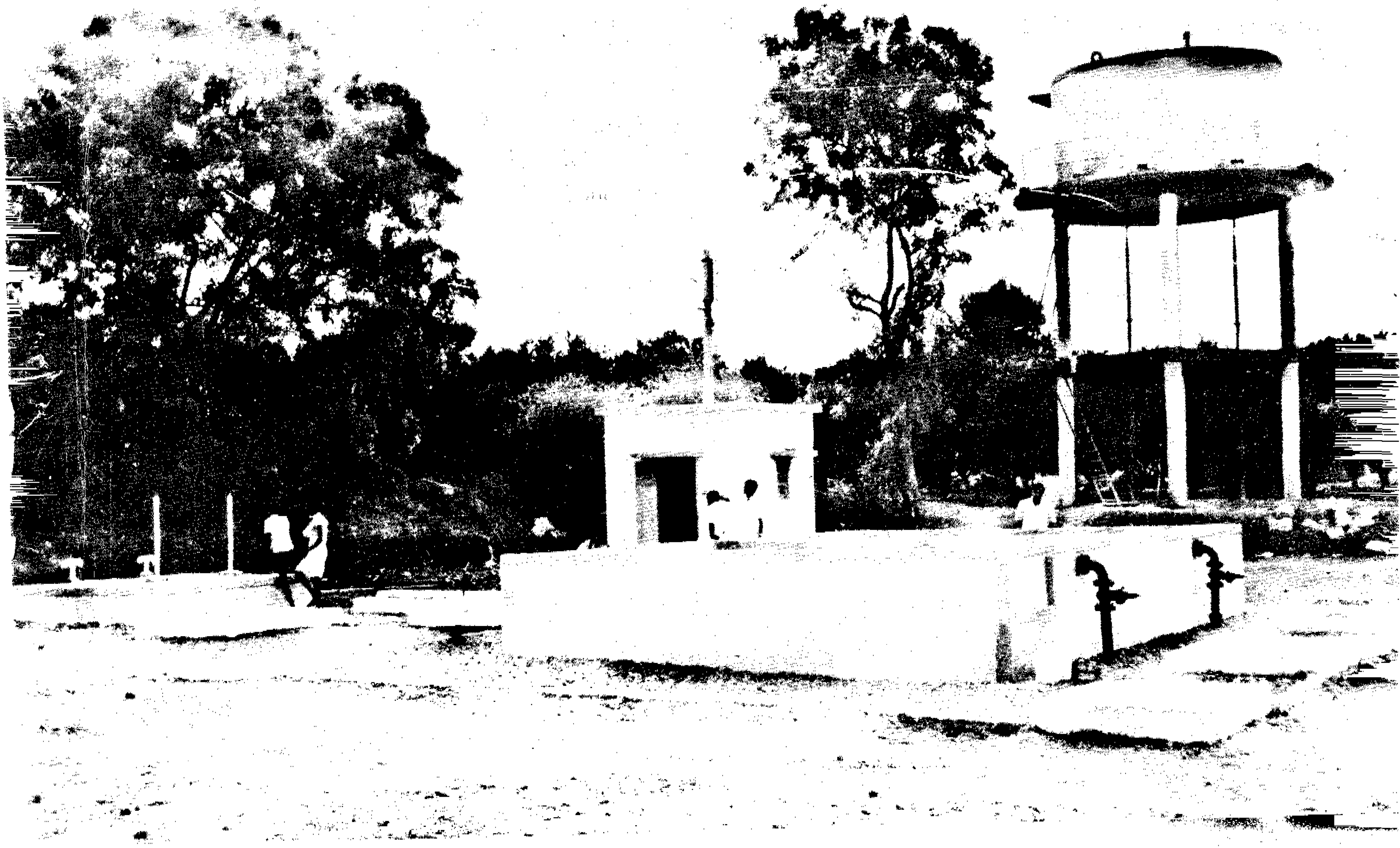
SLOW SAND FILTRATION

RESEARCH AND DEMONSTRATION PROJECT INDIA

FINAL REPORT



NATIONAL ENVIRONMENTAL ENGINEERING RESEARCH INSTITUTE (C.S.I.R.)
NAGPUR, INDIA

INTERNATIONAL REFERENCE CENTRE FOR COMMUNITY WATER SUPPLY AND SANITATION, THE HAGUE, THE NETHERLANDS.

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SLOW SAND FILTRATION

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Editors

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PREFACE

The goal of the International Water Supply and Sanitation Decade programme is to provide safe water and effective sanitation for all the people of the world by 1990. To achieve this goal in a time-frame of a decade as against a century or more taken by the developed countries needs political will, public support, administrative action leading to massive mobilization of resources at all levels in developing countries. The strategies to be adopted would require planning of programmes and projects that are technologically appropriate, socially relevant and at a cost affordable by member countries. This has been emphasised at the Conference on "Technical Cooperation among Developing Countries" (TCDC) in Buenos Aires (1978) and the UN Conference on "Science and Technology" in Vienna (1979).

Water purification by slow sand filtration has been successfully practised for over 150 years. The simplicity and reliability of this process makes it appropriate for small and village water supplies in tropical developing countries where land and labour are readily available. The International Reference Centre for Community Water Supply and Sanitation, The Netherlands, as part of its promotional activities, initiated an integrated research-cum-demonstration programme on slow sand filtration in order to review the existing knowledge on the subject and to promote its large scale application in developing countries. India, Ghana, Kenya, Sudan, Columbia, Thailand and Jamaica, in close collaboration with the IRC, have been actively participating in the programme.

This report summarises the results of applied research carried out by NEERI in the first phase of the programme and experiences in the development, implementation and evaluation of demonstration projects in selected villages. Arising out of the laboratory and field studies and a critical review of traditional slow sand filtration practice, guidelines for rational design and construction of slow sand filters have been presented.

A noteworthy feature of the demonstration project is the integrated multidisciplinary and collaborative approach by research scientists, field engineers, public health workers, government agencies and policy makers at local, national and international level. Health education and community participation have been effectively integrated in this programme. Hopefully, this report, should be of considerable interest and value to planners, water supply engineers, community health workers and national and international agencies.

(B. B. SUNDARESAN)
DIRECTOR

ACKNOWLEDGEMENTS

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The elected representatives, local leaders and people in the project villages have played a vital role in successful implementation of the project at village level.

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SUMMARY

An integrated research and demonstration project on slow sand filtration was taken up by NEERI in collaboration with the International Reference Centre for Community Water Supply and Sanitation (IRC), The Netherlands. The overall objective of the project was to review the present knowledge on the subject of slow sand filtration, establish and demonstrate under tropical conditions, its efficacy for treatment of surface waters and to promote its large scale application for rural water supplies in developing countries. The project has been implemented in two phases.

In the first phase literature and field survey was carried out to review the current status of slow sand filtration practice in India and identify areas of further research and development. Applied research on pilot and full scale units was undertaken with special emphasis on parameters that influence the performance of slow sand filters and their cost. In the light of the above, guidelines were formulated for rational design, construction, operation and maintenance of slow sand filters.

In order to test the guidelines developed from the first phase study and to demonstrate under prevailing local conditions the efficacy of slow sand filtration to policy makers and water supply professionals and engineers, four village demonstration plants (VDPs), one each at Pothunuru (Andhra Pradesh), Abub Shahar (Haryana), Borujwada (Maharashtra) and Kamayagoundanpatti (Tamil Nadu) were constructed. These installations designed to cover a wide variety of local conditions, both technical and socio-economic, were studied for their performance over a period of 2 years. Health education and community participation programmes were integrated with the theme of slow sand filtration and implemented in the project villages. Guidelines for cost effective design, construction, operation and maintenance of slow sand filters have been recommended.

As part of Phase II activities, NEERI in collaboration with IRC, organised at Nagpur during September 15-19, 1980, a meeting of representatives of participating institutions from Thailand, Sudan, Kenya, Ghana and India to review the progress of the project, develop guidelines for future implementation of slow sand filters and rural water supply schemes in general and indicate an implementation strategy with regard to technical, social and economic aspects. Extensive discussions and exchange of views between engineers and scientists on various aspects, resulted in a set of conclusions and recommendations. Further areas of research and development were also identified (IRC Bulletin Series 16, March 1981).

The strategy followed for the development, testing and evaluation of the various technical, organisational and social aspects of the programme at local and national level has served as a model for furture large scale implementation of rural water supply programmes. The project is also an example of how technical cooperation among developing countries can play a vital role in evolving appropriate treatment technologies in water supply of common concern for mutual benefit.

1. INTRODUCTION

Eversince the first slow sand filter was constructed in 1829 in London for purification of municipal water supply, it has been in continuous use as a reliable means of preparing potable water from polluted surface waters. The most convincing proof of its efficacy was first demonstrated in 1892 when the river Elbe from which the two neighbouring cities of Hamburg and Altona were drawing their water supply, was polluted resulting in a Cholera epidemic. Altona which filtered its supply, completely escaped from the epidemic while Hamburg with no filtration suffered more than 7500 deaths.

In India slow sand filtration has been practised from as far back as 1865 when the first slow sand filters were constructed at Palta Water Works near Calcutta for treating Hooghly river water. Madras city is another instance where slow sand filters were installed for treatment of impounded lake water. The KAVAL towns (Kanpur, Agra, Varanasi, Allahabad and Lucknow) of Uttar Pradesh are other places where slow sand filters, preceded by plain sedimentation basins were introduced towards the end of 19th century for treatment of river waters.

Increasing water demands and high cost of land and labour in the industrialised countries led to the development and adoption of systems that are compact, amenable for automation but require energy and chemical inputs. While these systems are relevant for large urban water supplies in developing countries, they have proved inappropriate for rural situations. A technology that is simple, reliable, cost effective and readily acceptable to the community is required. Slow sand filtration can fulfil these requirements. It has many advantages :

- Provides a single step treatment for raw waters with low turbidity.
- Simultaneously improves the physical, chemical and biological quality of raw water.
- Simpler to operate than alternate technologies.
- Low operating costs and based on labour rather than energy or chemical inputs.
- Reliable and no machinery to fail.
- Simple in construction with local materials and skills.
- Proven and tried technology with several decades of operating experience.

Slow sand filtration, though practised for over 150 years, is still one of the least understood processes. The complex mechanisms that bring about the purification have yet to be explained unequivocally. Water treatment system designers, often acting on ignorance of the potentialities of this technique, tend to neglect consideration of slow sand filters. Hence, the need arose to review the present knowledge on the subject, establish and demonstrate the efficacy of slow sand filters for treatment of polluted waters under tropical conditions and to promote their application for rural water supplies in developing countries. With these objectives, an inter-country research and demonstration project was initiated by the International Reference Centre (IRC) for Community Water Supply and Sanitation, The Hague, The Netherlands. The National Environmental Engineering Research Institute (NEERI), Nagpur, representing India, participated in this research-cum-demonstration project consisting of two phases :

2. PHASE I : APPLIED RESEARCH

In the first phase, the following activities were carried out in order to develop design criteria for slow sand filters appropriate for tropical conditions.

2.1 Questionnaire Survey

The object of this endeavour was to collect information on slow sand filtration practice in India with special reference to design, construction, operation and maintenance of slow sand filters and their application particularly for rural water supplies. Such a step would help identify areas of future research and development as well as in planning and implementation of the demonstration programme (Phase II). A questionnaire (Appendix I) seeking information on salient aspects of slow sand filtration was mailed to the Chief Public Health Engineers of States. The response from many states was prompt but the information furnished was incomplete.

Slow sand filtration was the only known method of municipal water purification when the earliest treatment plants were built in India. Most of these plants were designed to treat river/canal waters. The slow sand filters were preceded by plain sedimentation tanks with a detention period of 4–7 days depending upon raw water quality. In case of impounded source, no pre-sedimentation was generally practised.

The questionnaire survey has shown that more than 60 per cent of the plants served population in the range of 2,000–10,000. The sources of raw water were canals, rivers and impounded reservoirs or tanks and that sedimentation/extended settling was the most common form of pre-treatment. In a few plants, alum coagulation followed by sedimentation was practised during monsoon when turbidity was high. Almost all the plants were designed for the traditional filtration rate of 0.1 m/hr. The design usually provided for one or more standby filters which substantially added to the initial cost of construction of the plant. Underdrains made of bricks and pre-cast concrete slabs were commonly used. The choice was dependent upon the cost and availability of good quality bricks.

Data on raw water quality, its seasonal variation and performance of slow sand filters were very scant or not available. As regards operation and maintenance, short filter runs due to algal growth on filters or high turbidity during monsoon was indicated in a few cases. Visits to a few installations indicated that scouring of sand at the inlet to slow sand filters was a common observation. The practice of routine filter cleaning was often unscientific and resulted in avoidable downtime and poor performance of filters.

2.2 Pilot Plant Studies

In the light of information obtained from questionnaire survey and literature study, applied research was carried out on important aspects that have a bearing on the performance and cost of slow sand filters. Specifically, the performance study was in relation to the following:

- quality of raw water with regard to turbidity and bacterial pollution
- effect of filtration rate higher than the traditional 0.1 m/hr.
- influence of shading the filters
- effect of intermittent operation
- effect of high organic pollution in raw water, and
- use of builder-grade sand

2.2.1 Source of raw water

It was considered appropriate and desirable to conduct applied research using natural surface water so that the results obtained can represent field conditions. Ambazari, a nearby lake and one of the sources of water supply to Nagpur was therefore selected as raw water source for the study. Due to intermittent water supply, it was necessary to provide for raw water storage to ensure continuous operation of the experimental filters. Two masonry tanks each of 12.5 m × 6.4 m × 0.75 m depth were constructed to give a total storage of about 110 m^3.

2.2.2 Pilot filters

In order to obtain reliable and representative data and keeping in view the scope of studies, three pilot filters made of precast reinforced concrete pipes of 1.65 m diameter and 2.5 m long were used. The underdrain consisted of a manifold and perforated laterals all made of G. I. pipes. The supporting gravel was placed in 4 layers to give a total depth of 40 cm as per details given below :

		Size	Depth
Gravel	...	50 mm	10 cm
		18–36 mm	12 cm
		6–12 mm	6 cm
		2–4 mm	6 cm
Coarse sand	...	0.7–1.4 mm	6 cm

The pilot plant layout and filter details are shown in Figures 1 and 2 respectively.

2.2.3 Commissioning of filters

After placement of gravel and sand, the filters were gradually charged with raw water from bottom to remove entrapped air from the bed and to ensure that the sand grains were thoroughly wetted. When water level rose to about 30 cm. above the sand bed, raw water was admitted from top until it reached the maximum water level. The outlet valve was then gradually opened and adjusted manually with the help of a stop–watch and a measuring cylinder to give the designed rate of filtration. The progrees of initial ripening of the filter beds was monitored by testing the bacteriological quality of filtered water. Absence of *E. coli* in the filtrate was taken as an indication that filter had ripened. It was about five weeks before the filters were ready for regular observations.

2.2.4 Performance of filters at higher filtration rates

The design rate of a filtration has a direct bearing on the size of a slow sand filter and consequently on the cost of construction. Traditionally a filtration rate of 0.1 m/hr. has been adopted for slow sand filters. An increase in filtration rate with no adverse effect on filtrate quality can be of economic advantage. Very little information and experience were available with higher filtration rates under tropical conditions and hence, studies on this aspect were carried not.

One of the pilot filters (F 1) was run at 0.1 m/hr filtration rate while the other two (F 2 and F 3) were operated at 0.2 m/hr and 0.3 m/hr respectively. The feed water quality and the depth and grading of sand bed were the same for all the filters. Samples of raw and filtered waters were collected regularly and tested for relevant physico-chemical and bacteriological quality as per Standard Methods.

The performance of filters operated at 0.1, 0.2 and 0.3 m/hr rates of filtration is summarized in Table 1 and presented in Figures 3 and 4.

Table 1 – Effect of Rate of Filtration Summary of Filter Runs

Rate of Filtration	Run No.	Filter Run days	Net quantity of water filtered m^3
0.1 m/hr	1	27	141
	2	52	254
	3	37	181
0.2 m/hr	1	27	282
	2	19	182
	3	24	249
	4	35	323
0.3 m/hr	1	13	205
	2	27	389
	3	4	50
	4	7	110
	5	11	176
	6	30	408
	7	9	139
	8	7	107
	9	8	123

The turbidity of raw water was generally below 5 NTU except for a short period of 2 weeks when it increased to about 10 NTU. During the initial ripening period which lasted about 5 weeks, the turbidity of filtered waters was more than 1 NTU but below 2 NTU; later on it improved and remained below 1 NTU. It was observed that the filtrate turbidity seemed to follow an inverse trend with regard to rate of filtration. The filter operated at 0.3 m/hr

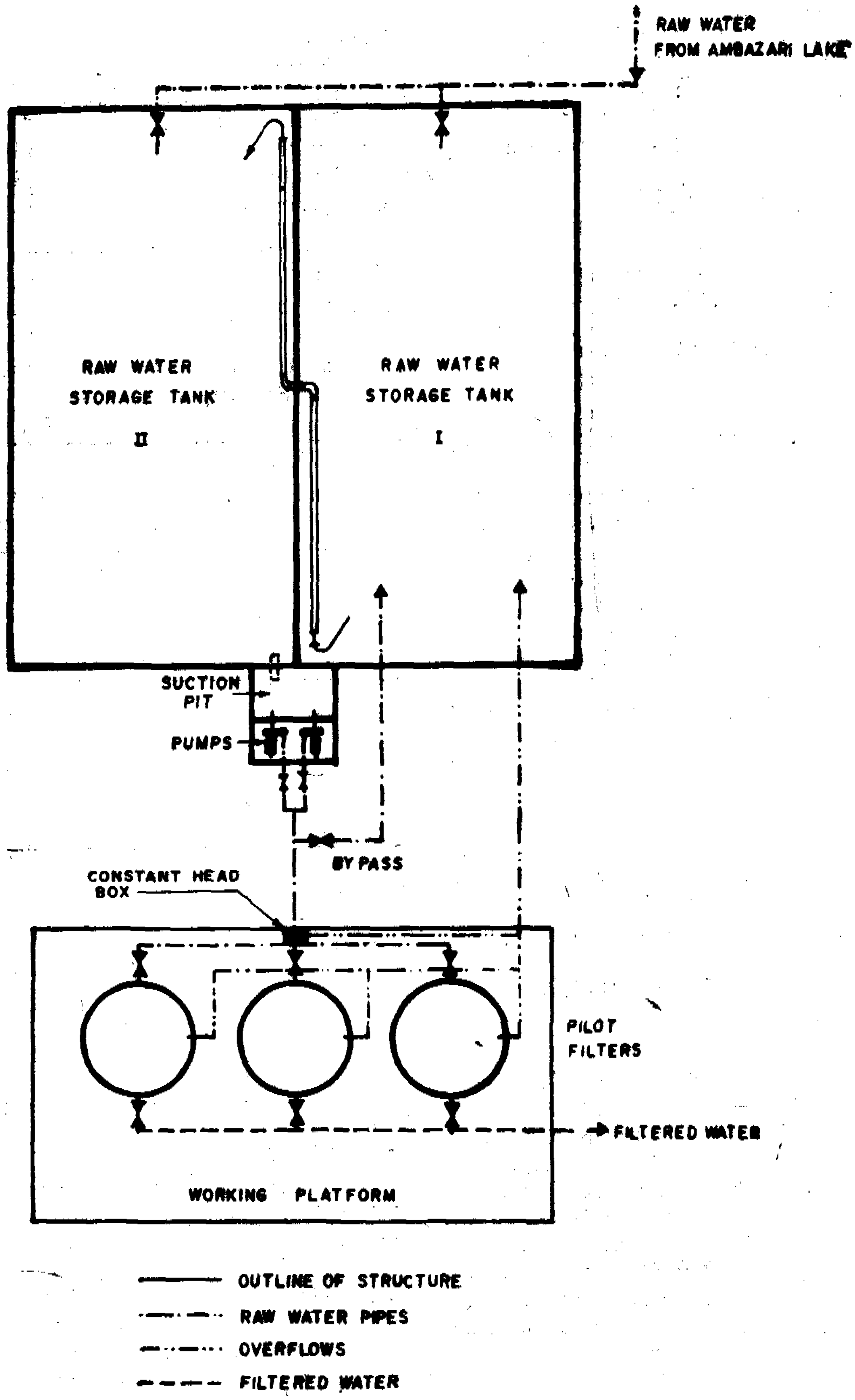
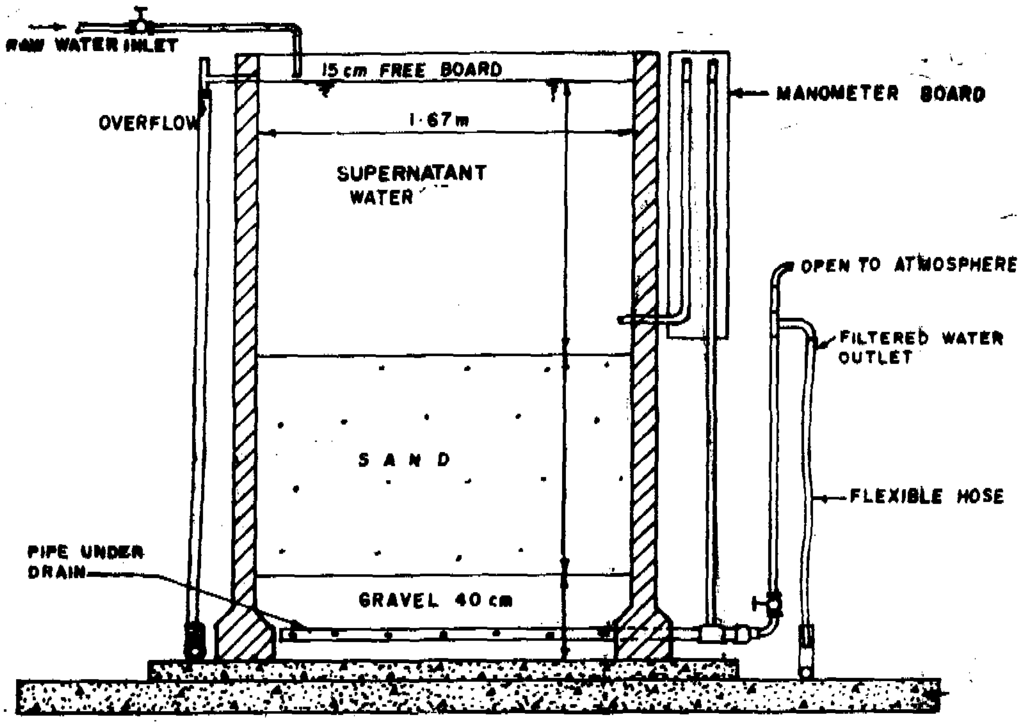
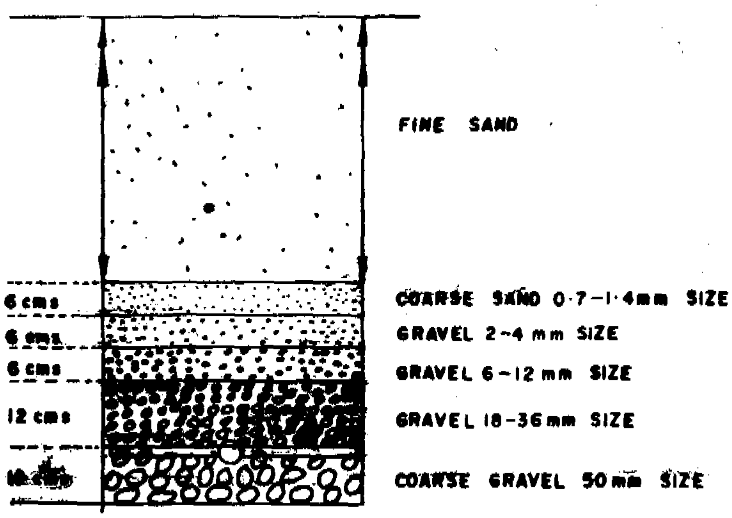


