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Commonwealth Science Council

Regional Rural Technology Programme

Report of the Regional Workshop on

Rural Drinking Water Supply

10-13 May 1982, Madras, India

Commonwealth Secretariat

CSC(82)RT-26

COMMONWEALTH REGIONAL (ASIA/PACIFIC)
RURAL TECHNOLOGY PROGRAMME

Report of the Regional Workshop on RURAL DRINKING WATER SUPPLY

10 - 13 May 1982, Madras, India

COMMONWEALTH SCIENCE COUNCIL
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CONTENTS

1.0 Introduction

The Commonwealth Science Council Rural Technology Programme has ten projects concerned with aspects of rural development in the Asia/Pacific Region. One project is concerned particularly with the problems of rural water supply. The project, which involves Bangladesh, India, Papua New Guinea and Seychelles is being coordinated by the Seychelles. Its objective is to identify, further develop (if necessary) and disseminate improved, low cost water purifying technologies suitable for application in small villages in rural areas.

The project was established in 1978 and it has proved a very useful forum for information exchange in the region. With the advent of UN International Drinking Water Supply and Sanitation Decade it was decided that the project should be further developed.

A workshop was therefore convened in Madras on May 10 - 13 1982 with the objectives of:

- exchanging information on the current situation in the participating countries
- examining available technologies for water purification in rural areas
- identifying technologies suitable for transfer to rural areas
- selecting technologies requiring further research and development and
- drawing up a programme of follow-up activities

2.0 Programme and Participation

A programme for the workshop is attached (Annex 1). After the opening session country papers were presented. Technical sessions then focused on the various methods available. The final day was devoted to discussions on follow-up activities.

The workshop was attended by 23 participants (Annex 2) from Papua New Guinea, Seychelles, Sri Lanka and India. In addition the workshop was attended by a representative from the WHO International Reference Centre for Water Supply and Sanitation.

3.0 Opening Session

The four-day regional workshop during May 10-13 on 'Rural Drinking Water Supply' organized jointly by the National Environmental Engineering Research Institute, (NEERI) Nagpur and the Commonwealth Science Council, with financial support from Commonwealth Fund for Technical Cooperation, was inaugurated by Shri A K Aranganathan, Chairman, Tamil Nadu Water Supply and Drainage Board on May 10, 1982 at Madras. Twenty-three participants from India, Sri Lanka, Papua New Guinea and Seychelles were present.

Shri C Ponnaiyyan, Minister for Cooperation and Law, Government of Tamil Nadu presiding over the function emphasisised the need for developing a low cost and efficient system of pumping water from deep borewells to ensure uninterrupted supply of safe drinking water in rural areas.

Dr B B Sundaresan, Director, NEERI, underlined the need for formulating viable projects for India and other developing countries during the 'International Water Supply and Sanitation Decade 1981-1990'. CSC offered a forum for exchange of information on technologies in the area of water supply which could be effectively utilised through this workshop.

Shri K N Johry, Head, International Scientific Collaboration, CSIR welcomed (Annex 3) the participants on behalf of CSC and said that the workshop was being held in India so that the participating countries could gain from the Indian experience in the field of Slow Sand Filtration. He said that National laboratories of CSIR are making useful contribution in developing low cost rural technology. He then went on to explain the history of the CSC Rural Technology Programme and described some of the highlights from the other projects.

4.0 Country Papers

The Indian country paper was presented by Dr Sundaresan (Annex 4) In it he focused on India's preparation and commitment to the International Decade for Drinking Water Supply and Sanitation. In particular he described the extensive study that has been undertaken into the status of rural water supply in India which involved information gathering at all levels from government to the individuals living in villages. From this study and others a programme for the decade had been evolved and was now bieng implemented.

Mr S Rosseau presented the Seychelles paper (Annex 5). He described the organization of water supply in the country, its current status and plans for the Drinking Water Decade. He then outlined the Seychelles experience with a variety of water treatment technologies, ceramic pressure candles, pressure filters, slow sand filters and rapid gravity filters. He closed by identifying potential topics for regional collaboration.

In Papua New Guinea (Annex 6) water supply has tended to receive a low priority because of plentiful supplies of water from rainfall. However a number of agencies are now involved including UNICEF and the Asian Develcpment Bank. In addition the Appropriate Technology Development Unit and Local Government Technical Service have been examining some technologies. When systems had been installed upkeep and maintenance often proved a problem and it was recognised that there was a considerable need to train villagers in the value of water supply and the need for its maintenance.

5.0 Technical Papers

The paper 'Technology Choice for Rural Water Supply' (Annex 7) examined the factors to be considered in designing rural water supply systems. Among the topics to be examined are:

i) Accessibility - taps in every house are ideal but costs dictate cheaper solutions such as public stand pipes or wells

ii) Water quality standards - the ideal is 100% safe water but again economics frequently dicate acceptance of lower levels of purity

iii) Source - the best available source should always be chosen bearing in mind distribution costs and level of pollution

iv) Method of purification to be used eg pot chlorination, iron removal, defluoridation, slow sand filtration etc.

The paper examined the various sources available and also described the means of purification available for village and individual household applications.

The experience of provision of water in rural areas of Tamil Nadu was described in the following paper (Annex 8). The problems of the state were described and the method used to classify village needs was explained. Depending on the needs and size of the village a standard 'package' is then installed taking into account the likely growth of the village. The importance of village level participation was stressed and the various arrangements to ensure pump repair described.

The next paper (Annex 9) described the design and operation of simple package treatment plans for the removal of iron and fluoride from rural water supplies. These materials are common contaminants in many water supplies and pose a considerable problem. The iron removal plant relies on the aeration of the water followed by filtration to remove precipitated iron. The fluoride removal plant involves dosing with alum and lime followed by filtration. The iron removal plant is available in a number of different designs.

A paper on package plants for rural water supply was presented by scientists from NEERI (Annex 10). The merits of such plants were assessed and then plants available in India were described; they included pressure filters, package slow-sand filters and multi-inlet/multi-outlet filters. Current work at NEERI was also described, in particular a new, simple unit offering chemical dosing, flocculation, clarification and fibration.

The merits of slow sand filters were described in another paper from NEERI Annex 11 a). The construction and operation of the filter was described and its suitablility to rural applications stressed. Various modifications to reduce costs were described and then the results of a number of demonstration projects explained. The success of these demonstration projects was related to the personnel involved and the importance attached to health education and community participation.

More work on slow sand filters was described in a paper from the International Reference Centre for Community Water Supply and Sanitation of the World Health Organization (Annex 11b). The basic technology was described and then it was explained how this was adapted to suit local needs and how local communities became involved in the operation of the plants.

The next paper (Annex 12) examined this aspect in greater detail by describing the results of a number of demonstration projects installed by NEERI. In this project villages receiving slow and filters were surveyed and based on the results of the survery on educational strategy evolved. This strategy was then implemented

The results achieved were reported to be very favourable and considerable improvements in health standards had been measured. For example parasite infection had dropped from 70% to 50% in 6 years. One of the reasons for this success was identified as the degree of local involvement that had been established in both the construction and operation of the water supply system.

The following paper (Annex 13) examined in detail the needs of the distribution system to be connected to the purified water supply. Three options are commonly available, public stand pipes, distribution reservoirs with taps, and house connections. The advantages and disadvantages of each were considered and the design parameters to be used were outlined. The paper closed with a consideration of means of revenue collection and a discussion on the importance of community participation.

Annex I

PROGRAMME

Monday, 10 May	1000 - 1100 hrs	...	Inauguration
	1100 - 1130 hrs	...	Tea
	1130 - 1300 hrs	...	Technical Session I Presentation of country reports India Seychelles Papua New Guinea
	1300 - 1400 hrs	...	Technical Session II i) Technology choice for rural water supply - Dr B B Sundaresan & R Paramasivam ii) Rural water supply systems in Tamil Nadu Planning & Implementation - R Krishnaswamy
	1530 - 1600 hrs	...	Tea
	1600 - 1730 hrs	...	Technical Session III and visit to SERC
Tuesday, 11 May	0900 - 1030 hrs	...	Technical Session IV i) Package Treatment Plants - An effective tool for rural water supply - H V Krishnaswamy & S R Algarsamy ii) Package plants for rural water supply V A Mhaisalkar, P Paramasivam and Mrs S S Dhage
	1030 - 1100 hrs	...	Tea
	1100 - 1300 hrs	...	Technical Session V Slow and filtration for rural water supplies - Ir H A Heijnen - Shri P Parmasivam - Dr P V R C Panicker
	1300 - 1400 hrs	...	Lunch
	1400 - 1500 hrs	..	Technical Session V1 i) Community Education and Participation in Water Supply and Sanitation - Dr P V R C Panicker, Mrs A S Gadkari, M W Yoshi, A V Talkhande ii) Planning consideration in rural water supply - Shri A Raman iii) Ground water extraction and supply through tube wells, radial collector wells and infiltration galleries including case studies - G Haridass

Tuesday, 11 May
cont'd

	1530 - 1630 hrs	...		Technical Session V11
			i)	Role of Solar Distrillation in Rural Water Supply - Dr R Pitchai and Shri T Damodara Rao
			ii)	Highlights of field visits TWAD
Wednesday, 12 May		...		Field Visits
Thursday, 13 May		...		Technical Session V111
	0900 - 1030 hrs	...		Identification of Areas for Regional Cooperation & Project Formulation
	1030 - 1100 hrs	...		Tea
	1100 - 1230 hrs	...		Adoption of Recommendations
	1230 - 1400 hrs	...		Lunch
	1400 - 1530 hrs	...		Concluding Session

REGIONAL WORKSHOP ON RURAL DRINKING WATER SUPPLY

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Welcome Address by Shri K N Johry, Head (ISC), CSIR

This is the first major activity under the rural technology project on rural drinking water supply. A number of countries are participating in this project, India, Bangladesh, Seychelles, Papua New Guinea and Sri Lanka. Seychelles is the regional coordinator for the project. As a result of the interaction between the members of this project during last two years, it was decided that this workshop be held in India so that the participating countries could see and gain from Indian experience particularly our experience with the slow sand filtration technique, which has been sponsored by the WHO International Reference Centre (IRC) For Community Water Supply & Sanitation and which has shown encouraging results. The Indian participants and NEERI will benefit from the experience of the other countries represented here and how they are tackling this problem. Seychelles with many islands has been keen to have a decontroled system and we would like to hear of their experiences.

The Commonwealth Science Council launched their rural technology programme in 1978 and identified a number of projects at a workshop held in Dacca, Bangladesh. At the first steering committee which was held in CSIR, New Delhi later in 1978, the number of projects were brought down to 20 and focal points identified in each of the participating countries. During subsequent meetings held to review these projects and as a result of the last CSC meeting held in 1980, it was decided to bring down the number of projects to 10. Due to the importance of the rural water supply of the region, this project has been on our active list. Out of ten projects now in progress, promising results have been achieved in projects dealing with water hyacinth, biogas, prime movers and small scale tool and implement production. It is a matter of satisfaction that apart from providing regional coordinators for four projects, India is participating in all the rest of the projects. The national laboratories of CSIR has been making a very useful contribution for these projects. Among other agencies, who have been actively engaged in these projects in India, I would like to particularly mention the Khadi and Village Industries Commission for the biogas project and Development Commissioner, SSI, for the project on small scale production of tools and implements. Both these organizations successfully conducted regional workshops last year and we had very encouraging reports of the benefits from the workshop from the participating countries. The CSC is now planning to hold another workshop on biogas later this year in view of the success of the earlier activity.

Workshops are also planned in low cost building and a training programme is also planned for designing of engines for the prime movers project at CMERI, Durgapur. An International Conference on Water Hyacinth is planned early next year to report the experience gained under CSC projects on various aspects of water hyacinth including those relating to use of the weed for control of pollution, biological control, chemical control and utilization of water hyacinth for paper production. A large number of countries and experts working on water hyacinth are expected to participate.

CSC is not a rich organization. We are fortunate to have support from the Commonwealth Fund for Technical Cooperation. The Water Hyacinth project has received substantial help from UNEP. However, despite resource constraints, the programme has achieved creditable success.

With this brief introduction to CSC and some of its programmes and with the hope that this workshop will come out with some concrete recommendations for early implementation to tackle this vital problem, I would like now to request the Chairman for his presidential address and advice to the participants.

WATER SUPPLY AND SANITATION DECADE - INDIA - AN OVERVIEW

by Dr B B Sundaresan & R Paramasivam, National Environmental Engineering Research Institute, Nagpur 440 020, India.

Introduction

The International Drinking Water Supply and Sanitation Decade Programme (1981-1990) states that safe drinking water and effective sanitation should be provided for all people by the year 1990. To achieve this goal with meagre resources in a time frame of a decade as against a century or more taken by developed countries, needs political will, public support and administrative action at all levels in the developing countries. As it may not be a totally realistic goal for all the countries, each nation has to establish its own target, develop an appropriate strategy and implement a plan of action to achieve the set goal.

A review of the current status of drinking water supply at global, regional and national level would be relevant. The data compiled by WHO[1] on service coverage for drinking water supply shows a clear percentage increase only in rural water supply (Table 1). As of 1980, the percentage of total urban population covered has registered a marginal decrease from the 1975 level of 77 per cent. This indicates that the urban coverage did not keep pace with the increase in urban population. The third world population has been growing steadily, so the number of people without facilities has also grown. According to WHO in 1975, 1233 million people in the third world (excluding China) had no adequate clean water which has risen to 1320 million in 1980. The rural population without access to clean water, however, remained virtually the same (1106 million in 1975 and 1143 million in 1980).

Table 1 : Service Coverage for Drinking Water Supply in Developing Countries (1970-1980)

	1970		1975		1980 (estimated)	
	Population served (in millions)	Percentage of total population	Population served (in millions)	Percentage of total population	Population served (in millions)	Percentage of total population
Urban	316	67	450	77	526	75
Rural	182	14	313	22	569	29
Total	498	29	763	38	995	43

Indian Scenario

In post-independent India, industrial and technological progress has been impressive, but water supply and sanitation programmes have lagged far behind. As of 1980, 67 per cent of urban and 31 per cent of rural population had reasonable access to safe water supply (Tables 2 and 3). Several factors have contributed to this slow progress.

The single most important constraint in rural water supply programmes has been inadequate financial inputs. In the past, financial allocation has not been in proportion to the needs of this sector due to the competing demands from other sectors on the limited resources. Inadequate and inappropriate organisational and administrative set-ups, lack of trained personnel at various levels and inadequate community participation have all contributed to the slow progress in this vital sector. The magnitude of the problem and the task ahead will be evident from the fact that one half of the population without reasonable water supply in the world are in the South-east Asia region and 65 per cent of this are in India. Because of its sheer size and diversity, India's efforts to achieve the target will be viewed with considerable interest by the rest of the world.

Preparation for the Decade Programme

Rapid assessment of the status of drinking water supply and sanitation in India was undertaken during 1977-1980 so that a clear picture would emerge. Sector studies in respect of all the States and Union Territories have been carried out. The technical wing of the Ministry of Works and Housing, viz, The Central Public Health and Environmental Engineering

Table 2 - Statewise Number of Villages in Different Population Groups - India.

Name of State and Union Territory	Group I less than 200	Group II 200-499	Group III 500-999	Group IV 1000-1999	Group V 2000-4999	Group VI 5000-9999	Group VII over 10,000	Total
Andhra Pradesh	5352	4383	5438	6411	4833	724	80	27,221
Assam	5578	6694	5950	3012	734	26	1	21,995
Bihar	17440	20483	15232	9313	4337	675	86	67,566
Gujarat	2054	4351	5242	4395	1968	248	17	18,275
Haryana	618	1400	1090	1673	975	148	8	6,731
Himachal Pradesh	12020	3723	861	260	50	2	-	16,916
Jammu & Kashmir	1748	2200	1556	764	226	9	-	6,503
Karnataka	4939	7949	7082	4556	2014	252	9	26,826
Kerala	2	2	2	16	122	316	808	1,268
Madhya Pradesh	19784	27276	16516	5952	1292	87	6	70,883
Maharashtra	5053	9088	10529	7439	3102	492	75	35,775
Manipur	974	476	237	172	79	8	-	1,949
Meghalaya	3192	1093	237	54	7	-	-	4,583
Nagaland	334	325	169	114	17	1	-	960
Orissa	18546	15223	8821	3546	830	22	2	46,992
Punjab	1887	3311	3577	2892	940	79	2	12,188
Rajasthan	8771	11010	7817	4008	1524	165	10	33,305
Sikkim	-	31	114	63	7	-	-	215
Tamil Nadu	988	1981	3425	4547	3902	752	140	15,735
Tripura	2995	969	473	222	65	3	-	4,727
Uttar Pradesh	27356	34856	28295	16081	5400	515	58	112,561
West Bengal	7604	10957	9085	6622	3342	412	52	38,074
Union Territory								
A & N Islands	266	72	32	19	1	-	-	390
Arunachal Pradesh	2405	413	107	38	10	-	-	2,973
Chandigarh	3	5	10	7	-	1	-	26
Dadra & Nagar Haveli	3	20	18	26	5	-	-	72
Delhi	20	23	53	79	60	6	2	243
Goa, Daman & Diu	66	74	82	85	77	23	2	409
Laccadives	1	-	-	1	6	2	-	10
Pondicherry	64	98	85	57	26	3	-	333
Mizoram	37	50	36	49	54	3	-	229
Total	150,072	168,561	132,990	81,973	36,005	4,974	1,358	575,936

Table 3 - Water Supply Service Coverage - India[3]

(Populations in thousands)

Name of the State/U T	Population benefitted with water as on 31-3-1981			Percentage of		
	Urban	Rural	Total	Urban	Rural	Total
Andhra Pradesh	6,908	16,740	23,648	62.54	41.50	46.00
Assam	525	3,496	4,021	21.87	19.90	20.14
Bihar	5,526	41,916	47,442	70.38	69.40	69.52
Gujarat	9,427	20,262	29,689	95.00	87.60	89.80
Haryana	1,128	2,757	3,885	47.16	27.30	31.12
Himachal Pradesh	325	1,804	2,129	96.73	46.35	50.37
Jammu & Kashmir	1,223	1,733	2,956	100.00	36.40	49.40
Karnataka	9,534	8,158	17,692	99.86	31.30	49.69
Kerala	2,847	6,046	8,893	60.76	28.41	34.26
Madhya Pradesh	7,094	13,036	20,130	72.30	30.14	37.94
Maharashtra	11,418	7,833	19,251	88.78	19.69	43.42
Manipur	261	269	530	71.70	24.45	36.20
Meghalaya	64	216	280	28.00	19.66	21.20
Nagaland	66	328	394	29.07	67.27	55.10
Orissa	1,022	2,950	3,972	37.44	12.12	14.68
Punjab	3,045	2,992	6,037	72.36	25.26	37.61
Rajasthan	4,059	9,892	13,951	65.70	36.26	41.70
Sikkim	24	32	56	22.43	21.92	22.13
Tamil Nadu	9,858	5,787	15,645	61.71	21.60	36.60
Tripura	105	741	846	39.62	40.29	35.21
Uttar Pradesh	13,990	6,488	20,478	88.80	7.20	19.37
West Bengal	4,659	6,439	11,098	30.75	15.79	19.84
A & N Island						
Arunachal Pradesh	25	392	417	90.00	64.58	50.30
Chandigarh	480		480	93.7		92.80
Delhi	4,700	284	4,984	79.7	100.00	80.60
Dadra & Nagar Haveli						
Goa, Daman & Diu	332	168	500	77.20	22.98	43.07
Lakshadweep		3	3		8.50	8.50
Mizoram	10	113	123	14.70	32.00	29.15
Pondicherry	174	245	419	78.73	67.30	70.66
Madras	3,475	140	3,615	81.20	50.00	79.29
Bombay						
Total:	102,304	161,260	263,564	66.91	31.07	32.99

Organisation (CPH & EEO) coordinates the decade programme at the national level. A series of meetings of Chief Public Health Engineers of all the States and Union Territories have been held to identify the minimum levels of service in urban and rural areas and prepare a plan of action. A national workshop on "R & D Needs for the Decade Programme" was organised at NEERI, Nagpur, in which Chief Public Health Engineers of various states, research professors and scientists participated.

The target proposed to be achieved during the decade has been set as :

(i)	Urban water supply	...	100 per cent
(ii)	Rural water supply	...	100 per cent
(iii)	Urban sewerage/ sanitation	...	100 per cent of all class I cities with sewerage and sewage treatment and 50 per cent in respect of class II and other cities with sewerage and other methods of sanitary disposal of human wastes. Note : (Overall coverage would be 80 per cent by means of sewerage or other simple sanitary methods of disposal).
(iv)	Rural sanitation	...	25 per cent or more to be covered with sanitary toilets.

Realizing the need to accept lower unit costs and standards of service as per the decisions taken at the Nagpur Conference in November 1979, the projected requirement of funds for the decade programme to achieve the goals set is around Rs.146 billion (US$16.2 billion) as under[2]:

		Indian Rupees (billion)	
(i)	Urban water supply	32	
(ii)	Urban sewerage and sanitation	38	
(iii)	Rural water supply	69	
(iv)	Rural sanitation	7	
	Total :	146	(US$16.2 billion)

(1 US$ = Indian Rupees 9.00)

An Apex Committee consisting of members from various Ministries and the Planning Commission has been set up by the Government of India for national policy formulation as well as guidance and overview of the programme to be initiated to achieve the objectives. Working groups, one to deal with financial resources for the decade programme, another to deal with materials and equipment and a third to deal with programme and manpower for the decade programme have been set up.

Evaluation of Rural Water Supply Systems

The strategies to be adopted would require planning of projects and programmes that are technologically appropriate, socially relevant and at a cost affordable by the country. The total estimated outlay being very high, the strategies for implementation of the programme have to be thoroughly gone into particularly on aspects like levels of service, design norms, operation and maintenance, manpower training and development, materials required for projects as well as timely flow of funds. It is also necessary to have a critical review and objective evaluation of rural water supply schemes already implemented in the country and identify factors that have contributed for their success and those that have hampered their progress. Such an evaluation which will help avoid pitfalls in future implementation of the programmes and optimum utilisation of resources, has been carried out by NEERI, Nagpur.

The overall objective of the study was to critically evaluate representative rural water supply schemes from different states with a view to identifying technological, administrative, financial and socio-economic constraints in effective implementation and operation of the schemes, to give the desired benefit to rural population. The criteria for the evaluation involved the design norms and levels of service envisaged at the time of planning and implementation of different schemes and their present performance and levels of achievement. More specifically, the following aspects have been covered :

(i) Collection of information such as design period, population, per-capita water supply and existing conditions of services.

(ii) Survey of sources of water supplies, their quality and seasonal variations.

(iii) Technological aspects relating to system design, construction and operation.

(iv) Problems in operation and maintenance, frequency of breakdowns, availability of spares, services facilities including manpower and training.

(v) Degree of service such as per-capita supply, duration of supply, location and number of public stand posts/hand pumps provision of house connections, etc.

(vi) Health status, health education, health impact and other indirect benefits.

Keeping in view the vastness of the country, a total of 66 schemes (Tables 4 and 5) from different states of India were selected for the study to represent the following categories:

(i) Schemes serving less than 1000 persons.

(ii) Schemes serving between 1000 and 10000 persons.

(iii) Simple hand pump tube wells.

(iv) Piped water supply schemes serving one or a group of villages with distribution through public stand posts alone.

(v) Piped water supply schemes with distribution through public stand posts as well as individual house connections.

In order to avoid possible bias in the selection of schemes, Chief Engineers were requested to provide a list of all the completed rural water supply schemes to be studied from different geographic locations within the state. From among these lists, eight to ten schemes were selected at random fulfilling the criteria laid for selection.

The field work comprises three major activities:

(i) Visits to the Public Health Engineering Departments to obtain information such as design data, engineering details, etc, about the schemes selected for evaluation and to hold discussions to discover their views and experiences on various aspects of rural water supply programmes.

(ii) Field visits to villages to study the schemes in detail as they exist, collect water samples for assessing water quality and to hold informal discussions with both government (revenue) officials and local body representatives.

(iii) Personal interviews with the villagers (users of public water supply) to collect information on water supply service, health status, awareness of water related diseases and their control, personal hygiene and environmental sanitation, benefits of water supply, etc. For this purpose, 5 per cent of the households in the village subject to a minimum of 30 and a maximum of 60, were selected at random using table of random numbers (specimen proformae developed and field tested are given in Appendix I).

With a view to compare the impact of providing an organised water supply on the health status of the user community, the rate of incidence of water-borne diseases, etc, reference villages were selected in addition to the study villages in each state. The reference villages were so selected as to have a population and socio-economic conditions comparable to any of the study villages with the exception that it does not have an organised water supply as yet and depends on water supply sources similar to those in the study villages.

The information and data collected from design office, field observations, personal interviews and discussions with engineers, local body officials and representatives of villages were consolidated, analysed critically and an objective evaluation prepared for each of the water supply schemes. Based on this study, a comprehensive evaluation report bringing out the present status, the constraints and recommendations for future implementation of rural water supply systems in India has been prepared.

Table 4 - Classification According to the Type of Scheme

State	Number and type of systems selected for study							Total No of villages
	Tubewells with handpumps		Piped water supply with PSPs only		with PSP + HC		Reference villages	
	< 1000	> 1000	< 1000	> 1000	< 1000	> 1000		
Orissa	2	1	-	1	-	2	1	7
Madhya Pradesh	2	1	-	-	-	3	1	7
Maharashtra	-	-	2	1	-	4	2	9
Kerala	-	-	1	1	1	1	1	5
Rajasthan	1	1	1	1	-	1	2	7
Tamil Nadu	2	-	1	1	-	2	1	7
Andhra Pradesh	-	2	1	1	-	2	2	8
Haryana	-	-	1	4	-	-	1	6
Gujarat	1	1	-	1	-	3	1	7
West Bengal	1	1	3	3	-	-	4	12
Uttar Pradesh	1	1	1	1	3	-	1	8
Total	10	8	11	15	4	18	17	83

Table 5 : Classification of Schemes According to O & M Agency

State	No of Schemes	Type of scheme			O & M Agency	
		Hand Pump	PSP	PSP + HC	Local Body	PHED/ Board
Orissa	6	3	1	2	-	6
Madhya Pradesh	6	3	-	3	3	3
Maharashtra	7	-	3	4	7	-
Andhra Pradesh	6	2	2	2	6	-
Tamil Nadu*	6	2	2	2	4	2
Kerala	4	-	2	2	-	4
Haryana	5	-	5	-	-	5
Rajasthan	5	2	2	1	1	4
West Bengal	8	2	6	-	2	6
Gujarat	6	2	1	3	3	3
Uttar Pradesh	7	2	2	3	-	7
Total	66	18	26	22	26	40

*O & M by TWAD but cost borne by local body

R & D Strategy

With the above background, the strategy and technology options for implementing rural water supply in regions with varying degrees of development and different hydrogeological conditions in addition to the difference between rural and urban environments become highly complex. The concept of commercialisation of water supply as a self-supporting proposition, let alone a profitable one, has seldom gained acceptance in rural areas of developing countries. Hence, the approach and strategy to be adopted for rural water supply programmes have to be imaginative and different from those for urban systems. The multi-disciplinary aspects of the profession ad another dimension to developing appropriate technologies. It is a misconception to assume that small water supplies are merely "scaled down" versions of urban installations requiring less engineering skill and ingenuity. The exact opposite may often be the case.

Environmental engineers and scientists exposed to American and European technological innovations have adhered to the line of least resistance in adopting technologies which were readily available. Such an approach has been useful in some cases, but has become irrelevant in a large number of cases. R & D does not stop simply with unravelling the basic mechanisms through scientific efforts or technological adoptions through engineering skills. It must be supported by other disciplines such as sociology, economics and health education. Instances are not lacking where processes and technologies claimed to have been successful in a developed country have failed to take-off in a developing country because social relevance and cultural acceptance were overlooked. The objectives of R & D effort should be :

(i) Determination of techno-economic feasibility of various options which are available for water supply and waste disposal;

(ii) Evaluation of economic and environmental system effects of technologies which provide for conservation of water, reclamation and reuse of waste-water;

(iii) Development of energy saving devices ; and

(iv) Technological innovations at intermediate technology levels to improve efficiency and enhance appropriateness.

Such an effort should be supported by modern tools of data collection, storage and retrieval. Information collection, collation and dissemination should be improved to provide for continuous flow of information between operating agencies and research institutions. Efforts undertaken to meet the decade programme requirements should thus take into consideration (i) the total concept and system approach, (ii) energy conservation, (iii) waste reuse and recycling, (iv) interaction with sociologists on aspects of community participation, (v) economic analysis and cost effectiveness and (vi) effective linkage between user departments and research organisations.

Conclusion

In conclusion, preparatory work for the decade programme with emphasis on rural water supply has been completed, which involved identification of problem villages, levels of service to be provided, strategy for plan of action on the basis of evaluation of completed schemes, financial resources required and constraints in organisational infrastructure. The programme has been launched at the national level for which political will and public support have manifested itself and administrative action has been initiated. Availability of institutional infrastructure, technological packages, skilled manpower, materials and supplies are assets in the total programme, but success or otherwise would depend upon effective coordination to provide funds and materials at the right time, in the right place with the right personnel.

