupees in terms of capital.

The International Decade of Drinking Water Supply and sanitation has aroused great degree of awareness about proper care to be taken in consumption and maintenance of water. A suitable emphasis on conversion of bad water into good water may help in restoration of natural system wherever it has become harmful for the local environment.

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their thinking process and related considerations. The voluntary agencies and others engaged in supply of water will find it handy for reference with respect to the problems which may be faced in their work. The users of water also can find at one place what they should get and how. Last but not the least, the scientists may also be inspired for achieving better solutions then those available today.

Shubra Chakravarty is Post Graduate Chemical Engineer with varied experience in Transfer of Technology and handled the wide range of lab to land programme in various sector of Industry. After Graduation and Post Graduate Research in Chemical Engineering at Jadapur University, Calcutta. She started professional carrier as lecturer in M.S. University of Baroda, but soon joined Council of Scientific & Industrial Research at its headquarters in Delhi. She also worked in Department of Chemicals and Department of Science and Technology, Government of India. She has over 40 publitions and presented technical papers in national and international symposium.

Since the last few years the emphasis of her work has been on the Technology for the people in accordance with the National Policy. She has participated in and studied a number of programme where indegenous technologies have been successfully demonstrated in solving the perennial problems of people at the village level. The analysis and explanation of the mathodologies will help the local bodies and workers in selecting the appropriate course of action resulting in long impact on state of society and economy.

The views expressed in this book entirely those of the author and not necessarily those of the CSIR.

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