Fig. 1 – Pilot Plant Layout – Schematic



FILTER SET UP



MEDIA DETAILS

Fig. 2 – Filter set-up/Media Details

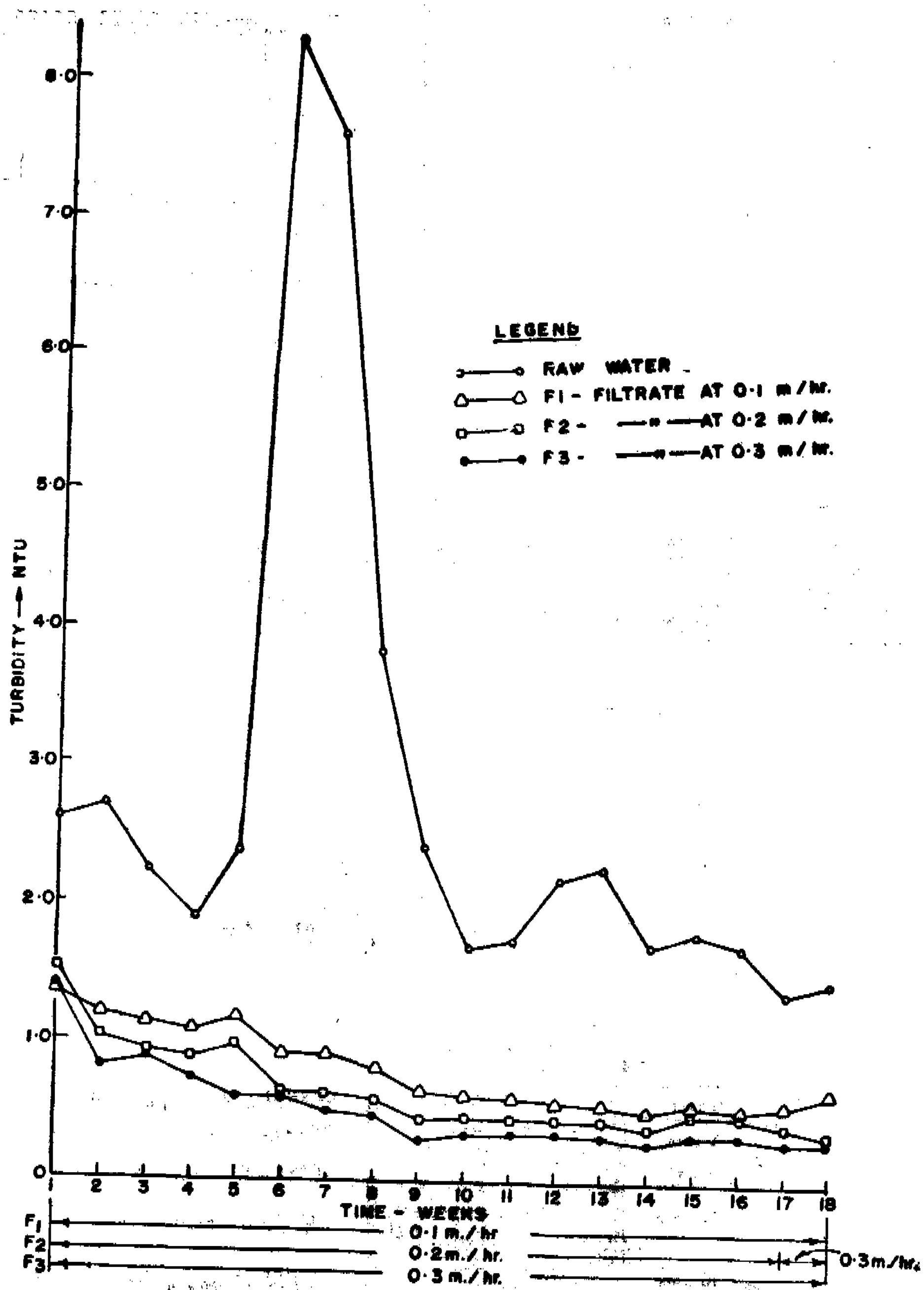


Fig. 3 – Effect of Rate of Filtration Turbidity of Raw & Filtered Waters

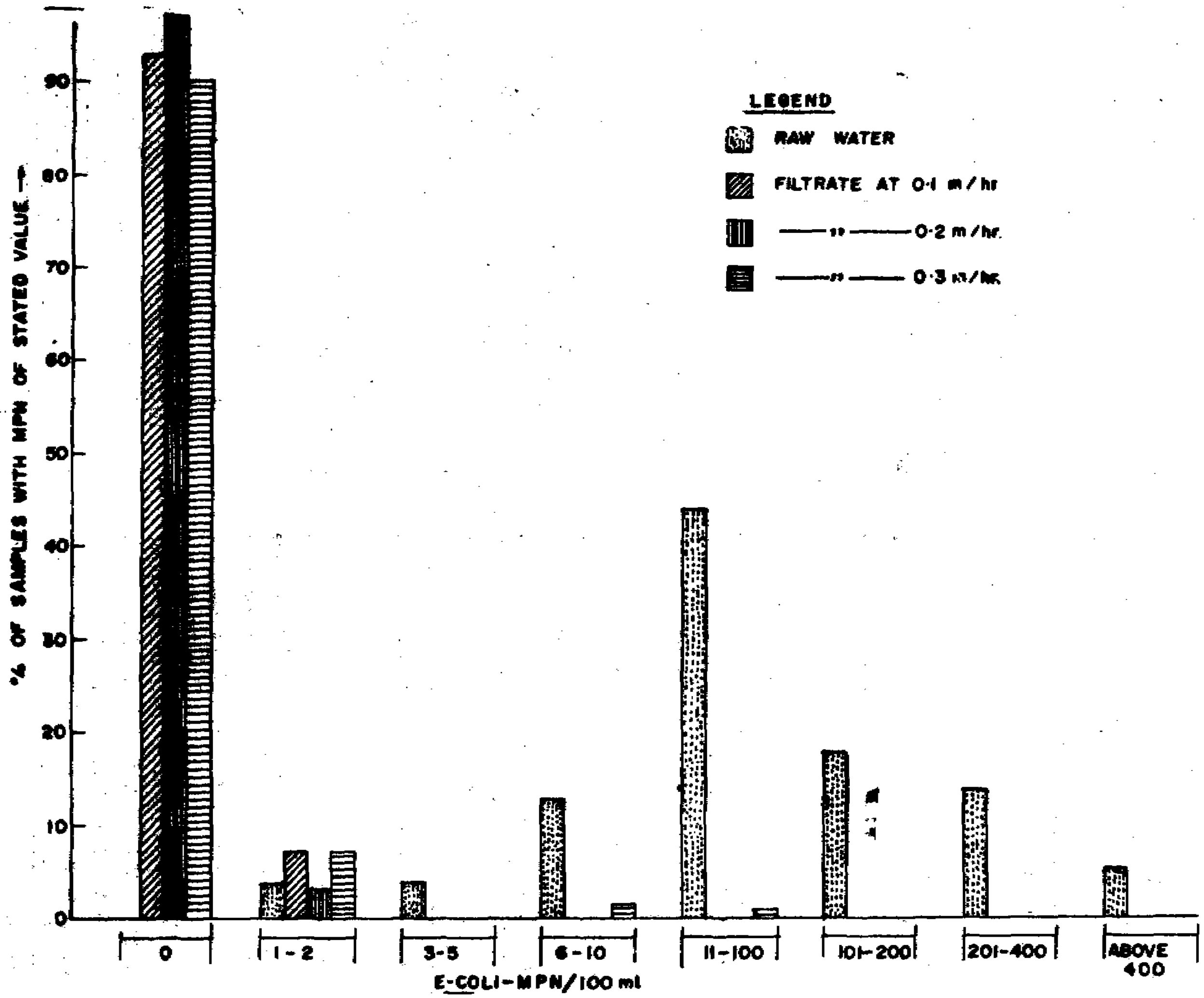


Fig. 4 – Bacteriological Performance of Filters At Different Filtration Rates

always produced a filtrate of lowest turbidity while those operated at 0.2 m/hr and 0.1 m/hr gave filtered waters of higher turbidity but less than 1 unit. This observation was also confirmed by statistical analysis of turbidity data using a completely randomised design and students T test of significance.

The dissolved oxygen in the filtrate was found to be lower with lower rates of filtration. This can be explained by the fact that at lower rates of filtration the raw water stays for a longer period in the filter and therefore, a greater depletion of oxygen by the biological system. No perceptible difference in the chemical characteristics such as alkalinity, hardness, chlorides and sulphates of filtered waters was observed. However, there was a considerable reduction in total iron due to filtration.

The organic pollution in raw water determined as chemical oxygen demand (COD), varied from about 6 mg/l to 10 mg/l. Due to filtration, the average reduction in COD was 54.3, 53.1 and 50.4 per cent respectively at 0.1, 0.2 and 0.3 m/hr filtration rates. Statistical evaluation by analysis of variance has shown no significant difference in COD removal with respect to rate of filtration. Similar observations are reported from Amsterdam Water Works where three covered filters have been operated for a full year at different rates of 0.1, 0.25 and 0.45/m/hr without any marked difference in effluent quality[1].

As for bacteriological quality, the filtrers operated at 0.1 m/hr and 0.3 m/hr delivered water free from *E. coli* on 66 and 65 occasions respectively out of a total number 71 samples tested. The filter operated at 0.2 m/hr gave a filtrate which was free from *E. coli* in 72 out of 76 observations. While this degree of bacteriological purity can be considered acceptable for rural supplies, as a precaution, terminal safety chlorination of filtered water is desirable.

The average length of run for the filters operated at 0.1, 0.2 and 0.3 m/hr was 45,26 and 13 days respectively. Assuming a downtime of 2 days per cleaning operation, the corresponding filter output per year would be 840, 1630 and 2280 m^3/m^2 respectively. It is evident from the data that the output of a filter increases with increase in rate of filtration but follows a law of diminishing return.

The results have clearly indicated that slow sand filters treating raw water of turbidity less than 10 NTU can produce a good quality filtrate at all the filtration rates of 0.1, 0.2 and 0.3 m/hr. The observations are of practical significance for the designer, in that the traditional filtration rate of 0.1 m/hr need not be held sacrosanct but higher rates could be used under favourable conditions of low raw water turbidity with the possible advantage of greater output and with no adverse effect on filtrate quality.

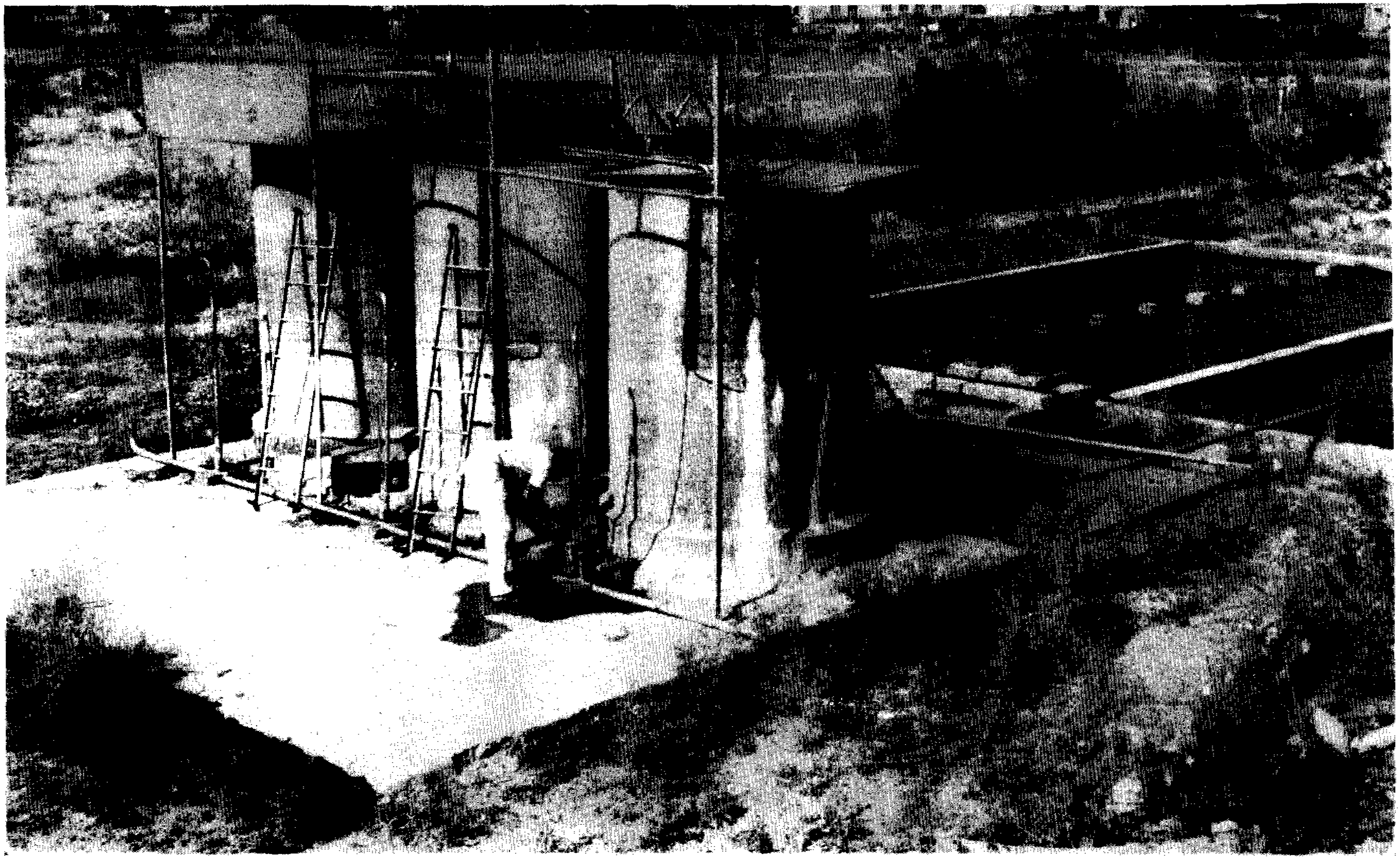
2.2.5 *Effect of Shading the filters*

Surface waters containing essential nutrients like phosphates, nitrates and carbon dioxide provide favourable conditions for the growth and proliferation of algae especially in tropical areas. When these waters are treated by slow sand filters, the algae can produce significant effects on the working of the filters. Whether these effects will be beneficial or harmful will depend upon the type of algae and a variety of other conditions. It was considered that some of the adverse effects, if any, of algae may be minimised by shading the filters to exlude sunlight from reaching them. The influence of shading on filter performance was, therefore, investigated.

One of the three filters (F 1) was covered so as to exclude sunlight completely while another was so shaded as to prevent direct sunlight but to allow only diffused light to the filter. The control filter (F 2) was open to sky. The experimental set up is shown in Fig. 5. All the filters were fed with the same influent. The salient observations of the study, which covered the summer months of April, May and June are discussed below.

Shading of filters either partly or completely did not have any influence on the filtered water turbidity which remained below 0.5 NTU at both 0.1 and 0.2 m/hr filtration rates. Shaded filters

1. Slow Sand Filtration – L. Huisman & W. E. Wood, WHO–1974, p. 44.



Experimental filters showing shading arrangements
with raw water storage tanks in the background

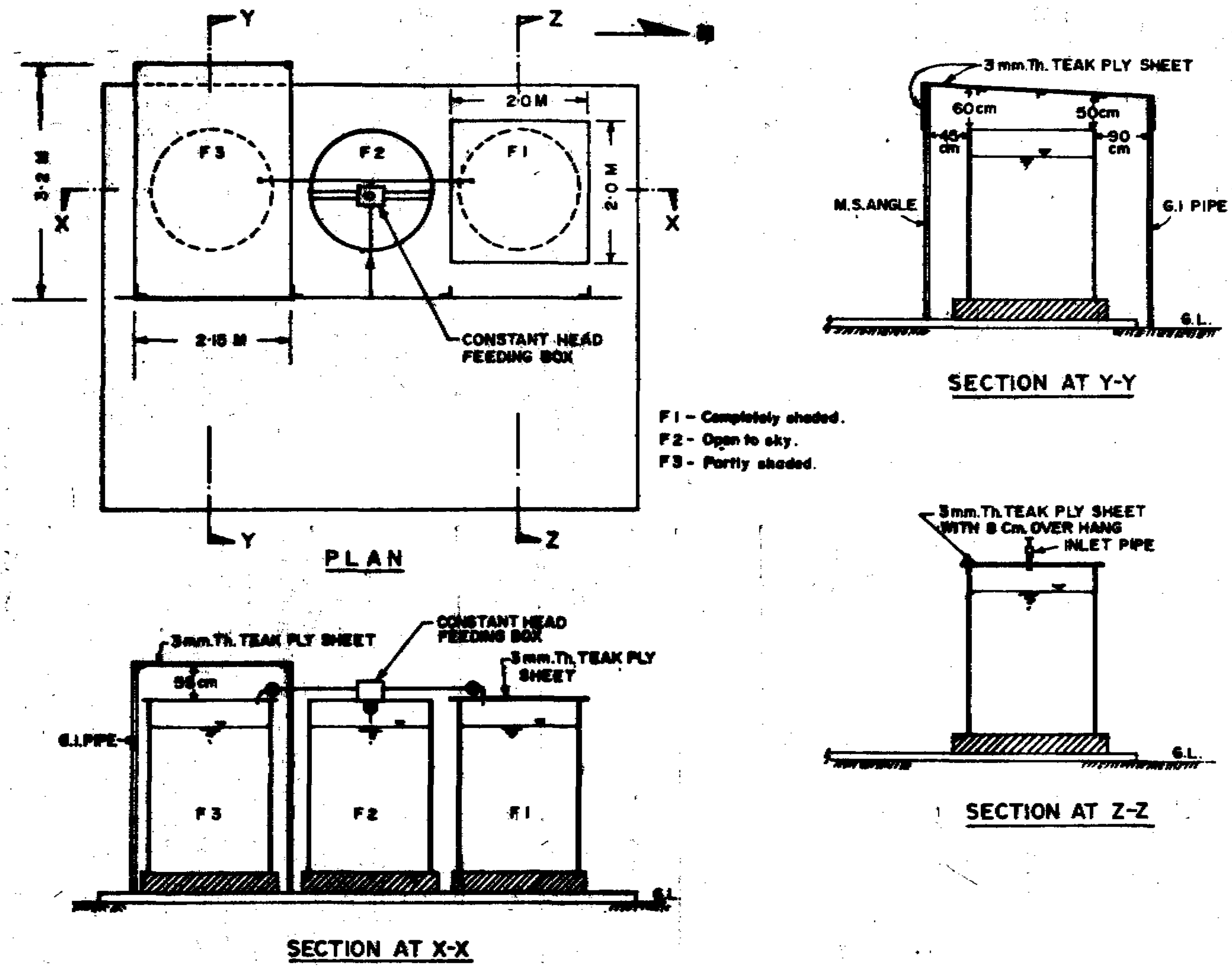


Fig. 5 – Details of Shading Arrangements

produced a filtrate with a more or less uniform dissolved oxygen as measured at 7.00 AM and 3.00 PM. However, the completely shaded filters gave a filtrate with relatively higher D. O. than that obtained from the partly shaded filter. The trend in filtrate D. O. of the control filter was one of minimum in the morning and maximum in the afternoon hours. This can be attributed to the enhanced photosynthetic activity of algae during day time followed by the respiration during night resulting in D. O. depletion. The limited data (Table 2) on algal counts from filter scrapings indicated a relatively small number in the shaded filters and these were predominantly diatoms. In the control filter, which was open to sky, there was a predominance of green algae.