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APPENDIX I

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE, NEHRU MARG : NAGPUR - 440 020

PROFORMA FOR INFORMATION ON HEALTH STATUS

H Q/Zonal Lab ______________________ Date ______________

Name of the Interviewer ______________________

Signature of the Interviewer ______________________

1. General Information

a) Name of the village ______________________

C D Block ____________ District ____________ State ____________

b) Ward No ____________ House No ____________

Number of persons in the family ...... Adults ______ Children ______

c) Respondent's Name ______________________

Sex ____________ ( )
(Male-1, Female-2)

Caste ____________ ( )
S C-1, S T-2, Other-3)

Educational status .... ( )
(Illiterate-1, Primary-2, Middle school-3, High school-4, Higher education-5)

2. Sanitation and Personal Hygiene

a) How do you dispose of sullage .... ( )
(Soakpit-1, Connected to drainage-2, Ordinary pit-3, Use in kitchen garden-4, No organised system-5)

b) What is your method of disposal of garbage and refuse .... ( )
(Composting-1, Throwing around the house-2, Dustbin-3, Alloted pits in the village-4, Pit in the house premises-5, Others (specify)-6

c) What is your method of disposal of animal dung .... ( )
(Composting-1, Alloted pits-2, Fuel-3, Others (specify)-4, N A-5)

d) Where do you and members of the family go for defecation ... ( )
Adult males : Openfield-1, Latrine-2, Both-3 .... ( )
Adult females : Openfield-1, Latrine-2, Both-3 .... ( )
Children male : Openfield-1, Latrine-2, Both-3 .... ( )
Children female: Openfield-1, Latrine-2, Both-3 .... ( )
Old and sick : Openfield-1, Latrine-2, Both-3 .... ( )

e) Type of Latrine .... ( )
(Chainflushed-1, Handflushed-2, Conservancy system-3, Pit-4, Septic tank-5, Public latrine-6, Bore hole-7, Other (specify)-8, Not applicable-9)

f) Condition of Latrine .... ( )
(Clean-1, Dirty-2, Not in use-3, Not applicable-4)

g) Do you wash hands after ablution .... ( )
(Yes-1, No-2, Not applicable-3)

h) If yes, with what .... ( )
(Soap-1, Mud-2, Ash-3, Others (specify)-4

i) Observe if the fingernails are properly cut .... ( )
(Yes-1, No-2)

3. Health Education

a) What will happen if you drink unsafe water .... ( )
(Cause disease-1, Cause minor illness-2,
Nothing happens-3, Does not know-4, Others(specify)-5

b) What will you do to make unsafe water safe .... ( )
(Boiling-1, Alum treatment-2, Disinfection-3,
Straining through cloth-4, Decantation-5,
Filter candle used-6, Does not know-7, Other devices-8)

c) Name a few water-borne diseases .... ( )
(Cholera/Gastroenteritis-1, No-0 .... ( )
Typhoid-2, No-0 .... ( )
Dysentery/Diarrhoea-3, No-0 .... ( )
Infectious hepatitis-4, No-0 (Jaundice) .... ( )

d) Do you know the preventive measures of the above diseases ... ( )
(Water treatment-1, No-0 .... ( )
Immunization-2, No-0 .... ( )
Personal hygiene-3, No-0) .... ( )

e) Do you go to a doctor immediately on falling sick .... ( )
(Yes-1, No-2)

f) Where do you go for medical treatment .... ( )
(Government hospital-1, Private hospital-2,
Private medical practitioner-3,
Household treatment-4, Others(specify)-5)

g) Specify the type of treatment .... ( )
(Allopathy-1, Homeopathy-2, Ayurvedic-3,
Unani-4, Others(specify)-5)

h) What is the importance of daily bath .... ( )
(Personal hygiene-1, Custom-2, Freshness-3,
Does not know-4, Others(specify)-5)

i) Do you think mosquitoes can cause any illness .... ( )
(Yes-1, No-2, Does not know-3)

j) If yes, name the diseases .... ( )
(Malaria-1, Filaria-2, Both-3, Does not know-4)

k) How mosquitoes can be controlled .... ( )
(Reducing the stagnation of water-1, Spray of insecticides-2,
Spray of oil-3, Does not know-4, Any other (specify)-5)

l) Do houseflies play a role in transmission of diseases........ ( )
(Yes-1, No-2, Does not know-3)

m) If yes, how .... ( )
(Contamination of food-1, Contact with body parts-2,
Both-3, Does not know-4)

n) Where do houseflies breed .... ( )
(Refuse/Cowdung heaps-1, In water-2, Dirty places-3,
Does not know-4, Any other (specify)-5)

Immunization Status

o) In the past, did any of the family members suffer from ...... ( )
(Polio, Diphtheria/Whooping caugh/Tetanus/Cholera/Typhoid/T B)
(Yes-1, No-2, Does not remember-3)

p) Are these diseases fatal .... ( )
(Yes-1, No-2, Does not know-3)

q) Can they be controlled by immunization .... ( )
(Yes-1, No-2, Does not know-3)

r) Have any members of the family got vaccinated in the past one year .... ( )
Typhoid - (Yes-1, No-2, Does not remember-3) .... ( )
Cholera - (Yes-1, No-2, Does not remember-3) .... ( )
Small pox - (Yes-1, No-2, Does not remember-3) .... ( )

s) Are your children vaccinated against .... ( )
Polio - (Yes-1, No-2, Does not remember-3, N A-4) .... ( )
T B - (Yes-1, No-2, Does not remember 3, N A-4) .... ( )
Small pox - (Yes-1, No-2, Does not remember,NA-4) .... ( )
D P T - (Yes-1, No-2, Does not remember-3, N A-4) .... ( )

4. Morbidity and Mortality Data

a) Did you have cases of the following diseases in the family ? If yes, note the recurrence in the last three years

Cholera/Gastroenteritis (No of times ______, No-0) .... ( )
Typhoid (No of times ______, No-0) .... ( )
Dysentery/Diarrhoea (No of times ______, No-0) .... ( )
Infective hepatitis (No of times ______, No-0) .... ( )
Worm infestation (No of times ______, No-0) .... ( )
Malaria (No of times ______,No-0) .... ( )
Polio (No of times ______, No-0) .... ( )

b) Did you find any reduction in the incidence of the following diseases in your family after the introduction of water supply .....

Cholera/Gastroenteritis .... ( )
(Yes-1, No-2, Not applicable-3, Does not know-4)

Typhoid .... ( )
(Yes-1, No-2, Not applicable-3, Does not know-4)

Dysentery/Diarrhoea .... ( )
(Yes-1, No-2, Not applicable-3, Does not know-4)

Infective hepatitis .... ( )
(Yes-1, No-2, Not applicable-3, Does not know-4)

Polio .... ( )
(Yes-1, No-2, N A-3, Does not know-4)

Malaria .... ( )
(Yes-1, No-2, N A-3, Does not know-4)

Filaria .... ( )
(Yes-1, No-2, N A-3, Does not know-4)

c) Any deaths in the family during the past three years due to :

Cholera/Gastroenteritis .... ( )
(Yes-1, No-2)

Typhoid .... ( )
(Yes-1, No-2)

Infectious hepatitis (Jaundice) .... ( )
(Yes-1, No-2)

Polio .... ( )
(Yes-1, No-2)

Malaria .... ( )
(Yes-1, No-2)

NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE, NEHRU MARG : NAGPUR - 440 020

PROFORMA FOR INFORMATION ON WATER SUPPLY

TYPE OF WATER SUPPLY SCHEME : Handpump/House Connection/Public Stand Post

Name of Village : Ward No : House No:

Respondent's Name :

1. a) Quantity (litres) of water obtained daily : ..... Morning ..... Evening
   b) Is it sufficient Yes/No
   c) If NOT, additional quantity (litres) required ...
   d) Quantity (litres) of stored water daily discarded .....

2. Quantity (litres) used for different purposes :

   Drinking ( ) Cooking ( ) Washing of clothes ( ) Washing utensils ( )
   Bathing ( ) Toilet & ablution ( ) Domestic Total ( )
   Cattle ( ) Any other ( )

3. Do you fetch water from other sources also Yes/No

If YES,	Source	Quantity(litres)	Purpose
a)	______	______	______
b)	______	______	______

4. a) Timings of water supply
   Morning From ____ To ____
   Evening From ____ TO ____
   b) Are the timings regular Yes/No
   c) Are the timings convenient Yes/No
   d) If NOT, indicate convenient timings
   Morning From ____ To ____
   Evening From ____ To ____

5. a) Is duration of water supply sufficient Yes/No
   b) If NOT, extra duration (minutes) required
   Morning From ____ To ____
   Evening From ____ To ____
   Total ______

6. Do you get extra supplies on special occasions (Diwali, Holi, Fairs, Festivals) Yes/No

7. Time (minutes) spent in fetching water
   Morning ______
   Evening ______

8. Difficulties (if) faced in meeting daily water requirement

   a) Overcrowding b) Distance too long c) Lift too high
   d) Insufficient pressure e) Personal reasons f) Any other

9. Are standposts conveniently located Yes/No/Not applicable

10. Do you need additional standposts in your locality Yes/No/Not applicable

11. Are you satisfied with the quality of water supplied Yes/No
    If NOT, reasons : a) Turbidity b) Bad odour c) Chlorine smell
    d) Bad taste e) Any other

12. Do breakdowns occur in water supply Yes/No
    a) Frequency of breakdowns/year ______
    b) Reasons : Failure of (i) Electricity (ii) Machinery (iii) Organisation

13. Sources of water supply used during such breakdowns

a) River b) Canal c) Well d) Tank e) Any other (specify) ____________

14. Do you experience problems in summer — Yes/No
If YES, nature of difficulty ____________

15. Do you have an individual house connection — Yes/No
i) If NOT, give reasons :

a) High water tax b) Distributory line far away
c) Public standpost quite near d) Well in house
e) High house connection fee f) Any other (specify) ____________

ii) If YES, your opinion about the water tax

a) High b) Reasonable c) Low d) No comments ____________

iii) Are you interested in having a house connection — Yes/No
If YES, amount (Rs.) you would like to pay annually ____________

16. What in your view are the benefits of piped water supply

a) Labour reduced in fetching water b) More time available for other work
c) Reduction in illness d) Increase in property value
e) Improved personal hygiene f) Coming up of new industries
g) Any other (specify) h) No response ____________

17. Any new problem cropped up due to introduction of water supply — Yes/No

If YES, specify ____________

India Country Paper

International Water Supply and Sanitation Decade (1981-1990)

Global Status

- Eighty per cent of the world's disease is linked to inadequate water or sanitation.
- Every hour, between 1000 and 2500 Third World children under five die simply because they do not get clean water to drink or enough water to wash themselves properly.
- Every hour, 50,000 children under five suffer from some form of diarrhoea.
- Every year, about 6 million children under five die from diarrhoea.
- Hour after hour, day after day, this is the price that the Third World's children pay for lack of clean water.
- It is against this background that the United Nations has declared the 1980s the International Drinking Water Supply and Sanitation Decade. The launching of the decade programme on 10 November 1980 marks a new era in the history of the U N.
- During the 1960s and 1970s, there was some increase in the proportion of people served by water supply and sanitation facilities. But this increase has been much lower than the increase in population.
- In 1975, 1350 million had no sanitation. 1980 this was 1730 million. The number of rural people without access to clean water remained virtually the same (1106 million in 1975 and 1143 million in 1980).

Community water supply in developing countries : percentages of population adequately served

Year	Urban population supplied with water: By house connections	By public standposts	Total urban	Rural population with reasonable access to water	Total
1962	32	25	58	-	-
1970	50	17	67	14	29
1975	57	20	77	22	38
1980	-	-	75	29	43

- Today 100 million more third world people have to drink dirty water than in 1975 and 400 million more than in 1975 have no sanitation.

Investments for Decade Programme

- The World Bank estimates that the total cost of clean water and sanitation for all by 1990 would be in excess of US$600 billion. This is on the assumption that in urban areas every household has a tap of its own and is connected to a sewerage system and that rural households will be served with stand-pipes or handpumps and individual latrines.
- The World Bank also estimates that by using cheaper and more appropriate technologies in both rural and urban areas, the costs could probably be halved to US$300 billion or less.
- The bulk of this sum will have to be raised by the developing countries themselves. WHO estimates that atleast one fifth to one third of the total capital investment will be needed as external aid. This would mean that external assistance of US$11,000 to US$19,000 will be required per minute.
- Developed countries alone spent US$360 billion on defence in 1979. If they diverted 10 days a year of their arms spending to the Decade, this would provide all the external aid needed.

- Even if external aid could be raised, the developing countries would still need to spend something, like US$ 20 billion every year from their own domestic resources. All these figures are only for capital expenditure. More money will be required to operate and maintain the water supply and excrete disposal facilities.

Status of Water Supply and Sanitation in India

India with a total population of about 685 million has 575,936 villages in which nearly 80 per cent of the people live. As of 1980, 67 per cent of urban population and 31 percent of rural population have been provided with reasonable access to safe water. In terms of actual number, the people covered with water supply is about 263 million.

India formally launched upon the Decade Programme in April 1981. A rapid assessment of the status of drinking water supply and sanitation was undertaken during 1977-1980. A series of meetings of Chief Public Health Engineers of all the States and Union territories have been held to formulate guidelines on the minimum levels of service and to prepare a plan of action. A national workshop was organized at NEERI in 1979 to identify R & D needs for the Decade Programme. The target set for the Decade Programme in India is :

(i) Urban water supply ... 100 per cent

(ii) Rural water supply ... 100 per cent

(iii) Urban sewerage/sanitation ... 100 per cent of all Class I cities with sewage and sewage treatment and 50 percent in respect of Class II and other cities with sewage and other methods of sanitary disposal of human wastes.

Note: (Overall coverage would be 80 per cent by means of sewage or other simple sanitary methods of disposal)

(iv) Rural Sanitation ... 25 per cent or more to be covered with sanitary toilets

The projected requirement of funds to achieve the target is as under:

	Indian Rupees (billion)
Urban Water supply	32
Urban sewage and sanitation	38
Rural water supply	69
Rural sanitation	7
	146

The Strategy

The attainment of the targets for the Drinking Water Supply and Sanitation Decade will require new approaches both in national strategies and in international support.

Simple, cheap and safe community water supply and sanitation schemes which people accept and use, should be promoted. Where schemes are understood and wanted by the community, people are likely to find more of the resources necessary to construct and operate them. If there is no appreciation of what communities want and need, blunders can be made. Several instances have been quoted as to how people destroyed or neglected water and sanitation facilities that were installed without prior consultation. Furthermore, technology must be appropriate. In addition to reduction in costs, installations should be simple to operate and maintain using the knowledge available in the village or small town concerned and should encourage local employment. For example, slow sand filters can provide simple, efficient and reliable means of purifying polluted waters for small community water supplies.

It has been increasingly recognised that the problem of rural water supply is closely linked to that of environmental sanitation and that if any project is to be successful, the approach should be an integrated and multidisciplinary one. Not only must appropriate technologies be applied but they must also be linked to other sectors of rural development including education of villagers on the importance of proper use of water supply and sanitation facilities. Community involvement and participation is another vital aspect which decides the success or failure of a water supply project or for that matter any rural development programme. Increasing involvement of the community in not just the construction and maintenance of the system, but in all stages of planning and implementation should be ensured to achieve the real benefit of investment in improved water supply.

WATER SUPPLIES IN THE SEYCHELLES
by Mr S Rousseau

Introduction

The goals for the 1981-1990 Water Decade were established at the UN Water Conference in Mar del Plata, Argentina in 1977. The proposal at the Mar del Plata Conference was later approved by the UN General Assembly and the official slogan became "Clean Water and Adequate Sanitation for all by 1990". The aim was 100% coverage - an ideal that few people believe can be achieved in full, and which has already been adjusted within WHO to 100% for water supply, 80% for urban sanitation, and 50% for rural sanitation.

The amount of money that needs to be spent to achieve the goal of the Decade is put at between US$200 billion to US$500 billion. The bulk of this money is to come from the developing countries themselves, and it must be noted that the developing countries have other pressing needs beside water and sanitation. At US$80 million a day, the Decade's call on international financial resources is daunting, even when put alongside other global estimates : US$240 million a day is spent on cigarettes; tranquilisers for what WHO calls non-essential uses cost US$10 million a day and the global arms bill is US$1400 million a day.

It has been said that if the developed countries alone diverted 10 days a year of their arms spending to the Decade it would produce all the external finance needed. Telling as that statistic may be, it is hardly likely to produce an overnight conversion of political ideologies to the tune of US$10 billion a year.

The message for the Decade that the UN is emphasing, in pushing forward the goals of the Decade, is the human and financial benefits.

As Arthur Brown, Chairman of Interagency Steering Committee Coordinating the UN Decade Activities, put it, "The humanitarian arguments are overwhelming. In addition it is a field in which technology is relatively simple and readily available, the cost effectiveness is very high and the results are quickly and clearly visible. If the Decade is only partially successful in achieving its goal for clear drinking water and sanitation for all by 1990 it would have more impact than any United Nations programme ever launched, in alleviating human suffering and increasing human potential."

Seychelles Action's Plan For The Decade

The Seychelles Water Authority with the help of a WHO expert Dr J W Kwaniana Duncan produced a report ICP/RSM/002 which was a Rapid Assessment of current and projected sector development to meet the objectives of the Decade.

The report made the following recommendations:

(i) Identification of a national focal point to be entrusted with coordination for the formulation of appropriate sector policies, plans and programmes and located in the Water and Sewerage Section of the Public Works Division. (The Seychelles Water Authority was formed on 1 January 1981 and took over the functions of the Water and Sewerage Division). The focal point is now Mr N F Nicholson, Engineer/Manager of SWAL.

(ii) Government should conduct manpower training and survey studies to determine present and future manpower needs in the sector as well as technical support for fellowships, curriculum planning, experts and teachers; establishment of training institutions and provision of technical and teaching materials and equipment.

(iii) External technical and financial assistance should be assured in the development and provision of low-cost technologies to provide sector facilities to marginal population especially in the outer islands of the Republic.

(iv) Further groundwater explorations should be undertaken, supported by external cooperation in the coralline islands, to determine maximum yield of aquifers.

The report also outline the external inputs required to meet the Decade Goals as follows:

- To review the water tariff introduced on 1 January, 1980. The present tariff recovers the cost of operation and maintenance costs, for water supply and sewerage disposal and minimal replacement of existing works. No charge is made for sewerage.

- To assist with the development of low-cost technology units to provide water supply and sanitation facilities to marginal population groups.

- To assist with the development of training programmes. The prospects for comprehensive manpower sector development programmes are not bright as there are no sub-professional training institutions in Seychelles. However in-service training is being provided for junior technical personnel.

- To assist with a Sanitation and Health Education Programme.

Evaluation of Existing Technologies Which Are Suitable For Rural Application

(i) Ceramic candle pressure filters: These filter units will produce potable water to supply up to 250-300 persons.

The body of the filter is of aluminium and steel construction, coated with non-toxic plastic and utilises 10 or 20 ceramic elements. The elements may be impregnated with silver nitrate which is a bactericide. Water passing through such filters is potable without further treatment. On larger schemes, the water is dosed with chlorine to protect it during transportation to the consumers.

Performance of unit: Seychelles installed the first such filter unit in 1977 to supply Anse Louis Village on the main island of Mahe. The unit is now supplying a village with population of approximately 300 inhabitants.

The output of the unit is regularly monitored and performs satisfactorily provided the elements are replaced regularly. Dosing chlorine with tablets or chloride of lime gives additional protection to the supply.

(ii) Small package water treatment plant utilising pressure filter of capacity of 14 m^3/hr. The body of the filter is made of galvanised mild steel. Filter media is quartz sand and activated carbon for colour removal.

Performance of filter: One such filter has just been installed at Quatre Borne a village in the south of Mahe. The filter unit has not run for a sufficient length of time for its performance to be fully assessed.

(iii) Vertical raked pressure filters: Where available head is not great SWAL have the intention of using vertical manually raked pressure filters. SWAL have had no experience with this type of filter, however the manufacturer of these units claims that after chlorination a potable water meeting the standard of WHO will be achieved. Funds are being sought to install this type of filter on Praslin.

(iv) Slow sand filters: SWAL have in operation two works which utilise slow sand filters. It is well know that after the initial cost of construction slow sand filters cost least to operate but the shortage of flat land means that slow sand filters are not viable.

Suitability and performance: The filters at Rochon, which where slow sand filters were commissioned in 1969 and give satisfactory results. Monitoring shows that 96% of bacteria is removed. The filtered water is chlorinated to give a safe supply of drinking water.

After periods of rain storms when the bacteria counts increases it has been observed that the percentage of removal decreases. At these times the colour of the water also increases and the filtered water often has colour and turbidity measurements above the WHO maximum permissible. Duration of such incidences is short.

Slow sand filters suitability and performance for small or large communities are well documented in many papers (for example, slow sand filtration - L Huisman C W E Wood; Slow sand filtration Project Report Phase I by NEERI).

(v) Rapid gravity filtration: This type of filtration is generally employed to treat large volumes of water, but can also be used to supply small communities. More attention has to be paid to the filtered water quality. Two works which utilises R G F are in operation on Mahe. Performance of one has been very satisfactory. The underdrain system on the other works failed shortly after acceptance necessitating extensive repair work.

(vi) Shallow wells: Some of the coralline islands depend on shallow wells for the supply of water. These are of course susceptible to pollution, from dirty buckets and inadequate protection from surface water pollution.

Installation of hand pumps and proper drainage around the well is one way of reducing the incidence of pollution and the wells can be used to supplement rainwater roof catchment. Consumers of such supplies are educated to sterilise drinking water by either boiling or filtration, using a domestic gravity ceramic filter. (The ceramic is of similar material as the sterasyl candle filters)

Possible Area For Collaborative Research and Development Under The CSC Project

1) The use of crushed coral for pH correction of water.
2) The use of quick or slaked lime for pH correction.
3) Testing of locally available materials for use with different types of filter:
   - slow sand filters;
   - rapid gravity filters;
   - pressure filters.
4) The use of activated carbon for the removal of colour.
5) Economic analysis of the use of the different type of filters.

Table 1: Community Water Supply

		1975		1980	
		No '000	%	No '000	%
Urban Population Served	By House Connections	12.1	57	18.4	75
	By Public Standposts	5.0	23	2.7	11
	Sub-total	17.1	80	21.1	86
Rural Population Served		23.7	65	33.1	80
Grand Total		40.8	71	54.2	82

Table 2 : Excreta Disposal

		1975		1980	
		No '000	%	No '000	%
Urban Population Served	Connected to Public Sewerage Systems	-	-	1.0	4
Urban and Rural	Pit latrines, Septic tank Soakway Systems	19.4	90	22.3	91
	Bucket Latrines	1.5	7	1.2	5
Rural Population with Adequate Disposal Systems		32.8	90	39.3	95
Grand Total		53.7	93	63.8	97

Estimated Population: 57 850 (1975) and 65 900 (1980) 63% Rural and 37% Urban.

VILLAGE WATER SUPPLIES IN PAPUA NEW GUINEA
by W Guthrie

Introduction

Papua New Guinea is a country located at the cross roads of Asia and the Pacific. It is the eastern half of the island of New Guinea plus the adjacent islands to the east including Bougainville, the most northerly of the Solomon Islands. The land area of 4 77500 km^2 lies between 1^0 and 9^0 south latitude and supports a population of 3 million people. Three quarters of the people are subsistence farmers living in small groups or villages within 160 rural local government councils.

Political Development

At independence in 1975 the country was divided into about 20 administrative districts with a centralised bureaucracy in Port Moresby by which all major decisions and most minor ones were made. However almost immediately pressure was applied by various quarters for a larger degree of autonomy in the running of the districts. The pressure lead to the national government defining its powers and assets of national importance and relegating all the rest to the respective districts, renamed provinces, complete with elected assemblies and a financial allocation with very few strings attached. Large functional areas of the health department were decentralised as were the powers over local government councils so that almost overnight the national government removed itself from the direct control of village water supplies.

A policy is presently being drawn up allowing some measure of direction to be given by the national government towards the spending of funds which it is preparing to allocate for improving rural water supplies. At the moment the picture is not clear particularly with respect to how much freedom the provinces should have in developing programmes. If there is a wide divergence in approach between provinces the planning authorities may have difficulty in setting priorities.

HISTORY OF WATER SUPPLIES

The country has had recent but intensive contact with western society with rapid technological change in the past 20 years. A generally high rainfall has meant that water supplies at rural level have had a low priority in the minds of most people, especially with the national government. The capital, Port Moresby, is located in the driest part of the country getting just over 1.0m of rain per year. The urban area is provided with an extensive gravity reticulated supply from the mountains to the north. The rural areas, which rely mainly on ground water, are the recipient of an expanded programme of village water supply construction funded by national government. Most of the rest of the country receives rainfall averaging 2.0 to 2.5m per annum with a few areas receiving as high as 4.5m.

Apart from church missions and institutional supplies, the health department has been the most active in rural water supply construction. Various departmental programmes over the last 30 years have been supplemented by a nationally subsidized programme using local government councils as the sponsoring agent. This programme, an annual event, began in 1969 and was intended to finance a wide range of projects of civil and architectural needs, of which water supply was only one. Although the annual government subsidy had reached US$9 million by 1975, the year of independance, only a small portion of this was for water supplies, thus reflecting the low priority the people, through their councils, attach to this field.

Although agencies like the Health Department and the engineers of Local Government, an advisory body attached to the Department of Works and Supply, push for an improved level of village water supply useage, the people put their priority on roads, bridges and primary education.

Only recently has the national government sponsored programmes directly affecting village water supplies. The first of these was a project funded by UNICEF which acted as a demonstration to villagers in the highlands. Following the initial project construction, the staff have remained to build the water supplies arising from the interest generated by the demonstrations. A large portion of the money spent on the self-generated projects was raised by the people requesting the supply. It was hoped the interest in construction would remain with the people when maintenance was required. It is too soon to tell whether this aim has been achieved.

There is a proposal before the planning office now for an Asian Development Bank assisted programme for village water supply construction in six provinces. The effectiveness of the policies now being formulated will be assessed when applied to the six provinces first selected following which all provinces will be included in the programme.

Other National Agencies Involved in Water Supplies.

1. Appropriate Technology Development Institute. Located at the University of Technology in Lae, the institute was formed in 1978. Its purpose is to undertake research into techniques which can lead to the local manufacture of items better suited to Papua New Guinea market requirements. In the field of water supplies they are investigating the performance of a locally produced hydraulic ram as well as a new brand imported hand pump from Bangladesh for use on shallow wells.

   They have been co-workers with the Local Government Technical Service in developing a technique for making ferrocement water storage tanks and are currently undertaking an investigation into a suitable material for ground level water catchment at the request of one of the provincial governments.

2. Local Government Technical Service.

   This group of roughly 100 artisans is a section of the Department of Works and Supply and specializes in the technical requirements of small rural projects mainly roads, bridges and water supplies. In the group are half a dozen engineers and architects who undertake design and supervise construction where required. In addition they run a school for the teaching of elementary skills of civil engineering to people who will be employed by the local government councils. One of the courses is for people who will construct and maintain village water supplies and consists mainly of basic plumbing skills. Part of the course is devoted to pointing out the need for improved water supplies so that the graduates can act as educators and assist in overcoming the reluctance of village leaders to attach a high priority to rural hygiene through increased water useage. The school has 2 instructors and averages 15 students including one or two each year from the Health Department, usually Health Inspectors whose duties include water supply construction. Emphasis is on practical work and a graduating class will have built actual supplies needed by the community within travelling distance of the school. Projects include spring improvements, small dams, polythene and PVC pipe joining, taps and standpipes, shallow wells and handpumps, galvanized iron and ferrocement tank construction, roof, gutter and downpipe plumbing, hydraulic ram installation, galvanized pipe threading and being familiar with terms used in pipe fittings and connections.

3. Bilateral agencies such as NZ Aid, International Human Assistance Programme and service clubs provide direct financial assistance to water supplies according to criteria laid down by the PNG Government. Large schemes may only be funded if the project is already approved in the national budget. Financial assistance outside the budget is only allowed for project less than K2,000.

MAJOR PROBLEM AREAS

The major obstacle facing Papua New Guinea on water supplies is a social, not technical one. Villagers are not particularly concerned about the need to have an improved supply of drinking water. For most of the year, all but a few parts of the country have a supply of water sufficient for traditional purposes. Without a greater public awareness of the need for increased quantities of potable waters, efforts by the Health Department and national planners to force the pace of construction will meet resistence by the users. There is ample evidence that existing supplies are not being maintained and the neglect is wasting up to 50% of the funds spent on construction in any given year. Irrespective of what percentage is considered "acceptable" waste, a more effective health education programme is a pre-requisite to any stepped up construction activity. All too often the village identifies the constructing authority as the agent for operation and maintenance, despite efforts to convey that it is the user who has the responsibility. As long as the water supply is seen to be superfluous to the real needs of the community the situation will not alter.

Aside from the long term goal of increased awareness through education certain factors can improve the situation.

The identification of a community leader or person sufficiently concerned to act as a focus for community action is one. Getting the support of a service group such as a women's organization, a youth group or church association can provide an effective substitute for general community concern. Identifying local leadership is thus a useful activity in a water supply programme for PNG.

TECHNOLOGY CHOICE FOR RURAL WATER SUPPLY

by Dr B B Sundaresan, R Paramasivam and V A Mhaisalkar, National Environmental Engineering Research Institute.

Introduction

With the launching of the International Water Supply and Sanitation Decade (1981-1990) programme, rural water supply in developing countries is receiving systematic attention from governments and international, bilateral and non-government organisations. Preparatory work has started in member countries to assess the magnitude of the problem, likely investments needed, material and manpower resources required and to formulate action plans to achieve the set target. For 100 per cent coverage (allowing for population growth) 1.8 billion people in developing countries will need to be reached with clean water during the decade[(1)]. According to a World Bank estimate, the total cost of clean water and sanitation for all by 1990 would be in excess of US$600 billion. The Bank has also estimated that by using cheaper and more appropriate technologies in both urban and rural areas, the cost could probably be halved to US$300 billion or less[(2)]. It is, therefore, imperative that the planning strategy, the methods of field delivery and technology to be adopted have to be imaginative, innovative and appropriate. This paper outlines some of the technological considerations for rural water supply and presents a few examples relevant to the socio-economic environment of developing countries.

Technology considerations

The major thrust during the decade programme will be directed towards the underserved and under privileged rural masses of the Third World. They present complex situations and peculiar problems. They are in small clusters, sparsely populated and often widely separated with poor communication facilities. They are socially poorly organised, have different socio-cultural backgrounds and are dependent mainly on agriculture. The literacy level is low, skilled people, materials of construction, chemicals and electricity are scarce or not available. The technology package, therefore, should be simple, efficient, cost effective and economic. Science is universal, but technology has to be local. There is often a tendency to oversimplify rural water supply systems as 'scaled down' versions of urban systems requiring less engineering skill and ingenuity, but the exact opposite may be the case.

Integrated approach

It has been increasingly recognised that the problem of rural water supply is closely linked to that of environmental sanitation and that if any project is to be successful, the approach should be an integrated and multi-disciplinary one. Not only must appropriate technologies be applied but they must also be linked to other sectors of rural development including education of villagers on the importance of proper use of water supply and sanitation facilities, however, simple they may be. Community involvement and participation is another vital aspect which decides the success or failure of a water supply project or for that matter any rural development programme. Increasing involvement of the community in not just the construction and maintenance of the system, but all stages of planning and implementation should be ensured to achieve the real benefit of investment in improved water supply.

Levels of Service

(i) Accessibility: The choice of technology is governed among other things by the intended levels of service - accessibility, per-capital supply and water quality standards. The accessibility of safe water supply in relation to the households where it is to be used, is one of the crucial factors in enhancing its health and socio-economic value. Ideally, a piped water supply with one or several taps in each household is the obvious solution. But this is the most expensive. The simplest of the installations, a sanitary dug well or a bore-well fitted with a hand pump located not only from the point of view of accessibility but also according to the hydrogeological conditions will be the least expensive.

In an intermediate stage, a simple piped water supply system with distribution through public stand posts can provide water in acceptable quantities at distances that are tolerable from a carrying point of view. One point source (hand pump or PSP) for every 200-250 population and PSPs with 2 taps located at a distance of 100-200 meters are generally found to provide a satisfactory level of service.

(ii) Per-capita supply: The per-capita supply varies greatly according to the population served, the technology used for producing water, the mode of distribution and the availability of water at the source. A minimum of 40 litres per capita per day when supplied through point sources and 70 litres when piped is generally considered satisfactory[3].