Table 2 – Effect of Shading – Quantitative Data on Phytoplankton from Filter Scraping

(Organisms per sq. cm.)

	Completely shaded	Open to sky	Partly shaded
	2125×10^2	2828×10^3	2115×10^2
Dominant/ Sub-dominant	Cymbella/ Navicula Denticula	Cymbella Navicula Denticula	Cymbella/ Navicula Denticula

This provides a possible explanation to the observation that there was no significant difference in the length of run between shaded and control filters. Similarly, there was no significant difference between the filters in the reduction of COD which ranged from 62 to 68 per cent. It was concluded that shading of filters helps to reduce the algal activity in the filters but does not materially effect the filter performance.

2.2.6 *Effect of Intermittent Operation*

In developing countries, for reasons of economy in operation and maintenance, small water works serving upto a few thousand population are designed to operate for a part of the day only. Studies were carried out in order to assess the effect of such intermittent operation on the filtered water quality and the practical implications thereof on the design and operation of filter system.

During the first part of this study, one of the three pilot filters was run continuously (as a control) and the other two intermittently for 10 hours a day from 7 AM to 5 PM. At the end of the operation cycle (10 hours) the outlet valves of the intermittently operated filters were closed and raw water inflow cut-off. The full depth of supernatant was left in stagnant condition till the filter operation was resumed next morning. Daily samples of filtrate were collected soon after starting the filters following overnignt stagnation and tested for bacteriological quality, turbidity, pH and dissolved oxygen. Periodic observations on the diurnal variation in D. O. of filtered waters were also made.

The turbidity of raw water was below 5 NTU for a period of about 10 weeks and later, due to monsoon, increased to a maximum of about 24 NTU. Irrespective of this variation in raw water turbidity, the filtrate from all the filters had turbidity values below 1 NTU. Similarly, the efficiency of COD removal and the bacteriological quality of filtrates from the control and test filters were quite comparable. A perusal of the diurnal variation in the D. O. of filtrate (Fig. 6) from the intermittantly operated filters indicated that the time of occurrence of minimum D, O. coincides more or less with the time at which the layer of water in contact with the schmutzdecke passes out as filtrate. This observation was suggestive of a possible deterioration in the bacteriological quality also of the filtrate due to intermittent operation. Hence, further studies were conducted to confirm this hypothesis.

For these studies a more intensive and elaborate sampling programme was followed and the observations were restricted to only one filter at a time. The test filter was operated continuously for 5–7 days in the beginning of the run to allow the proper development of required flora and fauna and subsequently switched over to intermittent cycle of 8 hours (9AM to 5PM) followed by stagnation for 16 hours. Hourly samples of filtrate were collected daily and tested for bacteriological quality.

The results of bacteriological tests (Tables 3 4, & 5) clearly show that when the filter

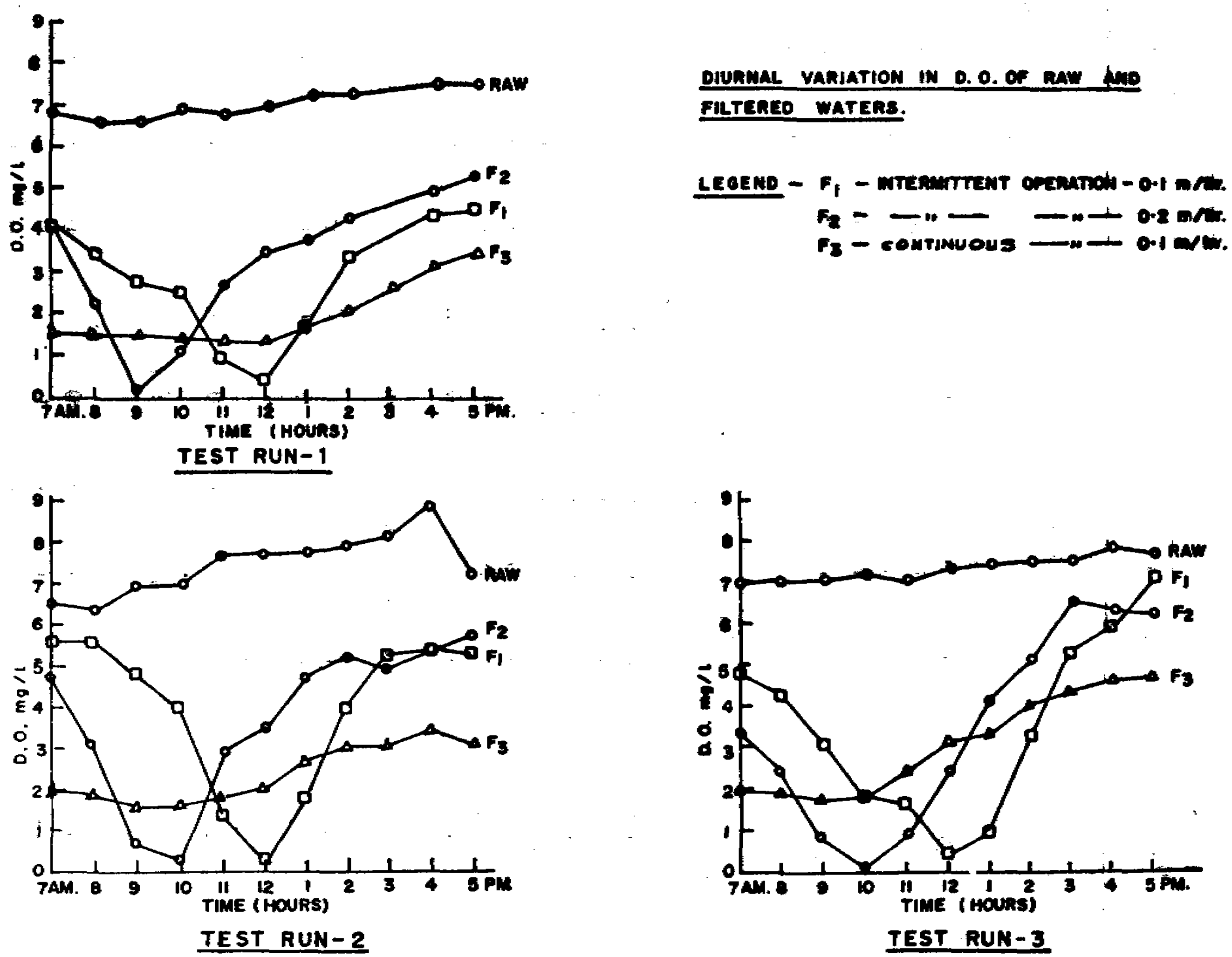


Fig. 6 – Diurnal Variation in D. O. of Raw and Filtered Waters

Table 3 – Bacteriological Quality of Filtrate Under Continuous and Intermittent Operation

Rate of Filtration : 0.1 m/hr

E. S. of sand : 0.25 mm U. C. : 2.92 Depth of sand : 57 cm

Time–Days	*E. Coli* MPN/100 ml.									
	Raw water 9 Am	Filtrate collected at								
		9 AM	10	11	12	1 PM	2	3	4	5
	Continuous operation									
1	920	0	0	0	0	0	0	0	0	0
2	33	0	0	0	0	0	0	0	0	0
3	240	0	0	0	0	0	0	0	0	0
4	33	0	0	0	0	0	0	0	0	0
5	79	0	0	0	0	0	0	0	0	0
6	33	0	0	0	0	0	0	0	0	0
7	1600	0	0	0	0	0	0	0	0	0
8	79	0	0	0	2	2	0	0	2	–
	Intermittent operation (9 AM – 5 PM)									
9	49	0	0	240+	240+	49	5	2	2	–
10	78	0	0	49	33	49	7	0	7	–
11	49	0	0	49	49	23	2	2	2	–
12	240	0	0	49	49	7	5	0	2	–
13	33	0	0	33	17	7	4	0	2	–
14	33	0	0	17	79	8	0	2	0	0
15	46	0	0	17	4	2	0	0	2	0
	Continuous operation									
16	17	0	0	2	0	0	0	0	0	–
17		0	0	0	0	0	0	0	0	–
18	8	0	0	0	0	0	0	0	0	–
19	17	0	0	0	0	0	0	2	0	–
20	33	0	0	0	0	0	0	0	0	–
	Intermittent operation with declining rate									
21	46	0	0	0	0	0	0	0	0	0
22	130	0	0	0	0	0	0	0	0	0
23	49	0	0	0	0	0	0	0	0	0
24	49	0	0	0	0	0	0	0	0	0
25	130	0	0	0	0	0	0	0	0	0

– Not Sampled

Table 4 – Bacteriological Quality of Filtrate Under Continuous and Intermittent Operation

Rate of Filtration : 0.2 m/hr.

E. S. of sand : 0.24 mm. U. C. : 2.1 Depth of sand : 58 cm.

Time–Days	*E. Coli* MPN/100 ml. Raw water 9 AM	Filtrate collected at 9 AM	10	11	12	1 PM	2	3	4	5
					Continuous Operation					
1	14	0	0	0	0	0	0	0	0	–
2	33	0	0	0	0	0	0	0	0	–
3	130	2	0	5	0	0	0	0	0	–
4	49	2	0	0	0	0	0	0	0	–
5	220	0	0	0	0	0	0	0	0	–
					Intermittent Operation (9 AM – 5 PM)					
6	350	0	0	240	79	49	33	33	33	33
7	46	5	5	49	79	49	13	23	8	17
8	17	0	5	33	13	2	2	8	2	5
9	33	2	2	79	22	7	5	0	0	2
10	22	0	2	79	22	2	0	0	2	0
11	23	0	2	33	2	2	2	2	0	0
					Continuous Operation					
12	130	0	0	0	0	0	0	0	0	–
13	23	0	0	0	0	0	0	0	0	–
14	240	0	0	0	0	0	0	0	0	–
					Intermittent Operation with declining rate					
15	49	0	0	2	0	0	0	0	0	0
16	33	0	2	0	0	2	2	0	0	0
17	79	0	0	2	5	0	0	0	0	0
18	13	0	0	2	5	0	0	0	0	2
19	22	0	0	0	0	0	0	0	0	0
20	23	0	0	2	0	0	0	0	0	0
					Intermittent Operation (9 AM – 5 PM)					
21	5	0	0	23	0	0	2	0	0	0
22	79	0	0	–	14	4	0	0	0	0
23	33	0	0	0	2	2	0	0	0	0
24	14	0	0	2	0	0	0	0	0	0

– Not Sampled

Table 5 – Bacteriological Quality of Filtrate Under Continuous and Intermittent Operation

Rate of Filtration : 0.1 m/hr.

E. S. of sand : 0.32 mm. U. C. : 2.59 Depth of sand : 75 cm.

Time–Days	*E. Coli* MPN/100 ml.									
	Raw water 9 AM	Filtrate collected at								
		9 AM	10	11	12	1 PM	2	3	4	5
		Continuous Operation								
1	31	0	0	0	0	0	0	0	0	–
2	33	0	0	0	0	0	0	0	0	–
3	49	0	0	0	0	0	0	0	0	–
4	31	0	0	0	0	0	0	0	0	–
5	8	0	0	0	0	0	0	0	0	–
6	49	0	0	0	0	0	0	0	0	–
7	33	5	4	23	0	2	2	5	0	–
		Intermittent Operation (9 AM – 5 PM)								
8	240	5	0	4	49	33	23	33	8	0
9	79	0	0	2	5	23	13	11	2	2
10	140	0	0	0	130	240	33	49	23	2
11	79	0	0	2	240	240	240	79	79	23
12	49	240	240	240	240	240	240	240	240	240
13	49	240	240	240	240	240	240	240	240	240
		Continuous Operation								
14	33	2	0	0	0	0	0	0	0	0
15	8	0	0	0	0	0	0	0	0	0
16	70	0	0	0	0	0	0	0	0	0
		Intermittent Operation with declining rate								
17	170	0	0	2	0	2	0	0	0	0
18	110	0	0	2	0	–	0	0	2	0
19	13	0	0	0	5	0	0	5	0	0
20	49	0	0	0	0	0	0	0	0	0

– Not Sampled

was run without interruption, a filtrate of consistently satisfactory quality was obtained. However, when subjected to intermittent operation, a definite deterioration in bacterial quality occured. The impairment did not occur soon after starting the filter, but after a period of time which was found to vary with the rate of filtration and the depth of filter sand used. Interestingly enough, the filter recovered gradually and produced a filtrate of satisfactory quality at the end of the operation cycle.

While intermittent operation of filters may lead to economy in operation and maintenance, the cost of filter construction will increase due to increased filter area requirement and also poses, as described above, the danger of an impairment of bacteriological quality of filtered water. In order to explore possible alternate methods of operation for field practice, the filter run was continued with a modifiction in operation. At the end of 8 hours (9 AM–5 PM) operation, raw water inflow to the filter was cut off but filtration was continued with a falling supernatant (declining rate) till next morning when supply of raw water was resumed. The sampling schedule remained the same and the data on bacteriological quality are given in Tables 3, 4 and 5. It is evident from the results that the alternative method of running a slow sand filter on a declining rate does not lead to any significant impairment of filtrate quality.

This alternative, while producing a filtrate comparable to that obtained under continuous constant rate operation, however, poses difficulties in the design and operation of raw water pumps and the associated pre–treatment facilities where provided. Further, in the declining–rate mode of operation, depending upon the rate of filtration and the time interval between successive raw water pumping, a stagnant condition may result due to complete draining of the supernatant especially in the initial stages of the run when the headloss is minimum. Therefore, a satisfactory solution which would eliminate this contingency and also result in a design with minimum filter area would be to provide for an uninterrupted operation of the filter. Even with restricted raw water pumping hours, this can be achieved by the provision of a separate storage tank of appropriate capacity which will feed by gravity raw water to the filter during non–pumping hours (Fig. 7) so as to ensure round the clock operation of the filters. For example, with only 8 hour raw water pumping (at a rate equal to 3 times the hourly output of the total filter area) divided into two shifts of 4 hours each with an interval of 8 hours in between and providing a raw water storage tank of 8 hour capacity placed at a slightly higher level, continuous filtration can be achieved.

2.2.7 *Performance of Filters Treating Highly Polluted Water*

The greatest advantage of a slow sand filter is its ability to remove organic matter and pathogenic organisms. However, very little published information is available on the extent of organic pollution that could be satisfactorily treated by slow sand filters under tropical conditions. This aspect of study was considered relevant to situations obtaining in rural areas where surface sources of water supply are used for other activities as well and hence invariably polluted.

In order to study the effect of high levels of organic pollution, experiments were conducted with lake water artificially contaminated by adding sewage. When sewage was added to the shallow raw water storage tanks, they started functioning as stabilization ponds. This was evident from the observations that the raw water gradually turned green due to intense algal growth and the increase in coliform count in raw water was not commensurate with the quantity of sewage added – phenomena typical of oxidation ponds.

The experiments were carried out for a period of 2½ months. Two of the filters were fed with sewage contaminated raw water while the control received raw water with no sewage added to it. Observations were recorded daily for temperature, D. O., turbidity and bacteriological quality of raw and filtered waters. Chemical analysis and quantitative enumeration of algae were also carried out regularly for influent and filtrate samples.

The chemical analysis of raw water indicated that the COD which was about 5 mg/l started increasing with daily addition of sewage. When a pollution level of 20 mg/l as COD (equivalent

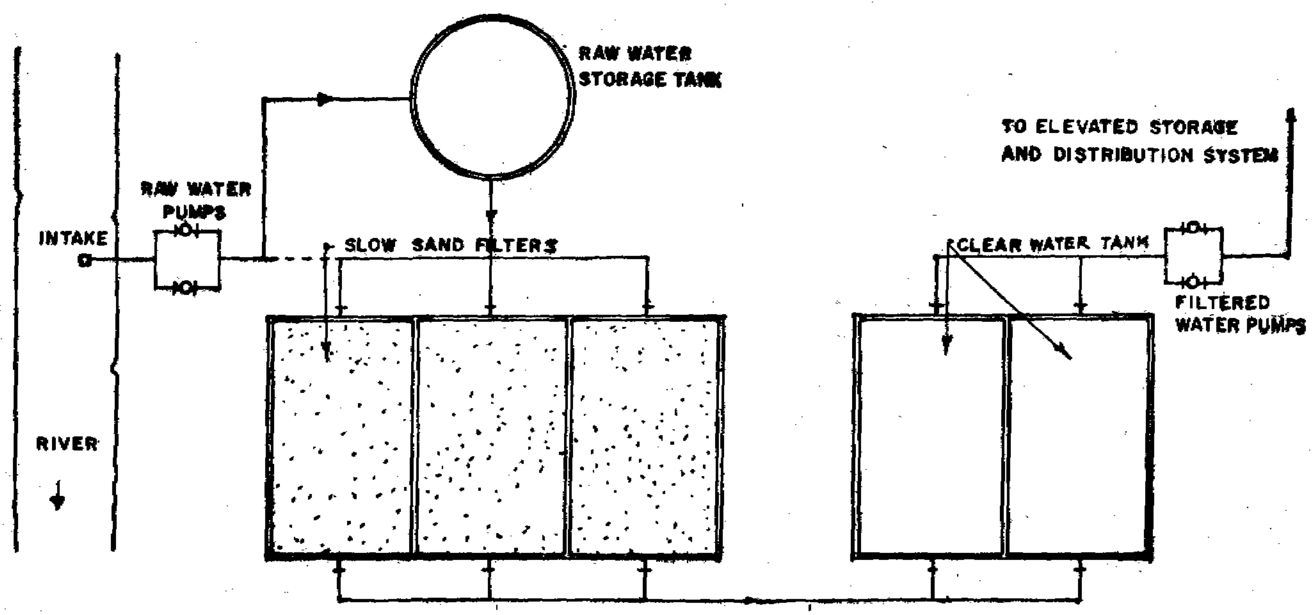


Fig. 7 – Schematic Layout of Filter Installation for Continuous Operation with Restricted Raw Water Pumping

to about5 mg/l BOD) was reached, the filter started giving out algae in the effluent and produced a filtrate of unsatisfactory bacteriological quality both at 0.1 m/hr and 0.2 m/hr filtration rates. At the time of filter cleaning, it was observed that the formation of Schmutzdecke was not satisfactory and the bed was infested with *Chironomus larvae*. It is known that these larvae are capable of disturbing the top active layer and even wriggling throug the bed. The presence of these larvae in large numbers may be one of the reasons for the poor bacteriological performance of the filter. When sewage addition was discontinued the filters recovered gradually and gave algae-free filtrate.

The studies have shown that slow sand filters gave a satisfactory performance when treating raw waters with normal levels of organic pollution and coliform concentration. However, when sewage was added to raw water as in the present studies, the filters produced a filtrate of unsatisfactory bacteriological quality. When the pollution level exceeded about 20 mg/l as COD, algae were observed in the filtrate in large numbers. Under these conditions suitable additional treatment or protection of catchment area may have to be considered.

2.2.8 Performance of Filters with Builder Grade Sand

Slow sand filter require a large volume of filter medium which is usually sand. Experience has shown that the cost of sand may constitute a sizeable fraction of the total cost of filter installation. While due care needs to be exercised in the specification and choice of sand for rapid filters, the relatively heavy expense of careful grading can be avoided for slow sand filters. Under many situations locally available sand can be used with no adverse effect on filter performance. This would bring down the cost of sand considerably. When the cost of a slow sand filter is reduced and made economical, the system has a greater chance of acceptance and application for rural communities. With this objective, the performance of slow sand filters with builder grade sand was evaluated. Builder grade sand as defined in the present study is river sand subjected to a minimum of screening to remove coarse and fine material as practised in building construction.

Three pilot filters, each with a different grading of sand, were used for the experiments. The specifications of sand used for the filters are given below :

Filter		Effective size mm	Uniformity coefficient	Depth cm
F1	...	0.25	2.92	93
F2	...	0.32	2.59	100
F3	...	0.21	2.10	100

The depth and grading of gravel used were the same for all the filters. The study was conducted for a period of about six month including the initial ripening period and the results are discussed under.

Turbidity observations for raw water and filtrates expressed as weekly averages for the period of study are shown in Fig. 8. The raw water was clear with a low turbidity (less than 3 NTU) for a major part of the study except for about 2 weeks when it exceeded 10 NTU but remained below 15 NTU. It may be seen from the results that the filtrate turbidity from all the filters was always well below 1 NTU irrespective of the variation in raw water turbidity.

The pollution level in raw water expressed as COD varied from about 6–13 mg/1, with an average value of 8.2 mg/1. The average reduction in COD after filtration through graded fine sand with an E. S. of 0.21 mm and U. C. 2.1 was 74.3 per cent. The other two filters in which medium (E. S. 0.25 mm and U. C. 2.92) and relatively coarse (E. S. 0.32 mm, U. C. 2.59) builder grade sands were used, gave a COD reduction of 63.57 and 67.16 per cent respectively. Statistical evalution of the performance of filters with respect to reduction in COD revealed that the filter with graded fine sand was more efficient than those with builder grade sands. However, the difference between the filters using medium and coarse builder grade sands was not significant.

The bacteriological results showed that more than 89 per cent of the filtered water samples

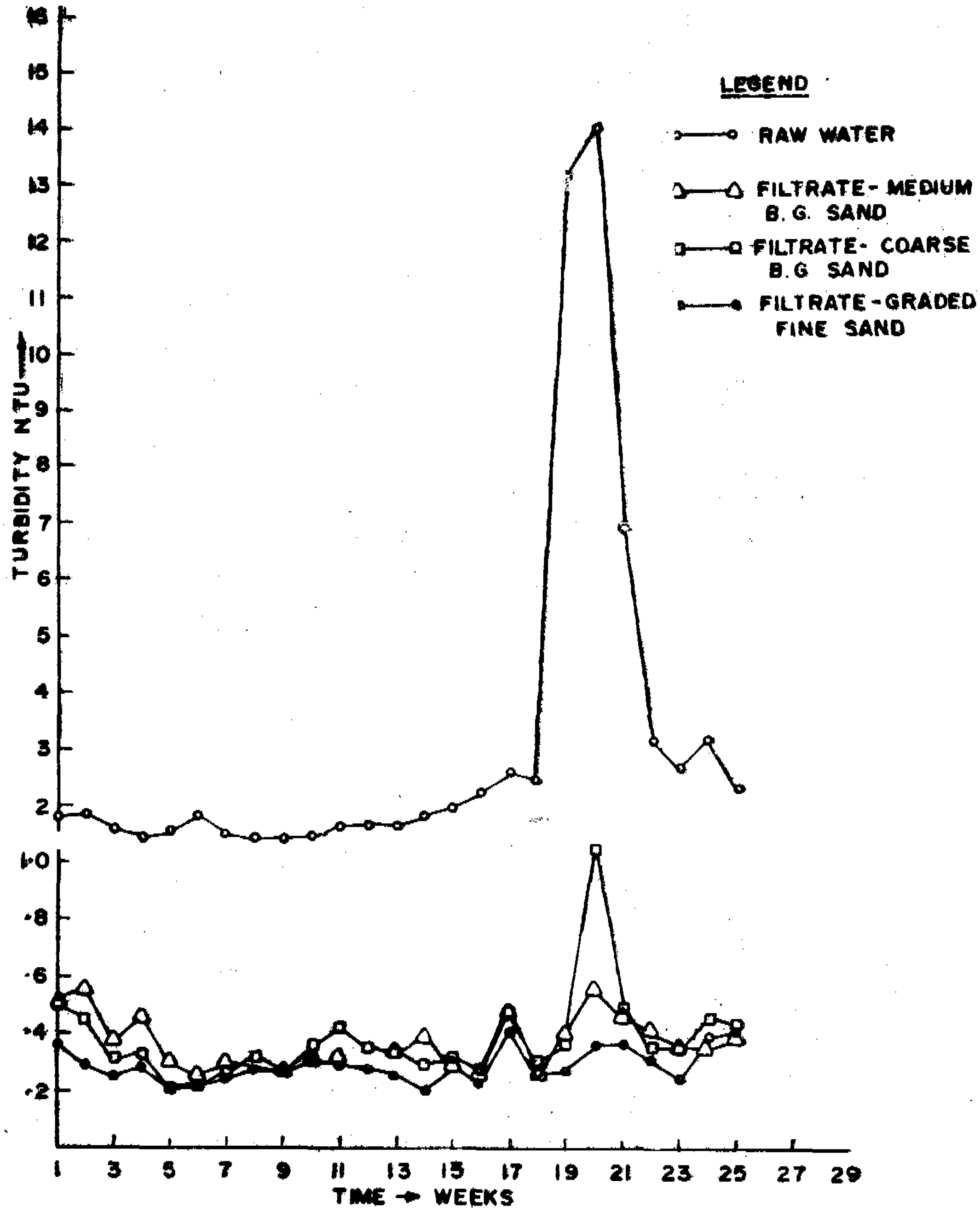


Fig. 8 – Experiments on Builder Grade Sand Variation in Raw & Filtered Water Turbidity

from the filters with graded fine sand and medium builder grade sand were free from *E. Coli*. The filter with coarse builder grade sand, however, produced a filtrate free from *E. Coli* only in 66 per cent of the samples. Statistical analysis of bacteriological data using the test for proportions, has revealed that graded fine sand and medium builder grade sand are equally efficient in removal of *E. Coli*. Coarse builder grade sand, however, appears to be less efficient.

The length of run for the filters varied considerably inspite of no significant change in raw water quality. Builder grade sands gave longer runs than graded fine sand. Considered in the order of increasing grain size, the average length of run at 0.1 m/hr filtration rate was 28, 35 and 38 days respectively. The corresponding length of run at 0.2 m/ hr was 6,8 and 18 days respectively. The depth of penetration of impurities increases with the rate of filtration and the size of sand grain. This implies that where coarser sand is used or higher filtration rate is adopted, it is necessary to scrape a deeper (about 3 cm) layer of top sand during filter cleaning. The deeper penetration of impurities when coarse sand is used is also confirmed by the presence of greater number of phytoplankton in the lower layers of sand bed. Builder grade sands with E.S. upto about 0.3 mm and U.C. below 3 give satisfactory performance and econmy in cost of filter medium and its maintenance.

2.3 Field Study

Performance evaluation study of a full scale slow sand filter installation at Umrer, near Nagpur was taken up to supplement laboratory research and to facilitate evolving a design that would take into account practical field situations. The flow sheet and salient features of the treatment plant with a design capacity of 2.7 mld are shown in Fig. 9 and Table 6 respectively.

Raw water from irrigation canal is pumped to earthern storage tanks from where it flows by gravity to the slow sand filters. Provision has also been made to pump canal water, if necessary, direct to filters. Filtered water, after safety chlorination, is pumped to serviee reservoirs for distribution through individual house connections and public stand posts.

The performance of the plant was studied over a period of about 16 months. The filters designed for a filtration rate of 0.17 m/hr were operated intermittently and for a period of 5–6 hours a day. Weekly samples at different stages of purification were collected and tested for relevant physico-chemical and bacteriological parameters. The data on turbidity of raw, settled and filtered waters are presented in Fig. 10. The filtered water turbidity was generally less than 2 NTU. There was no significant change in the dissolved salts of canal water after filtration. This observation confirmed the laboratory findings. The average Chemical Oxygen Demand (COD) of influent to the filter was 6.9 mg/l and a reduction of 56–59 per cent was observed due to filtration. The coliform count in the canal water varied considerably depending upon the season with the maximum MPN being 16000 per 100 ml. Morethan 50 per cent of the samples of canal water had a coliform MPN of 1000 and above. More than 60 per cent of the filtrate samples were negative for *E. Coli* thereby satisfying the drinking water quality standards even prior to terminal chlorination. The performance of the filters in general was was similar to that obtained with the pilot filters. The day today operation and maintenance of the filters and filter cleaning were guided and supervised by NEERI staff who also trained the local operators in their normal routine.

The field study resulted not only in the generation of data on the performance of slow sand filter under prevailing local conditions but also provided an insight into the operational and maintenance aspects of the system.

2.4 Conclusions

The following conclusions have been drawn from the studies carried out on different aspects of slow sand filtration :

- Slow sand filters treating surface waters of turbidity upto 30 NTU produced good quality filtrate with turbidity less than 1 NTU at filtration rates of 0.1, 0.2, and 0.3 m/hr (ie) even upto 3 times the conven-

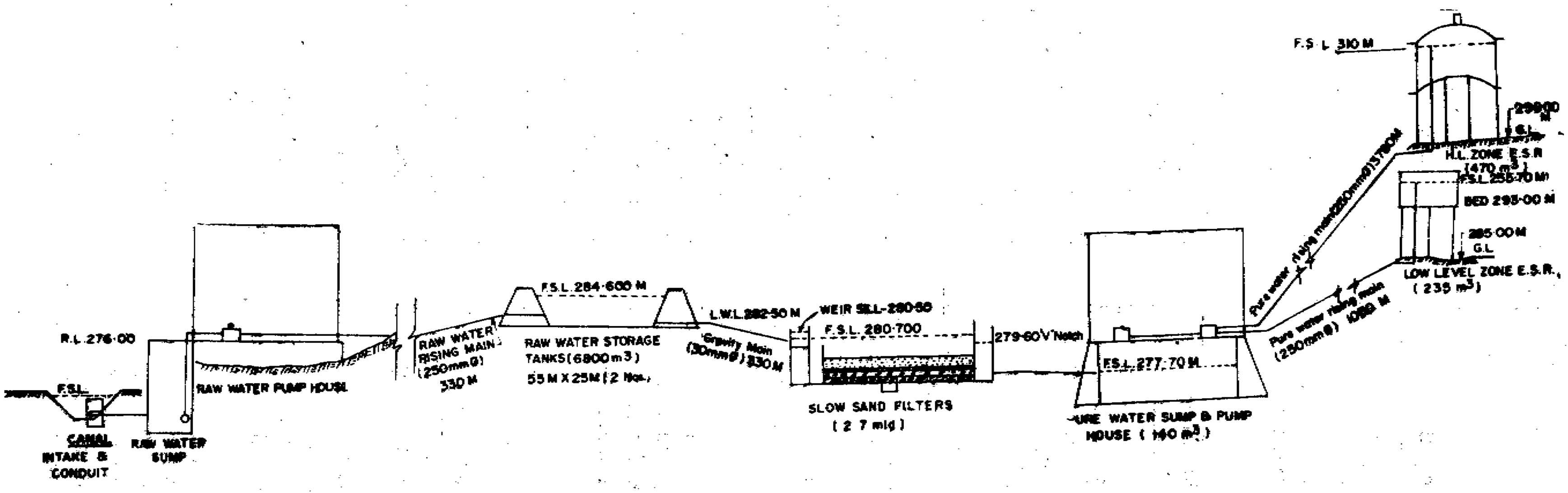
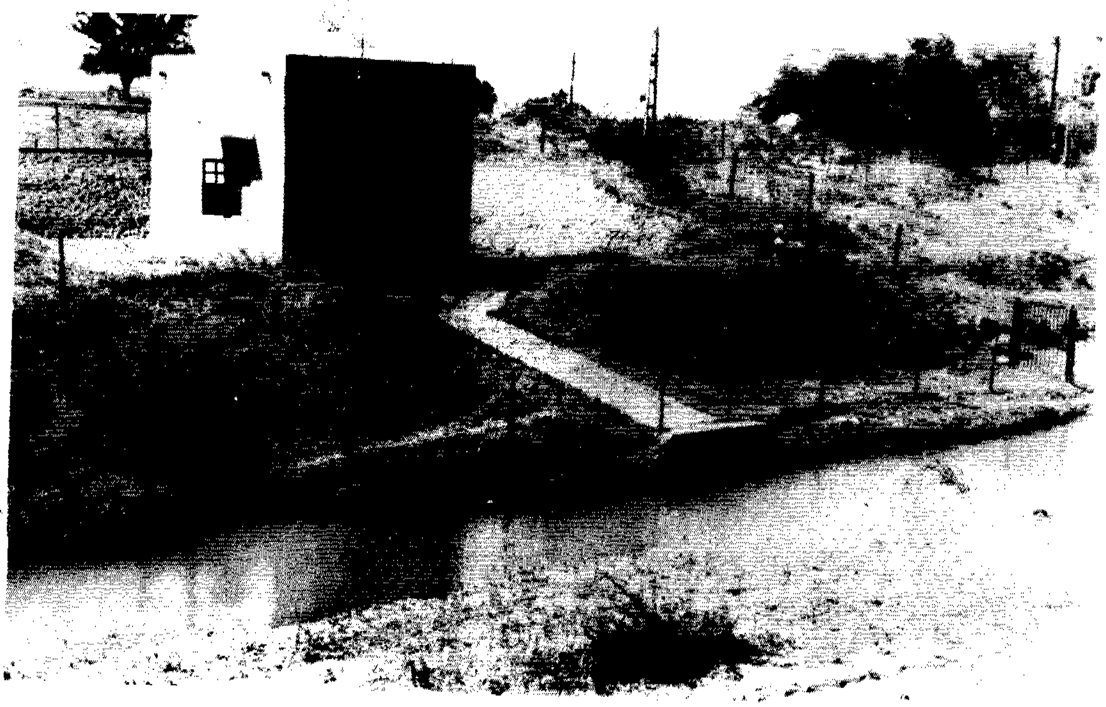
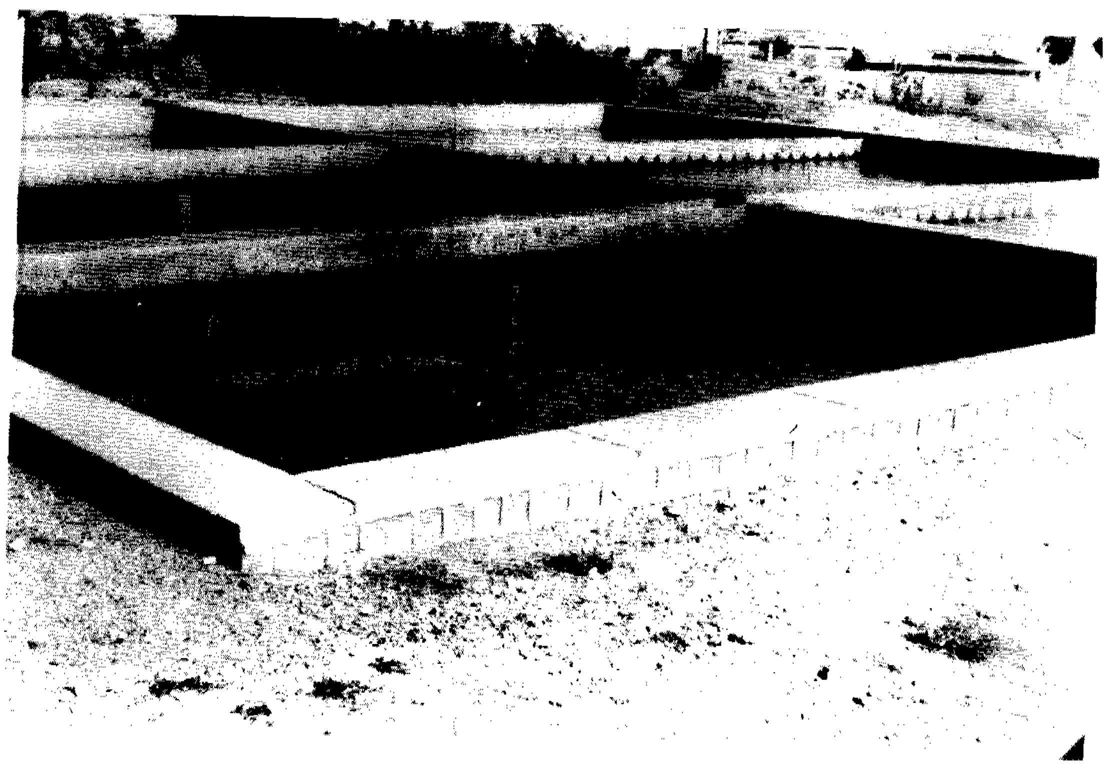


Fig. 9 – Umrer Water Supply Scheme (Flow Sheet)





Umrer water works - raw water canal & pump hous
(Top) slow sand filters (Bottom)

Table 6 – Salient Features of Umrer Water Supply Systems

1.	Location	:	50 km South-East of Nagpur
2.	Population	:	i) Immediate stage (year 1971) 27000 ii) Ultimate stage (year 2000) 35000
3.	Annual rainfall	:	130 cm.
4.	Source of raw water	:	Irrigation canal 8 km downstream of head regulator
5.	Total daily requirement	:	Immediate stage 1700 m^3 Ultimate stage 5000 m^3
6.	Present daily supply	:	570 m^3
7.	Hours of raw water pumping	:	Immediate stage–15 hr. Ultimate stage–22½ hr.
8.	Rate of raw water pumping	:	Immediate stage–115 m^3/hr Ultimate stage 230 m^3/hr
9.	Raw water sump	:	Semicircular 3.44 m. dia, 5 m depth
10.	Raw water pump house	:	Rectangular 5.5 m × 3.65 m.
11.	Raw water pumps	:	2 sets of 12.5 B. H. P. each
12.	Raw water rising main	:	250 mm dia. C. I. 'LA' class 350 m. length Bypass 300 mm dia C. I. pipe 43 m.
13.	Raw water storage tanks	:	Capacity 6800 m^3 size 55m × 25m × 2.15m 2 Nos.
14.	Raw water gravity main	:	300 mm dia R. C. C. 'P1' class 286 m length
15.	Slow sand filters	:	2 Nos. 25.5 m. × 12.45 m × 3.5 m.
16.	Filtered water sump	:	Rectangular, capacity 140 m^3
17.	Disinfection	:	By chlorine gas
18.	Filtered water pumping machinery		
	i) Low level zone	:	Deep well turbine pumps 2 Nos. 10 BHP each
	ii) High level zone	:	Deep well turbine pumps 2 Nos. 25 BHP each
19.	Filtered water rising main	:	i) Low level zone : 150 mm dia C. I. 'LA' class 1020 m. ii) High level zone : 250 mm dia C. I. 'LA' class 3780 m.
20.	Service reservoirs	:	High level zone capacity 470 m^3 Low level zone, capacity 235 m^3
21.	Number of house connections	:	845
22.	Number of public stand-posts	:	28 (4 taps each)
23.	Period of water supply	:	Intermittent (about 1½ hrs./day)

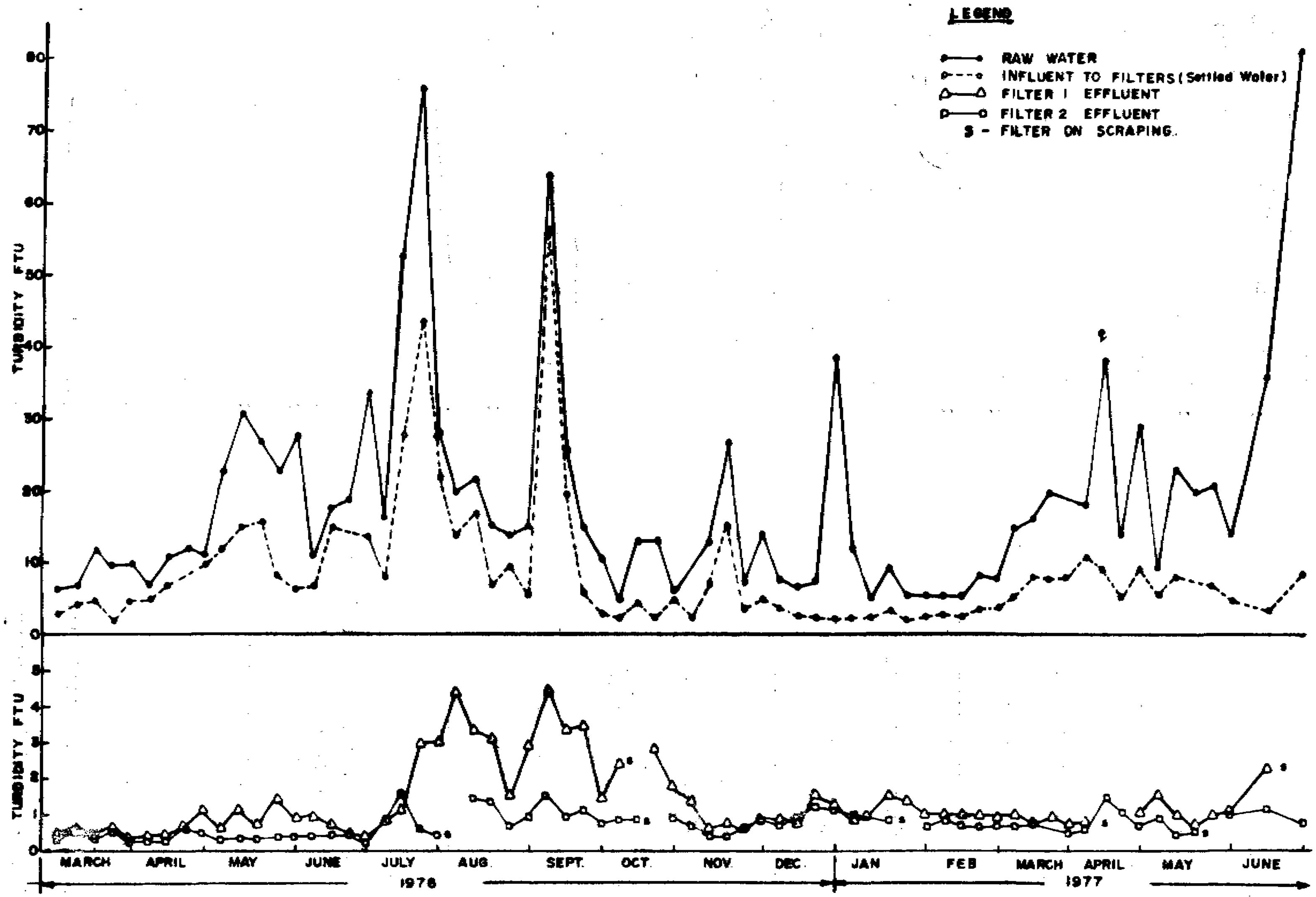


Fig. 10 – Performance of Slow Sand Filters At Umrer : Variation in Turbidity of Raw, Settled and Filtered Waters.

tional filtration rate. At higher filtration rates, the filtered water output increased, but the length of filter run decreased. The increase in output was, however, not directly proportional to the filtration rate.