(iii) Water quality standards: The standards of physical, chemical and bacteriological quality of drinking water should primarily aim at safeguarding public health and set as high as practical. The quality standards must be based on a realistic appraisal of local conditions and the possibilities of producing safe water, given the technology available. They can not be rigid but should be flexible and capable of being updated in tune with advances in knowledge about the occurrence, distribution and health significance of substances in water.

Source Selection

By a judicious choice of the source of water supply, the need for treatment and the consequent recurring cost could be minimised if not altogether eliminated. The source selection must be preceded by a detailed sanitary survey and when selected should be protected from possible contamination. For purposes of evaluating raw water quality with respect to its treatment, the following criteria may be considered:

(i) Water requiring no treatment - this group is generally limited to underground waters not subject to any possibility of contamination and satisfying in all respects the requirements of drinking water quality.

(ii) Water requiring simple chlorination or its equivalent - this group includes both underground and surface waters subject to minimal pollution (total coliform not more than 50 per 100 ml in any month) and meeting the physico-chemical quality requirements.

(iii) Waters requiring complete treatment (coagulation, filtration) including continuous post-chlorination - this group includes all waters containing organic and inorganic contaminants (turbidity, colour, bacterial pollution etc.)

(iv) Waters requiring special treatment e g iron and fluoride bearing waters, brackish waters etc.

The order of priority for selection of source would be as under:

(i) Water requiring no treatment to meet the quality requirements and which can be delivered by gravity, e g springs and protected drainage areas.

(ii) No treatment but requires pumping, e g well waters.

(iii) Requires simple treatment such as storage, chlorination, slow sand filtration or a combibation of these and could be supplied by gravity.

(iv) Simple treatment as in (iii) but requires pumping before delivery.

Rain Water Collection or Harvesting

In arid and semi-arid regions and in tropical islands where sources of surface water and ground water of satisfactory quality are unavailable or costly to develop, rain water continues to be the only source of domestic water supply. Rain water harvesting requires adequate provision for the interception, collection and storage of water. Either roofs or specially prepared ground surfaces can function as catchment areas. When stored for long periods, suitable measures to preserve the quality have to be adopted. In Central Mali, Botswana, Senegal and Sudan simple and ingenious methods to collect and store rain water are reported to have been developed[4]. In Gibralter and Jamaica, rain water harvesting is one of the very few options open for public water supply. Consumption from the limited public supply is reduced by numerous privately owned systems which collect rain water from individual house roofs[5].

Spring Water

In mountainous and hilly areas, spring water, when properly protected by suitable measures can provide a perennial source of supply without any treatment. Before development of a spring, a thorough sanitary survey should be carried out to obtain information on the origin of ground water, the nature of the water-bearing strata, the quality and yield of spring water during various seasons, the topography and vegetation of the surrounding area and the presence of possible sources of contamination. More detailed description of the methods of tapping spring water is presented elsewhere[6].

Infiltration Galleries

An infiltration gallery is a simple means of obtaining naturally filtered water from sub-surface. Essentially, it is a porous barrel laid within the sandybed, either axially or across a river course. A collecting well at the shore-end of the gallery serves as the sump from where the filtered supply is pumped to serve the consumers. The normal cross-section of a gallery comprises of a loosely jointed or a perforated pipe enveloped by filter media of graded sizes making up a total depth of 2-3 m (Fig 1). Such a system extensively practised in southern part of India for several decades eliminates the need for extensive treatment units such as settling tanks, filters etc, which are beyond the capacity of many rural and semi-urban communities. For small supplies, an infiltration well constructed right on a river bank can provide a simple source of filtered water.

Water Conveyance

Bamboo pipes which have been traditionally used in hill villages in Taiwan, Indonesia and the Philippines to transport water under gravity can provide a simple, low cost alternative to metal or plastic pipes. Recently 24 Indonesian villages on the slopes of Merapi Valcano, Java have laid a 90 km network of bamboo pipelines to supply water to 60000 people. Water supply projects using bamboo pipes are currently in progress in three Tanzanian villages. Buried and treated with preservatives, some bamboo pipes in Taiwan have been supplying safe water for more than 15 years[5].

Water Treatment

The treatment technology for rural drinking water will be primarily governed by two important considerations, the (raw) water quality and the size of the community to be served.

Ground Water

Ground water tapped by any one of the conventional methods such as driven wells, and drilled wells is usually free from turbidity and colour, bacteriologically safe and hence good enough to drink without any treatment. However, experience has shown that open shellow dung wells in rural areas are prone to faecal contamination. Proper disinfection of water from these wells with simple methods should be ensured to protect public health.

(i) Pot Chlorination: An earthen pot of 7 to 10 litres capacity with 6-8 mm diameter holes at the bottom is half filled with pebbles and pea-gravel of 20-40 mm size. Bleaching powder and sand (in a 1 to 2 mixture) is placed on the top of the pea-gravel and the pot is further filled with pebbles upto the neck. The pot is then lowered into the well with its mouth upon (Fig 2). A pot containing about 1.5 kg of bleaching powder should provide for about a week adequate chlorination of a well from which water is drawn at a rate of 1000-2000 litres per day. For small household wells, a unit consisting of two cylindrical pots (Fig 3), one inside the other has been found to work well (6). Other devices for well disinfection include drip feed chlorinators and constant head solution feed dosers.

When water from a well is pumped to an elevated service reservoir for supply by gravity, bleaching powder solution may be dosed by an arrangement as shown in Fig 4. Alternatively a differential pressure bleaching powder solution doser (Fig 5) can be used. The pressure difference created by insertion of an orifice or venturi in the delivery main is used to inject controlled quantities of solution into the water to be disinfected.

(ii) Iron removal: Ground waters often contain significant amounts of iron which is objectionable from both aesthetic and economic considerations. The iron can be oxidised in simple aeration units and removed in a sand filter with or without prior settling. A household iron removal unit which can be used in conjunction with a hand (force) pump is shown in Fig 6.

(iii) Defluoridation : There are several instances in India and parts of Africa where ground water is readily available for community water supplies but poses problems due to the presence of excessive fluorides. The Nalgonda technique developed by NEERI is a simple method for removal of fluorides. Depending upon the fluoride content and alkalinity of water, required quantities of bleaching powder and alum are added and the contents are thoroughly stirred for 10 minutes and allowed to settle for 1-2 hours. The supernatant, which is free from excess fluorides is fit for drinking. The method is amenable for application to individual as well as community water supplies.

Surface Water

Waters drawn from surface sources such as ponds and lakes, canals and rivers are usually polluted and hence should be treated for domestic supply. The type and degree of treatment would depend upon the raw water quality, its seasonal variations, the size of community to be served and other local conditions.

(i) Slow Sand Filtration: Is an excellent and most practical method of water treatment for rural and semi-urban water supplies. Slow sand filters (Figure 7) are simple to construct, operate and maintain, produce a high quality filtered water require no chemicals and are cost effective. When long periods of high turbidity are anticipated, simple pre-treatment such as storage, river-bed filtration or horizontal flow roughing filtration can sufficiently reduce the turbidity for treatment by slow sand filters. They require a relatively larger area than conventional treatment systems, but this is not a constraint in rural areas of developing countries.

(ii) Package Treatment Plants: Can play an important role in providing safe water to small communities and urban-fringe areas not served with piped water supply. They are usually pre-fabricated and pre-assembled and therefore have the advantages of standardisation and centralised supervision in their manufacture. Packaged plants provide for various unit processes and operations in a compact system. By virtue of their constructional and operational features, they require chemicals and skilled operating staff which means they are best suited to richer communities and institutions. A variety of package plants are commercially available to suit specific requirements.

Solar Stills for Fresh Water

In tropical areas with abundant sunshine, solar energy can be effectively harnessed to produce fresh water from saline or brackish water in solar stills. The technique is simple in operation and has a low maintenance cost. However, they have a low output per unit area and require a higher initial investment. Their use is therefore limited to supplying drinking water to isolated communities, light houses, saltworks etc. Following extensive laboratory and pilot plant studies, the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar has installed solar stills at Navinar light house (near Jamnagar) to supply drinking water and several other units to produce distilled water. There are a few large installations of 'greenhouse' type in full scale operation to supply larger communities, notably in Greece, Spain and Algeria[4].

Household Treatment

Isolated dwellings and farm houses with no access to piped water supply have to resort to household purification methods. Some of these, which can also be used as emergency measures when a regular supply is disrupted, are briefly mentioned below:

a) Domestic Sand Filter: The unit which is essentially a mini-slow sand filter (Fig 8) consists of a drum 40 cm dia and 100 cm deep made of G I, ferrocement or any other local material. It is filled with 5 cm layers each of 3.0-6.0 mm gravel and 0.7-1.4 mm coarse sand topped with 40 cm of fine sand of 0.2-0.3 mm size. Water to be filtered is allowed to flow into the unit through a strainer-*cum-distributor* placed at the top. It filters slowly through the sand layer and is collected in a storage vessel. The unit can give about 100 litres of clean water per day which can satisfy the drinking and cooking needs for a family of 6-8 persons.

(b) Candle Filters: Ceramic candle filters of the 'Berkefeld' type can provide a convenient means of household water treatment. The filter unit is made up of two containers with the filter candles attached to the upper container and covered with a removable lid (Fig 9). Water to be purified is poured into the top container, trickles through the candle(s) and is stored for use in the lower compartment. Only clean water should be used with ceramic filters as turbid water will clog the candles quickly. The candles need periodic cleaning/replacement depending upon their useful life. Manufactured indigenously by a number of Indian firms such filters are available in the market under different trade names.

(c) Chlorine Tablets & Ampoules: Chlorine containing compounds made from bleaching powder in tablet form and ampoules of chlorine solution are readily available in many countries. In India, based on the know-how developed by NEERI, a number of firms are manufacturing these. They are quite good for disinfecting small quantities of water but are costly. After adding the chemical in the prescribed quantity, the water is stirred and allowed to stand for 30 minutes before consumption. If the water is turbid, it may be necessary to increase the dose of the chemical.

Water Distribution

Water supply through individual house connections with one or more taps located at convenient points within the house and in adequate quantity and pressure will be the most ideal method of water distribution. It is also the most expensive system. Where people can afford such a system, it can produce social, economic and health benefits. It can also yield a revenue to the water agency to partly or wholly offset the operation and maintenance cost of the system. On the other hand, such a system is beyond the economic means of most of the communities in developing countries. Wastewater and sullage resulting from such a water supply, if not properly drained away, will create not only unsightly conditions, but also pose health hazards. For instance, the population at risk to filariasis in India has been steadily increasing with increase in water supply coverage. Stand-posts, for example, are subject to vandalism and negligence in use which can lead to wastage. They limit the use of water thereby reducing personal and domestic hygiene standards. In addition, it is often difficult to collect revenues from users of standposts. Inspite of their many short-comings, public stand posts should be preferred as the intermediate choice if water has to be distributed to a large number of people at a minimum cost and in a short span of time. The delivery system could be upgraded in stages as the community's economic status improves.

Conclusion

Summing up,the paper is an attempt to focus some of the important considerations in the choice of technology for rural water supply in the context of the decade goal to provide water for all by the year 1990. A few examples of water supply technology appropriate to the socio-economic environment of rural communities in developing countries have been reviewed. The importance of an integrated approach to water supply and sanitation, community participation and education has been indicated.

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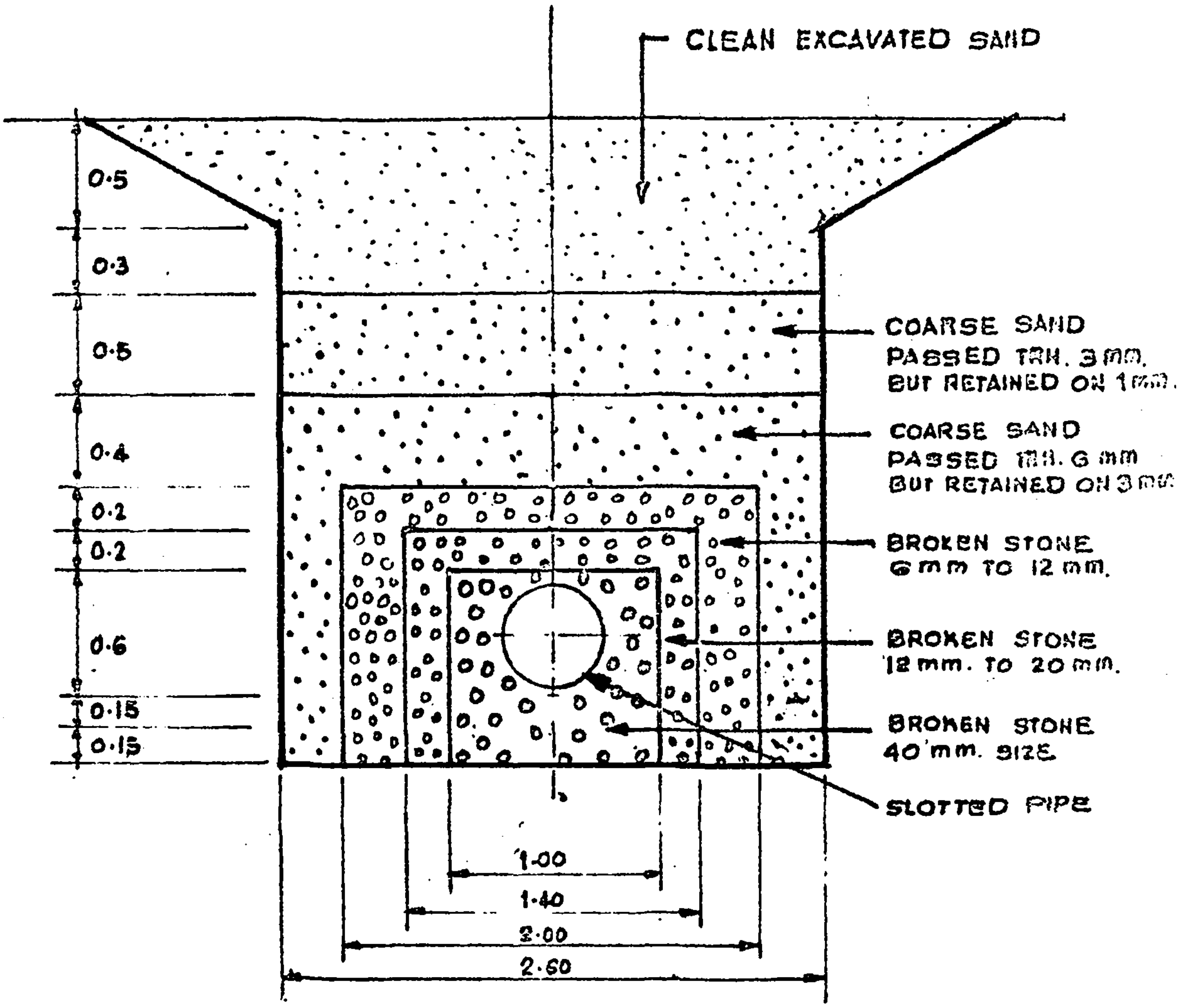


dimension in Meters

SECTION OF GALLERY

FIG 1

FIG. 2

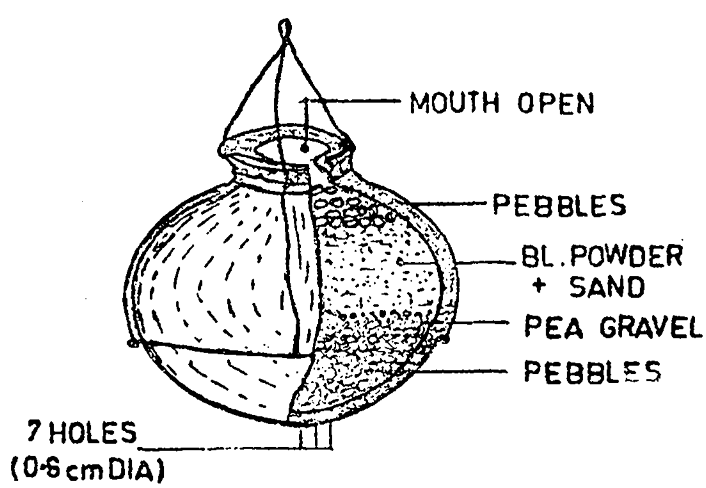


FIG. 3

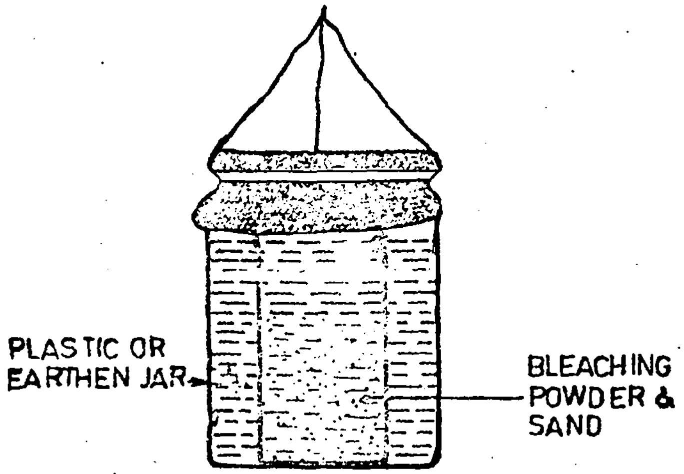
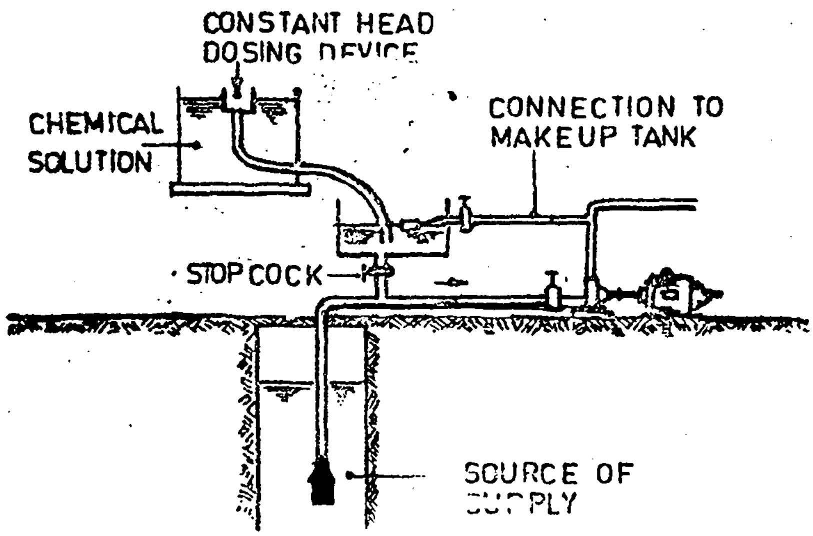


FIG. 4



SIMPLE CHLORINATION SYSTEMS

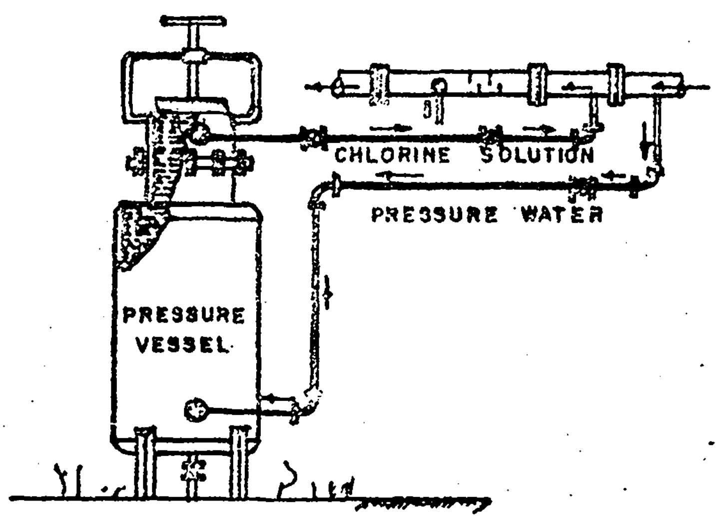


FIG.5 : DIFFERENTIAL PRESSURE B. P SOLUTION DOSER

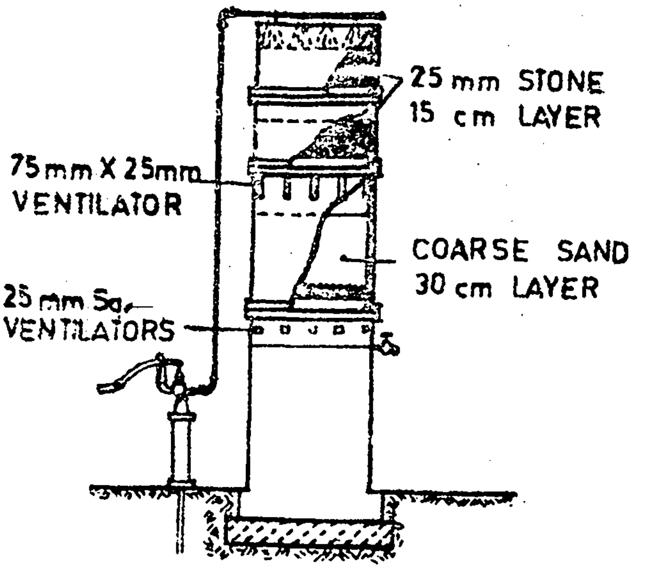


FIG. 6 SIMPLE IRON REMOVAL UNIT

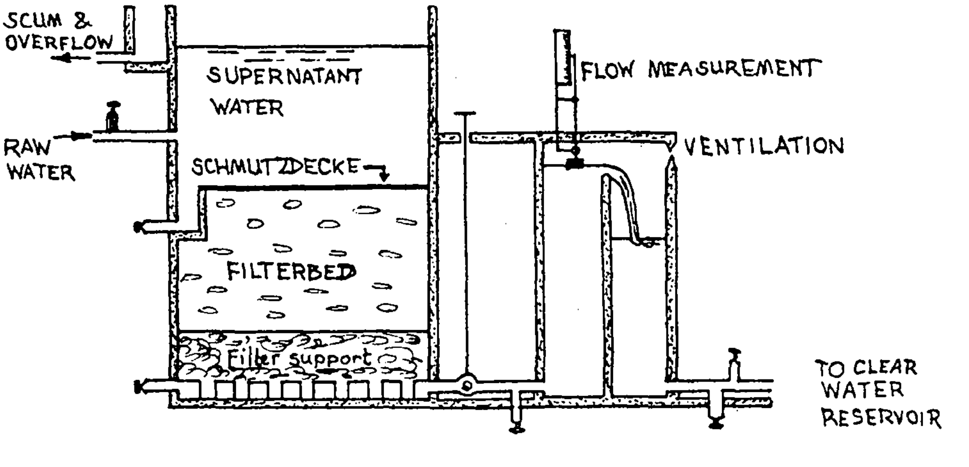
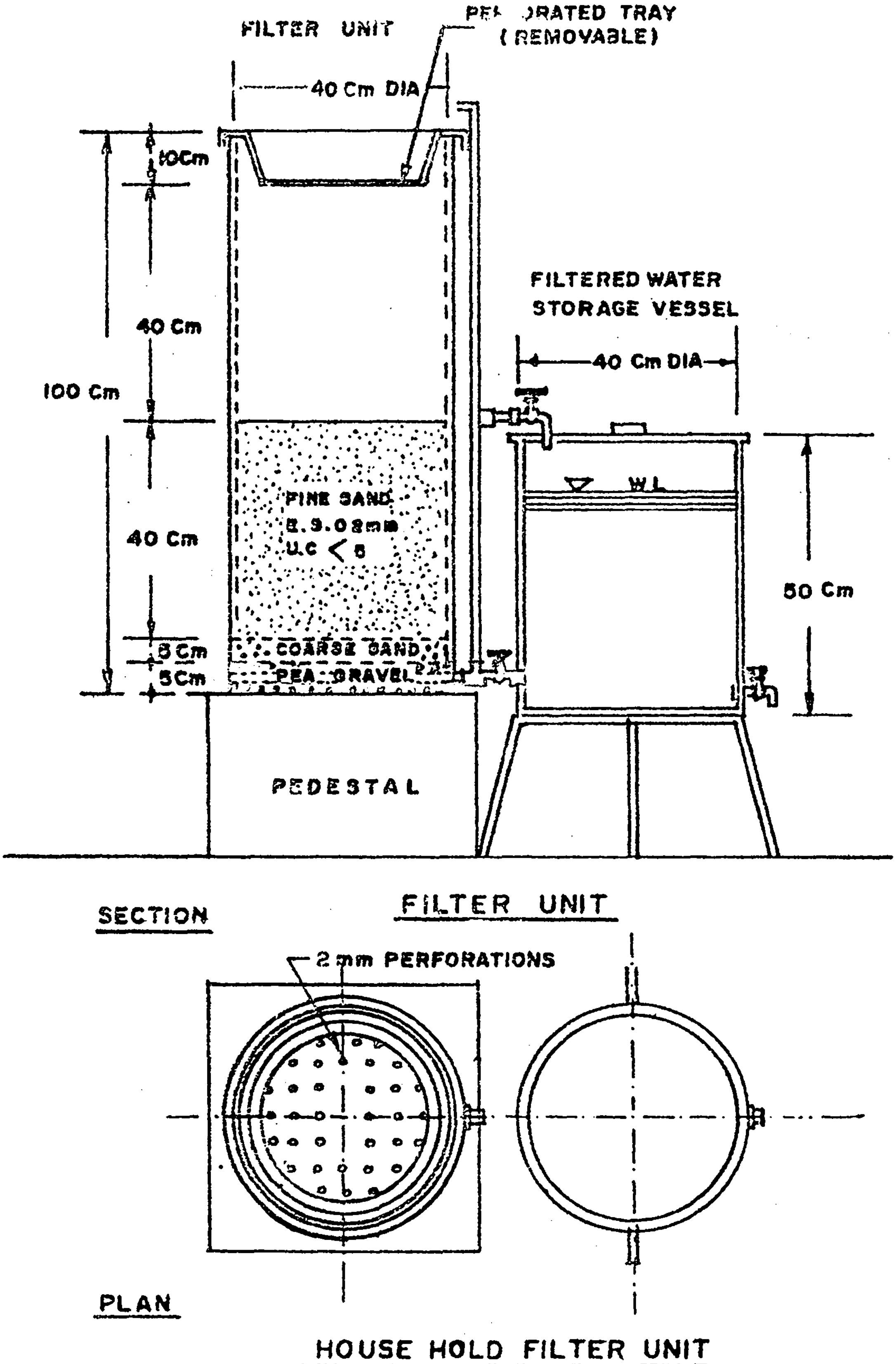


FIGURE 7: BASIC ELEMENTS OF A SLOW SAND FILTER



HOUSE HOLD FILTER UNIT

FIG. 8

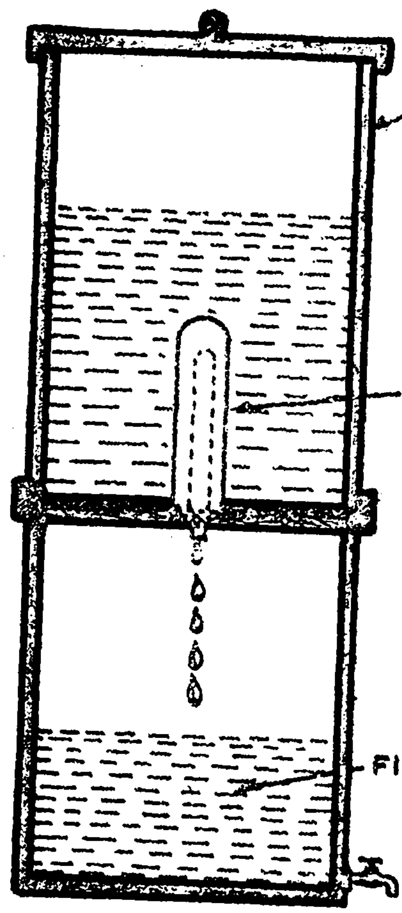


Fig. 9 CANDLE - FILTER

RURAL WATER SUPPLY SYSTEMS IN TAMIL NADU - PLANNING AND IMPLEMENTATION

by R Krishnaswamy, Chief Engineer (G & C), Tamil Nadu Water Supply & Drainage Board.

Introduction

The objective of the Rural Water Supply Programme is to make safe, potable and perennial water available in close proximity to the rural population. It implies among other things, that the system should be operated with a technology able to withstand rural conditions, capable of being restored in minimum time and at lowest cost in case of any breakdown and requiring the minimum maintenance by levels of technical personnel normally available in these areas. The national policy states that the government should strive to promote the welfare of the people independent of location, status, customs, habits etc. Thus the priority for water supply systems for rural areas lies on par with urban areas. In India, where about 80 per cent of the population live in rural areas and the country's overall economy is agriculturally oriented the physical, social and economic development of this sector requires no further emphasis. If the targets of International Drinking Water Supply and Sanitation Decade are to be reached, the investment on rural water supply on global basis should be raised to 3.9 times the current level. This document expresses the various stages of development in planning and implementation of rural water supply systems in Tamil Nadu.

Geographical Background

Tamil Nadu State lies between latitude 8°5' and 13°35' North and between longitude 76°15' and 80°20' East. The state extends to 130069 sq km with a long coastal line of about 1000 km. The climate is tropical with certain areas under temperate conditions for part of the year. The temperature varies from 18°C to 43°C averaging 30°C in the plains. The average precipitation is 945.7 mm and varies from 500 to 1750 mm. There is a narrow stretch of high mountains along the western edge of the state and this forms the important water shed Most of the rivers flow from West to East. About 73.4 per cent of the area is archean (hard rock), and the balance is sedimentary.

There are 5 major river systems and over 95 per cent of surface water utilisation is for irrigation through riparian rights. As regards ground water potential, it is estimated that about 18,000 M m^3 of recharge is available and that it is under various stages of exploitation. About 13,000 M m^3 is being extracted at present and the balance could be harnessed in specific areas. In absence of legislation to control extraction of ground water, the water table in many areas of the State is progressively going down. This hydrological imbalance forces unnecessary annual expenditure by way of deepening the wells and wastage of energy by way of extra lift of water.

In this State over two-thirds of urban water supply and invariably all the rural water supplies are from ground water.

Demographic Background

As per census figures the population of Tamil Nadu has grown as follows :

Year		Population in million
1941	...	26.27
1951	...	30.12
1961	...	33.69
1971	...	41.20
1981	...	48.30

The population growth has put a heavy load on developmental activities including provision of drinking water supply. The rural population as per the 1981 census is 28.80 million. This population is spread over 378 panchayat unions. From a study made during the middle of last decade, the rural areas have been identified into 47,075 habitations, the details of which will be dealt with later.