- Under varying conditions of raw water quality and filter operation, more than 85 per cent of the filtrate samples were free from *E.Coli*, thereby meeting the drinking water quality standards.
- When raw water containing 8–12 mg/l COD was treated at filtration rates upto 0.3 m/hr, the COD removal efficiency was 55 to 75 per cent. The efficiency was higher with higher initial COD concentration. No significant difference in efficiency was observed with respect to rate of filtration.
- The chemical characteristics of raw water such as alkalinity, hardness, chlorides and sulphates remained unaltered due to slow sand filtration. There was a considerable reduction in the total iron content of raw water.
- Under tropical conditions covering the filters to exclude sunlight did not materially influence the filter performance, but retarded the development and proliferation of algae.
- Intermittent operation of slow sand filters resulted in the deterioration of bacteriological quality of filtered water shortly after the start-up. However, a satisfactory filtrate was ensured when the filter was run with a falling supernatant (ie) declining rate filtratlon.
- Higher levels of organic pollution (COD 20 mg/l) in raw water adversely effected the filter performance resulting in deterioration of filtrate quality. The filters, recovered gradually and gave a satisfactory performance when the pollution level was reduced.
- Slow sand filters with builder grade sand were also effective and gave a filtrate of satisfactory quality.

Arising out of the laboratory and field investigations and critical review of slow sand filtration practice in India, guidelines were formulated for cost effective design of slow sand filters, their construction, operation and maintenance.

3. PHASE II – DEMONSTRATION PROGRAMME

3.1 Objectives & Scope

In a logical and functional way the demonstration programme follows the results of the first phase of the project. The broad objectives of the programme are :

- to demonstrate from technological and socio–economic points of view the suitability and appropriateness of slow sand filtration for community water supplies in rural and urban fringe areas by constructing full scale plants at village level under different local conditions,
- to develop and improve design criteria for construction of slow sand filters and appropriate pre–treatment installations that are simple to operate and maintain,
- to prepare guidelines for design, construction, operation and management of small slow sand filters in developing countries, and
- to develop and test a strategy for introduction of water supply in rural communities.

The main elements of the programme are continued applied research and investigations, transfer and exchange of know–how and experience through and integrated, multi–disciplinary approach involving village communities, research workers, field engineers, health agencies and policy makers at local, national and international level. Support activities of a motivational character were interwoven with the main theme of slow sand filtration to promote community participation and a self generating (multiplier) effect. In short, the second phase of the project was aimed at developing and demonstrating a strategy characterized by integrated approach, internal and international collaboration and development of local resources and capabilities for future large scale implementation of community water supplies in developing countries.

3.2 Project Organisation – Project Managing Committee (PMC)

The main purpose of establishing a Project Managing Committee at national level is to improve and promote collaboration between governmental authorities, ministeries, research institutions and executing agencies concerned with water supply and sanitation. Such a collaboration and coordination within the country is considered a pre-requisite for effective planning, organisation and successful implementation of the project and also future large scale national water supply programmes.

The Project Managing Committee for India consisted of representatives of the following organisations/institutions :

1. Adviser – Central Public Health and Environmental Engineering Organisation (CPH & EEO), Ministry of Works & Housing, Govt. of India.
2. Director & Scientists, National Environmental Engineering Research Institute (NEERI), Nagpur.
3. Chief Public Health Engineers of the States of Andhra Pradesh, Haryana, Maharashtra and Tamil Nadu where the village demonstration plants were constructed.
4. Director, Central Health Education Bureau (CHEB), Ministry of Health & Family Welfare, Govt. of India.
5. International Reference Centre (IRC) for Community Water Supply and Sanitation, The Hague, The Netherlands.

The PMC met periodically to formulate policy decisions, review and discuss the progress of the project and to provide general guidelines for effective implementation.

Within the overall frame work of the project, the various activities were implemented by the national and local agencies concerned. As the lead agency for India, the primary responsibility for progress lay with NEERI (CSIR), which coordinated the programme between the participating agencies in addition to the research and development inputs to the project. The public health engineering departments of the participating states were responsible for the construction of the village demonstration plants with technical support from NEERI. The Central Health Education Bureau, New Delhi, in collaboration with the state health departments, implemented a programme of community education and motivation for effective use of water supply purified by slow sand filters. The local communities participated through cash contribations, by making available land for construction and in decision making regarding the choice of the caretaker for the treatment plant and the number and location of the public stand posts within the village. Orientation of the project to suit the local circumstances and constraints both technical and socio-cultural, is an important feature of the programme. Optimal use of local resources in terms of know-how, experience, inventiveness, man-power, materials and finance was promoted. The international co-ardination and support was extended by IRC through NEERI.

3.3 Selection Criteria for Demonstration Sites

Recognising the vastness of the country, varied geohydrological conditions and the prevailing differences in socio-economic development of rural communities, the following criteria were considered in the selection of villages for location of demonstration plants so as to cover a representative cross-section.

Village need :- Absence or inadequacy of existing potable water, prevalence of water-borne diseases.

Demography :- Suitable size and density of population.

Village interest :- Community interest and its willingness to participate in the project.

Nature of raw water source :- Quality of raw water, its variation, adequacy of the source in terms of its yield and its distance from the village.

Type of treatment needed :– Villages where ground water of good quality was not readily available and treatment of surface water was necessary, were considered appropriate.

Socio-economic status and village potential :– The economic growth potential, exsiting village institutions such as schools, health units and organisational infrastructure.

Facilities for investigations – Villages easily accessible and reasonably close to a testing laboratory.

With the above criteria as the background, consultations were held with the public health engineering departments of a number of states who were appraised of the scope and objectives of the demonstration programme. These were followed by preliminary visits to prospective villages in order to study the local conditions – both technical and socio-economic and to assess the willingness of community and government agencies for participation in the programme. Within the overall frame work of selection criteria, four villages were selected from different parts of the country representing a typical cross–section with respect to the nature of raw water source, the size of community and its level of socio-economic development. An extensive community education and participation programme was concurrently introduced in the villages. This integrated approach in which the community, the public health department and the water supply agency closely collaborated with each other was chosen in order to (i) develop and maintain favourable attitude by the community towards the water supply system being introduced and to enlist their continued cooperation and interest, (ii) promote community organisation to coordinate local inputs to the water supply project including finance and labour. (iii) train one or more community members to operate and maintain the water supply system and (iv) promote through health education of community members, personal hygiene and sanitation, preservation of water quality from delivery point till consumption and prevention of wastage of water, nuisance around public stand posts and damage to the water supply system. Through the implementation of the community education and participation programme an attempt was made to sustain the commitment of the community towards the water supply system and enhance its lasting operation.

3.4 Design and Construction of Village Demonstration Plants (VDPs)

From the results of applied research carried out in the first phase of the project, and a critical study of the traditional design practice, and a number of slow sand filter installations in the country, the common problems experienced in their operation and maintenance, modifications were evolved and suitable guidelines formulated for design and construction of slow sand filters for community water supplies. while doing this, due attention was given to keep the cost of installation minimum consistent, with operational efficiency and simplicity. The typical layout of a twin bed installation along with details is shown in Figure 11. However, the layout for individual demonstration plant (s) was decided keeping in view the local conditions and constraints. The shape of filter units, their size and number and the material of construction were determined based on considerations of cost and availability of materials.

The projected (design) population for the demonstration plants ranged from 1300–12700 persons, which is representative of the bulk of villages/towns of India where water treatment plants will be required. Apart from being geographically distributed over the country, the project villages also represent typical socio–economic conditions of rural India. The four demonstration plants cover a variety of situations in terms of raw water source, the type of pretreatment provided, filter shape and construction details. The raw water sources varied from river fed canal, canal fed from an impounded source, an upland perennial river to a river subject to seasonal floods. Summer storage tanks of 30–40 days detention period provide the pre–treatment for two of the plants, a plain settling tank followed by a horizontal flow pre–filter in the third and an infiltration gallery constructed across the river–bed in the fourth plant.

The filters at two sites are circular in shape while the other two plants have rectangular units with common wall construction. The underdrains in one of the plants consists of a system of PVC pipe manifold and laterals fitted with permeable capsules. In the second, the underdrain is made of precast concrete bricks – the bottom layer laid on edge and the top layer laid flat so as to form a series of laterals connected to a central channel. The top layer of bricks had perforations (holes) for passage of filtered water. The underdrain for the third one was similar to conventional brick underdrain but made of pre-cast concrete. Thus a variety of innovative structural designs has been incorporated in the demonstration plants.

4. VILLAGE DEMONSTRATION PLANTS

The locations of the four village demonstration plants are shown in Figure 12 and their salient features summarized in Table 7. The following is a brief description of the plants.

4.1 Borujwada (Maharashtra)

General

Villlage Borujwada is located at latitude 21°22' and longitude 35°57', 30 km, from Nagpur in Kalmeshwar Block, Nagpur district, Maharashtra State. One of the three revenue villages under Borujwada Panchayat*, it is situated on the left bank of river Kolar and is readily accessible throughout the year. The village with 110 families has a population (1981) of about 780 persons. The average annual rainfall of the village is 1070 mm, mainly spreadover a period of 4 months from June to September. The climatic conditions are extreme-the minimum temperature in winter is around 10°C and the maximum during summer is 46°C.

The main occupation of the village folk is agriculture and the major crops grown are wheat and cotton. Economically the village is not well-off. The average annual income of majority of the families is less than Rs. 2,500/–. The village is electrified recently and has a primary school.

Prior to the introduction of piped water supply with treatment by slow sand filtration, the village met its water requirements from a public open dug well and the river Kolar. The yield of the well reduced considerably during summer and the quality of water was unsatisfactory chemically and from bacteriological point of view (Tables 8 and 9). The river, on the other hand, apart from being polluted was subject to seasonal floods resulting in high turbidity during rainy season.

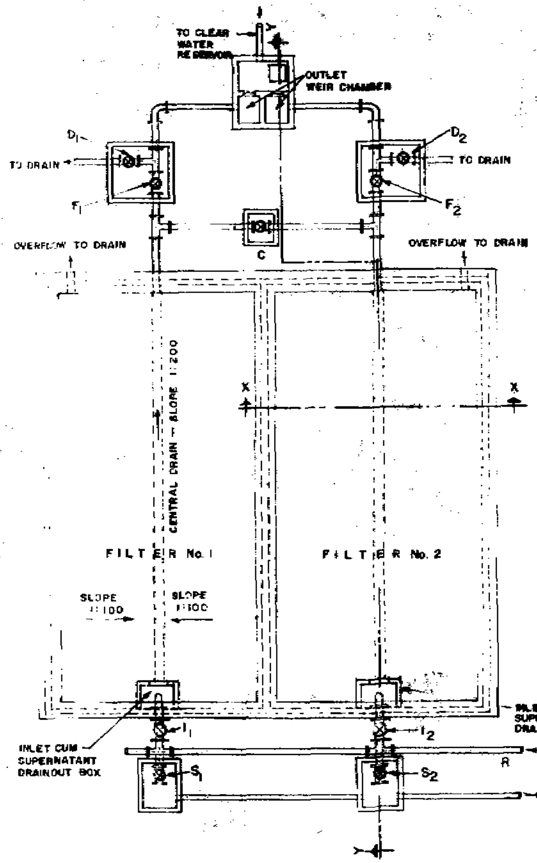
Socially well organised, the villagers take keen interest in the development programmes of the village. Borujwada is one of the ten villages in Nagpur district where a rural sanitation programme has been introduced by NEERI in collaboration with the Zilla Parishad*, Nagpur and active participation by the villagers. It was the first village to accept individual household sanitary latrines by all the families for which it received a cash award of Rs. 10,000/– from the Zilla Parishad. This amount was paid to the Government by the village as part of its cash contribution towards the cost of the water supply project.

Plant Description

The source of raw water to the treatment plant is the river Kolar, tapped on the upstream of the village. As the surface flow in the river during summer diminishes considerably, raw water is drawn through an infiltration gallery (Figure 13) constructed across the river bed so as to tap sub-surface flow and to ensure adequate supply throughout the year. The infiltration gallery also provides a simple and economical means of pre-treatment to obtain a uniform quality of raw water irrespective of its seasonal variations. Any other form of pre-treatment would have entailed one more pumping resulting in increased capital and running costs. The infiltered water is collected in a jack well from where it is pumped for further treatment by slow sand filters. The filtered water from the clear water sump after disinfection using bleaching powder solution is pumped to an elevated service reservoir for distribution by gravity through public stand posts (6 nos.) and recently through

* Local body of elected representatives for civic administration

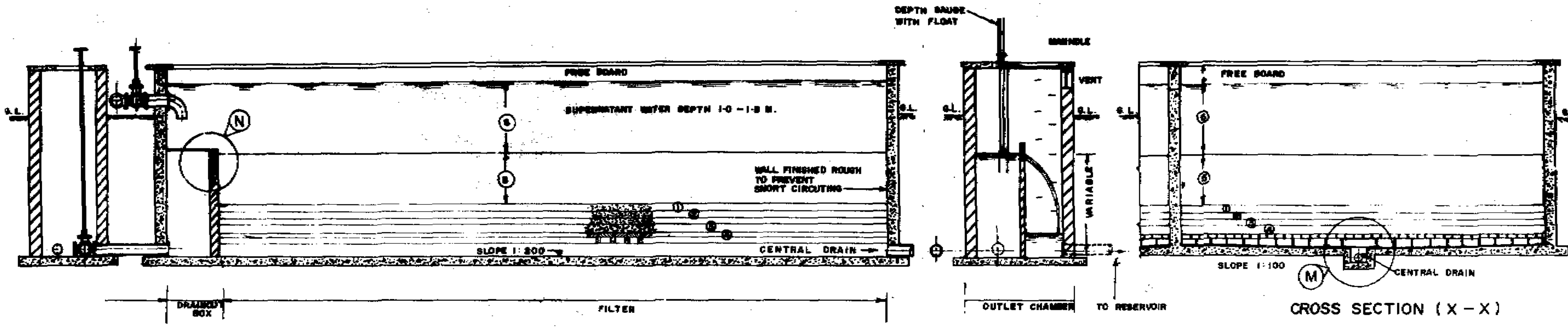
*District level body of elected representatives



LAYOUT PLAN

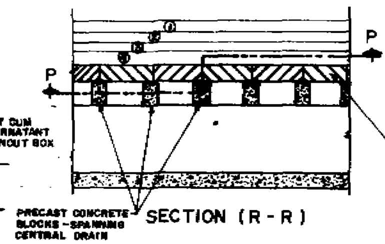
REFERENCE

R ------- RAW WATER MAIN
I_1, I_2 ------- INLET VALVES FOR FILTERS
F_1, F_2 ------- FILTERED WATER OUTLET VALVES
S_1, S_2 ------- SUPERNATANT DRAINOUT VALVES
D_1, D_2 ------- DRAINOUT VALVES
C ------- FILTER INTERCONNECTING VALVE
1 ------- TOP LAYER 6 cm. Th. 0·7 – 1·4 m.m. COARSE SAND
2 ------- 2 nd. LAYER 6 cm. Th. 2 – 4 m.m. GRAVEL
3 ------- 3 rd. LAYER 6 cm. Th. 6 – 12 m.m. " } OR HARD BROKEN STONE
4 ------- BOTTOM LAYER 12 cm. Th. 18 – 36 m.m. "
5 ------- FINE SAND EFFECTIVE SIZE 0·2 – 0·3 m.m.
6 ------- SUPERNATANT WATER DEPTH 1·0 – 1·5 M.

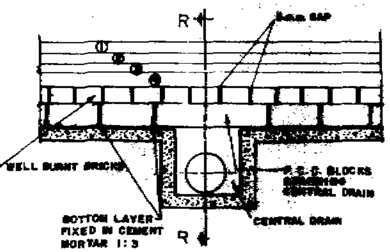


L – SECTION (Y – Y)

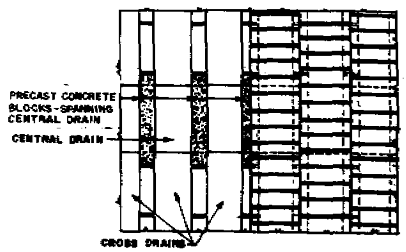
CROSS SECTION (X – X)



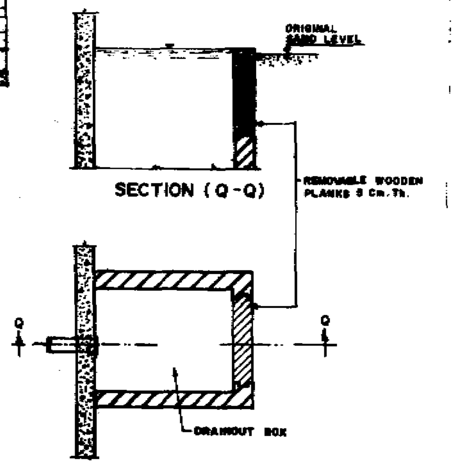
SECTION (R – R)



DETAILS AT M



SECTIONAL PLAN (P-P)

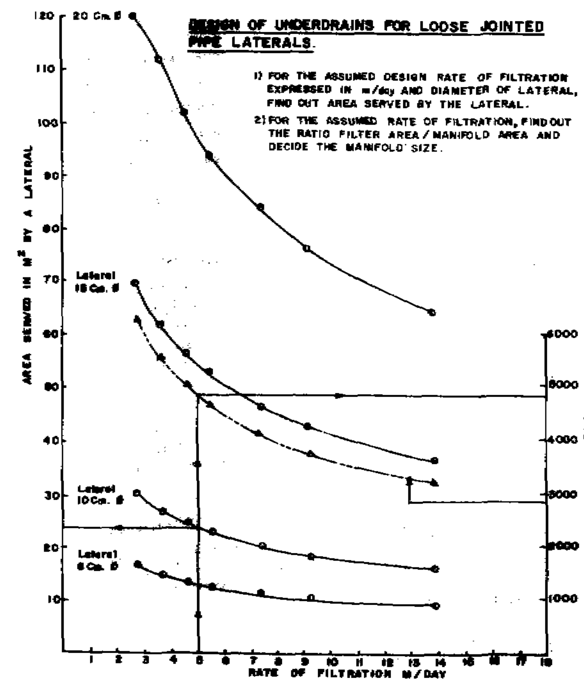


SECTION (Q – Q)

PLAN

DETAILS AT (N)