Rural Water Supply Background

Till late 1970, provision of drinking water supply in rural areas was not adequate and budget provision in this sector was far below the demand. A total sum of Rs.201.24 million has been spent in this sector from 1895-1971. There was no comprehensive programme till about 1971, resulting in stagnation in the provision of rural water supply to villages. A modest start was made from the end of 1971-72 based on the then available statistics. Subsequently in 1973-74 a study was made on the status of drinking water supply in rural areas based on the additional statistics from various organisations and the villages were classified under three heads :

- scarcity villages
- endemic villages
- inadequate villages

Scarcity village refers to one without any potable water source within 1.6 km, where the water table is more than 15 m below ground level or where there is inadequate water supply to weaker sections; endemic village-refers to one which need either the protection of the existing source or treatment of water available in the source, (cholera endemic, guinea worm infested etc, or due to non-potability); and inadequate village refers to one which does not have adequate or sufficient water supply or supply is not perennial.

A programme was evolved and water supply to endemic and scarcity villages was provided from 1974 to 1976. Due to drought conditions, additional schemes were also taken up during 1976-77 to provide water supply to villages affected by drought. However, a large number of representations from the public came during the progress of the above works. Subsequently a review of the earlier classifications indicated the following:

- the unit namely village was not clearly defined
- the data was not collected on a scientific pattern but based on views of individual revenue officers
- the data were collected in some places where the officers did not have adequate knowledge of that area, nor did they check the water sources scientifically
- the statistics were inaccurate due to several reasons such as misclassification, non-reporting etc.

Hence, to eliminate the above short comings, a re-survey was taken up in 1976. This time the term 'habitation' as a unit was introduced and defined as a 'cluster of houses with a minimum population of 100 and more than 250 metres away from a neighbouring habitation'. A good source has been defined as a 'publically owned, protected, perennial source of potable water'. The data were then collected by over 5000 gram-sevaks (village level workers) and were checked by various other officers. The results of the above re-survey brought out the following six categories of habitation:

Classification	Definition	No of habitations
Type 1	Habitations with no source within 1 km distance from the habitation	3,567
Type 2	Habitations where the source yield only non-potable water for a distance upto 1 km	2,051
		5,610
Type 3	Habitations where water is potable and perennial but the source is either privately owned or unprotected	4,955
Type 5	Habitations where there is no good source within the habitations but an alternative good source is available within 1 km	1,107
Type 6	Habitations where there is good source available	28,908
	Total:	47,075

Planning of Rural Water Supply Systems

Although the priority was defined as above, in the first instance habitations coming under types 1 and 2 were taken up in 1977-78 under the minimum needs programme in the State Government sector and under the accelerated rural programme under the Central Government Sector. The water supply systems in rural areas are installed conforming to the following norms:

NORMS FOR RURAL WATER SUPPLY PROGRAMME

Population Group (ultimate stage)	Source	Service Reservoir	Distribution mains
1. 0-300	a. One deep borewell with hand pump if the source is inside the habitation (or)	-	-
	b. One deep borewell with power pump if the source is outside the habitations	10,000 litres with staging height of 6 m	500 m length
2. 301-750	One deep borewell with power pump irrespective of whether the source is inside or outside the habitation	15,000 litres with staging height of 6 m	1000 m length
3. 751-1500	-do-	30,000 litres with a staging height of 6 m	1500 m length
4. 1501-3000	-do-	60,000 litres with staging height of 7.5 m	2000 m length
5. Above 3000	-do-	100,000 litres with a staging height of 7.5 m	2500 m length

NOTE :
1. Ultimate population : 130 per cent of present population
2. Per-capita supply : 40 litres/day
3. Public fountains : One public fountain for every 150-present population

The total cost of covering all the habitations is about Rs. 4,200 million.

By 1980, the work on providing water supply to habitations 1 and 2 was nearing completion. At this stage the Government of Tamil Nadu revised the priority of providing water supply. Integrated development of a region was taken up and water supply was clubbed with other needs of the rural areas such as roads, schools etc, the region prioritised and habitations coming under types 1 to 5 were taken up in the region. This facilitated development of the entire region in all aspects. Incidentally this provided facilities for planning and implementing comprehensive water supply schemes in most of the regions. The above programme was taken up in 3 phases comprising:

I Phase	...	69 Panchayat Unions
II Phase	...	150 Panchayat Unions
III Phase	...	159 Panchayat Unions

The above three phases have been taken up from the years 1980-81, 1981-82 and 1982-83 onwards respectively. Under this programme, all the habitations upto category V will be completed by 1985. Provision of water supply to habitations under type 6 where the water supply is inadequate will be taken up during the period 1985-1990. Thus it is planned to complete the rural water supply systems in accordance with the International Water Supply and Sanitation Decade Plan of 1981-1990.

Implementation

Implementation of rural water supply poses a lot of problems in locating the source and mode of construction. However, the problem of locating the source is being tackled by trained geologists using geophysical equipments and by other methods. The TWAD Board have acquired 69 drilling rigs to implement the programme. RCC service reservoirs are constructed for maintenance-free service. Wherever required, alternative materials like PVC, HDPE, AC are used for pipe lines. A central purchase and stores organisations has been developed to plan and procure materials for the schemes. Research and development activities have also been oriented in providing necessary plant in rural areas for removal of iron in water. A method for lifting water using Gobar Gas has also been taken up on trial basis and is currently under evaluation.

The works so far completed are furnished below:

Financial year	Habitations benefitted Type 1 and 2	Type 3 to 5	Expenditure incurred (Rs. in millions)
1977-78	1,140	-	71.5
1978-79	1,404	-	86.03
1979-80	843	-	102.23
1980-81	1,196	1,104	180.70
1981-82	606	3,052	300.00

The remaining works are programmed to be completed as contemplated earlier. In this connection, it is to be pointed out that the initial finance for rural water supply systems are met from State and Central Funds. The Government have arrived at a norm of slashing percentage from 60 to 5 to be contributed by the Panchayat Unions depending on their financial conditions towards cost of providing these rural water supply schemes. But no panchayat has come forward to share the cost of the system.

Community Participation

Community participation, a tool for planning and management, may be distilled into the following four criteria :

a. involvement in planning programmes

b. involvement in implementing programmes

c. sharing benefits of programmes

d. involvement in evaluation of programmes.

Taking into account the educational and socio-economic aspects of the community, it is possible to involve the community in sharing the benefits of the programmes. The rural mass in Tamil Nadu is fully prepared to share the benefits of the programme and that is a very important element in planning and implementation.

Operation and Maintenance

At present about 27,000 hand pumps and 11,900 power pumps are under operation in Tamil Nadu. A three-tier system was developed in Tamil Nadu, which was also extended to other parts of this country. Under this system, the hand pumps are maintained by personnel such as pump caretakers at habitation level, a fitter at Union level and a mobile team at Division level. The village caretakers are trained to carry out minor repairs and for day to day maintenance works. A fitter is located at union level and is meant for limited repairs beyond the capacity of the caretaker. A mobile team is located in division level (one or more in a District) for major repairs on pumps.

With power pump schemes, a mobile team with all facilities is provided for repairs of a block of 500 power pumps and an electrician for a block of 100 pumps. Operation of the pumps is carried out by local bodies.

As mentioned earlier the real benefit of providing a social welfare programme such as rural water supply depends largely on the ability of a system to be put back into use in the shortest possible time, preferably at village level itself with the men, materials and methods available locally. In this regard, the present India Mark II pump was considered better to other types of hand pumps based on the periodicity of major repairs, longivity etc. However, the above pump requires a mobile team whenever the pump has to be taken out for repairs. UNDP in collaboration with World Bank has programmed to take up field testing and development of a rural water supply hand pump with a view to improve upon the performance and reduce the cost of maintenance. The TWAD Board is in a position to participate in the UNDP World Bank project as the monitoring - maintenance organisation of the State has been well established and is also active.

PACKAGE TREATMENT PLANTS-AN EFFECTIVE TOOL FOR RURAL WATER SUPPLY

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Introduction

The water supply systems in rural areas depend mostly on ground waters and occasionally impounded tank/lake waters. Though the quality of such waters, especially the ground waters are considered superior to other waters such as river water with respect to turbidity and bacterial quality,ground water can be worse in certain respects due to the presence of chemical constituents such as iron and fluoride.

Water Quality

Ground water, which is the major potential source of rural water supply systems in the country, is contaminated either with iron or fluoride. Figure 1 shows the states and zones where the iron bearing ground exist in India. It shows that the iron bearing waters are found in pockets, in the Southern, Central, Eastern and North Eastern parts of India.

A survey(1) conducted on the quality of ground waters in and around Madras City, indicate a varied concentration of turbidity, *iron etc in ground water* (Table I).

Figure 1 - States Showing Pockets of Iron Bearing Water in India

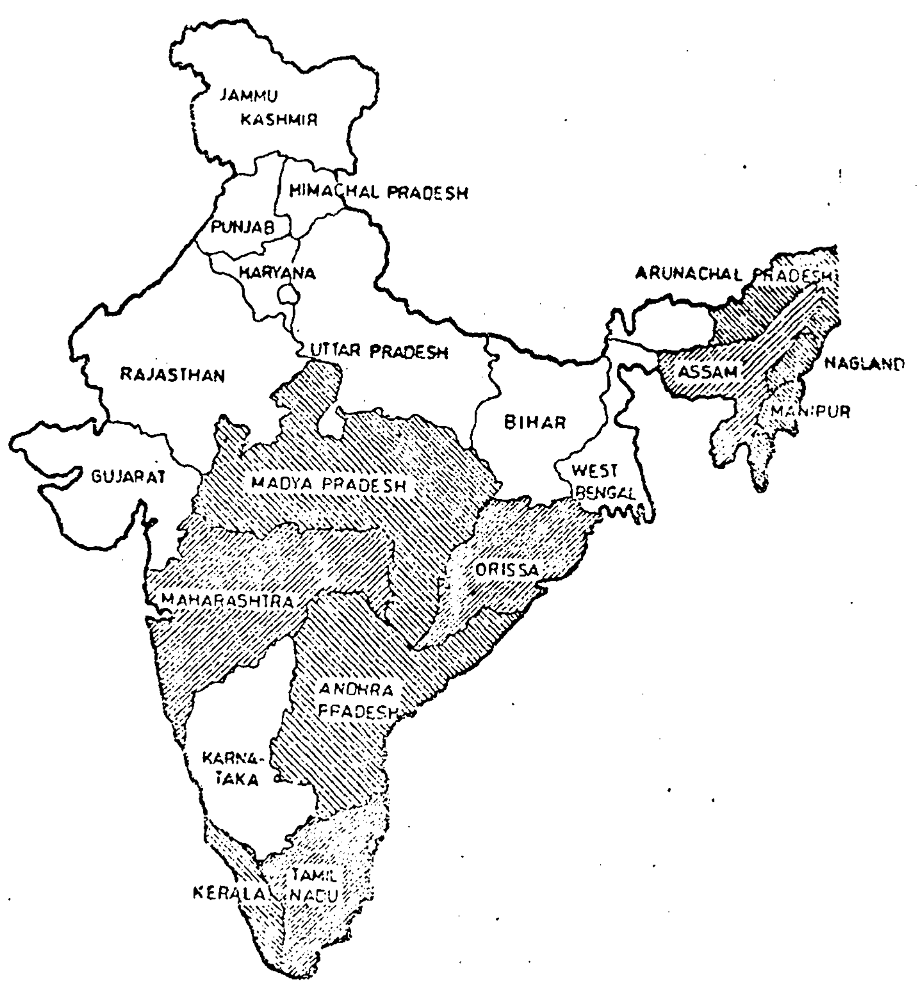


Table I: Characteristics Of Groundwater In And Around Madras City

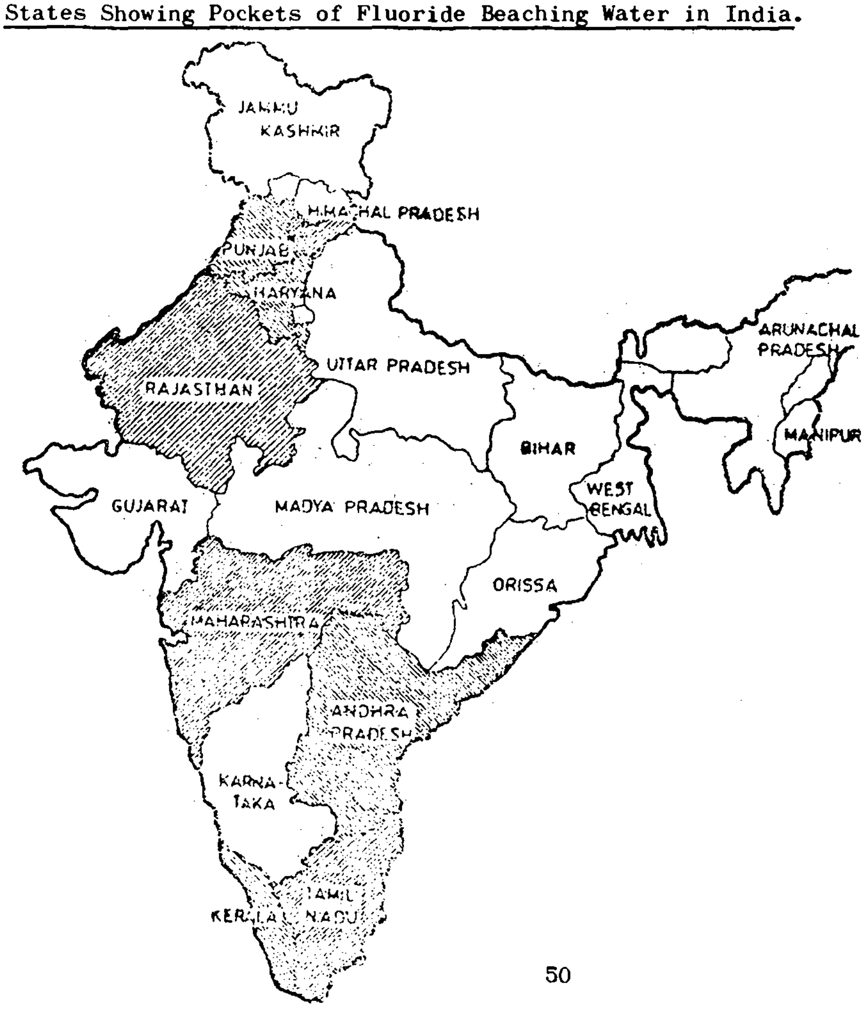
	Location	Source	Characteristics		
			pH	Turbidity (mg/l)SiO_2	Total iron (Fe)mg/l
1.	Saligram, Madras	Open well	6.4-7.2	165-370	6.4-9.4
2.	Bhana Veedu Thottam	Open well	6.4-6.7	8-14	0.5-1.8
3.	Sriharikota	Open well	6.7	70	3.5
		Bore well I	6.8	24	2.4
		Bore well II	6.2	47	3.3
		Bore well III	6.7	400*	2.6
		Bore well IV	6.4	900*	2.4
		Bore well V	6.7	1160*	3.2
4.	Avadi, Madras	Bore well	6.8-7.2	87-94	5.0-6.2

*New Wells

From Table I, it can be seen, that the turbidity and total iron content of open well waters vary from 8 to 370 mg/l and 0.5-9.4 mg/l respectively. In the case of bore well waters, (except the new ones) the turbidity and total iron content were in the range of 24-94 mg/l and 2.4-6.2 mg/l respectively.

Similarly, it is seen that the ground water of certain zones in 7 states, namely Kerala, Tamilnadu, Andhra Pradesh, Maharastra, Rajasthan, Haryana and Punjab are known to contain fluoride in varying degrees (Fig 2). The fluoride bearing ground waters is reported to contain fluorides ranging from 1.50 to 5.00 ppm[2]. It is also shown[3] that the impounded lake/tank waters contain turbidity in the order of 28-42 mg/l. Hence, the ground waters which are tapped for rural water supply systems through dug wells and bore wells, also require treatment for removal of iron or fluoride and improvement in turbidity and bacterial quality.

Figure 2 : States Showing Pockets of Fluoride Beaching Water in India.



Treatment Constraints

Provision for the treatment of rural water supply systems poses certain problems. They are as follows:

- small quantities of water requiring treatment for the thinly populated groups;
- difficulty for site execution adopting the usual course of tendering;
- supervision; and
- non-availability of skilled or semi-skilled plant operators in the rural areas.

Further, the main components of rural water supply systems such as pumps and treatment plants are required to operate intermittently for only a few hours in the morning and few hours in the evening. Another important factor in rural water supply, is the absence of appropriate, cheap, simple and effective treatment for contaminants such as iron and fluoride in the ground water.

Development - Iron Removal

In order to obviate the above shortcomings and thereby ensure safe potable water to the millions of rural masses, it is felt necessary to devise an appropriate treatment system of pre-fabricated type, which would be simple and easy to transport, install, operate and maintain by the local people.

As pointed out earlier, in order to provide an adequate treatment for the rural water supply system with ground and impounded lake/tank waters as main source of supply, the object is to improve the raw water with respect to turbidity and bacterial quality and to remove constituents such as iron and fluoride.

Process Selection

In a recent study it was shown(1) that the soluble iron in ground waters could be removed by aeration, sedimentation and filtration. The test results of the above study are summarised in Table II.

Table II : Iron Removal Studies

	Source	Raw Water		Aerated and Settled		Filtered	
		Soluble Fe(mg/l)	Total Fe(mg/l)	Soluble Fe(mg/l)	Total Fe(mg/l)	Soluble Fe(mg/l)	Total Fe(mg/l)
1.	Bore well	Nil	2.4	Nil	0.91	Nil	Nil
2.	Bore well	0.18	2.6	Nil	2.00	Nil	Nil
3.	Bore well	Nil	2.4	Nil	0.45	Nil	Nil
4.	Bore well	Nil	3.2	Nil	0.87	Nil	Nil
5.	Bore well	Nil	3.3	Nil	0.25	Nil	Nil
6.	Bore well	Nil	5.0	Nil	3.25	Nil	Nil
7.	Open well	Nil	7.2	Nil	3.63	Nil	Nil
8.	Open well	Nil	7.4	Nil	3.75	Nil	Nil
9.	Open well	Nil	3.5	Nil	-	Nil	Nil
	Average:	-	4.10	-	1.90	Nil	Nil

As seen in Table II, the process of simple aeration and sedimentation effected iron removal to an extent of 53 percent, leaving an average iron content of 1.90 mg/l from 4.10 mg/l. Further, the process of filtration accounted for complete removal of iron, producing totally iron-free water.

Formulation

Taking the above into consideration, it was attempted to formulate a simple iron removal unit comprising spray aeration, settling and filtration. Aeration, besides oxidising the soluble iron, removes the dissolved gases such as carbon dioxide, hydrogen sulphide, etc which could be present in ground waters. Settling is intended to remove the easily settleable oxidised iron and turbidity causing settleable particles. Filtration serves as the final polishing system and removes the non-settleable oxidised iron particles and other turbidity causing colloidal particles.

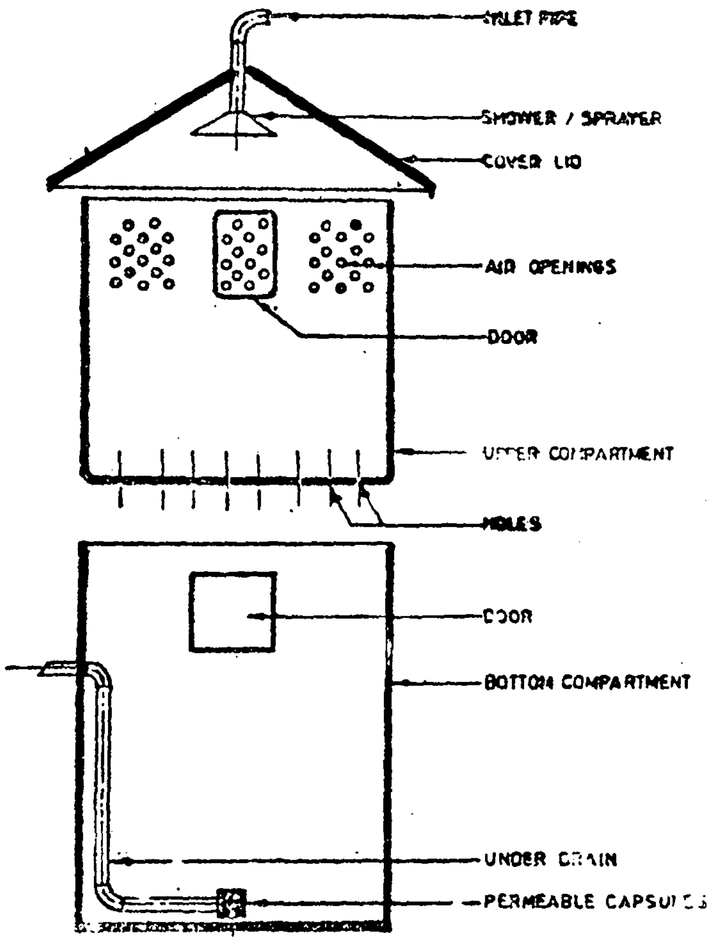
It is known that the removal of soluble iron could be accelerated by sorption due to ferric flocs deposited on a supporting medium, the affinity of sorption is higher for coal than for silica surface. Hence, it was desired to incorporate a coke tray beneath the aeration zone.

Capacity Range

It was intended to have the package plants developed in different ranges to suit the above situations. The package plants intended for hand pumps installations, have a treatment capacity of 450 lph. The units for power pump schemes were developed in two ranges - one, to serve a population of 500 persons and the other for 1500 persons. The package plants suitable for hand pumps and power pump schemes are denoted as Type I and II respectively.

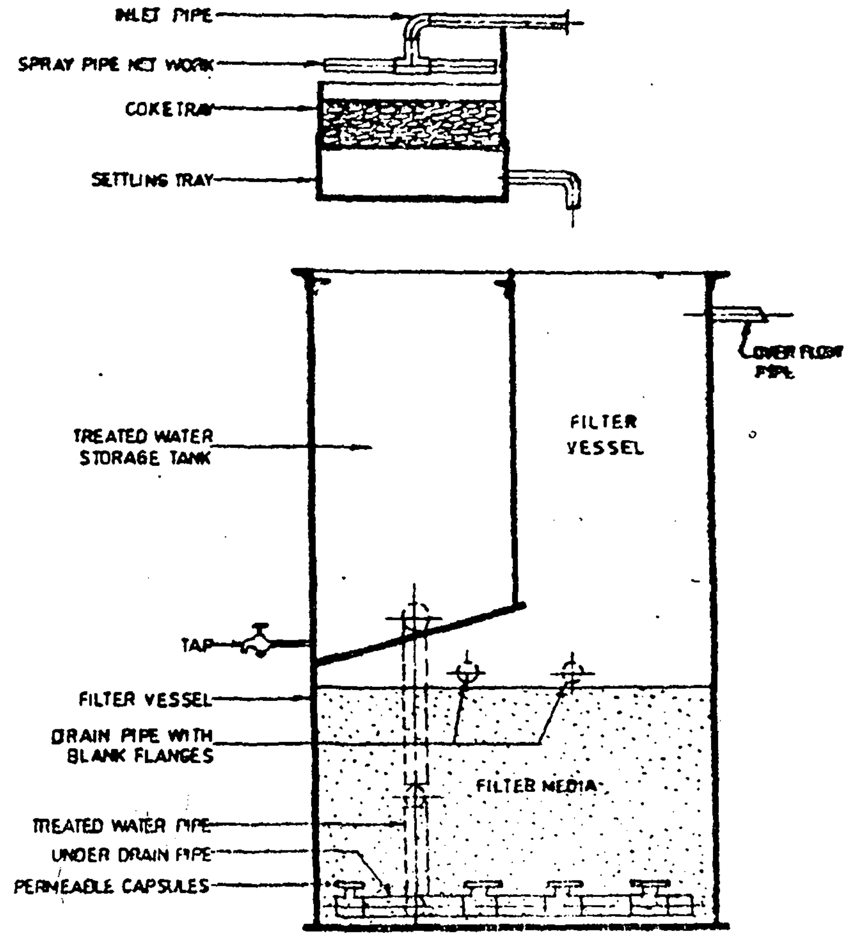
Plant Components

The Type I unit is made up of three parts (Fig 3), made up of the bottom compartment, the upper compartment and the lid. The bottom compartment is the filter vessel with same medium. The upper compartment is provided with a coke medium, to support the ferric flocs resulting from the oxidation of soluble iron by spray aeration, which is achieved by means of the shower fitted in the inlet feed pipe. The third part, is the cover lid to be placed over the upper compartment. The unit is provided with patented permeable capsule underdrain system.



TYPE-I PACKAGE WATER TREATMENT PLANT

FIG: 3



TYPE-II PACKAGE WATER TREATMENT PLANT

The Type II package treatment plants comprise the main filter vessel containing filter medium with PVC laterals and patented under drain permeable capsules (Fig 3). The plants are also provided with in-built treated water storage tanks. The accomplishment of iron removal components, consisting of a coke tray and a settling chamber, is placed over the treated water storage tank. The raw water is pumped and sprayed over the coke medium through a spray pipe network and thereafter allowed to settle in the lower compartment before filtration takes place in the main filter compartment. The treated water storage tank is provided with taps through which water is drawn into pots and vessels.

Plant Performance

The performance of package plants was observed on demonstration units located in and around Madras. The data collected over a period of five months are presented in Table III.

Table III: Performance of Package Plants At Bhanaveeduthottam

	pH		Turbidity (mg/l		Iron (Fe)mg/l	
	Raw	Treated	Raw	Treated	Raw	Treated
1.	6.4	7.2	13.0	1.2	1.2	0.1
2.	6.4	6.9	12.7	1.2	0.5	Nil
3.	6.7	7.2	13.7	1.2	0.65	0.1
4.	6.7	7.2	12.0	1.2	1.75	0.20
5.	6.7	6.7	8.0	0.35	1.50	0.15

The performance data presented in Table III, are in respect of Type II package plant put up at a village known as Bhanaveedu Thottam near Poonamalli on the outskirts of Madras. The plant was installed in November 1977 for treating water of a shallow open well. The plant did not require washing operations after 3 months of usage. This is due to the low turbidity and low iron content of raw water.

The experience in the other case with Type II plant at Sevasamajam Boys' Home, Saligram (Madras) was very different. Upon installation, the plant was commissioned and the quality of treated water was found to deteriorate after 2 days of operation. This was investigated and the behaviour of the plant was attributed to the high turbidity and iron present in the raw water (Table IV).

Table IV: Raw Water Characteristics At Saligram

	pH	Turbidity mg/l SiO_2	Iron mg/l Fe
1.	6.4	310	6.4
2.	6.6	265	6.5
3.	7.1	165	7.2
4.	7.2	220	6.6
5.	6.8	370	9.6

In order to reduce the turbidity on the filter, a plain pre-settling tank was incorporated before the filter unit. By providing the plain pre-settling tank, the load on the filter was considerably reduced (Table V), thereby improving the performance of package plant.

Table V: Characteristics of Settled Water at Saligram

	pH	Turbidity mg/l SiO_2	Iron Fe mg/l
1.	6.5	26	2.95
2.	7.3	20	3.25
3.	6.9	53	3.40
4.	7.3	43	3.25

The removal of turbidity and iron was estimated at 86 and 56 per cent respectively. The settled water was found to have a moderate turbidity, varying from 20 to 53 units and iron varying from 2.95 to 3.40 mg/l. After making provision for the settling tank, the filter medium of the package plant required washing once in 7 to 10 days after operation.

The package plants were also found to improve the bacterial quality of treated water, as seen from the data presented in Table VI.

Table VI: Bacterial Quality of Treated Water at Bhanaveedu Thottam

Source	Total coliform PN/100 ml	Faecal coliform MPN/100 ml	E Coli MPN/100 ml	Total plate count MPN/ml
Raw water	2.1×10^3 to 4.6×10^3	3.9×10^2 to 7.5×10^2	2.3×10^2 to 4.3×10^2	1×10^7
Treated water	4.3 x 10 to 9.3 x 10	9.0 x 10	4 x 10 to 9 x 10	4.3×10^3

Although the package plants could improve the bacterial quality of treated water, the treated water would still require disinfection which could be carried out with the patented PVC chlorine cartridge employing bleaching powder, especially in the treated water storage tank of Type II plants.

Material For Construction

In order to bring down the cost of the plants, the Type I Units were first made in RCC and marketed. Subsequent experience in handling and transportation of individual and bulk units, especially to distant places had indicated damages to the units and hence, it was attempted to make the plants in mild steel with epoxy painting inside and attractive enamel painting on the outside. Although the mild steel units are stronger and non-breakable, they call for regular maintenance such as painting, due to rapid corrosion of units especially located on coastal areas. In order to improve the units and make them free from regular maintenance of plants shells, it was desired to completely fabricate the plants in FRP. Thus, the Type I plants are now made available in RCC, M S and F R P.

The empty weights of these units are presented in Table VII.

Table VII: Empty Weights Of Type I Units:

Type of Unit	Weight in Kgs
R C C	200
M S	80
F R P	12

In view of the large sizes involved in Type II Units, the plants are fabricated in M S with epoxy painting inside and attractive enamel paint on the outside.

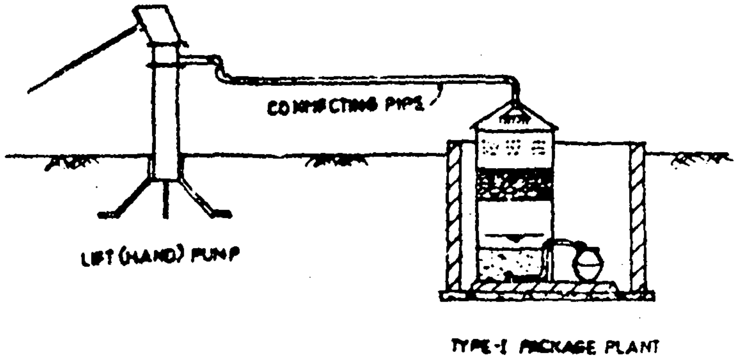
Placement Of Package Plants

The Type II plants can be located on or below ground level, to suit the handpumps or be provided at elevated positions adjacent to existing overhead storage tanks of residential buildings. The plants can also be provided at the floor levels of houses with tapping from the overhead tank. In such cases, a storage tank of adequate capacity may be provided if required. Installation of Type I plants for existing lift (hand) pumps call for lowering the unit in a pit (Fig 4), as the plant height is more than the pump spout height from the base alternatively, the pump base can be lifted on to a pedestal, facilitating the position of package plant on or near ground level. In case of an alternative arrangement for operating the pump handle with ease, it may be necessary to provide an operating platform of sufficient height in line with pump pedestal level. The Type I plants can also be installed at ground level with force lift (hand) pumps. In this case, both the pump base and the plant base will be kept on or above ground level as shown in Figure 4.

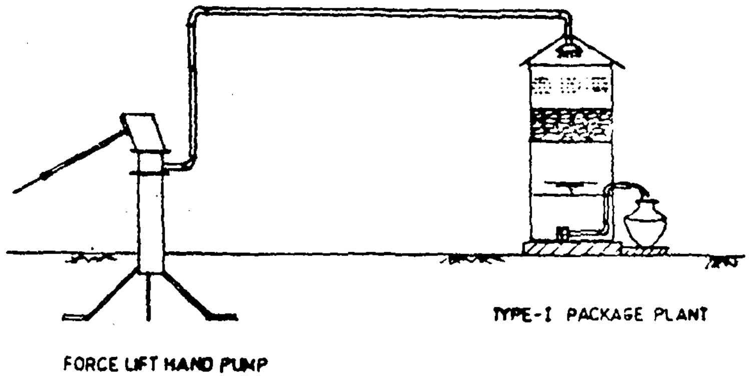
Type II plants can be mounted on masonry pedestals at ground level. While the raw water is either pumped or fed from elevated storage tanks, the treated water can be collected in pots, vessels, etc from the taps provided in the package plant. The arrangement is shown in Fig 5.

Type II units can also be mounted on stagings of required height of gravity distribution of treated water to the required places (Fig 5). In this case, the staging platform should be large enough to accommodate operating personnel at the time of installation and cleaning of package plant.

In the case of existing water supply installations having well, raw water pumps and overhead tank, the package plant can be incorporated in between the raw water pumps and the overhead tank. The treated water from the package plant has to be collected in a sump (an additional provision). The existing pumps will first feed the water into the plant and the treated water will then be collected in the sump. After operating the plant for the required duration, the treated water collected in the sump can be pumped to the overhead tank by the existing raw water pumps. For this operation, suction and delivery lines should be provided as shown in Figure 5.

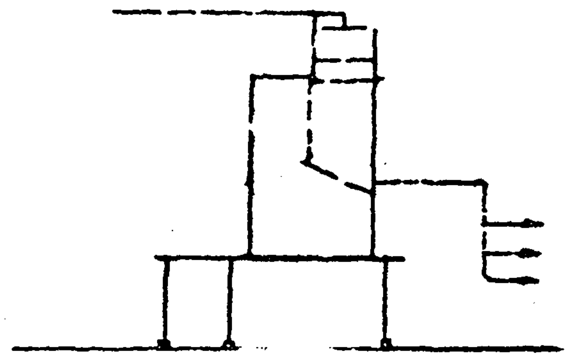


TYPE - I PACKAGE PLANT INSTALLATION WITH EXISTING LIFT HAND PUMP

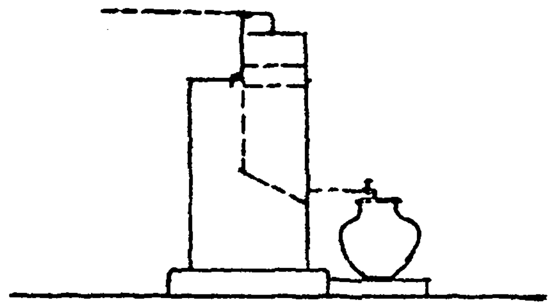


TYPE-I PACKAGE PLANT INSTALLATION WITH FORCE LIFT HAND PUMP

FIG 4



TYPE II PLANT AT ELEVATION



TYPE II PLANT AT GROUND LEVEL

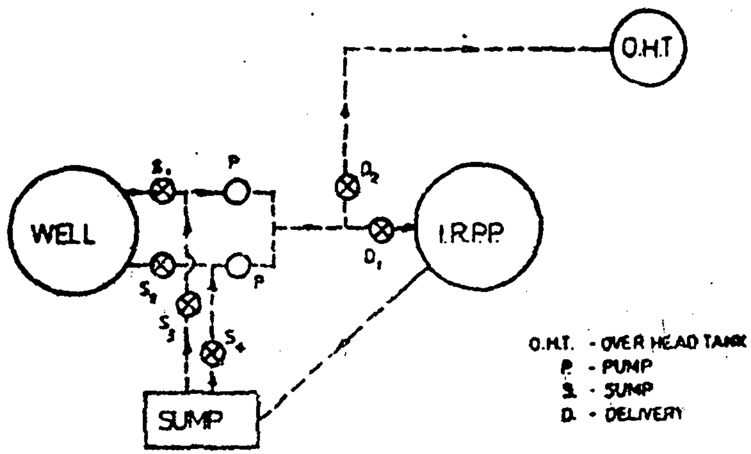


FIG. 5 TYPE-II PLANT
WITH EXG. PUMPS AND OVER HEAD TANK

Filter Washing

The package plants will require washing of the filter medium. Necessity of washing is ascertained as and when there is overflow through the overflow pipe provided in the filter compartment of the units. The interval between successive washings varies and depends on the initial turbidity and iron content. Experience indicates a smaller interval of one week for turbidity around 40 mg/l and 1-2 months for waters with low turbidities (less than 10 mg/l). Washing of the filter medium involves removal of first 6 to 10 cms of filter medium and washing is done manually with water so as to free it from sediment.

The coke medium needs washing once in 6 to 24 months, depending on the iron content in raw water. In the case of Type I, plant door openings are provided in both bottom and upper compartments to enable removal of the top layer of the filter medium and coke, when required. The unit is also provided with a drain pipe to empty the water in the bottom compartment prior to the removal of filter medium for washing. The Type II unit is provided with drain pipes and blank flanges which can be removed to drain out the water column on the filter bed. These plants are also provided with conventional backwashing arrangement by reversing the flow from treated water storage tank to the filter unit. This is found useful for low turbidity waters. The wash water will be collected through the drain pipe provided just above the top of the filter medium.

Installations In India

A sizable number of R&C Package plants have been installed in various parts of the country. The total number of units installed at present is 178, of which the Type I units there are 147, of Thpe II-A 18, and of Type II-B 13. The state-wise deployment is shown in Figure 6.

Figure 6: Installation of R & C Plants In India

Package Plant For Fluoride Removal

Similar to the package plant developed and marketed, efforts have already been made to develop a defluoridation unit-fluoride removal plant suitable for hand pump installations. The treatment system selected for the development of defluoridation package plant is of conventional chemical treatment employing alum and lime. It was shown [4] in a case study, that with the alum-lime treatment the raw water fluoride content of 2.6 mg/l could be reduced to 1.0 mg/l. The fluoride removal pattern, was investigated and is graphically represented in Figure 7.

The first testing installation is to be deployed shortly in the field. The demonstration package plant consists of chemical dosing system, flocculation, settling and package plant filtration unit (Fig 8).

Summary

Water treatment in rural areas and isolated colonies poses great problems, as the in situ execution of conventional treatment systems such as slow sand and rapid sand filters are not feasible and practical, due to the large number of dwellings that use the hand pump and power pump schemes as the mode of water supply.

Prefabricated package units will provide an ideal solution for such situations. The package plants developed for hand and power pump schemes for water having iron and turbidity have yielded excellent results. The treated water quality of such package plants is well within the acceptable standards in respect of turbidity and iron. The plants are easy to instal, operate and maintain. They do not involve addition of chemicals or use of mechanical instruments.

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PACKAGE PLANTS FOR RURAL WATER SUPPLY

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Introduction

An adequate supply of safe water is regarded as an every day necessity of life in large centres of population. This basic amenity, however, is not readily available to small communities and institutions which are remote from public water supply undertakings. Small water systems can not benefit from economies of scale as do large urban systems, because the number of connections served is small. Certain types of services however, must be provided no matter how few the service connections. Package water treatment plants can meet the needs of such communities wherever there is a source of supply suitable for extraction. Package plants incorporate various unit processes and operations in a compact system. They are usually pre-fabricated and pre-assembled and therefore, have the advantages of standardisation and centralised expert supervision in their manufacture. By virtue of their construction and operational features, they generally require chemicals and skilled operating staff, which can be more readily provided only by economically independent communities. This paper briefly presents the basic requirements of a package plant, factors influencing their choice, reviews available in design and experience and describes a simple system being developed in NEERI.

Requirements Of A Package Plant

Package plants should be capable of producing finished water, of quality comparable to that obtainable from any conventional field installation. To suit rural areas and isolated communities, a package plant, should as far as possible satisfy the following requirements:

- low capital cost
- simplicity of operation and maintenance
- maximum reliability with minimum mechanical equipment
- low operation and maintenance cost
- quick and easy to install with minimum on-site construction work.

Factors Influencing The Choice Of Package Plants

The specification and choice of any individual plant, will depend on the quality and nature of water to be treated and the desired quality of the finished water. For example, a spring water with low turbidity may need only filtration followed by chlorination, whereas river water may need coagulation, clarification, filtration and chlorination. Where the surface water contains not more than 20-30 units of turbidity and colour less than 10 ppm, alum addition followed by direct filtration and chlorination should prove adequate. Ground water often contains a significant amount of unoxidised iron or fluorides. In such cases, it is necessary to provide for settlement followed by filtration and chlorination. Availability of a regular supply of chemicals and trained operators, is a crucial factor in the successful application of package plants. From practical considerations it may not be economical to design a plant for less than a few hundred population. The maximum capacity upto which a package plant can be economical will depend upon local conditions. Restriction on the size of an individual unit is governed by transport facilities and road clearance.

Package Plants In India

In India, package water treatment plants have been in use for several years, mainly for industrial and swimming pool water treatment. More recently, these plants find increasing application in community water supplies. A few of the conventional types and recently developed systems are briefly described :

Pressure Filters

Wellknown as package plants, these are suited for direct filtration of alum dosed raw waters with low turbidity (<20 units). They have been used extensively for small water supplies in collieries and also for rural water supplies in Andhra Pradesh and in a few other states. Experience with pressure filters for rural water supplies, however, has not been satisfactory because of poor operation and maintenance.

When raw water turbidity exceeds above 20 units for long periods, provision for clarification preceeding filtration is essential. Package plants are available which incorporate chemical dosing, clarification, filtration and disinfection i e from source to overhead distribution reservoir with one step pumping. With trained staff manning these plants, high quality finished water could be obtained.

Package Slow Sand Filters

Where raw water turbidity is uniformly low (<30 units), package plants employing slow sand filters can provide the appropriate treatment technology. These filters can also be used to purify water from open dug wells, which are generally found to be grossly contaminated. Filter units made of pre-cast R C C pipes having a diameter of 1.0 m and operating for 24 hours a day at a filtration rate of 0.1-0.2 m/hr depending upon the raw water quality, can produce 1.9-3.8 m^3 of filtered water per day. At a rate of 10 litre per capita (only for cooking and drinking) this can cater to the needs of 190-380 population. As a second line of defence, chlorination may be desirable. The system consists of raw water storage tank, filter unit and filtered water storage tank. Preceeded by aeration, such units can be used for treating iron bearing ground waters.

Multi-inlet, Multi-outlet (MIMO) Filters

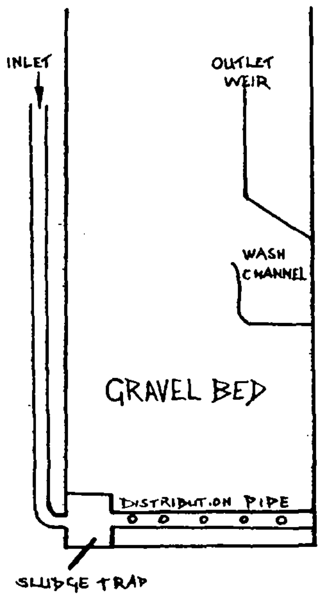
Developed at Roorkee University[(1)], the package consists of (i) an inlet-cum-stilling chamber, (ii) parallel flow alum doser, (iii) solid media flocculator, (iv) multi-bottom settler, and (v) MIMO filter and parallel flow chlorine doser (Fig 1) The special features of the design are the multi-bottom settler and the MIMO filter. The multi-bottom settler consists of closely spaced inclined plates set at a slope sufficient to induce self cleaning action. The detention time is only 5-10 minutes as compared to 2-3 hours in conventional units. The settled water is distributed to the filter through a number of inlets and the filtered water is also collected by a number of outlets. Because of this, the filtration rate is as low as 2.4 m/hr. The filter sand used is rather fine and the depth of sand between the inlet and outlet is also less (20 cm) than the conventional. Such units are reported to give satisfactory performance with raw waters of turbidity as high as 4000 units.

Commercial Designs

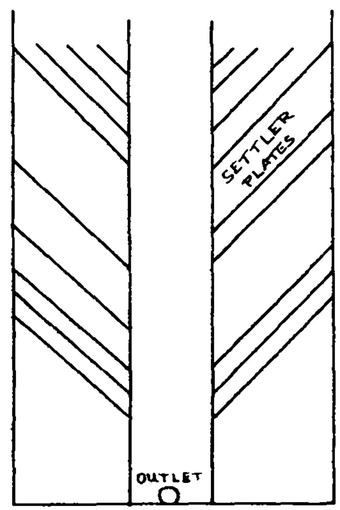
There are a number of commercial firms in India who have developed their own designs of package plants under different trade names. These plants which are essentially based on known principles of water treatment, have their special characteristics of design and operation. Small package plants with provision for manual chemical addition and mixing and operated on batch a system, are also marketted.

Lessons From Experience

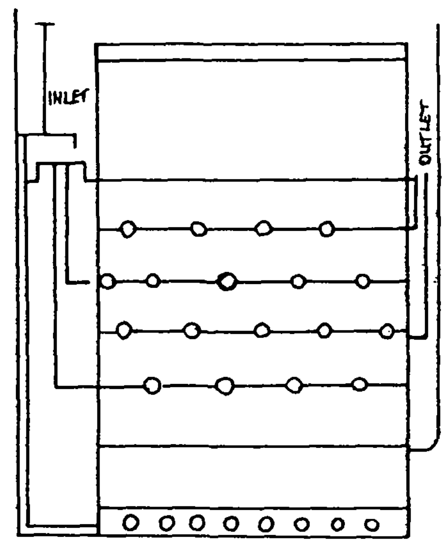
There is limited published information on the performance of various types of package plants used in India. The findings of performance evaluation studies of package water treatment plants in USA highlighted below, however, should serve as a pointer to the shape of things that may exist in developing countries. Ninety per cent of the water systems in the US serve less than 10,000 people and account for 21 per cent of the population served by community systems. Small systems tend to have more water quality problems and facility deficiencies than do large systems. Table 1 summarises results from the community water supply survey conducted in 1969[(2)]. It can be seen from the Table, that 50 per cent of the utilities serving 500 people or less did not meet the USPHS drinking water standards. As utility size increases, the percentage of utilities meeting the standards increased.



SOLID MEDIUM FLOCCULATOR



MULTI-BOTTOM SETTLER



MULTI INLET, MULTI OUTLET FILTER

FIG. 1

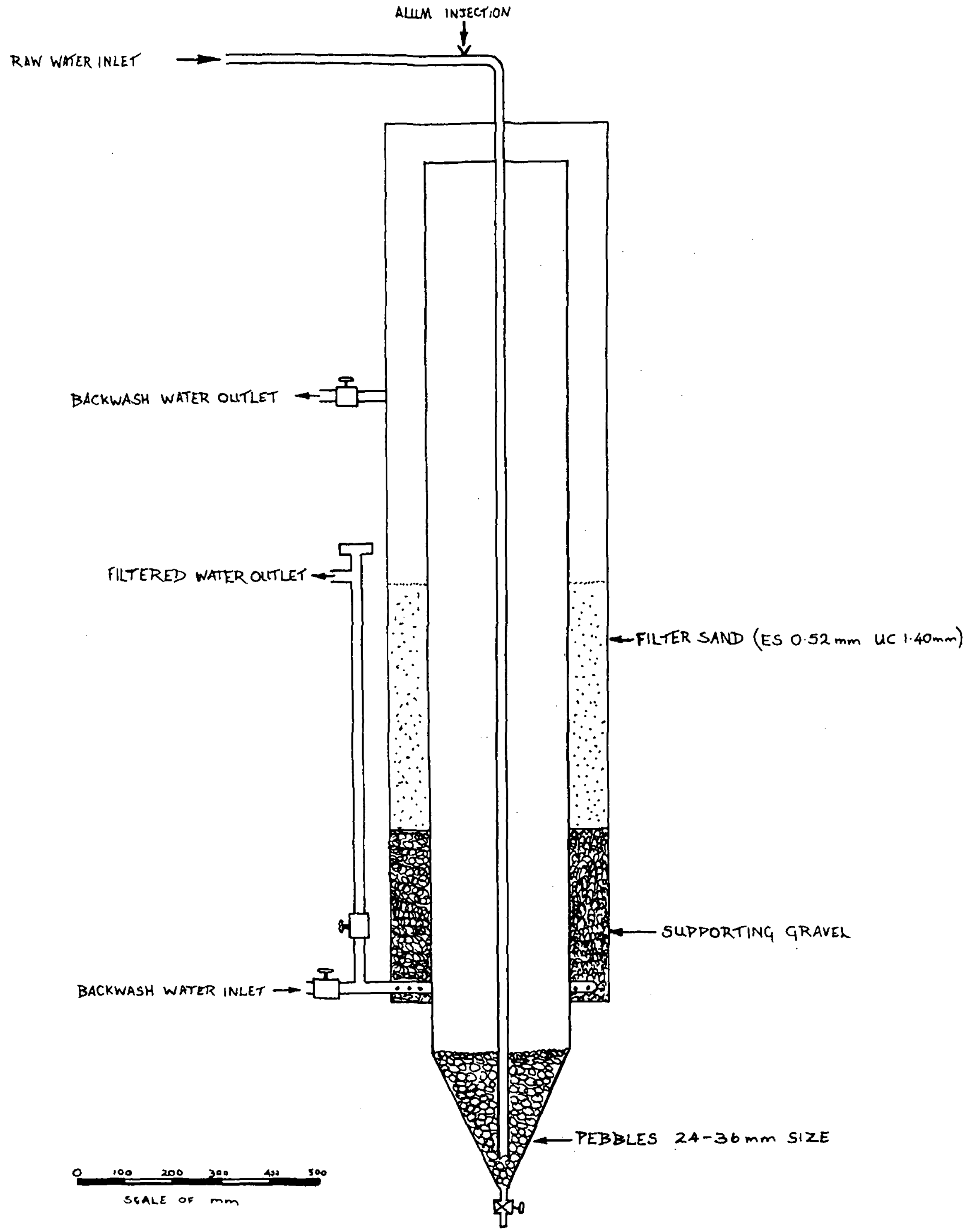


FIG 2: WATER TREATMENT PLANT

Table 1 - Summary Of Water Quality Evaluation

	Population Group Served			
	500 or less	501-100,000	Greater than 100,000	All Populations
Number of systems	446	501	22	969
	Percent of Systems			
Evaluation of systems				
Met drinking water standards	50	67	73	59
Exceeded recommended limits	26	22	27	25
Exceeded mandatory limits	24	11	0	16
Survey population in each group (in thousands)	88	4,552	13,463	18,103

A recent evaluation study of 36 package water treatment plants constructed in the 1970's show the following[3]:

The majority of sites visited had personnel who did an inadequate job of plant operation. In one case, an operator was incorrectly reading a burette, causing all of his titration calculations to be off by a factor of 10. In another case, the operator was not determining turbidity properly. At most plants, chemicals had been purchased according to the manufacturer's recommendations and were used in the same dosage every day regardless of raw water quality. Some operators had not purchased chemicals or had not added chemicals that had been purchased. Coliforms were detected in the finished water of 3 out of the 31 plants in operation. Eight did not meet the federal turbidity standard of 1 NTU. The report concludes that package plants when properly operated and maintained are capable of providing good quality drinking water. All these indicate the need for greater simplicity and better reliability of package water systems.

Work At NEERI

As part of its R & D on simple, low cost water treatment methods, NEERI is currently working on the development of a package plant suitable for treating surface waters of varying turbidity. The system provides for chemical (alum) dosing, flocculation, clarification and filtration in one modular unit. The special features of the design are the use of unconventional coagulation/flocculation system and elimination of practically all mechanical equipment (excepting valves and piping). A schematic of the unit is shown in Figure 2.

Raw water dosed with the coagulant chemical enters the unit at the bottom of the hopper and rises upward through the pebble bed where coagulation and flocculation take place. The pebble bed and the space above can function as a sludge blanket clarifier. The clarified water then flows down the filter in the annular space between the cylindrical portions. The filtered water is collected from the outlet provided just above the sand level of the filter.

Though this would limit the maximum permissible headloss, the chances of air-binding and occurrence of negative head with the attendant problems are liminated. No rate controller is required and the filter would operate with a variable head i e the water level above the sand bed will continually increase as the filtration proceeds. When the permissible (predetermined) maximum level is reached, the filter is back-washed as in the case of a conventional filter. Only hardwash for a period of 10 minutes is adequate to leave a clean bed. There is no need for a headloss indicator. The entire unit can be made of steel, or fibre reinforced plastic.

A laboratory unit designed to treat 90 litres/hour has been fabricated (design data in Table 2) and its performance studied for treating raw water with a turbidity in the range of 50-300 NTU. The performance data are presented in Table 3. It can be seen that with a raw water turbidity upto 300 NTU, a settled and filtered water turbidity of less than 20 NTU and 1 NTU respectively could be consistently obtained. Further studies are in progress to assess the performance of the plant with raw waters of different turbidity and at different flow rates.

Table 2 : Design Data

Design flow rate	:	90 lit/hr
Pebble bed flocculator:		
Media size	:	25 to 38 mm
Depth	:	30 cm
Clarifier:		
Surface overflow rate	:	1.3 m/hr
Detention time	:	1 hr 45 minutes
Filter:		
Rate of filtration	:	1.01 m/hr
Filter sand :		
Effective size	:	0.52 mm
Uniformity coefficient	:	1.4
Depth	:	60 cm
Supporting gravel (graded):		
Size	:	0.7 to 25 mm
Depth	:	27.5 cm

Underdrain system - Perforated G I Pipe of 12 mm diameter with 6 mm diameter orifices (26 nos) spaced at 5 cm c/c.

Table 3 : Performance Data

Raw Water Turbidity (NTU)	Alum dose (mg/1)	Turbidity - NTU Settled water	Turbidity - NTU Filtrate	Length of run (hrs)	Terminal headloss (cms)
95-120	20	10-18	0.2-0.5	72	58.5
160-210	60	6.5-18	0.2-0.8	46	50.0
54-110	50	4-14	0.2-0.6	48	48.0
260-300	50	7-18	0.5-1.0	26	-
58-120	30	12-24	0.4-1.0	26	23.0

Conclusion

In the coming years, greater application of package plants will be made, stimulated by the rising construction costs that preclude the use of custom designed treatment facilities for small communities. Experience with package plants in India and the USA indicates that with proper selection operation and maintenance, these plants are capable of producing finished water to meet the requirements of quality standards. The need for more simplicity and greater reliability of these plants should prompt further research and development to evolve systems that are appropriate to the needs of small communities in developing countries.

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SLOW SAND FILTERS FOR SAFE WATER IN RURAL AREAS

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Introduction

Modern technology offers a choice of treatment methods that can produce virtually any desired quality of product water from any source. The limiting factor is cost rather than technology. Water supply systems for villages have to be technologically sound, economically viable, environmentally compatible and socially relevant. When ground water of acceptable quality and in adequate quantity is readily available, it would be the first choice due to simplicity and economy. There are numerous instances, however, where ground water is not available or if available poses problems due to excessive fluorides, iron and manganese or high salinity. In such cases, surface waters may be the only sources of water supply. These are invariably polluted and have to be treated for domestic supplies. The treatment system should be such that it meets the real needs of the population and is within the capabilities of the community to implement, operate and maintain.

Slow Sand Filtration

Slow sand filtration is essentially a biological purification process in which the water to be treated is passed through a bed of filter medium, usually sand. During its passage, the suspended and colloidal impurities are retained in the bed, harmful bacteria, viruses and cysts are substantially reduced or eliminated, organic matter is broken down into simple innocuous substances and a safe water is produced. The advantages of the process such as its simplicity of design, operation and maintenance and its ability to bring about a simultaneous improvement in physical, chemical and bacteriological quality of raw water make it an appropriate technique for small and medium water supplies in developing countries. In each of its functions, it represents the nearest approach to the processes that occur in nature and has unusual powers to suffer misuse without failure and a capacity for self-regeneration after such misuse[1]. When raw water turbidity is high (30 NTU) for long periods, pre-treatment by storage, sedimentation or simple rapid filtration may be necessary.

The slow sand filter essentially consists of a water-tight cistern containing a supernatant raw water reservoir, a bed of filter sand, a system of underdrains and a set of filter regulation and control devices (Fig 1). It is cleaned periodically by removing 2-3 cm layer of filter sand including the biologically active film on top. These filters require a relatively larger area and manual labour for cleaning, both of which are readily available at low cost in rural areas of developing countries.

Integrated Research and Demonstration Project

Eversince their introduction for purification of municipal water supply about 150 years ago, slow sand filters continue to enjoy the reputation as a reliable means of water treatment. Even today industrialised cities like London, Antwerp and Amsterdam use slow sand filters in large numbers. There is a general, however, misconception among water supply professionals in developing countries, that slow sand filters are old fashioned and therefore inferior to the more recent but sophisticated systems. In order to demonstrate the relevance and efficacy of slow sand filters and to promote their large scale use for rural water supplies, a research and demonstration project was taken up by NEERI in collaboration with the International Reference Centre (IRC) for Community Water Supply and Sanitation, The Netherlands.

Applied Research

The project has been implemented in two phases. In the first phase, literature survey and applied research on pilot as well as full scale installations of slow sand filters were carried out under different operating conditions and raw water quality. Specifically the performance of filters in relation to the following was studied:

- the quality of raw water with regard to turbidity and bacterial pollution;
- the effect of filtration rates higher than the traditional 0.1 m/hr (2 gallons/sq ft/hr);

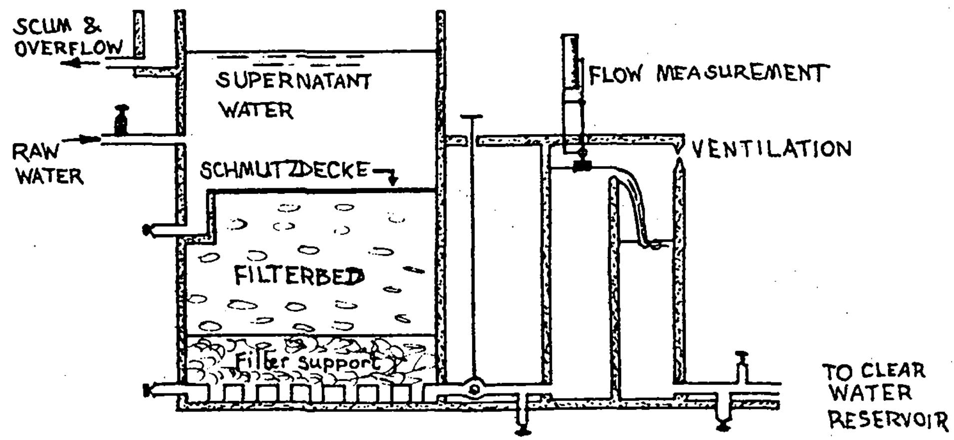

FIGURE 1: BASIC ELEMENTS OF A SLOW SAND FILTER

- the influence of shading the filters;
- the effect of intermittent operation;
- *the effect of high organic pollution in raw water and the use of buildergrade sand.*

Salient findings of practical significance from Phase I study are:

(i) slow sand filters deliver a bacteriologically safe water under normal operating conditions and raw water quality;

(ii) with favourable raw water quality (turbidity less than 30 NTU and organic pollution less than 30 mg/1 measured as COD) slow sand filters can be operated at 2-3 times the traditional rate of 0.1 m/hr, with no deterioration in filtrate quality. This finding can help economic design of filters;

(iii) shading of slow sand filters to exclude sunlight retarded the development and growth of algae but did not materially influence the performance of the filters. Covering filters with a roof is, therefore not essential;

(iv) intermittent operation of slow sand filters resulted in filtrate of unsatisfactory bacteriological quality. However, the deterioration was insignificant when continuous filtration was ensured even with a falling supernatant (declining rate operation);

(v) slow sand filters with builder grade sand give a performance comparable to that with graded sand. Cost of filter sand can thus be kept to the minimum.

Arising out of the laboratory and field studies and critical review of slow sand filtration practice in India, guidelines have been formulated for cost effective design of slow sand filters, their construction, operation and maintenance[2].

Demonstration At Village Level

The guidelines developed in the first phase of the study for design and construction of slow sand filters were tested under prevailing field conditions. Four demonstration plants at village level (VDPs), one each in the States of Andhra Pradesh, Haryana, Maharashtra and Tamil Nadu were constructed. Salient features of these plants are summarised in Table 1. In the selection of villages for location of demonstration plants, due consideration was given to the population size, the actual needs of the village, the source of raw water, the socio-economic and cultural background of the community and its willingness to participate. All the four plants have since been commissioned and their performance evaluated under local conditions.

Table 1 - Demonstration Slow Sand Filter Plants in India - Salient Features

Description	Plant I	Plant II	Plant III	Plant IV*
State	Andhra Pradesh	Haryana	Maharashtra	Tamil Nadu
Village	Pothunuru	Abub Shahar (Group of Villages)	Borujwada	Kamayagoundanpatti
Population:				
Present	3254	8719	699	8500
Projected	6236	12695	1315	10000
Design per capita water supply -1pd	45	45	70	45
Plant capacity - m^3/hr	17.5	24	5.75	22.60
Raw water source	Canal	Canal	River	River
Pre-treatment	Storage	Storage	Infiltration gallery	Plain sedimentation + horizontal prefiltration
Slow sand filters	11.0 m x 8.0 m 2 nos	10 m dia 3 nos	5.0 m x 3.8m 2 nos	12 m dia 2 nos
Distribution	Standposts	Standposts	Standposts	Standposts + house connections
Per capita cost	US$8.00	US$16.00	US$26.00	US$5.00

*(Existing system meets part of the supply)

Project Organisation

A noteworthy feature of the project is the integrated, multidisciplinary and collaborative effort among research workers, field engineers, government agencies and policy makers at local, national and international levels. In order to effectively plan, organise and implement the country programme and keeping in view the future large scale implementation of slow sand filtration for rural water supplies, a Project Managing Committee (PMC) was constituted with Director, NEERI, Chief Public Health Engineers of the participating states, Advisor, Central Public Health and Environmental Engineering Organisation (CPH & EEO), Ministry of Works and Housing, Government of India, Director, Central Health Education Bureau (CHEB), and representative of WHO & IRC as members. The PMC reviewed from time to time the progress of the programme and provided guidelines for successful implementation.

Health Education

Clean water alone will not significantly alter the health status of a community unless an effective health education programme forms an integral part of the water supply project, in order to bring about desirable change in the knowledge, attitude and practice of the users. In Thailand, for instance, many villages after bore-holes were drilled providing copious clean water, people continued to get their drinking water from the village ponds where the water-buffalo lived. They complained that the water from the bore-holes had no taste, and only an extensive education programme convinced them that deaths of their children and their recurrent diarrhoea was the result of contamination of their traditional water source[3].