INLET CUM SUPERNATANT DRAINOUT BOX



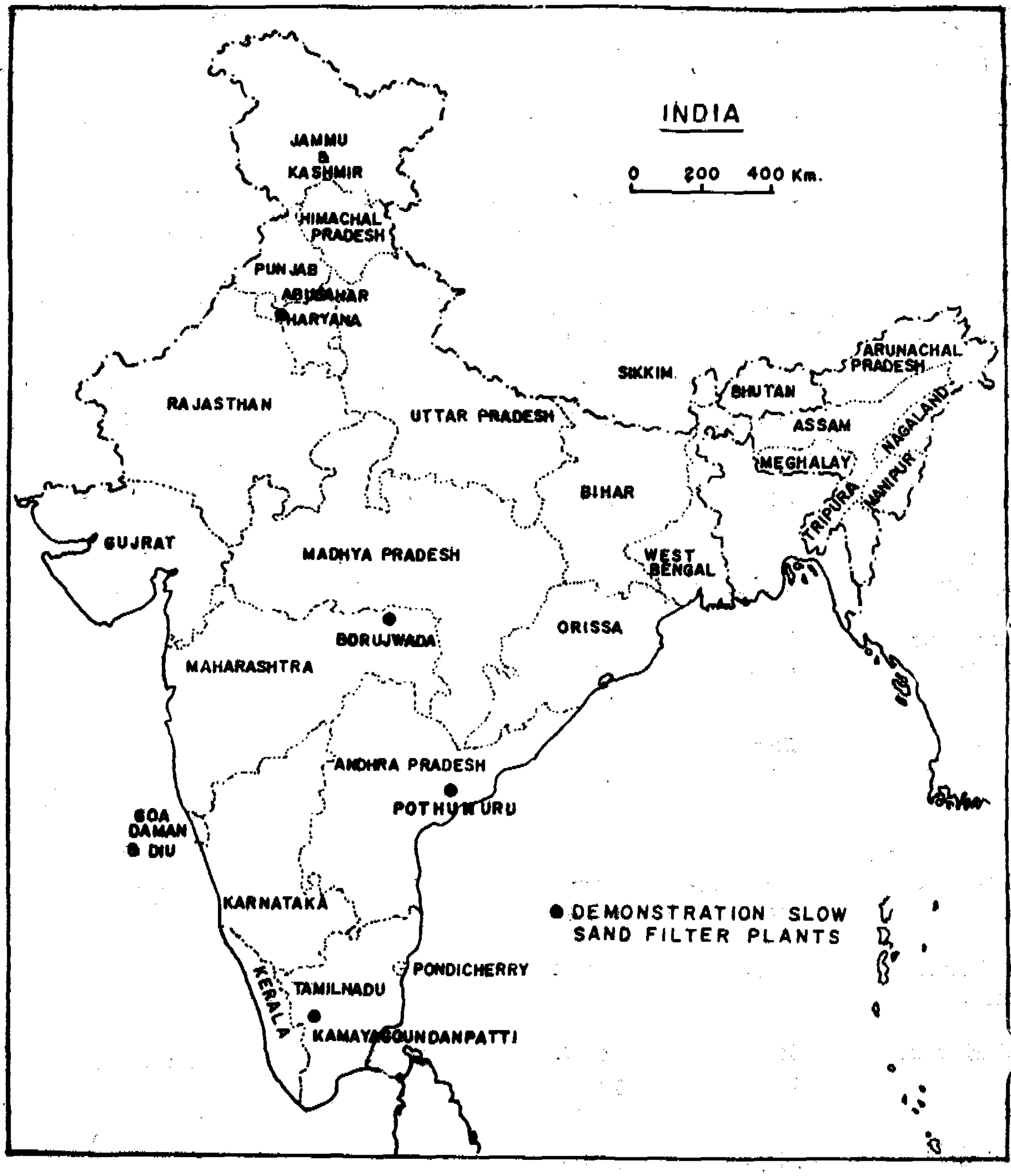


Fig. 12 – Map Showing Location of Demonstration Plants

Table 7 - Demonstration Slow Sand Filter Plants in India

SALIENT FEATURES

	Plant I	Plant II	Plant III	Plant IV
State	Andhra Pradesh	Haryana	Maharashtra	Tamil Nadu
Village	Pothunuru	Abub Shahar (group of villages)	Borujwada	Kamaya-goundanpatti
Date completed	April 1980	March 1979	November 1979	March 1979
Population Design	1971 : 3250 2001 : 6250	1971 : 8700 1991 : 12700	1976 : 700 2006 : 1300	1976 : 8500 1986 : 10000
Design water supply	45 lpcd	45 lpcd	70 lpcd	45 lpcd
Plant capacity	17.5 m^3/ hr	24.0 m^3/ hr	5.7 m^3/ hr	22.6 m^3/hr
Raw water source	Eluru canal	Bhakra Irrigation canal	River Kolar	River Suruliar
Pre-treatment	Storage $3\frac{1}{2}$ monhts	Storage 1 month	Infiltra-tion Gallery	Plan Sedimentation + horizontal prefiltration
Slow Sand Filters	11×7.9 m^2 (× 2)	10 m dia. (× 4)	5×3.8 m^2 (× 2)	12 m dia. (× 2)
High level Storage	91 m^3	135 m^3	35 m^3	90 m^3
Distribution	Stand-posts	Stand-posts	Stand-posts	Standposts and house connections
Estimated cost-Rupees*	368,000	1,668,000	270,000	410,000

*Indian Rs. 9/- = 1 US $

Table 8 – Physico-chemical characteristics (averages) of Borujwada well water

Parameters	1980											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Turbidity (NTU)	0.52	0.62	0.72	0.81	0.75	1.55	2.0	0.27	0.76	0.85	1.1	2.1
pH	7.3	7.7	7.9	8.1	8.0	8.0	8.0	7.9	7.7	8.4	8.3	7.8
Conductivity μmho/cm	–	Not	estimated	–	1840	1750	1800	1700	1800	2000	1800	1700
Alkalinity as $CaCO_3$	530	541	565	538	500	542	531	514	552	610	573	573
Dissolved solids	869	1215	1093	1267	1000	1323	1347	1168	1263	1142	1126	1165
Total hardness as $CaCO_3$	796	850	855	715	617	765	768	732	784	844	756	764
Calcium hardness as $CaCO_3$	276	240	103	84	66	149	112	204	200	306	384	224
Chlorides as Cl	145	154	168	188	160	173	175	187	198	216	207	196
Sulphates as SO_4	39	42	42	43	38	38	41	41	41	50	41	41
Iron (total) as Fe	N.D.	0.04	0.04	0.06	0.04	0.18	0.02	N.D.	N.D.	N.D.	N.D.	0.26
Phosphate (ortho) as PO_4	0.07	0.07	0.07	N.D.	0.28	0.15	N.D.	N.D.	0.11	0.12	0.07	0.12
Nitrate as NO_3	112	138	92	184	179	161	142	128	144	155	146	130
Fluoride as F	0.4	0.37	0.44	0.36	0.6	0.42	N.E.	N.E.	0.5	N.E.	1.0	N.E.
Dissolved Oxygen	2.9	2.8	2.9	1.8	2.2	5.0	1.1	2.4	0.7	1.0	0.7	0.9
Chemical Oxygen Demand	1.2	1.1	1.3	10.1	3.1	8.4	3.7	1.6	2.9	4.4	5.5	5.5
Total Organic Carbon as C	N.E.	11.6	10.7	17.5	36.0	35.9	36.7	25.0	44.1	35.6	48.4	N.E.

All values except pH are expressed as mg/l

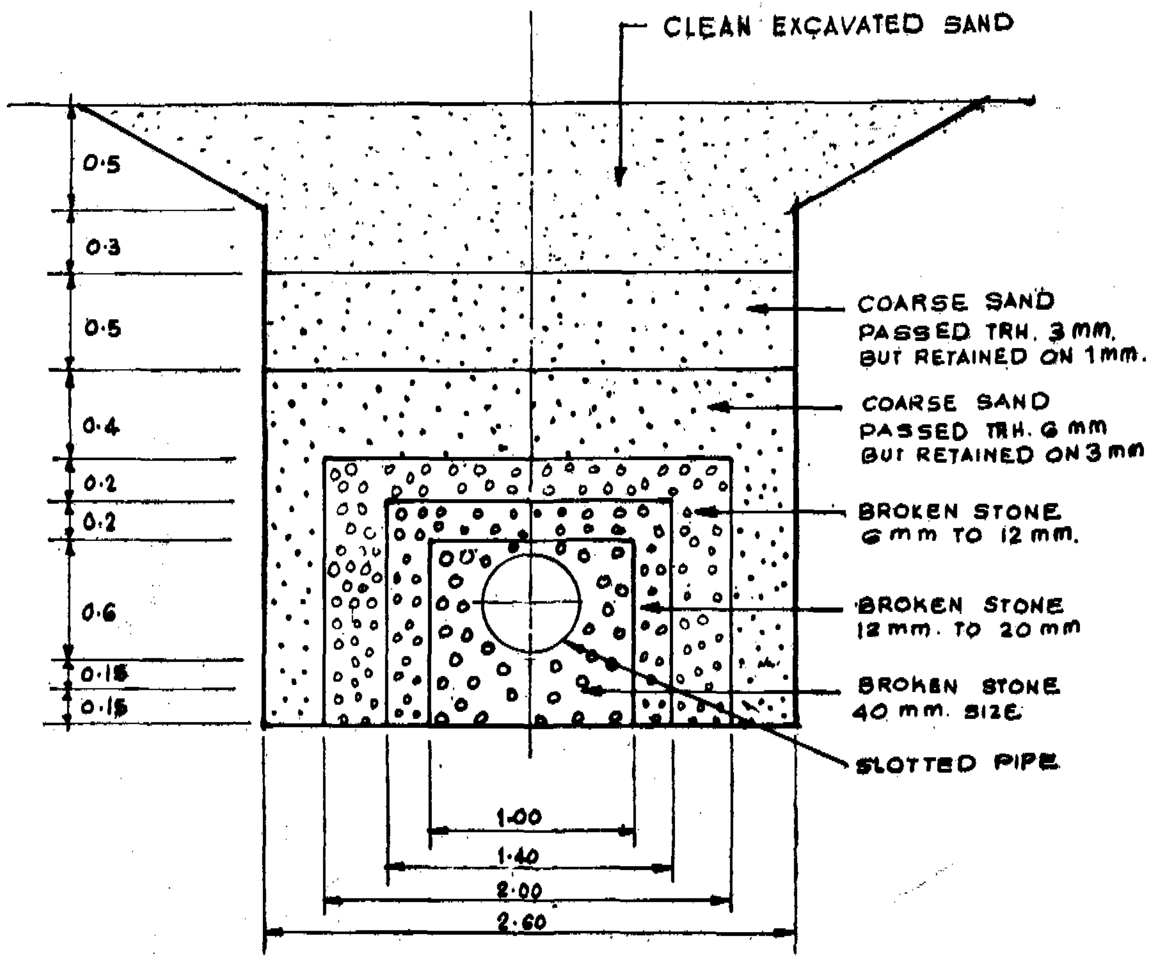
N. E. – Not Estimated
N. D. – Not Detectable

Table 9 – Borujwada – Bacteriological Quality of Well Water

January – December 1980

Month/Date	Coliforms	Fecal coliforms	*E. Coli*
	MPN/100 ml		
January			
4	9200	490	490
8	2800	2200	1700
29	5400	1100	1100
February			
12	9200	2400	2400
26	5400	700	490
March			
11	5400	790	790
25	2400	540	540
April			
8	16000	Not estimated	Not estimated
22	9200	1700	1700
May			
5	5400	1700	1700
19	2400	2400	2400
June			
8	540	240	79
**18	0	0	0
July			
8	24000 +	24000 +	24000 +
August			
11	9200	500	2400
September			
8	24000	2400	2400
October			
13	2400	2400	2400
November			
10	16000	16000	16000
December			
8	5400	3500	3500

** chlorinated on the previous day of sampling.



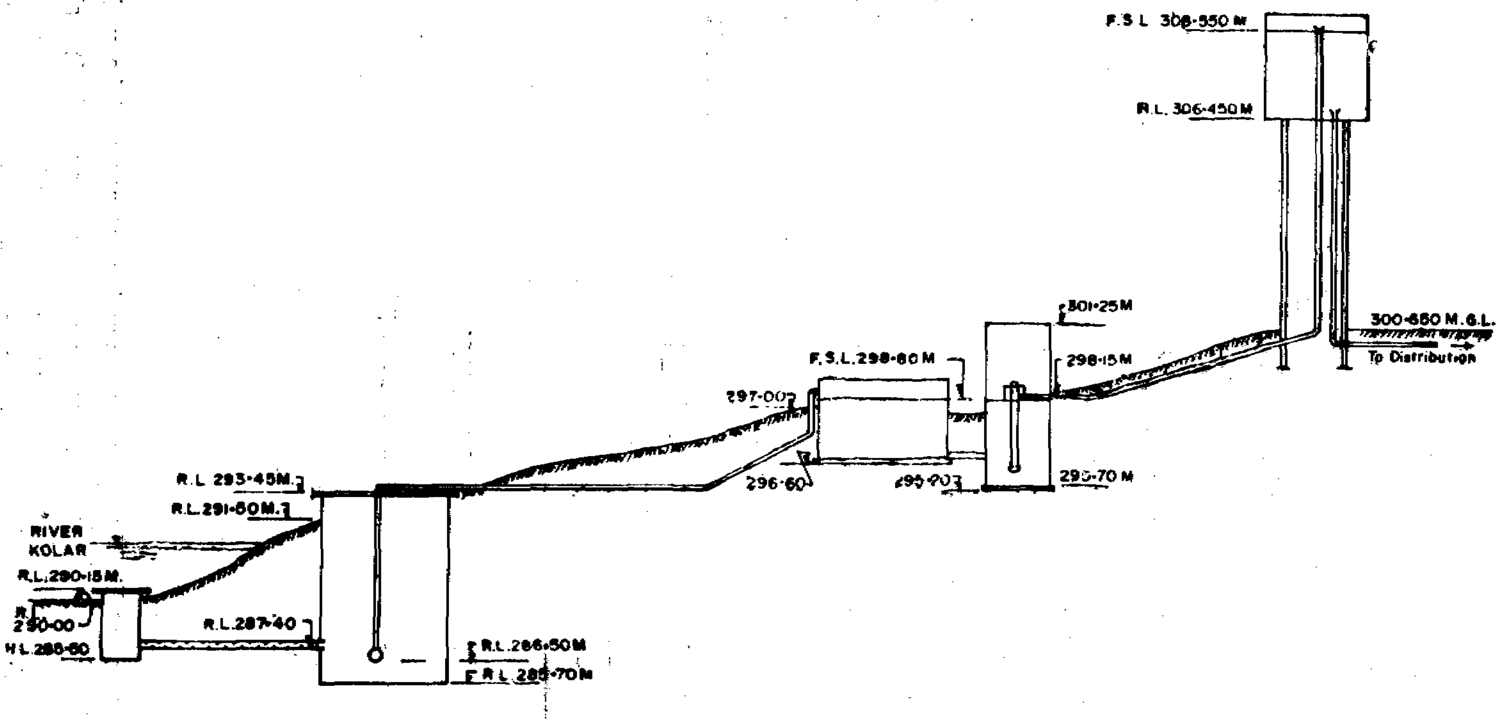
SECTION OF GALLERY

Fig. 13 – Infiltration Gallery

(All dimension in Meters)

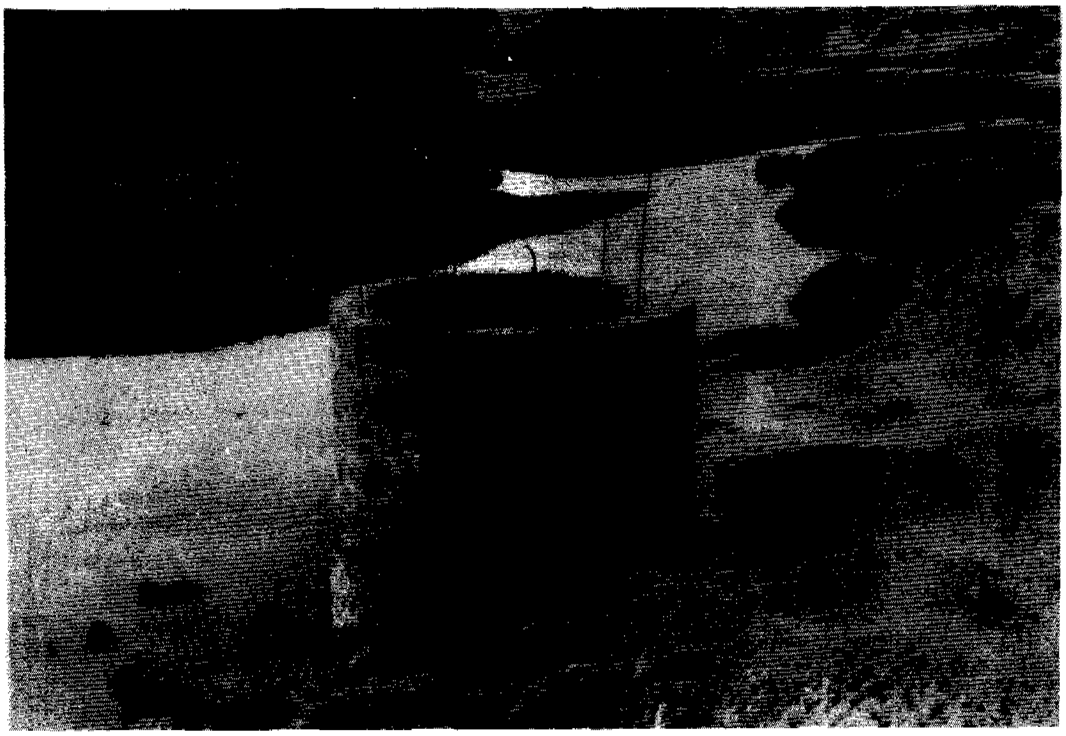
a few individual house connections as well. The flow sheet of the treatment plant and the principal features of the water supply project are given in Fig. 14 and Table 10 respectively.

The layout of the plant was so arranged as to be compact and to facilitate easy day today operation and maintenance of the various units. A common pump house built above the clear water sump facilitates operation of both raw and clear water pumps. A simple sand washing platform has been provided for washing scraped sand (Figure 15).



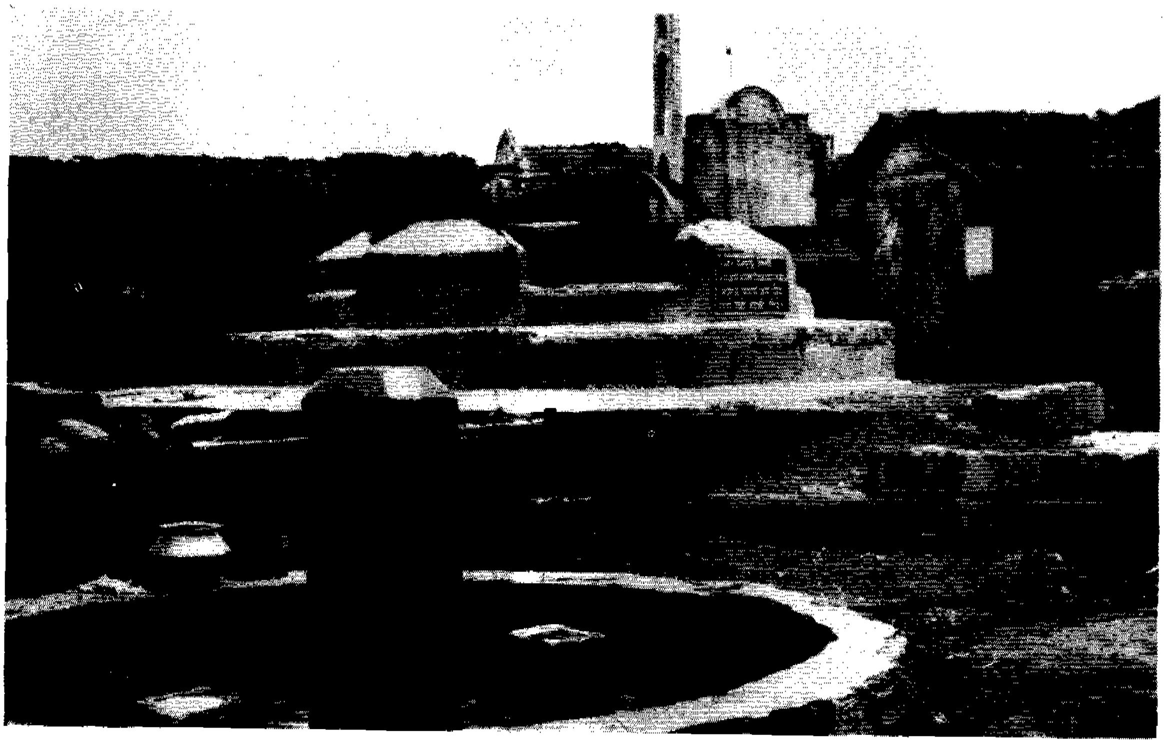
1-5 M DIA INSPECTION WELL	INFILTRATION GALLARY	3.5 M DIA JACK WELL	80 mm DIA A C PRESSURE PIPE CLASS II RAW WATER RISING MAIN LENGTH 180 M	SLOW SAND FILTERS-2 Nos 8-0 M. X 3-8 M EACH	PURE WATER SUMP & PUMP HOUSE 3-0 M. X 2-0 M.	80 mm. DIA. A. C. PRESSURE PIPE CLASS II PURE WATER RISING-MAIN, LENGTH 90 M.	ELEVATED SERVICE RESERVOIR CAPACITY – 35000 LITRS	TO DISTRIBUTION

Fig. 14 – Flow Diagram of Borujwada Water Supply Scheme
State : Maharashtra



Kolar river at Borujwada with collection well of infiltration gallery

The slow sand filter showing inlet cum drain out chamber



A typical public stand post at Borujwada with the community well (background) in disuse after the *introduction of SSF water supply*

Surveillance of water quality at consumers' end

Table 10 – Principal Features of Borujwada Water Supply Scheme

General		
Name of the village	:	Borujwada
Development block	:	Kalmeshwar
District	:	Nagpur
State	:	Maharashtra
Design Data		
Population (1976)	:	700
Design population	:	1300
Source of water supply	:	River Kolar
Per capita water supply	:	70 litres per day
Plant capacity (SSF)	:	5.75 m^3/hr.
Engineering Details		
Infiltration gallery (Pre–treatment)		
Type	:	R. C. C. slotted pipe 450 mm. dia.
Length	:	10 m.
Depth of gallery below river bed	:	2.7 m.
Collection Well		
Diameter	:	3.5 m.
Depth	:	10 m. below G. L.
Raw Water Pumps		
Type	:	Submersible
Number	:	Two (one standby)
Capacity	:	5750 l/hr.
Total head on pump	:	16 m.
B. H. P. of motor	:	2.0
Slow Sand Filters		
No. of units	:	Two
Shape and size	:	Rectangular 5.0 m × 3.8 m × 2.7 m deep
Design filtration rate	:	0.15 m/hr.
Filter sand	:	E. S. 0.26 mm. U. C. – 2.1 Depth 1.0 m (initial)
Type of Under–drain	:	Pre–cast Cement Concrete Bricks

(Contd.)