A health education strategy developed by Central Health Education Bureau (CHEB), New Delhi, with modifications to suit the local needs and requirements has been implemented in the project villages by the state and local agencies with overall coordination by NEERI. Popular lectures were delivered to villagers on hygiene, collection and disposal of sullage and refuse. This was supplemented by audio-visual films and display of charts, posters and flashcards on a number of health related topics like nutrition, family welfare, cholera, malaria, filaria and control of water-borne diseases through supply of safe water. The community response to these programmes has been encouraging.

Community Participation

It is increasingly recognised that the success of any rural development programme including water supply, depends very much on effective participation by the community. Programmes have been most successful where the community is involved right from planning to implementation. This has been achieved to a large measure in this demonstration project. It was not surprising that in one village, the leaders were not well informed and therefore had some mis-conception about the suitability and efficacy of slow sand filtration for water purification. A detailed discussion between the agency staff and the leaders with a genuine exchange and accommodation of views could establish mutual understanding and confidence. This has greatly enhanced the involvement and commitment of the community towards lasting operation and maintenance of the water supply system when handed over. An individual selected from among the local residents of the village has been given on-the-job training in routine operation and maintenance of the plant as well as the distribution system.

Conclusion

The integrated research-cum-demonstration project has established the efficacy of slow sand filters, for small and medium water supplies. With the new knowledge gained through laboratory research and field studies, it is now possible to design cost effective slow sand filter systems for community water supplies. The impact of the study is evident from the renewed interest of water supply professionals in slow sand filtration. In the design of new schemes, due consideration is given to this method of water treatment in view of its advantages.

The strategy followed in the development, testing and evaluation of various technical, organisational and social aspects of the programme at local and national level has served as a model for future large scale implementation of rural water supply programmes. This acquires special significance in the context of the 'Decade' programme which aims at providing safe drinking water for all by the year 1990. The project is also an example of how Technical Cooperation among Developing Countries can play a vital role in evolving appropriate treatment technologies for solving water supply problems of common concern for mutual benefits.

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SLOW SAND FILTRATION - APPROPRIATE TECHNOLOGY FOR SAFE WATER

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1. Introduction

To promote the large scale application of slow sand filtration (SSF) for community water supply in developing countries, a number of research institutes and water supply agencies in developing countries initiated the integrated research and demonstration project on slow sand filtration, in close collaboration with the International Reference Centre for Community Water Supply and Sanitation. The project embraces applied research, demonstration programmes, the exchange of information and the transfer of knowledge and experience. These are the preparation for large scale implementation programmes. All project activities are implemented in and by the developing countries themselves and coordinated by IRC.
The project comprises the following phases:

1. Applied research by institutions in participating countries on the basis of international collaboration.
2. Development and implementation in an integrated way of village demonstration plants by the participating countries.
3. Dissemination and exchange of information on research and demonstration activities to other developing countries, to stimulate larger scale use of slow sand filtration.

RESEARCH, PHASE I

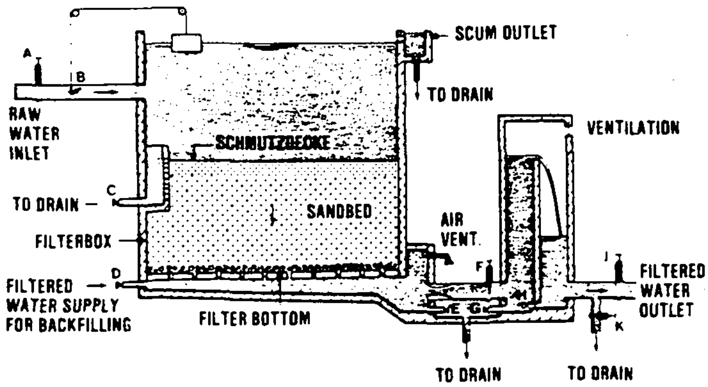
Applied research in Phase I of the project was executed from 1976 to 1978 by research institutes in Ghana, India, Kenya, Sudan and Thailand.

Apart from gaining experience with the slow sand filtration process, the specific objective of these programmes was to develop appropriate criteria for the design, construction, operation and maintenance of slow sand filtration schemes under local conditions in these countries.

Specifically the performance of SSF was investigated in relation to:

- effluent quality under various levels of bacterial pollution an turbidity in the raw water.
- effect of filtration rates higher than the standard 0.1 m/hr.
- influence of shading of filters.
- effect of intermittent operation.
- effects of organic and bacteriological overloading.
- use of ungraded sand as filter medium.
- effects of pre-treatment.

Basic elements of a slow sand filter.



The Equipment

A slow sand filter basically consists of a box containing a supernatant raw water layer, a bed of filter medium, a system of underdrains and a set of filter regulation and control devices. Figure I shows the basic elements. The filter box can be made of concrete, ferrocement, stone masonry or simply dug out in the soil, with protected sloping sides.

The depth of the tank is about 3 m and the area can vary from a few tens to several hundreds of square metres. At the bottom of the tank an underdrain system (the 'filter bottom') supports the filter bed and drains away the filtered water. The bed is composed of fine sand, usually ungraded, free from clay and loam, and with as little as possible organic matter in it. The filter bed normally is about 1.0 m thick, and the water to be treated (the 'supernatant water') is at a depth of 1.0-1.5 m above the filter bed.

The slow sand filter is provided with two main influent and effluent lines. Valves B and F in these lines are meant respectively to keep constant the raw water level and the filtration rate. For clarity of illustration all influent and effluent lines necessary for proper operation and maintenance are shown separately in Fig. I, but in practice they are combined and placed together to save on construction costs.

The Process

Slow sand filtration is a purification process in which the water to be treated is passed through a porous bed of filter medium. During this passage, the water quality improves considerably by degradation of organic matter, by reduction of the number of micro-organisms (bacteria, viruses, cysts), by removal of suspended and colloidal material, and by changes in its chemical composition. In a mature bed a thin layer called the **Schmutzdecke** forms on the surface of the bed. This **Schmutzdecke** consists of a great variety of biologically very active micro-organisms which break down organic matter, while a great deal of suspended inorganic matter is also retained by straining. The cleaning of the slow sand filters is relatively simple and is done by periodical removal of the top layer of the filter bed, including the **Schmutzdecke**. The effect of the purification process on the water quality depends on many factors, such as raw water quality, the rate of filtration, grain size of the filter medium, the temperature and the oxygen content of the water.

The investigations in Phase I confirmed the reliability and efficiency of slow sand filters and led to the compilation of a handbook on design and construction incorporating the existing knowledge and the research findings (IRC Technical Paper 11).

Photo 1. Silt traps as pre-treatment, Peace River Demonstration Plant, Jamaica.

DEMONSTRATION, PHASE II

The next and most recent emphasis of the project was placed on the implementation of the demonstration programmes. During this phase Colombia and Jamaica also joined the project.

In Phase II the primary aim of the project is to demonstrate at the village level the effectiveness of slow sand filtration as a simple and reliable purification technique able to produce safe drinking water at a low recurrent cost. This is accomplished by the implementation of a number of so-called village demonstration plants, integrated water supply projects in selected villages.

In each of the participating countries the villages were selected on the basis of the following main criteria:

- surface water should be the only source of drinking water available. The characteristics of the raw water should further allow for treatment through SSF.
- the provision of an adequate water supply system should further be a priority need of the community.
- the community should be willing to actively participate in the planning, construction and management of the water supply scheme.
- for the sake of the SSF-project it was necessary to ensure that the final results of the demonstration phase would have a wide validity. To warrant this a certain measure of diversity needed to be incorporated in the project. Sites for the village demonstration plants were therefore chosen to represent a variety of climatic and geographic conditions, and socio-cultural and socio-economic settings.

Phase II also includes the development, testing and evaluation of models for the organizational and institutional infrastructure, at national and local levels, required for the repetition of these projects within the scope of large-scale implementation programmes.

Table 1 summarizes completed projects.

Demonstration villages with completed SSF plants.

Participating Countries	Demonstration Villages
India	Kamayagoundanpatti Pothunuru Borujwada Abubshahar
Colombia	Alto de los Idolos Puerto Asis
Kenya	Kisekini West Karachuonyo
Thailand	Ban Thadindam Ban Bangloa Ban Thaluong
Sudan	Rahad Scheme Villages 18 and 19
Jamaica	Endeavour

The planning, implementation and evaluation of the programmes are carried out in and by the participating countries themselves. The general responsibility for the programme in each country lies with a Programme Managing Committee in which various disciplines and agencies are represented. This specifically concerns:

- water supply agencies at national and regional levels
- health service agencies at national and regional levels (including health education)
- community development agencies at national and regional levels
- national research and development institutes in the field of public health and environmental engineering.

The direct responsibility for each of the demonstration projects lies with local coordination committees comprising representatives of the communities as well as representatives of the executing agencies at local level.

Because of the broad composition of the committees, the various components of the demonstration projects and the organizational requirements can be taken care of in an integrated way.

A major function of the committees is the establishment and/or strengthening of multidisciplinary collaboration at national and local levels, so that liaison is maintained with other sectors such as primary health care and integrated rural development.

Involving the community

As is now widely recognised, the introduction of any water supply scheme to a community should not solely be based on technical considerations but should also take into account the views and wishes of the future consumers. Further, to ensure optimum health impact of the water supply, the population needs to be extensively and repeatedly informed about the health implications that the provision of safe water may have when used in a hygienic way. Thus, to support the smooth integration of the water supply scheme in the community a Community Education and Participation component was included in the programme for Phase II. Through greater perception of health benefits and through the sharing of views with the water supply agency and contributions in labour, cash and kind, an understanding of the importance of and a feeling of propriety towards the water supply scheme will be created within the community. This should eventually lead to the self-reliant management of the scheme and a responsible behaviour towards it of each of the community members.

The majority of the participating countries have now completed the construction of the village demonstration plants and are presently monitoring the performance of the system and evaluating the effectiveness of the integrated approach.

Full reports on the specific country activities are being finalized. Those on the SSF-projects in Colombia, Thailand, India and Jamaica (interim only) will be available shortly.
As a follow up to the demonstration phase a third and final phase has been initiated during 1981 which focuses on the dissemination of the results obtained in the SSF-project through distribution and commissioning of publications on the subject and the organisation of (inter)national seminars.

In the context of Phase III of the project attention is also given to a number of research topics identified in phase II. Investigations are presently carried out on the following:

- The economic and management implications of declining rate filtration/ India.
- The design of a suitable and fool-proof inlet control arrangement for slow sand filters/India.
- The minimum thickness of the filter medium required to produce a bacteriologically safe water, in relation to the filtration velocity and the range of temperatures prevailing under (sub)-tropical climatic conditions/India.
- comparison of efficiency between upflow and downflow slow sand filtration /Colombia
- performance testing of existing SSF plants/Cameroon
- development of small prefabricated filters/India
- (horizontal roughing filtration/Tanzania)

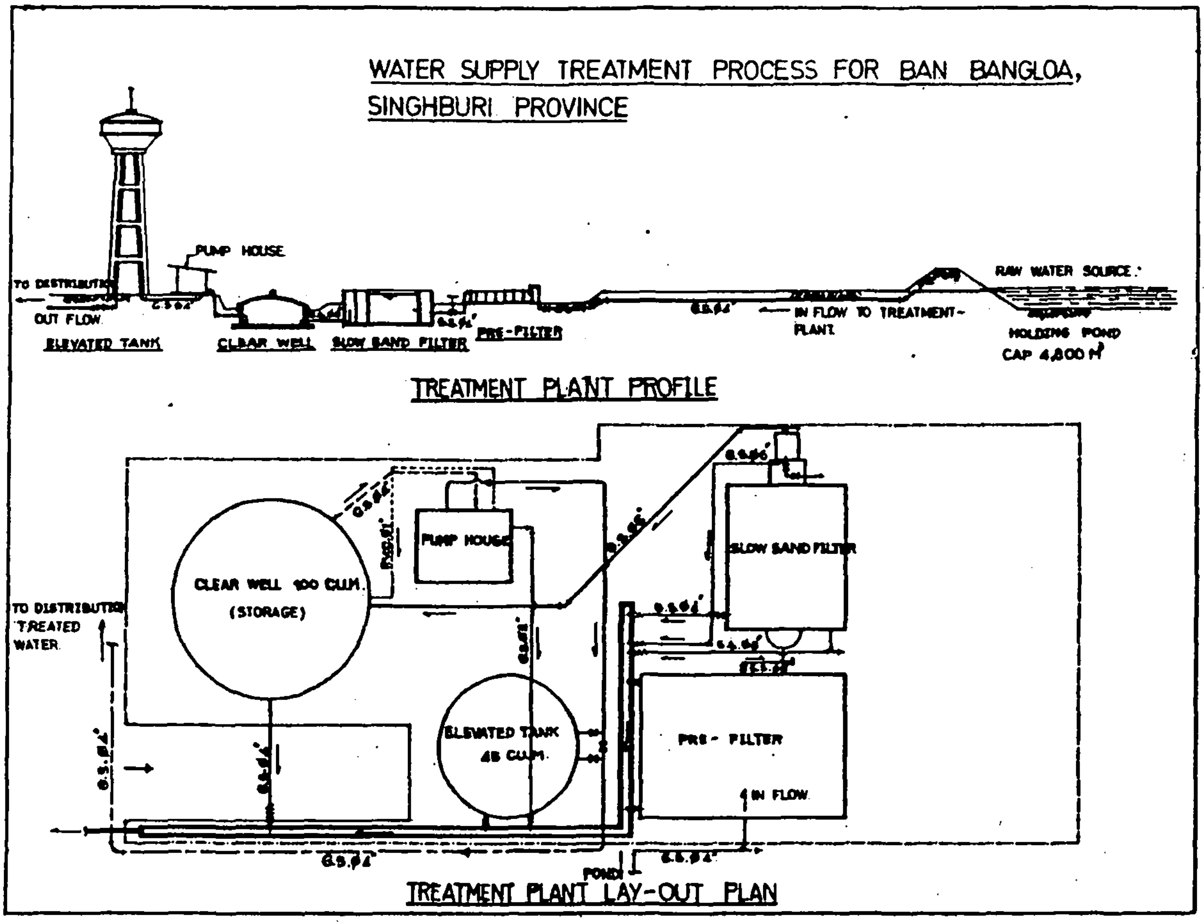
Following this rather extensive introduction on the slow sand filtration project I now like to discuss with you a number of interesting features of the projects executed. I will concentrate on the results of phase II as these from a practical point of view are the most interesting. As Mr. Paramasivam in the next introduction will brief you in detail on the Indian achievements in the various research activities executed by the National Environmental Engineering Research Instiute and in the actual application of SSF in the four village demonstration plants, I will deal only very superfcially with the SSF project in India.

2. Design and Construction

The most essential information required for the planning and design of rural water supply schemes concerns the level of service and the size of the population to be served. The executing water agency should, in consultation with the community, decide upon the level of service. This will include decisions on the number and siting of standposts, the number of house connections and the quantity of water supplied per person per day. Population figures can be retrieved from the available national census data. However, care should be taken with regard to the general reliability of the census and it is also worthwhile to check whether the population covered by the village name in the census is the same as the population and area, that will be served by the new system. If doubts remain, the engineering department should try to gather its own data in order to avoid designing a plant which is out of tune with the requirements of the community. Since most rural communities do not comprise more than 5,000 people, this data gathering exercise is usually quite feasible.

The daily output of the plant can now be determined from the data collected. Additional information on the growth-rate of the community and the expected rise in water requirements for drinking and economic purposes (farming, watering of cattle), can be combined with the present demand in order to obtain an estimate of the future drinking water requirements of the community.

As there is little economy of scale in the design of a slow sand filter, there is little to be gained by increasing the size of a filter in order to provide service over a longer time into the future. Moreover in developing countries where governments have to be extremely thrifty and where capital is scarce, it is only sensible to reduce the initial investment in water works and so minimize the amount of money tied up in yet unused capacity.



If a design period of 10-15 years against one of 20-30 years can be adopted, the initial investment and consequently the interests due will be reduced thus allowing drinking water agencies to spread their funds more thinly and provide more communities with a SSF-water supply. It should be noted here however, that it is usually necessary to design the other elements of the water supply scheme for a design period of 20-30 years, while also the lay-out of the plant should allow for future expansion. The construction of an additional slow sand filter is fairly simple and can easily be incorporated at the end of the 10-15 year period, assuming of course that the increased drinking water consumption by the community justifies this course of action.

During the planning phase of the water treatment plant sufficient attention should be given to introduce such elements in the final design as to ensure safe and uninterrupted operation of the system. Hence at least two filter units should be provided. In this case, when one filter is taken out of service for cleaning purposes, the other filter will still be running at an acceptable filtration rate of 0.2 m/hr (i.e. twice the normal design rate of 0.1 m/hr).

As indicated earlier 14 demonstration plants have been constructed in the context of the SSF-project. They serve present populations ranging from 1000-15.000 inhabitants, with a daily quota between 45-150 liters per head. The construction of the headworks, filters, storage reservoirs etc. has been executed by contractors and skilled labourers hired for the job. Unskilled work such as trench digging and excavations as well as locally available building materials were usually provided free by the community as part of their contribution to the project.

Special features

The underdrains of the plant at Kamayagoundanpatti (India) consist of a system of PVC pipe manifold and laterals with locally developed permeable capsules which are placed at 1.0 m c/c and topped with a thin layer of pea gravel. This type of underdrain has been found to be effective and cheaper than the conventional ones.
In general hard broken stone, which is more readily available and cheaper than rounded pebbles, has been used as supporting gravel layers.

As is more or less common in Latin American the treatment plant in Alto de los Idolos/Colombia included two upflow slow sand filters. This has operational advantages since cleaning of the filters can very easily be achieved by reversing the flow and allowing the supernatant to rapidly drain to waste. Although the efficiency of the filters was more than 80% in reducing the M.P.N. index of total coliforum in 3 out of the 4 samples collescted, the bacteriological quality was not satisfactory. It was therefore decided to adapt one of the two filters into a downflow slow sand filter and make a comparative study of the operational and bacteriological performance of up-flow and down-flow slow sand filtration. The programme of investigations will comprise the monthly monitoring of pH, temperature, turbidity, color, iron and E.Coli at the inlet and the outlet of the filters. The research programme will last one year, starting from June 1981.

Preliminary results indicate that the performance of the downflow filter is markedly better than that of the upflow filter. Bacteriological efficiency of the downflow filter ranges from 85-95%, while turbidity and color are usually reduced below 1 unit and iron below 0.1 mg/l. The upflow filter presently seems not capable of removing more than 80-90% of bacteriological pollution. The physico-chemical efficiency is also considerably lower than the downflow filter.

However the limited number of, especially bacteriological, samples taken does not yet allow for firm statements with regard to the performance of either type of filtration.

Photo 2 Promoter checking for chlorine content
Alto de los Idolos, Colombia

3. Operation and Maintenance

The most effective way to operate a slow sand filter is to run it for 24 hours a day. Applying that mode of operation ensures an effluent quality of excellent hygienic standards. However, if that is not possible, the only alternative which is then acceptable is declining rate filtration. This specific mode of operation can be applied to bridge the gap between shifts of full-scale operation of the filter.

> At the end of a shift the operator closes the inlet valve but the filtration regulating valve is kept in the normal position. The supernatant water will drain through the filter at a continuously declining rate, in that way still producing filtered water even though the operator is absent. Operating the filters at declining rate requires a larger filterbed area than continuous operation but is sometimes necessary in case of intermittent power supplies, or to reduce the cost of fuel and operator's wages. The effluent quality of filters which between shifts are operated at declining rate, is quite acceptable and only a slight deterioration of the overall bacteriological performance of the filters can be noted.
> A refinement of this technique can be applied in treatment plants where the pumping capacity is higher than required. Instead of throttling the pumps it can be considered to allow the supernatant to rise 10 to 15 cm above the design raw water level, then cut the pumps and allow filtration to take place till about 10-15 cm below design raw water level (2-3 hrs). Subsequently the pumps are started again and the process is repeated. Such a mode of operation can reduce actual running time of pumps by well over 50% and thus leads to a considerable reduction in the cost of fuel. The slight variation of filtration velocity is not likely to have a lot of influence on the effluent quality.

Intermittent operation should not be allowed since it has been shown conclusively that an unacceptable breakthrough of bacteriological pollution occurs 4-5 hours after restarting the filters.

Two main features of the slow sand filtration are the relatively easy operation and the considerable improvement of physical and bacteriological characteristics of the raw water treated. Ease of operation very much depends on proper design and construction, while the efficiency of the purification process fully depends on the time allowed for the development of the filterskin and the bacteriological flora. Temperature and raw water quality determine to a great extent, the period required for so-called ripening. This period may range from several weeks to a few months. Since ripening may take quite some time, it is evident that proper chlorination has to be applied in those cases when public demand forces the waterworks authorities to supply water from the plant, before ripening is completed.

Under normal operating conditions, the filtration rate will be kept as constant as possible. However, due to clogging, the resistance of the filterbed gradually increases and therefore, the operator has to compensate for that by opening the valve regulating the filter velocity a little bit every day. When the regulating valve has been fully opened and the rate of flow starts to decrease the filter has to be taken out of service for cleaning.
Depending on the seasonal variation of the raw water quality, especially with reference to turbidity, the interval between consecutive cleaning operations may vary between 60 and 90 days.

Cleaning of the filterbed is accomplished by draining the supernatant water and scraping the top 1-2 cms of the bed.
After cleaning, the filter has to be refilled with water. This process, called backfilling, has to be done from the bottom up in order to drive out the air bubbles which have been introduced during the cleaning exercise. In the absence of a overhead storage tank, backfilling may well be realized by using filtered water from the adjacent filter. If this method of operation leads to a temporarily reduced output of the plant, the population should be informed in advance about the reduced supply.

When the filter is put back into service, a period of at least 24 hours is required to allow for re-ripening of the bed. After that period, the bacteriological flora has sufficiently re-established itself to be able to produce safe effluent which can then be put back into the supply. It should be noted here that in the cooler areas in the tropics (e.g. mountains), this ripening period might have to be extended to a few days.

Furthermore in order to enhance the simplicity, reliability and cost-effectiveness of the overall-treatment system, the possibilities for gravity flow should be exploited to the maximum. A gravity system allows filtration to take place continuously. This is the optimum mode of slow sand filter operation; it also leads to a considerable increase in reliability, since there are no pumps required which may break down or not run at all because of lack of fuel or power. Even if only a partial gravity system can be designed, preference should be given to such a design over that of a fully-pumped system.

> At Ban Thadindam/Thailand the raw water is taken from an imponded spring. The Slow Sand Filter is constructed on a slope providing sufficient head to supply the consumers by gravity without the need for pumping. The operator of this plant has shown very poor attention to his work because he complained that the salary paid to him is too low. Most of his time, he spends outside the village working on his farm. In spite of this, his absence does not trouble the villagers since the water is supplied by gravity and the system has automatically continued to function adequately in quantity and quality. This is a very ideal situation for a village water supply.

4. Pre-treatment

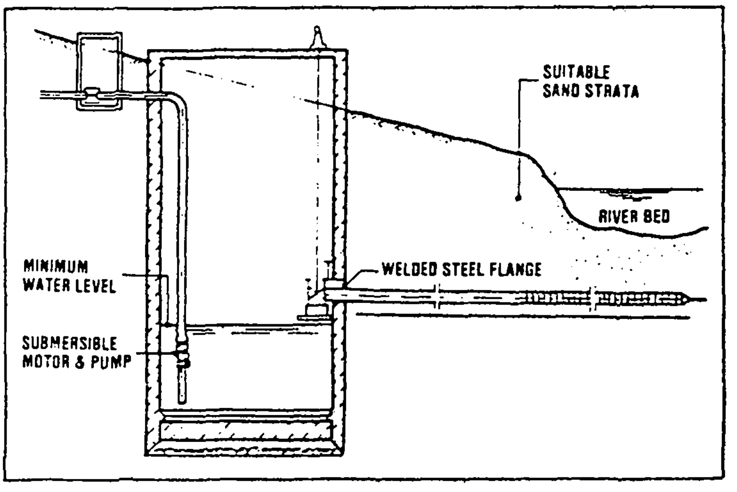
The most important drawback of the slow sand filtration process is its vulnerability toward excessive turbidity. Raw waters with turbidity values of 50 NTU or more for periods of a few weeks cause rapid clogging of the slow sand filters. From an operational point of view the frequent cleaning activities and thus reduced output which are caused by high turbidities are not acceptable. Pre-treatment can then offer a solution. Various types of pre-treatment have been used in the demonstration plants of the SSF-projects.

Irrigation-canals and storage reservoirs.

In Haryana/India, Rahad/Sudan and Ban Bangloa/Thailand water is abstracted from irrigation canals. The low velocity of the canals obviously led already to a settling of suspended particles. For management reasons the irrigation authorities usually close down the canals for a period of four to six weeks each year. Thus in addition the water supply schemes needed a storage reservoir with sufficient capacity to cover the no-intake period. In Abub Shahar/Haryana this system is functioning quite well with turbidities of the raw (irrigation) water between 0.3-7.4 NTU and after storage (before filtration) between 0.2 and 1.5 NTU.

Riverbed filtration

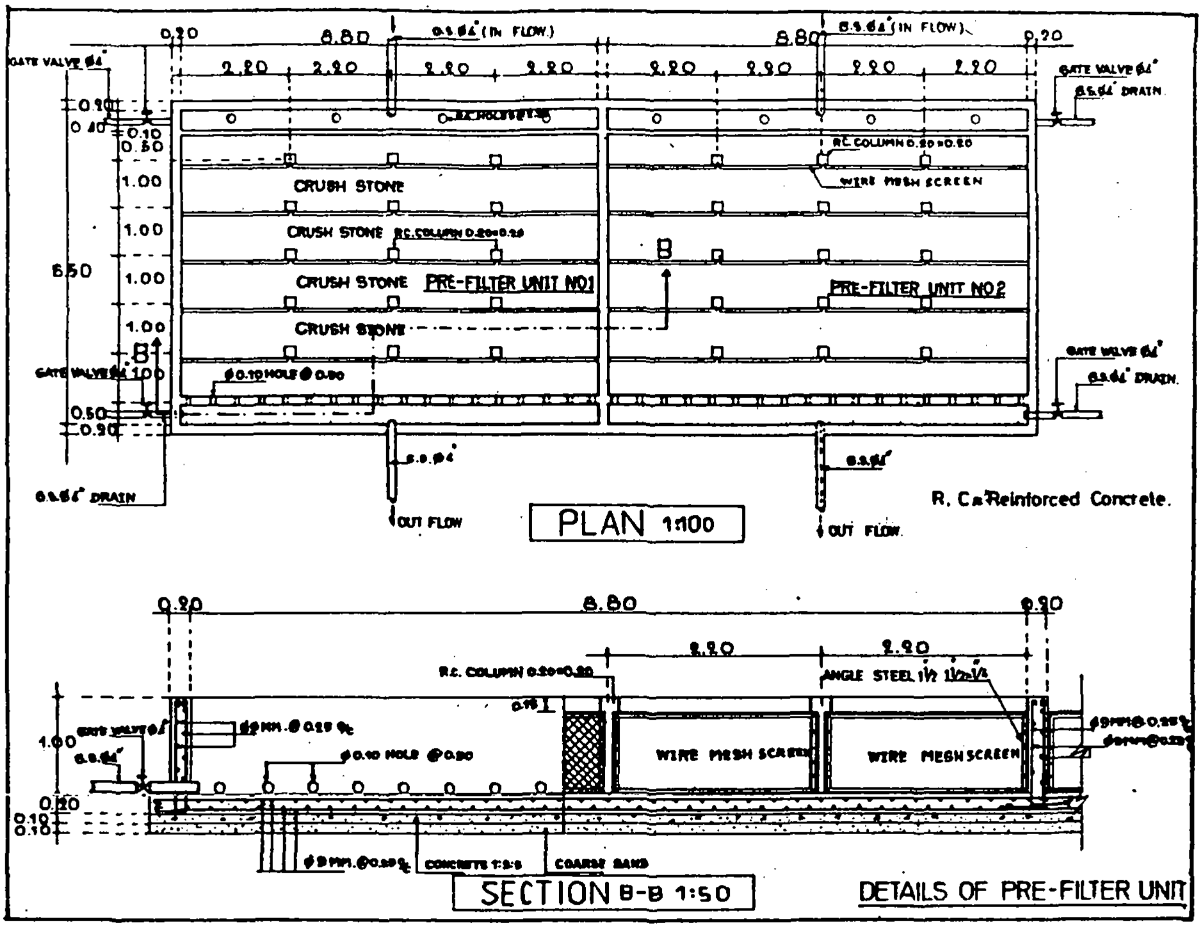
A very effective means of pre-treatment has been applied in Borujwada/India. Riverbed filtration reduces turbidities of the raw water ranging between 2.4 and 440 NTU to 0.35 and 3.5 NTU after pre-filtration (1980).



Riverbed filtration

Horizontal-flow coarse-material prefiltration

Horizontal flow prefiltration may be carried out in a rectangular box similar to a basin used for plain sedimentation. The raw water inlet is situated at one side of the box, the outlet at the opposite side. In the main direction of flow the water passes through various layers of graded coarse material (in the sequence coarse-fine-coarse). The vertical depth of the filter bed may be designed at about 1m (range 0.8-1.5m) and suitable filtration rates are in the range of 0.4-1 m/h (horizontal flow). The total length of the filter bed, run through by the water, may vary between 4 and 10 metres. A typical lay-out of a horizontal flow prefiltration unit is given on the next page.



The experimental results from laboratory investigations executed at AIT show that these pre-filtration units, after a maturation period of a few weeks, are quite suitable to remove part of the suspended matter of raw waters having a turbidity content up to about 150 NTU. Turbidity removal of 60-70% is reported. This type of filtration has been applied in two of the Thai demonstration plants. Unfortunately the results of the field investigations that were executed by AIT have not yet reached the author. A full report is however to be published within a few months.

The University of Dar es Salaam in Tanzania has started a slow sand filter research project in which this type of pre-filtration is one of the major research topics. Two interesting reports have been published so far. Results are however in my opinion not yet sufficiently consolidated to make firm statements of the efficiency of the pre-filtration. But progress is promising and field testing is envisaged in the SSF-plants of Handeni, Tabora and Wanging' Ombe.

5. Financial implications

Capital investment and running expenditures should be considered together when deciding what the financial implications are of a choice between slow sand filtration and rapid filtration.

Financial departments of governments and international donor agencies, of old, have only looked at the initial investment since that for them was the most direct burden on their budget. Over the last few years it is more and more being recognised that operation and maintenance are vital to continued running of the systems already installed. Budget experts are now starting to point out that the cost of operation and maintenance is growing so rapidly that government budgets will not be able to support the upkeep of the existing and future systems since these would absorb too much of the national budget. This situation calls for action. Governments should support promotional activities of water supply agencies to charge fair and payable water rates from their consumers and also urge them to design those systems for which the total economic and social cost (cost of capital investment and running expenditures) is minimal.

In this respect slow sand filtration can play an important role. Its capital outlay may be slightly higher than conventional treatment systems but running cost are a lot lower. Furthermore, its simplicity of operation and maintenance adds to the reliability of the system, and so ensures that the consumers are always provided with a good quality water.

Calculations in Thailand indicate that the break-even point for slow or rapid filtration is reached after about 8 years (1980). After 8 years slow sand filtration becomes the cheaper option.

Up to 2 mld the cost of construction of slow and rapid filters in India (1978-1980) was comparable. Added to the fact that operation and maintenance costs for a slow sand filter are always lower than that of a rapid sand filter plant, the logical conclusion must be that slow sand filters are economical upto a population of about 50,000 (a plant of 2.5 mld to provide a per capita supply of 50 lpd). It can be seen from the population census of India that this population size covers almost the entire rural communities and nearly 90 per cent of towns in the country.

6. Community Participation

The availability of sufficient and safe water is a basic human right, which at present is still only a privilege of a minority of the people living in rural areas and urban fringes of developing countries. In many countries therefore communities are required to assist the responsible water supply agencies with the construction and operation of the water supply scheme. This type of participation is often initiated or stimulated by the agencies in order to reduce the cost of (unskilled) labour and building material while furthermore a lesser initial cash investment from the agency is required through a community contribution. This then should make it possible to serve more communities with the limited funds available.

This approach has also been used in the various SSF country projects. However in several cases the project committees have tried to go beyond the above described agency-oriented approach and create a more genuine community involvement also in the planning, maintenance and management. And rightly so, because it should be recognized that the community has a right to participate in decision making with regard to any aspect of the new scheme. Certainly, engineering and financial conditions may restrict the number of alternatives that can be offered to the community but users have a legitimate interest both in the reasons for major choices and in more detailed questions such as the siting and number of standposts. Planning in consultation with the community will result in a service which meets the needs of the users more closely and which will therefore be better appreciated, more carefully used, and protected against vandalism and other negative attitutes.

The following steps are usually found in the Community Participation process:

- application for the installation of a water supply scheme by a community (Harambee villages/Kenya) or identification (and promotion) by the agency which leads to a formal application by the community (Colombia).

- sanitary, engineering and socio-economic survey by the water supply agency. In the context of the SSF-project a baseline survey was executed by the health agency participating in the project (ref. health education).
- consultation with the community about the water supply scheme, setting up of a water committee discussion of the baseline survey results (Jamaica) and the directions derived therefrom with regard to the health education programme.
- signing of a contract between the community and the agency for the construction of the scheme. The contract lays down the responsibilities of the agency and the community with reference to cash, loans, materials and labour to be provided.
- transfer of the management of the scheme to the local water committee with continued supervision and maintenance assistance from the water agency.

An example of this sequence of steps is given here for the projects started by the Instituto Nacional de Salud (National Institute for Health) in Colombia which in principle is responsible for water and sanitation projects in rural communities with less than 2500 inhabitants. This institute (I.N.S.) employs special promotors who are trained in community mobilisation etc. to stimulate the community involvement.

> After the preliminary project allocation the technical and socio-economic feasibility is determined. The socio-economic study includes existing environmental sanitaiton conditions and willingness and capacity of the households to contribute of the project. The preliminary design, including estimated construction costs in cash and kind for user households and estimated user rates, is presented to a users' assembly. For the construction of the water supply scheme a contract is made up between the junta de acción comunal (JAC), an elected community development committee which acts as the local representative of the community, and I.N.S. This contract is countersigned by all heads of households participating in the scheme.
>
> All unskilled labour and local materials are donated by the future users. They also pay part of the construction costs, in the form of a community loan and sometimes a household deposit. The terms of the loan depend on the economic conditions as

apparent from the socio-economic study. The value of local contributions to construction can vary from 5% to over 25% of the costs, depending on the type of works. The loan is paid back from the user rates. There are great differences between the communities in the size of the household contribution in cash and kind.

In general, users pay a flat rate. This rate covers operation and maintenance costs, loan repayment and reserves. When the promotor finds a great variation in capacity to contribute he may propose a weighted rate. This is still rare, however. The major constraint is the identification of valid and acceptable indicators of payment capacity.

Voluntary labour is only given by user households. Each household sends one adult member on a fixed day of the week. This facilitates a smooth labour organization and limits the negative effect of labour withdrawal from local agriculture.

Once completed the system is managed by an administrative committee. This consists of a member of the JAC, a user representative and an I.N.S. promotor. The continued I.N.S. supervision is a condition for a successful management. A better coverage by the mobile promotors and better training of the committees must lead to a better administration, especially with regard to rate payment.

The project in Thailand ran along similar lines. In Jamaica, however, the potential for participation in the construction, operation and maintenance and management was very limited for a number of reasons:

- The supply of drinking water has always been a government service, for which the user pays taxes and rates.
- The communities within the parishes (districts) are no real units in an administrative or social sense. Migration to urban areas and abroad is high. This affects the feelings of togetherness and the availability of voluntary labour.
- The unions are strong and would certainly object against voluntary labour in construction and operation and maitenance.

However, through the efforts of the health education bureau in Jamaica the local health committee in St. James was resuscitated. Meetings of the committee with the water agency and the health education bureau led to an increased awareness of the health and access benefits of the water supply scheme. This in turn resulted in a large number of applications for a house connection which managementwise is very beneficial to the water agency.

A few positive effects of the participation programme need still to be mentioned.

- The little extra money left over after payment of loans and operating expenditures has in Alto de los Idolos over the last two years resulted in the construction of an office/store for the water committee, the protection of the intake through an afforestation programme and the provision of a loan for the rebuilding of a local primary school. New developments which the community was not able to undertake before the water supply scheme was constructed.
- Similar effects have been noted in Ban Bangloa/Thailand where the profits of the water supply were to be used for the setting up of an agricultural cooperative.

7. Health Education

Before a start was made with the health education programmes a baseline (health) survey was executed in the project villages. This survey was used to draw up a syllabus of topics and habits which needed to be discussed during the health education sessions with the community.

The impression exists that during the health education programmes executed during the SSF-project the top-down teaching method was used more widely than the dialogue.

However, in the area of health education, the aim is to bring about voluntary changes in practices. People must feel that it is in their own interest to change. This implies not only that it is useless just to tell people to change, but that in explaining why it is in their interest the community worker must be thoroughly familiar with the problems faced by the people. Communication from the people to the community workers, as well as in the other direction, is essential. The best way of providing a continuous two-way communication is through community participation in the process of education itself. This provides for a constant interaction in which information retarding problems and ideas about solutions pass in both directions. It can also have the effect that the example and influence of some community members and the authority of the community as a whole may be brought to bear on the actions of all. When people decide together to adopt a change, there is a good chance that they will do so successfully.

The likelihood of achieving a significant effect on health practices through community participation can be expected to be much greater if the community has also participated in the planning and installation of the water supply. It will be possible to develop a greater interest and deeper understanding of both clean water and of the complementary behavior changes which are required for the prevention of water related diseases.

In most of the programmes the emphasis was on films and other audio-visual means. In addition, in Kenya for instance, community meetings were organised to discuss the educational topics. Consultations were further held with opinion leaders and women's groups. Through posters, folk songs and health education teaching at schools in the project area further discussions were stimulated.

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EXPERIENCES IN COMMUNITY EDUCATION AND PARTICIPATION (CEP) IN WATER SUPPLY AND SANITATION PROGRAMME - by Dr P V R C Panicker, Mrs A S Gadkari, M W Joshi and A V Talkhande, National Environmental Engineering Research Institute, Nagpur-440020, India.

Introduction

It is generally agreed that community education and participation is essential to the long term success of water supply and sanitation facilities. The socio-economic, cultural and political conditions in different areas within the country (like India) and from country to country may vary, and therefore the experiences in field-work will also vary. In India, NEERI has pioneered an integrated rural development programme in a few villages around Nagpur. NEERI has also introduced Slow Sand Filtration demonstration plants in four states of India, in collaboration with IRC (Netherlands). Experiences gained during the introduction of water and sanitation in these projects are presented in this paper.

Community Education

Drinking water supply through slow sand filter plants was introduced in Abub Shahar (Haryana), Borujwada (Maharashtra), Kamayagoundanpatti (Tamil Nadu) and Pothunuru (Andhra Pradesh) by NEERI through state PHE Departments with financial aid from WHO-IRC. Community education and participation activities were intended to prepare the community for effective utilization of improved water supply and sanitation facilities and were developed in close cooperation with CHEB, New Delhi, as well as with the state health education bureaus of the four participating states. A uniform methodology was followed in all the project villages, except for some minor changes to suit the local conditions and needs.

Educational diagnosis

To diagnose the educational needs of the community and to prepare an appropriate design and implementation strategy for the field delivery system, the following information was collected through personal interviews with members of the community:

(a) general information of the village, with reference to socio-economic, cultural and political aspects;

(b) demographic information of families, existing facilities for water and sanitation, their knowledge, attitude and practice (KAP) of these systems, the problems faced and the various diseases associated.

The awareness of personal hygiene and clean environment was poor in most of the households. Most of them expressed the need to have a better system of water supply in their village so that it would add to their convenience. Only a few realised that the new system of treatment through slow sand filters, would be much safer than the one existing. The role of drinking water in the transmission of some communicable diseases was known only to the educated few. The communities, in general, did not fully avail of the benefit of immunization programmes, since many of them did not realise that vaccination would benefit them.

For drinking water, a number of sources were in use in these villages. Dung wells, hand-pump tube wells and also river water were used and the people were not conscious of the quality.

Sanitary conditions in these villages were also very unsatisfactory. Open surface drains existed (though partially) in two villages. Open-field defecation was the common practice in all the villages, except in the case of a few families who had latrines in their premises. Composting of garbage and dung was done in two villages, though the process was not scientifically followed.

Education Strategy

Based on these findings, community education strategy was formulated and implemented through committees at various levels. Training of the community health workers and leaders (formal and informal) was conducted to prepare them to undertake the field work in educating the community. They were expected to organise meetings and deliver information on various aspects of health and disease, water supply, personal hygiene, environmental sanitation etc, at the grass-root level.

The educational activities comprised of mass meetings, group meetings, individual contacts, visits of doctors, exhibitions, medical examination of school children, display of posters and short slogans screening movie films, immunization campaign and technical demonstrations supported by a number of educational aids.

Results

After the introduction of educational activities into the community, changes noticed were remarkable. During evaluation, it was found that the communities in all the four villages have accepted the treated water from SSF plants. They use only tap water for cooking and drinking purposes. The drinking water was stored in clean earthen or metalware, depending on the economic status of the family.

The inputs in health education has also improved the hygienic habits of the people. Information and communication methods have shown a favourable change in knowledge, attitude and practice of the people. This was apparent from the increase in construction of latrines, compost pits, soakage pits, biogas plants and taking house-connections for safe water supply, in all the four villages.

The village Borujwada, has shown much more improvements than the other villages, due to more inputs by way of the integrated development programme which was started in 1975. In this village, the community has accepted and is satisfied with the quality of treated water from SSF plant and uses only tap water for cooking and drinking. With the result, the rope which was used earlier to draw water from the traditional well is now being used for other purposes. Only a few people go to river for washing clothes and bathing.

The drinking water was found stored in clean earthen or metalware, depending on the economic condition of the family. These containers were also found well covered, and a tumbler with a long handle was kept separately for taking out water for drinking in almost every family. The fact that all the 25 samples of water collected on different occasions from the storage vessels of individual households, selected at random, were negative to E.coli is a clear indication of good domestic hygiene. In a large measure, this can be attributed to the impact of educational inputs on the community.

Latrines have been constructed and have been in use during the last two years, in every family. Improvement was also noticed in the status of personal hygiene of adults and children. In addition to the above, there was an appreciable change in the knowledge of the community regarding water-borne and water related diseases, with reference to the base-line data.

Except for a few cases of diarrhoea and dysentery, incidence of cholera, typhoid and jaundice were not reported from this village after the SSF plant has been put into operation.

A resurvey of the population for enteric parasitoses and anaemia (by stool and blood examination) has revealed that the prevalence of parasitic infection has come down to 54 per cent (1981) as against 70 per cent in 1975. Similarly an appreciable improvement has been found in haemoglobin level also. Anaemia was detected in 74 per cent of the population in 1975, whereas in 1981 only 44 per cent were anaemic.

A definite improvement has also been noticed in the environmental conditions in the village Borujwada. Patches of night-soil and the faecal stench of the days of open-field defecation no longer exist in this village - a testimony of the acceptance and use of latrines by the community.

A good number of soakpits are working in the village to take care of wastewater from houses and public stand posts. Refuse and dung are composted in pits. A biogas plant has also been put up recently in one of the houses. Street lights have been installed in the entire village. Many families have taken house connections for electricity and from water distribution system. A flour-mill and a fodder-cutting plant run on electricity, have also been installed in the village.

All these ultimately point out a real awakening of the community of the village Borujwada as a whole, to improve their conditions of living in a better environment. And this awakening has been the result of various inputs into the village over a long period in general, and a sustained effort of community education in particular.

Community Participation

In all the four project villages the communities participated in a number of ways. Education activities were conducted with the full involvement of the formal and informal leaders of the community.

Meeting a part of the total expenditure of the treatment plant by the community is considered a good form of their participation. In Abubshahar an amount of Rs.20,000 was raised by the community for this purpose. Similarly in Kamayagoundanpatti, Rs.361,000 was taken on loan from LIC by the local body to partly meet the expenditure.

In Borujwada, the land required for the construction of SSF plant and the overhead reservoir was readily given by the owners. The community was very much involved during the planning of the project including site selection and location of the stand posts and contributed Rs. 20,000 towards their share of the expenditure on the project. Now, the plant is operated by two persons of the village who were also associated with the construction of the plant right from the beginning. The maintenance and administration of the SSF plant and the distribution system are managed entirely by the village representatives. This has imbibed the feeling of responsibility in the community to properly operate and maintain the plant, in their own interest.

Similarly in the sanitation programme, towards the construction of latrines, the householders have borne the cost of constructing the superstructure with materials of their choice. Manual labour involved in the transportation of building materials and construction was also borne by the individual household.

The research and demonstration project is a unique experiment in multi-disciplinary and inter-agency approach towards a common goal-improvement and protection of public health. To bring about through health education, a favourable attitude and behavioural change in tradition-bound village folk with low level of general education and poor economic conditionsis a slow process. It requires sustained efforts from both the community and service agencies and effective coordination between them. There are also a few constraints which should be recognised. The socio-political makeup of the community has a significant effect on the success of such peripheral activities. Frequent changes in community leadership and government machinery adversely affect such programmes. Health education, though a part of the routine activity of the health staff, is generally not given the priority it deserves. Nonetheless the project has served an important objective of demonstrating a methodology for guided introduction of community education for effective use of protected water supply.

PLANNING CONSIDERATIONS IN RURAL WATER SUPPLY DISTRIBUTION SYSTEMS

by A Raman, Scientist & Head, NEERI Delhi Zonal Laboratory.

Introduction

This paper discusses some of the aspects that require consideration when planning a distribution system component of Rural Water Supply Schemes (RWS). The topics discussed are, the objectives to be set out in planning the distribution systems and the various options available. Community participation and revenue collection aspects are also discussed.

Objectives In Planning

The major objective in planning a village distribution system, should be to ensure convenient distribution of water. This requires that distribution points be close to users and that there is an adequate number to avoid overcrowding. Convenient distribution will save time and labour required for water drawal. It may also promote health, by inducing people to draw more water and use it for personal hygiene.

Other objectives in planning are:

- preserve water quality by preventing back-siphonage into pipelines;
- reduce stagnation of spill-water and sullage;
- reduce wastage and misuse of water; and
- facilitate system management (operation and revenue collection).

Distribution System Options

The options available for village water supply distribution are :

- public stand posts (PSP);
- distribution reservoirs with taps (DR); and
- house connections (HC).

The PSP system does not provide high degree of convenience. It may not be of benefit to health, because quantity of water drawn is restricted and drinking water is liable to contamination during storage.

Distribution reservoirs often involve longer fetching distances than a PSP system and may be less convenient. They are suited only for very small communities.

HC systems give a good degree of convenience. They have greater health promotion potential than PSP systems, because they encourage greater water use and give less chance for post-contamination of water. Also they are better suited for revenue collection. They will generate, however, more sullage, requiring concurrent arrangements for sullage collection and disposal. They also encourage water misuse, e g for gardening and cattle washing.

While HC systems are seen to have several advantages over PSP systems, they cost more because of the increased water demand, longer runs of pipe required to serve all localities (especially when houses are scattered), and the need for sullage drains. In developing countries, cost of individual RWS schemes has to be kept to a minimum so that limited resources available can be used to serve as much of the population as possible. This factor weighs against the general adoption of HC systems and favours the use of PSP system.

The question arises as to why HC system can not be provided on the pipes to be run to the PSP system, as there will no increase in installation costs. The problem here would be one of social acceptance of a privilege, made available only to a section of the village population.

A rational policy in regard to HC and PSP systems for village water supply is as follows:

- provide HC system where pipelength required is only marginally greater than for PSP system, with PSP system limited to poor areas;

- where pipelength required for HC system is significantly greater than for PSP system, then provide PSP system in the first instance. This is done in such manner, that it can be upgraded to the HC system at a later stage. The upgrading could be done when the village is ready to meet the upgrading cost or when national resources improve. It should be stressed, that when HC systems are contemplated, proper sullage collection and disposal arrangement should also be provided.

Design Parameters

Direct pumping into a distribution system is not desirable. The supply to PSP and HC system should be only through an elevated service reservoir located within each village. The reservoir capacity should not be less than 40 per cent of the ultimate daily supply. The reservoir elevation required should not be more than 6-7 m. This presents possibilities for masonry construction of the reservoirs (except floor slab and roof slab) for small villages, such as prefabricating the reservoirs, using reinforced fibre glass or pressed steel.

The distribution system lay-out can be either branched or looped. In village conditions, the former can often be used on its own. The layout should suit requirements for every house that may want a connection in the future, but in order to reduce cost, initial pipe runs should be kept to the minimum serving only the PSP systems and omitting all looping.

Pipe sizes should suit the ultimate requirements. The sizes will be influenced by the peak factor assumed for design and increase in pipe sizes may not increase costs significantly. Hence, an ample peak factor, say 3, should be chosen for village distribution systems.

Pressure provision may not affect costs greatly, but high pressure will cause leakage and wastage. A minimum main pressure of 6 m should suffice in village schemes.

Public Stand Posts

The PSP is the point of contact between water supply technology and the public. Hence, maximum care should go into planning, construction and upkeep. The PSP system has inherent disadvantages already discussed, and planning should aim to minimise them.

Walking distance to the PSP system should be small (not greater than 500 m and preferably only 200 m) and less than to the old village sources. Also their number should be adequate inorder to prevent overcrowding (not less than 1 per 250 persons).

The minimum discharge rate required at a PSP is a matter for rational design. For example a tap serving 125 persons with 40/lpd supply and peak factor of 3, will require a discharge capacity of 11/l pm. Irrespective of design requirements, discharge capacity should not be less than 5/lpm. This poor discharge makes people damage taps, nor should discharge be greater than 15-20/lpm. which will then increase wastage. The tap size and the lead pipe size of the PSP systems should be designed to give the required discharge at the pressure available in the main.

Both, waste-not taps and ordinary screw taps have been used for PSP systems. The former costs more than the latter, and do not seem to have any special advantage, which will be discussed later. Hence, a sturdy, drip-proof screw tap would be sufficient for PSP systems. A stopcock preceding the tap is always desirable.

The PSP structure costs are a small fraction of the total cost of an RWS scheme. There is, therefore, no advantage gained in cutting its cost at the sacrifice of convenience to the users and at the risk of damage. In many villages, PSP system attempts at economizing have often led to breakage of pillars, leaking of pipe-joints, splashing of water outside the platforms, cracking or tilting of platforms due to undermining of foundations by spilt water,and water stagnation in and around the platforms. All this results in great inconvenience to the public.

It is necessary that PSP systems are planned and constructed so as to eliminate these problems. Also, the tap arrangements should suit local customs such as, collection (type of vessel, method of fetching). Special attention is necessary for the removal of spilt water. Wherever possible, it should be led into ponds where it may be used by cattle or led to fields for irrigation crops or into drains. Soakaways should be used only where the soil is permeable. The inconvenience to the public from spilt water can be greatly reduced by locating PSP systems in peripheral streets of villages.

Auxiliary facilities at PSP system for washing clothes, bathing of children, and cattle watering also require consideration. They are desirable, as they help to increase the benefits of the scheme. The auxiliary facilities, however, should be located away from the taps, otherwise it may lead to contamination of the water which is being drawn for domestic use.

Virtues Of Intermittent And Continuous Supply

In India, most RWS schemes are designed for 24 an hour supply with a peak factor of 2-2-5. In practice, however, the water is supplied only intermittently, 2-3 hours in the morning and about the same period in the evening. This practice, is probably the same in many developing countries.

The strongest objection to intermittent supply, is that it presents serious possibilities for pollution through back-siphonage. The danger is particularly serious in house connection systems, because of the difficulty in ensuring proper plumbing of private connections under village conditions.

Intermittent supply has also other objectionable features. It generates overcrowiding at public standposts and restricts water use because of the inconvenience of supply timings. It also restricts auxilary use of public stand posts for such desirable activities, such as childrens bath, washing of clothes and cleaning of utensials.

Intermittent supply will also increase installation cost, as its rational design requires adoption of a higher peak flow factor and a provision for an increase number of standposts. It will also increase operational requirements, because of the need valve operations for at least 4 times a day, whereas a continuous system may require no valve operations. The foregoing points indicate, that intermittent supply is undesirable for RWS schemes and continuous supply seems appropriate.

Two arguments are usually raised, however, against continuous supply in RWS schemes. The first, is that it presents greater possibilities for wastage. It will be discussed later that intermittent supply may itself be a cause of wastage and wastage in continuous supply may not be very difficult to control.

The second argument has been, that, a continuous system presents difficulty in distributing a limited quantity against a higher demand. This difficulty may not be real in PSP schemes unless they have been designed for very low rates of supply. The drawals in these schemes, seldom exceed 25-30 lpd per head. The problem is often one of making the people draw and use more water from the PSP systems so that it may improve health. In HC schemes the difficulty under discussion may indeed arise, but it should be met by an escalating rate structure based on metered supply and not by a proposition which risks health, besides being costly.

Control Of Wastage

Wastage of water has to be controlled, as it means increase in operational cost and shortage of water for the population it serves.

In PSP schemes, some wastage occurs when pots and buckets are being filled, but such wastage will be small and is unavoidable.

More serious wastage occurs at PSP systems under the following situations:

- when taps are left open after the water is drawn. Open taps have been encountered frequently in intermittent systems and they have been found to cause considerable wastage of water towards the end of the supply periods when the drawal reduces;

- when taps are removed altogether. In village conditions, this situation arises not so much due to theft or vandalism as in urban areas, but due to attempts to increase the discharge of PSP system with poor pressure.

Costly waste-not taps have been tried in order to control wastage at village PSP system, but have been ineffective. These taps have to be held by hand while filling the user's containers and this become a bother. The taps are, therefore, very often propped up or wedged so as to remain open continuously which serves no purpose.

Intermittent supply is often thought of as a method for reducing wastage, but the practice as discussed, appears to be one of the causes of wastage. The only effective strategy for waste-control at village PSP system appears to be, to provide continuous supply at adequate pressure thus removing the irritants in the supply and to promote social control over vandalism and wilful wastage.

In rural water supplies with house connections, the problem may be one of misuse of the limited quantity of protected water for gardening and washing of cattle, than of wastage. It is doubtful whether intermittent supply can check such misuse. The effective way may be to meter house connection and have an escalating rate structure which will discourage excess drawal, even with continuous supply.

Revenue Collection

The discussion here, is not concerned with whether to collect water charges in village water supply schemes or how much to collect. It is concerned, with the possible strategies for collection of water charges under different types of distribution systems.

In the PSP system, the suggestions for collecting water charges have been:

- collection at the PSP when any one draws the supply;
- collection as a surcharge or a general tax;
- collection as a separate watercharge from each household.

The first suggestion will not be practical in village conditions (for various reasons, such as need for a guard at each PSP and abuse of position by the guard) and it may not be desirable, as it will restrict water use.

The second suggestion may not be feasible, as levels of general tax in villages are very low and surcharge for the water supply may have to be as much or greater than the basic tax. Also, there is the problem, that general taxes are collected only at yearly intervals. The third suggestion may be practical in a village situation.

With regard to HC system, charging the beneficiaries may not be difficult and the charges could be on a fixed or metered basis. The second alternative is preferable, as it will help to control misuse of water, as discussed earlier.

The main problem in revenue collection in village water supplies is dealing with defaulted payments. In PSP systems, there can be no penal action such as cutting-off supply and in HC systems penal action may not be practical because of the social position of the defaulters. Also, there may be a danger of damage to the system in case of penal actions.

The only way of checking payment default in the village situation, is to exercise social pressure against the defaulters whether they come under HC or PSP systems. Social control can only be effective when water rate collection is enjoined by the local community organisation, rather than a water authority based outside the community.

Community Participation

It accepted that community participation is essential for the successful working of a rural water supply scheme. Community participation is primarily needed in managing the distribution system, forming as it does, the interface between technology and the community.

The community should be consulted at the planning stage, where it will be ascertained whether the PSP system of distribution is acceptable to the people. If the people desire a HC supply, they should be informed of the cost and the final choice should be made with their approval. Community opinion should also be sought on location of standposts and the standpost details. The construction of auxiliary facilities at PSP system should be the community's initiative.

It is at the operation stage that community participation is most important, vis-a-vis, the distribution system. Without such participation, there may be damage to public stand posts, wilful wastage of water and even final failure of the scheme.

It may be best if the operation of the village distribution system is left to the village community, even though operation of the treatment works, pumping stations and transmission mains are retained by the water authority. The devolution suggested, will increase the involvement of the community leaders and motivate them to control wastage and vandalism.

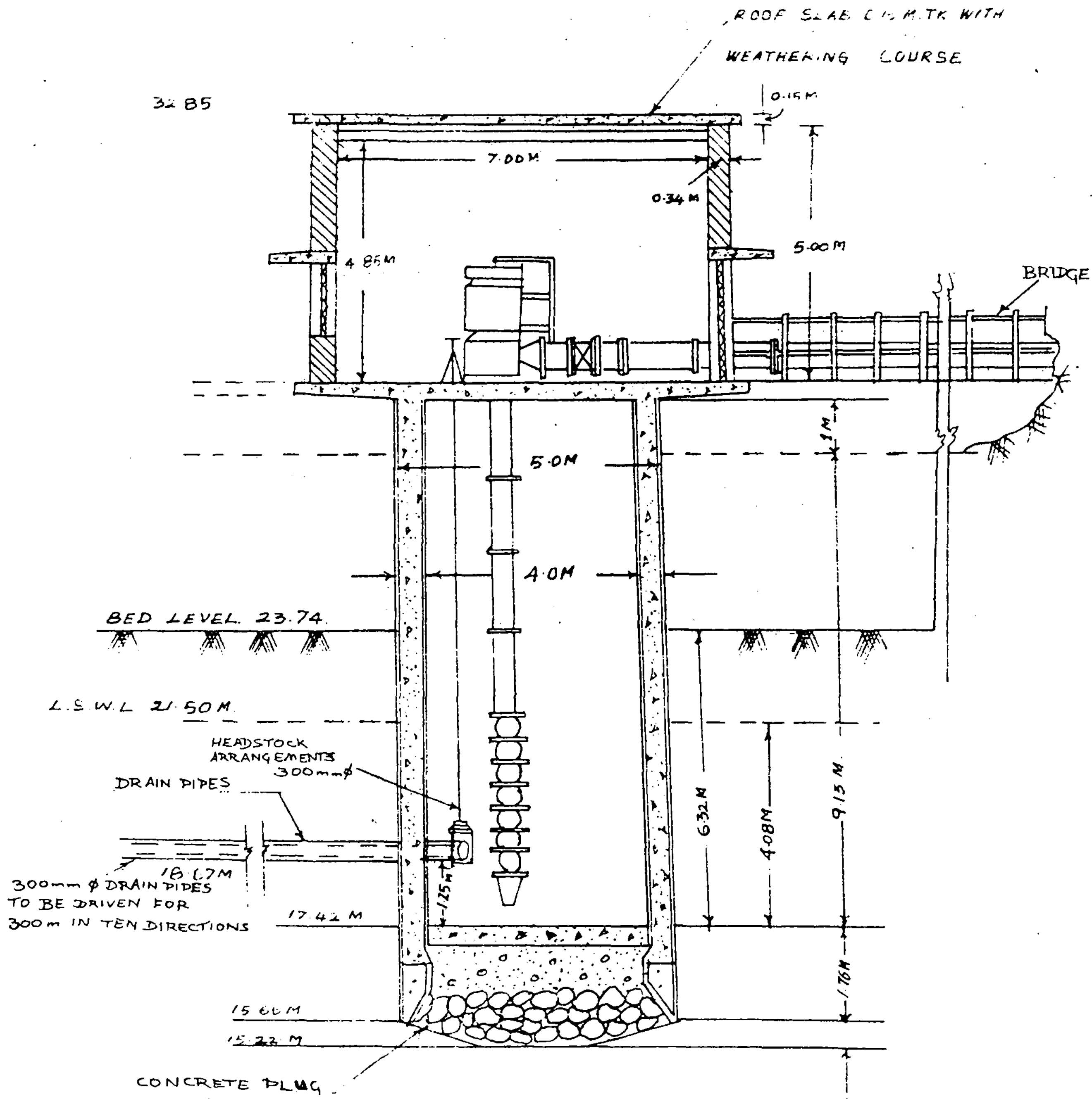
The operational requirement in a village distribution system will be small, particularly when continuous supply is practised. Maintenance will also be small and will consist only of repair of leaky taps, upkeep of PSP structures and attention to spillage disposal arrangements. A caretaker nominated by the community, should cary out these jobs without much effort with minimal training. As regards collection of water charges, without community involvement it may not be possible to deal with defaulted payments.