Table 10 – (Contd.)

Clear Water Sump		
Capacity	:	12,000 litres
Size	:	3 m × 2 m × 3 m (deep)
Clear Water Pumps		
Type	:	Centrifugal
Number	:	Two (one standby)
Capacity	:	5750 l/hr.
Total head on the pump	:	16 m.
B. H. P. of motor	:	2.0
Elevated Service Reservoir (R. C. C.)		
Capacity	:	35,000 litres.
Height above G. L.	:	9.5 m.
Distribution system		
Length	:	535 m.
Type of pipes used	:	80 mm. A. C. pressure pipes 90 mm. PVC pipes
Public stand posts	:	6 nos. each with 2 taps
House connections	:	4 No. – 15 mm. size

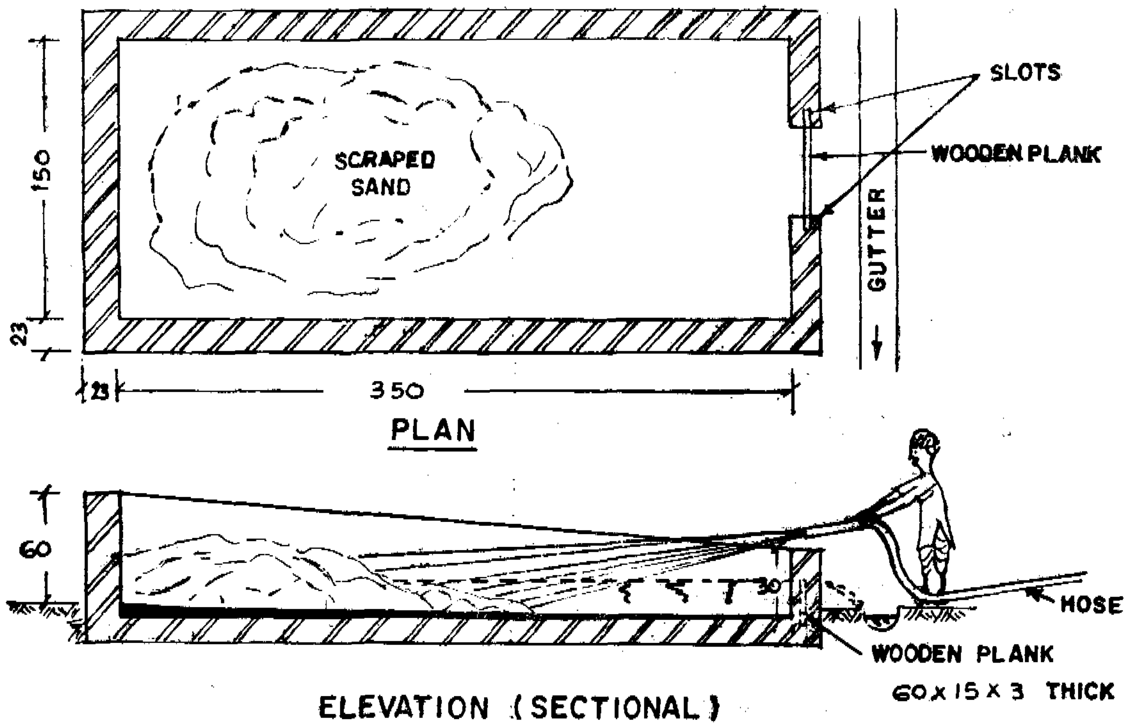


Fig. 15 – Sand Washing Platform

(All dimensions in cms)

4.2 **Abub Shahar** (Haryana)

General

Village Abub Shahar is located at latitude 29°53′ and longitude 74°36′ in Dabwali Block, Sirsa District, Haryana State. It is situated 14 km. from Dabwali, on Dabwali–Suratgarh road. The present population of the village is about 8700. The main occupation of the villagers is agriculture and major crops grown are wheat, gram and cotton. Out of 734 families, about 300 are landless labour and depend upon agricultural operations for their livelihood. The village is electrified and has other amenities such as post office, bank, primary school, sub-health centre, etc. The village panchayat represented by various caste groups takes interest in the village development programmes and has contributed a sum of Rs. 22,000 for the water supply project.

Plant Description

The water supply system for Abub Shahar and Sakta Khera group of villages is designed for a perspective population of 12,700 persons. The treatment plant located near village Abub Shahar draws raw water from the Bhakra Canal. Summer storage tanks of 27 days capacity have been provided to take care of the canal closure periond. In view of the fairly good quality of canal water throughout the year and long storage, no further pre-treatment prior to slow sand filtration has been provided.

Raw water from the storage tanks is drawn into a section well from where it is pumped to a high level tank which feeds the filters by gravity. The plant has been designed for 8 hour pump operation divided into 4 hour in the morning and 4 hour in the evening and 24 hour filter operation with raw water storage of 1/3 daily demand in the high level tank. The filtered water is pumped to an elevated service reservoir of 135 m^3 capacity for distribution through public stand posts. The flow sheet of the plant is shown in Figure 16, and the principal features are given in Table 11.

4.3 **Kamayagoundanpatti** (Tamil Nadu)

General

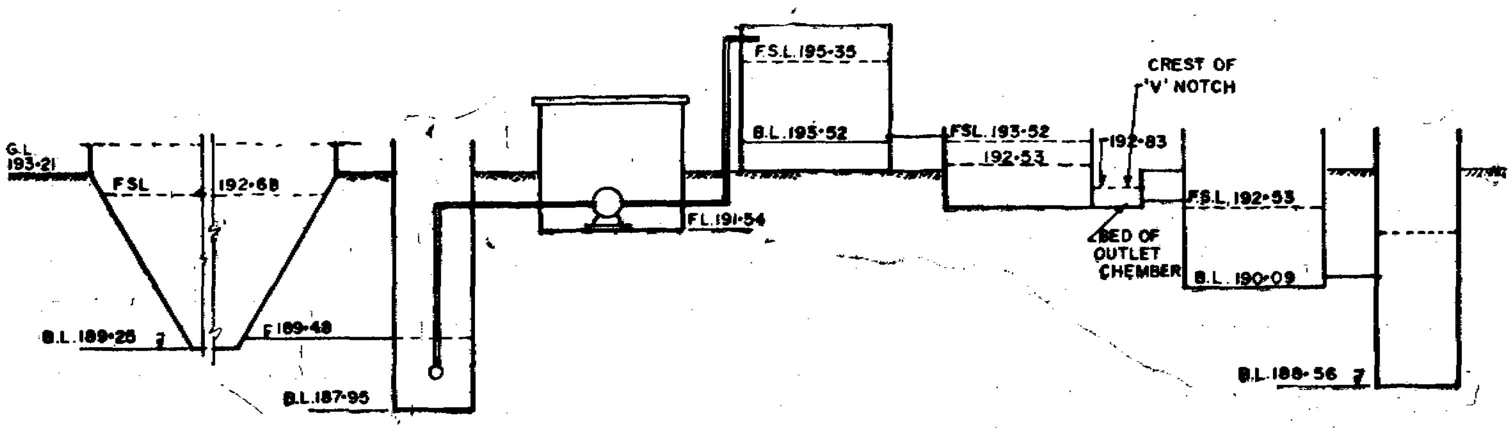
Village Kamayagoundanpatti is situated in Cumbum block, Madurai District, Tamil Nadu. There are aboul 2,200 families with a present population of about 12,500. The village is well connected by road and the nearest town is Cumbum situated 3 km. away in the Cumbum valley. Suruliar, a perennial upland river flows 1 km. away from the village.

Socio-economically the village is fairly well placed. There are about 500 families which are in high economic status. They are mostly planter and land owners. The common crops are paddy and spices like cardamon and pepper. There are another 400 families who can be placed in a group of medium economic status. Most of the amenities, typical of urban towns, such as schools, post-offices, banks, telephones, government dispensaries, police station etc., are available in the village. Literacy rate is also fairly high.

Kamayagoundanpatti has been receiving treated piped water from a central treatment works supplying water to 8 Cumbum valley panchayats. The supply from this old treatment plant has been dwindling over the years. Designed originally for 230 m^3/day for an ultimate population of 10,000, the present supply has reduced to 166.5 m^3/day resulting in scarcity of drinking water. The demonstration plant has been designed to augment the supply by 450 m^3/day.

Plant Description

Raw water from river Suruliyar is drawn through an intake into a collection well and pumped to the treatment works located 2 km. away, near the village. The pump house is located over the collection well itself. The raw water is settled in a plain sedimentation tank of 2 hours detention time and then passed through a horizontal flow pre-filter before final treatment by slow sand filtration. The filtered water, after safety chlorination, flows by gravity to the existing ground level service reservoir for distribution through public stand post and individual house connections. The flow sheet of the treatment plant and principal features are given in figure 17 and Table 12 respectively.



SUMMER STORAGE (SEDIMENTATION) TANKS 2 NOS CAP - 9360 M³ each	RAW WATER SUCTION WELL 1·5 M.DIA	PUMP CHAMBER SIZE - 7·3 M X 4·5 M.	HIGH LEVEL TANKS 2 NOS DIA - 8·5 m Depth - 1·8 m	SLOW SAND FILTER BEDS 10·0 M.DIA (4 Nos)	OUTLET CHAMBER	CLEAR WATER RESERVOIR 2 NOS 7·0 M.DIA	CLEAR WATER SUCTION WELL 1·5 M.DIA

Fig. 16 – Flow Diagram of Abub Shahar Water Supply Scheme
State : Haryana

Canal water storage tank - Abub Shahar

Circular slow sand filters - Abub Shahar

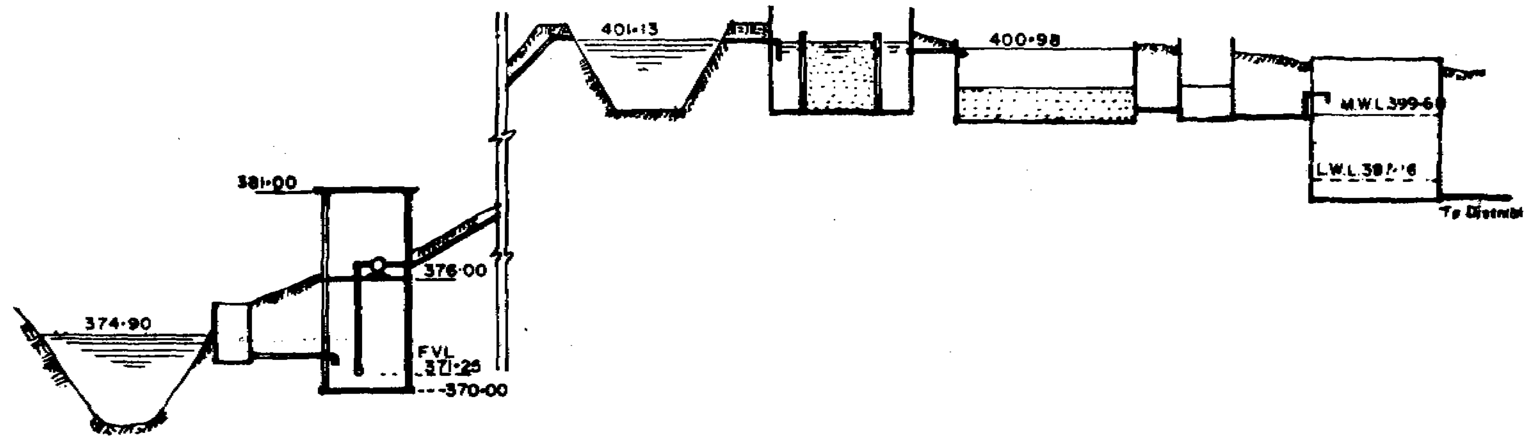
Table 11 – Principal Features of Abub Shahar Water Supply Scheme

General		
Name of village	:	Abub Shahar
Development Block	:	Dabwali
District	:	Sirsa
State	:	Haryana
Design Data		
Population (1971)	:	8700
Design population	:	12700
Source of water supply	:	Bhakra Main Canal
Per capita water supply	:	45 litres per day
Plant capacity (SSF)	:	24.0 m^3 / hr
Engineering Details		
Storage-cum-sedimentation tank With side slopes 1½ : 1 (pre-treatment)		
Number	:	Two
Size	:	Top 57.0 m×57.0 m Bottom 45.0 m×45.0 m Mean 51.0 m×51.0 m Eff. Depth : 3.6 m
Capacity	:	9360 m^3 each
Suction Well		
Diameter	:	1.5 m.
Depth	:	1.5 m.
Raw Water Pumps		
Number	:	Two (One standby)
Capacity	:	68,000 lits./hr.
B. H. P. of motor	:	7.5
High Level Tank		
Nubmer	:	Two
Diameter	:	8.3 m.
Eff. depth	:	1.8 m.
Capacity	:	98 m^3 each

(Contd.)

Table – 11 (Contd.)

Slow Sand Filters		
No. of units	:	Four
Shape and size	:	Circular, 10 m. dia., 3.0 m. deep
Design filtration rate	:	0.1 m/hr.
Filter sand	:	Effective size : 0.25 mm. Uniformity Coefficient : 3 Depth : 1 m (Initial)
Clear Water Reservior		
Number	:	Two
Diameter	:	7.0 m. each
Effective depth	:	2.5 m.
Capacity	:	96 m^3
Suction Well		
Diameter	:	1.5 m.
Depth	:	1.5 m.
Clear Water Pumps		
Number	:	Two (one standby)
Capacity	:	68,000 lits./hr.
B. H. P. of motor	:	20
Elevated Service Reservoir (RCC)		
Capacity	:	1,35,000 litres
Distribution System		
Length	:	9000 m.
Type of pipes used	:	A. C. pressure pipes & PVC pipes of sizes 100 mm. 120 mm. & 150 mm. dia.

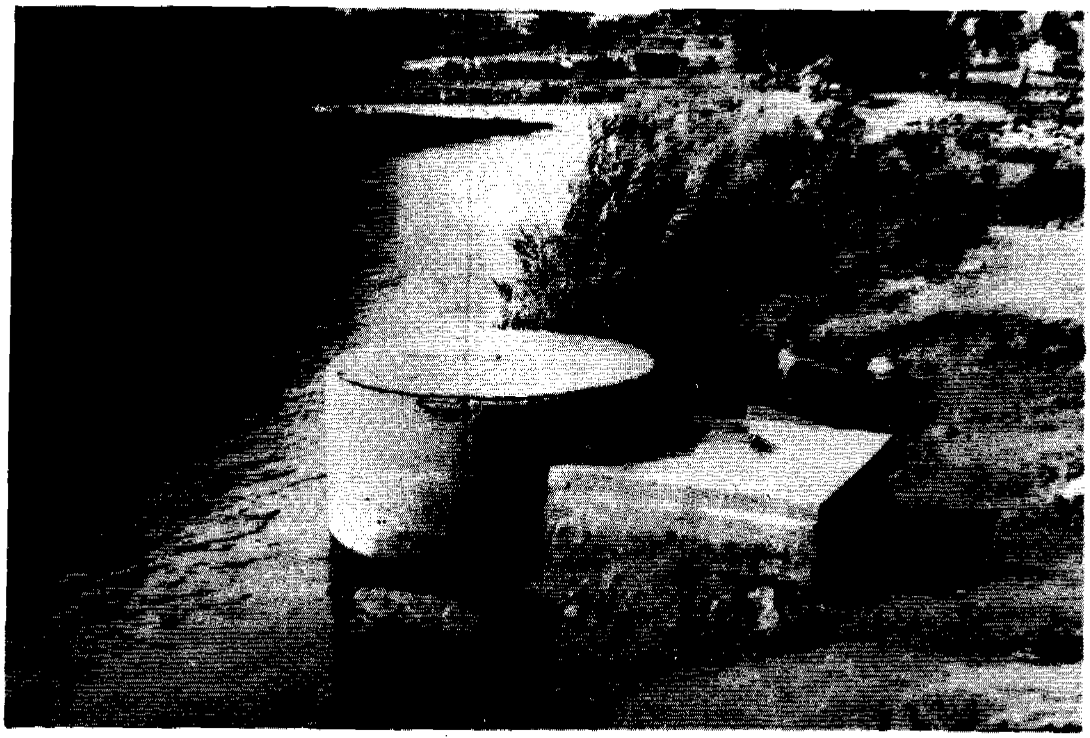


SOURCE SURULIAR RIVER	RAW WATER PUMP HOUSE	RISING MAIN	RECTANGULAR PLAIN SETTLING TANK 6 X 4 X 2·0 M.	PRE FILTER UNIT 6·0 M DIA 2·6 M DEPTH	SLOW SAND FILTERS 12·0 M. DIA. – 2 Nos.	CLEAR WATER WELL 2·0 M. DIA	GRAVITY MAIN	EXISTING G. L. S. R. CAPACITY– 90,000 LITS.

Fig. 17 – Flow Diagram of Kamayagoundanpatti Water Supply Scheme
State : Tamil Nadu

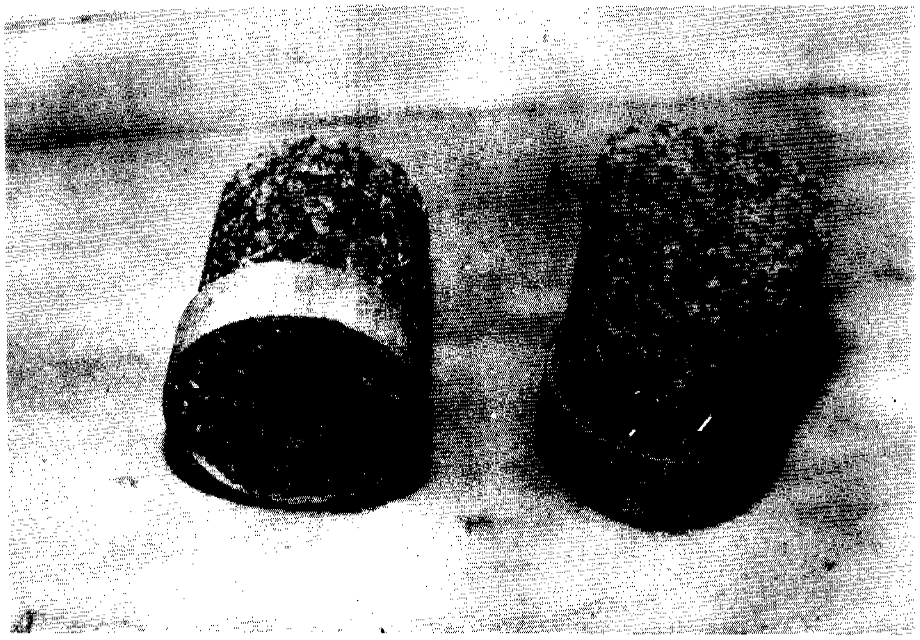
Table 12 – Principle Features of Kamayagoundanpatti Water Supply Scheme

General		
Name of the village	:	Kamayagoundanpatti
Development block	:	Cumbum
District	:	Madurai
State	:	Tamil Nadu
Design Data		
Population (1976)	:	8,500
Design population	:	10,000
Source of water supply	:	River Suruliar
Per capita water supply	:	45 lits. per day
Plant capacity	:	22.6 m^3/hr.
Engineering Details		
Raw Water Pumps		
Type	:	Centrifugal pumps
Number	:	Two (one standby)
B. H. P. of motor	:	5.0
Plain Sedimentation Tank (Pre-treatment)		
Number of units	:	One
Shape & Size	:	Rectangular, 6.0 m × 4.0 m × 2.0 m (deep)
Design surface overflow rate	:	1.0 m^3/m^2/hr.
Design detention time	:	2 hours
Horizontal flow pre-filter (Pre-treatment)		
Number	:	One
Shape and Size	:	Circular, 6.0 m dia. × 2.6 m deep
Filter media	:	Pea gravel 3 to 10 mm size
Design velocity of flow at mid section	:	1.5 m/hr.
Slow Sand Filters		
No. of units	:	Two
Shape and size	:	Circular, 12.0 m dia., 3.0 m deep
Design filtration rate	:	0.1 m/hr.
Filter sand	:	Effective size : 0.3 mm. Uniformity coefficient : 2.5 Depth : 1.0 m (initial)
Type of underdrain	:	PVC laterals with permeable capsules
Ground level service reservoir		
Capacity	:	90,000 litres
Distribution		
No. of public stand post	:	23
No. of house connections	:	309

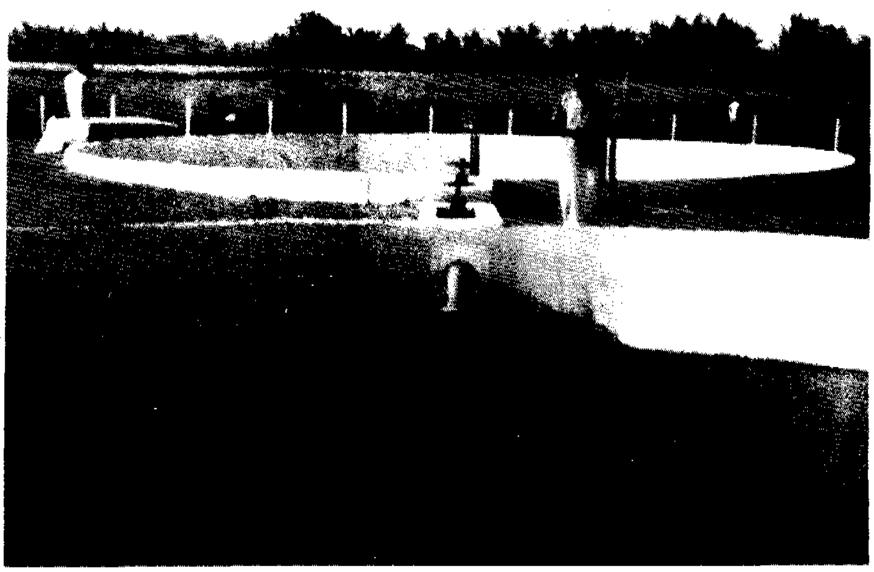


Suruliar river with intake well - Kamayagoundanpatti

Slow sand filters with permeable capsule underdrains



A close-up view of the permeable capsule



A view of the slow sand filters - Kamayagoundanpatti

Formal commissioning of slow sand filtered water supply - Kamayagoundanpatti

Special features

* The underdrains of the plant at Kamayagoundanpatti (Tamil Nadu) 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.