Conclusions

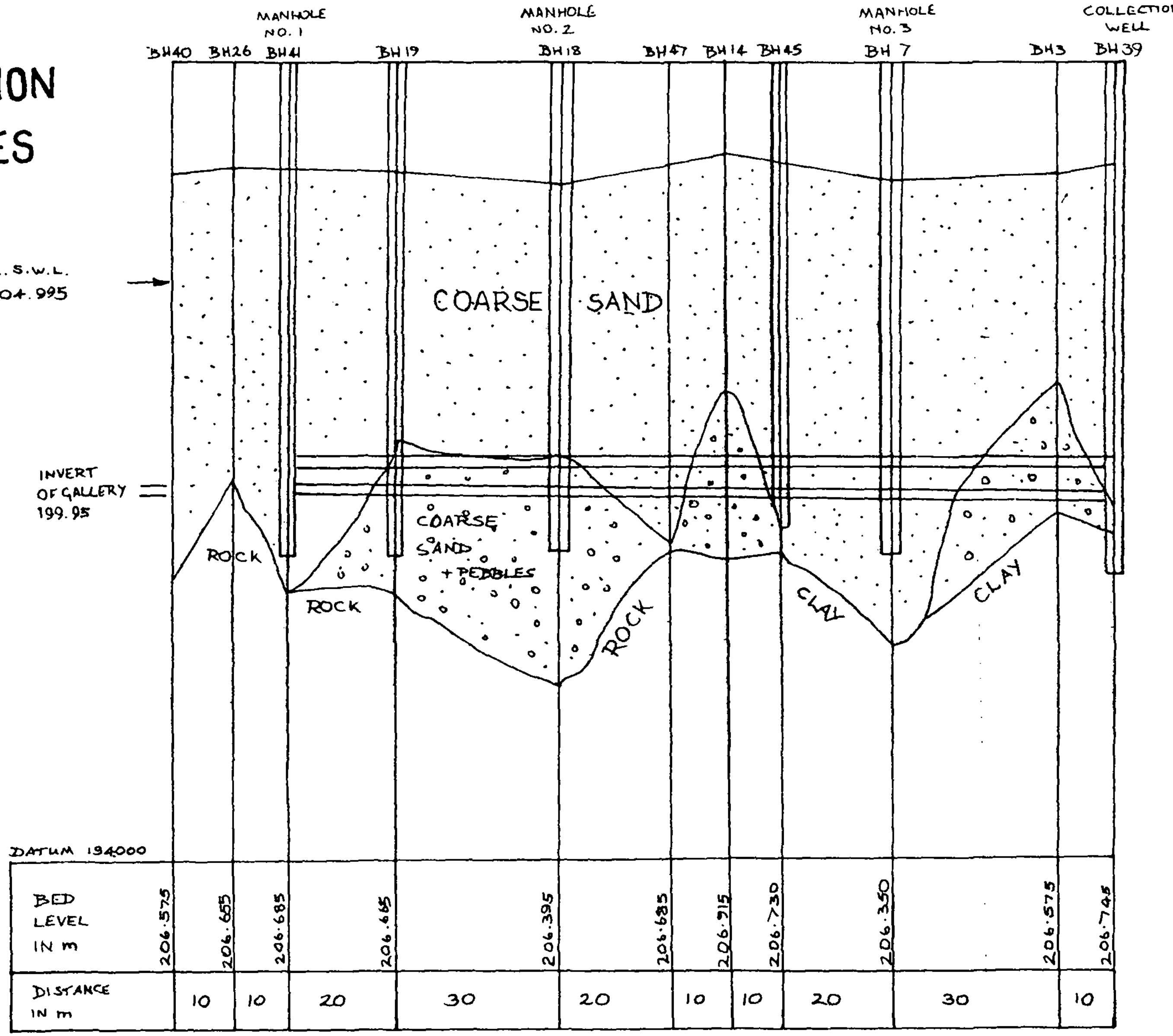
The paper has discussed some aspects that have to be considered when planning village water supply distribution systems. The discussion is based on the community response to village water supply schemes observed in the north-west regions of India. It is concluded that community response will depend on social, economic and cultural characteristics and will vary from community to community.

Some of the aspects delt with in this paper, demand detailed field studies. One important field for further study, would be the advantages of intermittent and continuous supply in village situations. Another would be the virtues of PSP and HC systems. Further study is also necessary on field performance of different types of taps and different approaches to system maintenance.

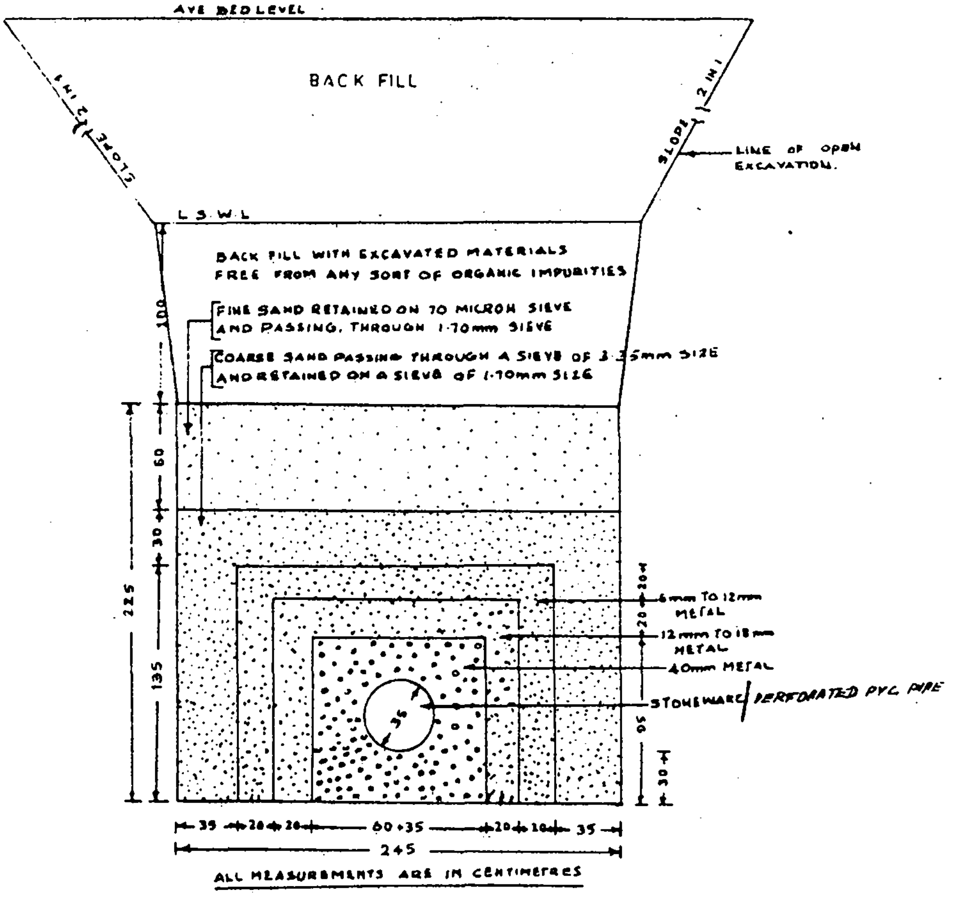
SECTION OF COLLECTOR WELL



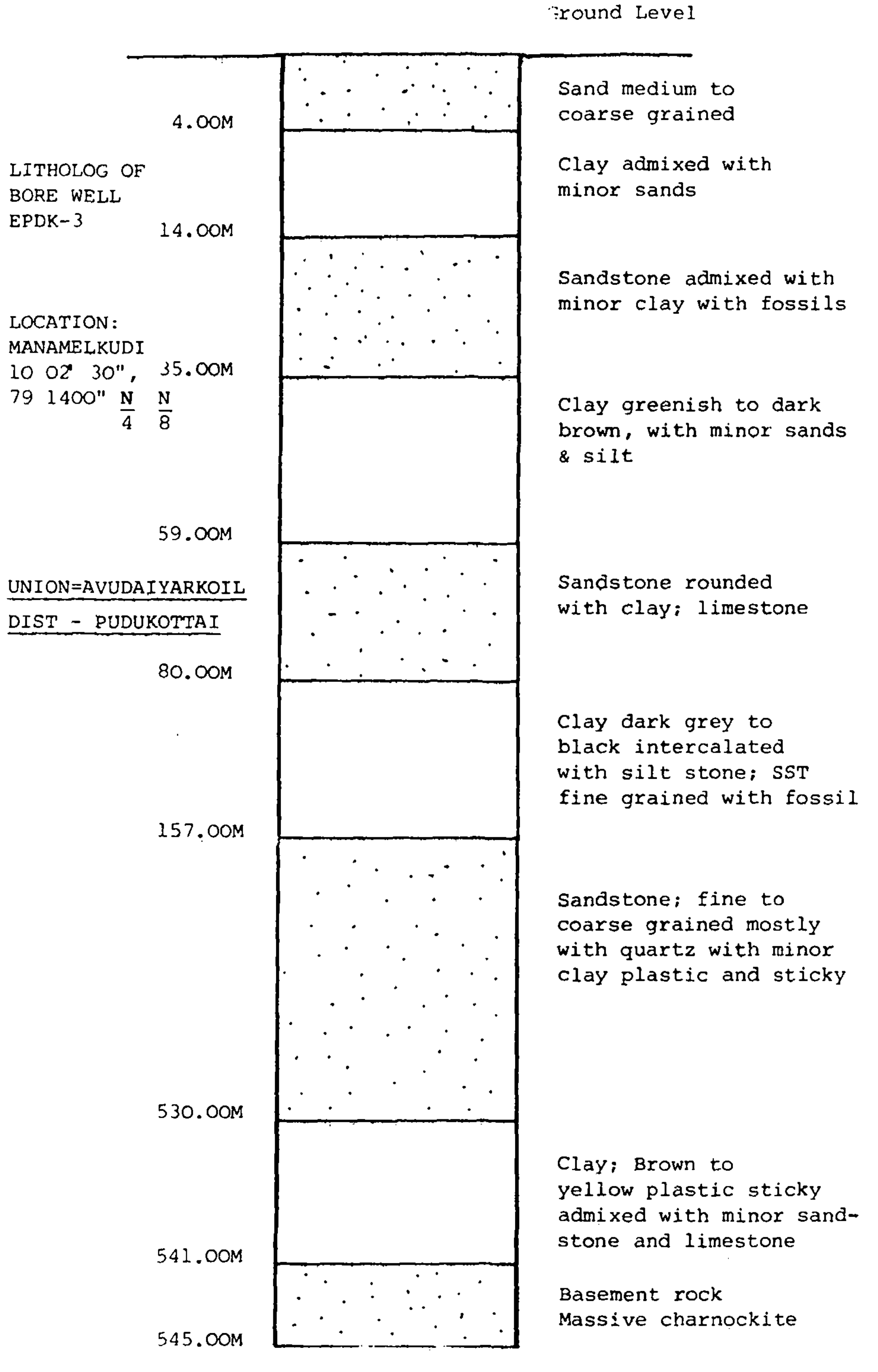
LONG SECTION OF BOREHOLES



SCALE: HOR 1cm = 10m
VERT 1cm = 1m



A TYPICAL SECTION OF AN INFILTRATION GALLERY


Ground Level
LITHOLOG OF
BORE WELL
EPDK-3
LOCATION:
MANAMELKUDI
10 02' 30",
79 1400" N/4 N/8
UNION=AVUDAIYARKOIL
DIST - PUDUKOTTAI
4.00M
14.00M
35.00M
59.00M
80.00M
157.00M
530.00M
541.00M
545.00M
Sand medium to coarse grained
Clay admixed with minor sands
Sandstone admixed with minor clay with fossils
Clay greenish to dark brown, with minor sands & silt
Sandstone rounded with clay; limestone
Clay dark grey to black intercalated with silt stone; SST fine grained with fossil
Sandstone; fine to coarse grained mostly with quartz with minor clay plastic and sticky
Clay; Brown to yellow plastic sticky admixed with minor sand-stone and limestone
Basement rock
Massive charnockite

GROUND WATER EXTRACTION AND SUPPLY THROUGH TUBE WELLS, RADIAL COLLECTOR WELLS AND INFILTRATION GALLERIES INCLUDING CASE STUDIES

by Shri G Haridass, Exective Engineer (Research Division) Tamil Nadu Water Supply & Drainage Board, Madras

Introduction

Utilisation of ground water as a source dates from ancient times. With the development of various technologies and industries, the necessity for perennial and potable water was felt that the 17th century onwards. The Science of hydrology was founded in the 17th century and geology was developed in the 18th century. From those days, the field of ground water hydrology has develped a lot. In the last few decades, ground water exploitation has increased hundred-fold. In spite of these facts, a large number of intricacies about ground water hydraulics are yet to be solved and require a lot of experience and efficient intrepretation.

A conservative estimate indicates that over 97 per cent of all the fresh water available in the planet is in underground reservoirs. Ground water storage is a changing phenomenon depending on various factors at both micro as well as macro levels. Hence the study of ground water supply and extraction through various means requires a detailed study, especially in the case of community water supplies with regard to dependability, economy etc. Further ground water sources can be broadly classified as sub surface aquifers and deep aquifers. The former requires detailed investigation on the nature of soil and the recharge characteristics whereas the latter requires a detailed study of the geology of the strata as well as hydrological aspects. In any case, ground water is invariably moving under hydraulic priniciples. The flow rate through any porous media is proportional to the hydraulic gradient and inversely proportional to the length of flow. In this document, the factors affecting the variations in the above parameters and thereby the extraction and supply through various ground water sources will be dealt with.

Geological Considerations

Rocks can be broadly classified as igneous, sedimentary and metamorphic, based on their origin. Igneous rocks are a poor source for water unless the fault and fracture patterns formed due to tectonic activities are favourable. However, in case of Basalt lavas (extensive in North India) it is a good source of aquifer due to large joint openings and other cavities. In case of sedimentary rocks, good aquifers can be met with in unconsolidated sedimentary deposits including gravel, sand, silt and clay. The yield is poor in case of consolidated and cemented sand stones, siltstones, conglomerates etc. Limestone formations with solution channels and caverns are also good aquifers. Metamorphic rocks such as Gneiss, schists, marbles, quartizite etc., have poor yield and depend on the characteristcs of the primary rocks.

The more the decomposition and weathering, the more the water bearing capacity of the rock increases. The porosity of rock varies from 1.5 percent in slightly weathered rock to as much as 40 per cent in highly decomposed rock.

The characteristics of various formations are detailed below:

	Porosity (Percent)	Specific yield (Per cent)	Pemeability m/day
Gravel	25	22	600 - 1000
Gravel and Sand	20	16	200 - 800
Sand	35	25	250
Sand stone	15	8	.005 - 2

Ground Water Supply in Tamil Nadu

Nearly two thirds of Urban Water Supply Schemes depend on ground water as their source. 90 per cent of such ground water sources are from sub surface in various river beds. The balance is extracted from deep aquifers. Invariably the rural water supply schemes are provided with ground water sources, especially through tube wells except in case of a few comprehensive schemes and for places near to sub-surface sources.

Ground Water Supply in Tamil Nadu is appreciable in various river basins where quaternary alluvium is present. In Cauvery delta the transmissivity per food width varies from 200-300,000 gpd/ft, with an average of 20,000 gpd/ft. In most of the alluvium in Palar the co-effiencent of permeability ranges from 12 500 to 20 000 gpd/ft^2. Where the thickness of sand varies from 2 to 12 m in general and upto 22m in certain places. Most of the rivers in this state are non perennial and as already stated only flow for a few days or a few months in a year. But at plains, most of these river beds offer good sub surface flows. A large number of infiltration wells, infiltration galleries and collector wells in addition to siphon wells are located in these river beds to supply a number of Urban Water Supply Schemes and a few Rural Water Supply Schemes. There are certain regions of artesian aquifers especially in Neiveli (sand stone) and in East Ramanathapuram regions. Controlled exploitation of these regions became imminent due to possibility of salt water intrusion as they happened to be near sea shore. In hard rock (Archaean) regions, water is available in certain regions where there is sufficient weathering and deomposition.

In general tube wells are preferred in the hard rock zones as the quantity available will be less than 100 - 250 lpm. Most of these tube wells or bore wells are meant for Rural Water Supply Schemes as well as for Urban communities in scarcity areas.

Tube Wells

Tube wells are invariably preferred in Rural Water Supply Schemes in Tamil Nadu for the following reasons.

1 Large variation in ground water level in various places due to vagaries of rainfall.

2 The well could be installed within a day for extraciton of water in small quantities

3 The method is cheaper in the case of small water supply shemes up to about 1000 lpm where enough ground water is available at or near the point of consumption

4 Where the aquifer is very deep with low co efficient of permeability or where good aquifers are available below 10 to 20 m or more

Detailed surveys on the geology are undertaken and resistivity meters are used for locating the points for bore wells.

In the case of hard rock regions generally 125 mm or 150 mm bores are drilled at varying depths. The casing pipe is limited to the top soil cover and fixed on the hard rock. The development of the well is carried out and the yield is tested based on pumping tests after development. In the case of sedimentary regions, pilot bore holes are sometimes carried out and depending on the bore log or lithology, development of a production well is carried out. The yield tests are conducted generally be constant discharge tests and observing the drawdowns. A typical detail of a bore well is shown in appendix 1.

Collector Wells

These are caissons of 4 to 6 m internal diameter sunk into an aquifer to a greater depth and at times upto an impermeable stratum. The bottom of the well is plugged. This type of well is suitable for aquifers of 10 to 25m depth with sufficient sub surface flow. Radial slotted steel pipes of 200-300mm dia are driven horizontally into the aquifer at the most likely level of the aquifer in different directions.

1.1 Comprehensive Water Supply Scheme to Manamelkudi and 47 Other Habitations - Using Tube Wells as Source

A comprehensive water supply scheme to Manamelkudi and 47 other habitations in Avudayarkoil Panchayat Union was designed with a common deep bore well as the source. The population of all the 48 habitations is 30, 255 in 1978 and ultimate population is worked out as 39,338. At the rate of 40 lpcd, and adopting 16 hour of pumping the requirement was worked out as 1210 lpm.

There is no perennial river or potential aquifer at sub surface level in this area. Being tertiary sedimentary deposit area with sufficient ground water potential, it was proposed to have bore wells as the source for this scheme. However, in this area all shallow bore wells upto 60 m depth as well as deep bore wells upto 150 m depth put down earlier are found to contain only brackish water. An existing artesian well put down at Manamelkudi, of about 304 m depth indicated that the quality of water below 150 m depth is potable. The diameter of the above artesian bore well is only 100 mm; hence it was proposed to put down deep bore wells of larger diameter for about 360 m depth in the same area to draw the requirements of the proposed comprehensive water supply scheme. Further study of ground water in this region was taken up and it was decided to locate two bore wells, to provide water supply to all the above habitations.

An artesian bore well of 356 mm x 203 mm was sunk upto 527 m. The logging of the well was carried out and it was decided to provide blank pipes and slotted pipes at locations shown in the plan. The yield after development of the well was also found to be 979.66 lpm for a draw-down of 6.1 m. Hence it was decided to provide water supply to all the habitations from this well at the first instance and to provide another bore well at a later date when necessity arises.

The scheme has been commissioned and is working satisfactorily.

1.2 Litholog details of borewells

Location	: Manamel Kudi
Union	: Avadaiyar Koil
District	: Pudukottai
Latitude	: 10^{o} 02' 30"
Longitude	: 79^{o} 14' 00"

Bore hole Diameter

400 mm = GL - 24.0 m

250 mm = 24.0 m - 526.0 m

222 mm = 526.Um - 545.0m

Type of mud	: Bentonite
Mud resistivity	: 2.8 Ohm m/25^{o}C

Free flow test

Step Draw Down

Calculated yield for 6.1m draw-down is 979.66 lpm

Limestone	5	2	10^{-2} -2
Clay	45	3	0.1
Quartizite, granite	1	.5	.01

In general, in highly weathered igneous and metamorphic rocks tube wells or dug wells can yield between 45 - 120 lpm and at some places as much as 250 lpm. In unconsolidated formations, the yield will vary depending on the type of aquifer.

For classification of geological age the systems are classified as below in order of absolute back dates in years.

Geological time scale systems

System	Absolute dates in million years
Quaternary	0 - 25
Tertiary	25 - 65
Cretaceous	65 - 140
Jurassic	140 - 200
Iriassic	200 - 240
Permian	240 - 290
Carboniferouc	290 - 350
Cambrian	505 - 605
Pre Cambrian	605 - 2500
Archaean	2500

Hydrology and Hydrogeology of Tamil Nadu

This rock classified according to age in Tamil Nadu is as follows:

Archaean	73.4 per cent
Sedimentaries	
Gondwana (clay)	1.9 per cent
Cretaceous	1.2 per cent
Tertiary	6.7 per cent
Quaternary allunium	16.8 per cent

Tamil Nadu has a net area of 1,300,357 km. The average annual rainfall is 945.7 mm. The distribution of rainfall is 19 per cent between January - May, 34 per cent between June - September and 47 per cent between October - December. The annual precipitation amounts to about 123 km^3, whereas that actually utilized is around 25 km^3. The average annual ground water recharge is estimated to be 18 km^3. There are about 1.6 million wells in existance in Tamil Nadu. The current rate of extraction is in the order of 13 Km^3. Hence there are further chances of extraction of an additional 5 to 6 Km^3 of ground water. With a proper Engineering Management, it could still be possible to tap as much as 45 Km^3 of ground water based on precipitation. This can be achieved by improved land use patterns, artificial ground water recharge, basinwise ground water development and conjuctive use of both surface and ground water.

Appendix 2

Water supply scheme for Kovilpatti and way side villages from radial collector well in Tamiraparani River

The above scheme required the provision of a water supply to the tune of 8.31 mld (1.92 mgd) at the intermediate stage and 11.67 mld (2.57 mgd) at the ultimate stage. Forecasting a future extension of water supply to some other beneficiaries, it was decided to abstract 15 mld (3.3 mgd) of water from Tamiraparani River through a collector well. The river is a perennial one, but the summer flow is insufficient to feed the scheme. Hence it was decided to abstract sub-surface flow from the river. The strata is a very good aquifer with coarse sand and pebbles. A m internal diameter collector well was sunk upto 8.52 m below the bed level and radial drains were provided at 5.32 m below ground level for a total length of 330 m. Yield test for the above well was conducted and found to be in excess of 11.67 mld (3.3 mgd)

The scheme was commissioned in 1975 and has functioned satisfactorily for over 7 years. The details of the radial collector well are shown in the enclosed sketch.

Appendix 3

Comprehensive water supply scheme for Kaipadi Town Panchayat and other Panchayats using infiltration gallergy as source

A proposal of tap water to town Panchayats, Katpadi, Kalinjur, Dharapadavedu and village Panchayat Virudampet in North Arcot District was formulated with the River Palar as the source. Even though there is no surface flow in the River Palar for most of the months of the year, there is sufficient sub-surface flow and hence the River Palar was chosen as the source.

The requirement of water for the intermediate stage in 1991 will be 4.14 million litres (4,313 lpm) and for the ultimate stage in 2006 will be 5.36 million litres (5.584 lpm). To abstract this quality, an infiltration gallery for a length of 136 m with 3 Nos of manhole wells, was proposed and installed. The manhole wells also have porous block steining for 3.45 m, to act as infiltration wells. The salient details of headworks are:

Average bed level of river	:	206.645 m
Low summer water level	:	204.995 m
Invert of gallery	:	199.950 m PVC slotted pipes
Maximum Flood level	:	209.520 m

The scheme was brought into beneficial use in 1976. The details of river strata and the alignment of the gallery is shown in figure. A typical cross section of a gallery is also appended.

Collector wells are favourable for drawing water from 5 mld to about 50 mld from a single structure. As the driving of radials progress fine media are desanded and an insitu filter is created. The collector well utilises as much as 90 per cent of available head of water and the entrance velocity upto 5m/sec is obtained which accounts for low operation costs. The system is limited to places where a coarse medium is available (2 mm) and where the depth of aquifer exceeds 8 m. The extraction can be carried out at different layers of the strata depending on the availability of coarse media. One of the collector wells installed in Tamil Nadu is shown as detailed in appendix 2.

Infiltration Galleries

Infiltration galleries are structures resembling a filter insitu. They are located in potential aquifers or river beds or other unconsolidated shallow aquifers of 5-10 m depth. They are favourable in places where either an impermeable layer is met with, below shallow depths, or salt water instrusion may be likely to arise. Galleries are preferred where the requirements of infiltration wells or tube wells will be too great and where sufficient ground water potential exists. The alignment of the gallery is made based on the strata characteristics obtained from test bores. Galleries are alighned along with test bores having coarse media as well as without any clay pockets.

The structure is made of perforated pipes or loose jointed pipes horizontally laid around which stone and sand media are spread out as in the case of a filter. The media vary from broken stone (38 mm) down to find sand (retained in 70 micron sieve). The gallery is connected to manhole wells at 75 m intervals and collection or pumping is made from a collecting well which creates sufficient draw-down for permeation through the gallery. The rate of extraction varies with the sub-surface flow of water and generally around 30 lpm/m length of gallery. In some cases sub survace barrages are provided down stream which will help in inundating the strata.

A case of infiltration gallery functioning in Tamil Nadu is detailed in appendix 3.

Role of solar distillation in Rural Water Supply
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Introduction

In Tamilnadu, availability of surface water for public water supplies is limited. This has necessitated exploitation of ground water to a large extent. At present, the water from many of the bore-wells installed suffers from excessive amounts of constituents like iron, fluoride, nitrate and dissolved solids. When no alternative source is available, the users have to use the poor quality water with attendant problems. To some extent, it is possible to provide for removal of iron and floride. Removal of nitrate is also technically feasible.

Removal of dissolved solids is feasible by chiefly two methods, viz., reverse osmosis technique and solar distillation. Reverse osmosis is being tried in many places but it requires a high energy usage and sophisticated technology. Solar distillation on the other hand, is simple and uses only the abundant available solar energy. However, costwise, solar distillation is very expensive and can be tried only where no other alternative is possible.

PRINCIPLE AND CONSTRUCTION OF SOLAR DISTILLATION STILL

The heat part of the solar energy is trapped in a glass windowed vapour tight container with available brackish or saline water. This heat raises the temperature of the brackish water to about 70°C or more. At this temperature, the water evaporates and is obstructed by the glass pane. The vapour condenses on the under side of the glass pane and flows down the slope of the glass pane to be collected by a distillate gutter which draws out the distillate. The structure can be of wood or manonry. Yields of 2 litres per square metre per day are usual. The unit can be used independent of the quality of water available. The distillate, being pure water, can be used immediately. If precautions are taken no disinfection may be needed. The glass panes are given a slop to facilitate the condensed vapour to flow easily to distillate gutter. The solar still can be constructed to have double sloped glass panes or with sloping on one side as required.

BRIEF DESCRIPTION OF SOLAR DISTILLATION STILL AT PERARIGNAR ANNA UNIVERSITY OF TECHNOLOGY

The Perarignar Anna University of Technology at Madras has 2 units at the Centre for Environmental Studies and one unit at Kovalam. The former are small units, one of which is made of wood and the other built of masonry. The solar distillation still at Kovalam is a fairly large unit which is under study and is supplying about 500 litres of water per day to about 20 families in the vicinity.

The wooden model has a size of 1.83 m x 1.22 m. This was constructed in 1978. It is now used for study in improving yield of distillate on a pilot scale. Usually it yields about 5 litres per day. The entire yield is obtained in the daylight hours. No yield is noticed during the night.

The masonry model was constructed in 1979. There are two stills of 1.80 m x 1.04 m size separated by a trough 0.50 m wide. There is provision in this design to harvest the water falling as rain on the still area in the rainy season since it is of the same quality. Further, during rains, no distillation may occur and the rain water may be a good substitute for the distillate. The cost of this unit was Rs 1 100/-. This unit has a total surface area of 5.58 sq metes of which 3.74 square metres are of glass. The yield has been recorded continuosly for 3 years and varies daily from 7 litres in the cooler period to 10 litres in the hot season.

The solar distillation unit at Kovalam, a hamlet 30 km south of Madras on the sea shore, is modelled on the masonry unit at the Centre for Environmental Studies. There are 16 bays each 14.8 m x 1.04 m in size. The total area of glass panel amounts to 250 square metres. The daily yield recorded shows a variation from 400 litres in November-December to 700 litres in May-June.

As mentioned before, about 20 families nearby use the water in the focal wells is saline and cannot be used. The cost of this unit was Rs 80 000/- approx.

EXPERIENCES IN SOLAR DISTILLATION TECHNIQUE

In the day to day maintenance of the solar distillation still at Kovalam many problems are encountered. The plumbing arrangements, the pumping and feeding of water into the still to maintain a depth of 5 cm, profuse growth of algae in the stagnant water in the still, choking of the water pipes, deposition of fine sand on glass surface, vadalism from nearby school children and breakage of glass panes due to many factors are some of the frequent recurring problems. Unless these are successfully handled the yield of the solar still can deteriorate rapidly. One paid labourer is now employed to look after the still, pump water into it from a brackish water well nearby and distribute the distillate. He gets Rs 10/- per day. The annual maintenance for cleaning the still free of algae and salt deposits, replacing broken glass panes, securing the glass masonry seal by use of tape etc will cost again about Rs 5 000/- annually. The total maintenance per year may be about Rs 8 500/- annually. The average yield is about 500 litres per day. On this basis, not taking into consideration the cost of the solar still the water from the solar distillation still will cost about Rs 46.6 per 1000 litres.

The smaller masonry unit at Centre for Environmental Studies costing Rs 1 100/- can however be adopted for an individual house to supply the drinking water, where no other source for drinking water exists. In such a case, costing of water many not have the same importance and the sole fact of potable water availability will decide the adoption of the still.

STUDIES ON IMPROVEMENT OF YIELD

In many evaporation pan studies, it has been observed that daily evaporation rates in Madras range from 2 mm to 8 mm per day. Even though a heat trap using glass panels is used in solar stills, the yield is very low compared to natural solar evaporation. Using the multiple effect it should be possible to achieve a rate of evaporation in excess of natural evaporation. Towards this end, studies have been carried out at the Centre for Environmental Studies.

In one study, pebbles were used in the masonry solar distillation still at the Centre for Environmental Studies. This increases the yield by about 20%. In another study a black dye was used to render the water contents of the solar still black and thereby attain a higher absorption of solar heat. This resulted in a 50% increase in yield. Surprisingly, a combination of pebble and dye was not as effective as dye alone and gave only about 40% increase in yield. There are further problems in application of this technique to larger solar distillation units which are yet to be studied. Future studies will aim at increasing the trapping of solar heat by giving coatings to glass panels used. Methods to use the latent head of vapourisation when the vapour condenses should also be worked out to increase the distillate yield.

APPLICABILITY OF SOLAR DISTILLATION TO RURAL WATER SUPPLIES

The cost of the solar distillation technique is very high and consequently this can be used only in situations where other alternatives are not available. However, the technology is simple and with reasonable care, it should be possible to obtain a yield consistently. However, individual houses can be given small distillation units with say 4 square metre units upplying about 10 litres/day for the drinking water needs only in very difficult areas. Probably maintenance of these units can be much simpler than large units supplying water to a community. In exceptional circumstances, large units may also be justified and the present know-how is sufficient for its maintenance. Looking at the cost of the product water, it would appear that this solar energy for drinking water can be only a very special application. However, if methods for increasing the yield were to succeed spectacularly, solar distillation may become a highly desirable method which can be independent of rain, by reclaiming sea water.

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