* The permeable capsule is an open container made of small granular inert material bonded together. The capsule is fixed in Tees which are connected together suitably so as to constitute a system of underdrains. The capsule is designed to permit easy entry of water while retaining the sand on the outside. The underdrain system at Kamayagoundanpatti is designed to permit 2 m^3/min of water per sq. m. area.

* In general hard broken stone, which is more readily available and cheaper than rounded pebbles, has been used as supporting gravel layers.

4.4 Pothunuru (Andhra Pradesh)

General

Village Pothunuru is situated 13 km. from Eluru on Eluru–Gundugolanu road in Bhimadole Block, West Godavari District, Andhra Pradesh. The village with a major panchayat has a present population of about 4,000. The main occupation of the villagers is agriculture and the major crop grown is paddy. Economically the people are fairly well-off. The village is electrified, has a health sub-centre, 2 primary schools and a high school, a sub-post office and a veterinary hospital and a bank.

There is one public well and about 20 private wells in the village. The water from these wells is saline and generally not used for drinking purposes. Water from Eluru canal stored in fresh water tanks is used by the village folk for drinking purposes. The summer storage tanks are subject to pollution. Water-borne diseases were common among the people. There was a felt-need for provision of protected piped water supply to the village and the demonstration slow sand filter plant has come as a welcome relief to the community.

Plant Description

Raw water from Eluru canal fed by river Godavari is stored in summer storage tanks. The capacity of the tanks is 45 days' ultimate water supply requirements of the village. In view of this long storage additional pre-treatment before slow sand filtration was considered not necessary. However, as an additional safety against occasional high turbidity and floating weeds and debris the intake well is surrounded by a gravel pack. Stored water drawn through an intake well located close to tank bund is pumped to the slow sand filters for purification. Filtered water from clear water sump is pumped to an elevated service reservoir and supplied to the village through public stand posts. The flow sheet of the demonstration plant is shown in Figure 18. The principal features of the plant are given in Table 13.

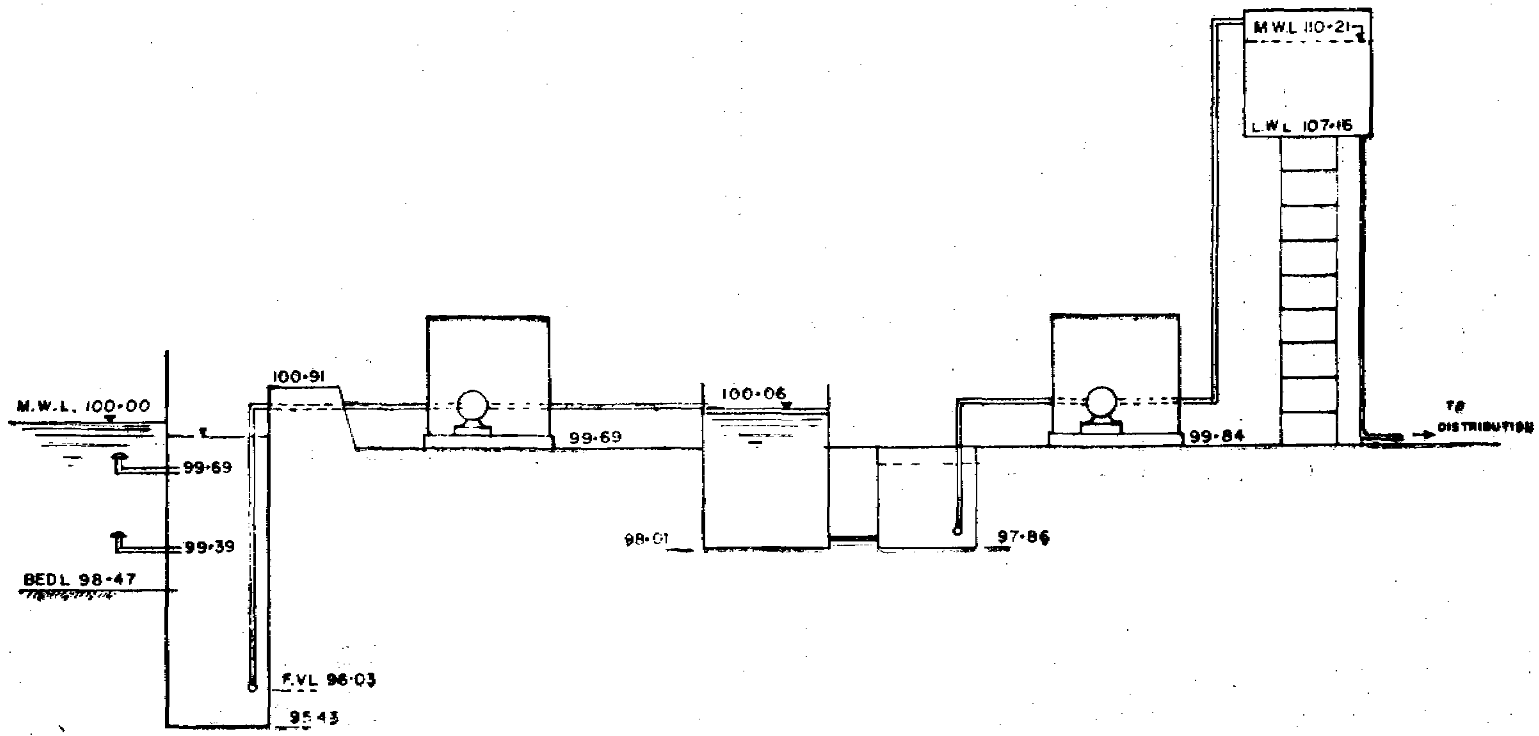
5.0 PERFORMANCE EVALUATION OF DEMONSTRATION PLANTS

5.1 Introduction

An important element of the demonstration programme, is an engineering evaluation of the four village demonstration plants under prevailing field conditions so as to test and further develop the guidelines arrived at during the first phase of applied research. The field evaluation had, in addition, two important objectives : (i) to identify the possible operation and maintenance problems of village level slow sand filter plants and remedial measures thereof and (ii) to impart in-plant training to the local operator and equip him with necessary knowledge and skill for eventual taking over of the plant for future routine operation and maintenance.

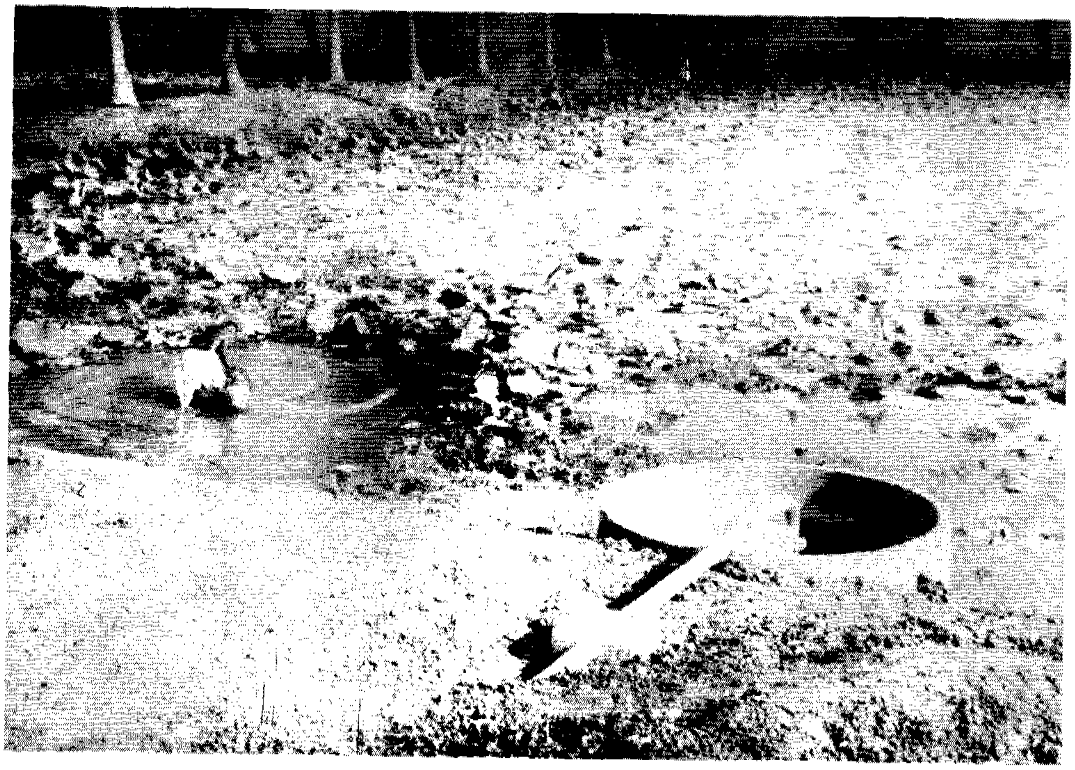
5.2 Methodology

The performance of all the four plants was studied for a period of at least one year so as to cover seasonal variations. During preliminary

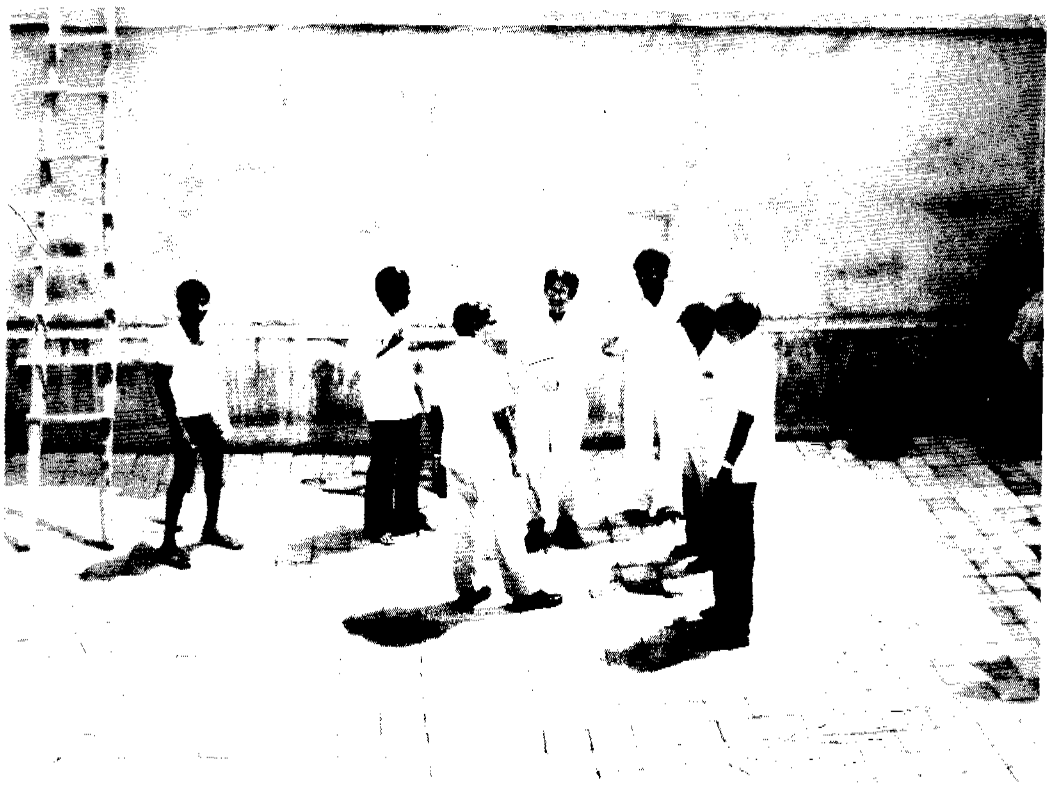


SUMMER STORAGE TANK	INTAKE WELL	RAW-WATER PUMP HOUSE	SLOW SAND FILTERS (2 Nos)	FILTERED WATER SUMP	FILTERED WATER PUMPS - TWO Nos. (ONE STAND-BY)	OVER HEAD SERVICE RESERVOIR
SIZE - 100M X 200M. CAP. - 27000 m^3	DIA - 1·83 M DEPTH - 3·30 M	SIZE - 3·05 M X 3·66 M. No. OF PUMPS - TWO (ONE STAND-BY) 2 B H.P EACH	SIZE 11·00 M X 7·5 M	DIA. - 4·2 M DEPTH - 2·4 M. CAP. - 17·5 m^3	7·5 B.H.P. EACH	CAP. - 91,000 Lts STAGING - 9·2 M.

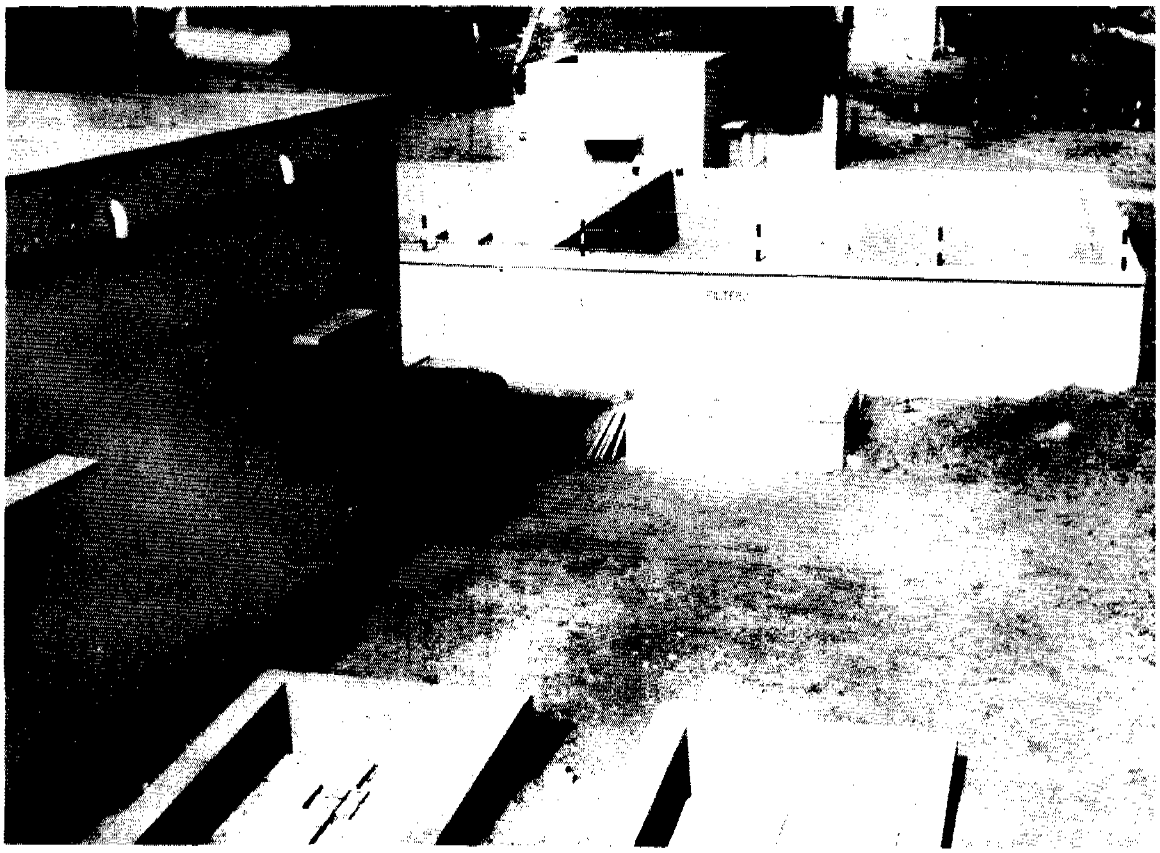
Fig. 18 – Flow Diagram of Pothunuru Water Supply Scheme
State : Andhra Pradesh



Raw water storage tank with intake well
Pothunuru



Filter box with pre-cast cement concrete
underdrain - Pothunuru



Slow sand filters, pumphouse and sand washing platforms (foreground) - Pothunuru

Table 13 – Principle Features of Pothunuru Water Supply Scheme

General		
Name of the village	:	Pothunuru
Development block	:	Bhimadole
District	:	West Godavari
State	:	Andhra Pradesh
Design Data		
Population (1971)	:	3250
Design population	:	6250
Source of water supply	:	Eluru Canal
Per-capita water supply	:	45 lits./day
Plant capacity	:	17.5 m^3/hr.
Engineering Details		
Storage-cum-sedimentation tank (Pre-treatment)		
No. of tanks	:	One
Average size of tank	:	200 m × 100 m × 1.35 m deep
Capacity	:	27,000 m^3
Intake Well		
Diameter	:	1.8 m
Depth	:	3.3 m
Raw Water Pumps		
Type	:	Mono-block centrifugal pump
Numbers	:	2 (one-standby)
Discharge capacity	:	17,500 lits./hr.
Total head on pump	:	5.5 m
B. H. P. of motor	:	2.0
Slow Sand Filters		
No. of Units	:	Two
Shape and size of units	:	Rectangular, 11.0 m × 7.9 m 3.0 m deep
Design filtration rate	:	0.1 m/hr.
Filter sand	:	Effective size – 0.3, Uniformity coefficient – 2.2 Depth–1.0 m (initial)
Type of Underdrain	:	Precast cement concrete bricks with open joints
Clear Water Sump		
Diameter	:	4.2 m.
Total Depth	:	2.4 m.
Capacity	:	17,500 litres.

(Contd.)

Table 13 – (Contd.)

Clear water pump

Type	:	Centrifugalpumps
Number	:	Two (one standby)
Discharge capacity	:	17,500 lits./hr.
Total head on pumps	:	20 m.
B. H. P. of motor	:	7.5

Elevated Service Reservoir (R. C. C.)

Capacity	:	91,000 lits.
Height above G. L.	:	9.2 m.

Distribution System

Type of pipes used	:	R. C. C. pipes, Class P2
Size & length of pipes	:	80 m., 100 mm and 150 mm. 1820 metres length (total)
No. of public stand posts	:	18 nos. with one tap each 5 nos. with two taps each

visits, depending upon the unit operations involved, the location of sampling points was decided for collection of raw, pre-treated and filtered water samples. After commissioning the plant, the progress of initial ripening was assessed by collecting filtered water samples regularly and testing their bacteriological quality. The absence of *E. coli* in filtered water was taken as a general indication that the filter has ripened. While the plan of work was similar in all the cases, the frequency of field visits to individual plants was decided keeping in view the available facilities and local constraints. For example, weekly visits were made to the plant at Borujwada, which is only about 30 km. from Nagpur. For the other three plants, which are about 150–200 km. away from the nearest NEERI laboratory, the frequency was once or twice a month.

The samples collected during each visit were tested for essential parameters like turbidity, degree of pollution determined as chemical oxygen demand (COD) / chlorine demand and bacteria indicators of faecal pollution (ie) coliforms, fecal coliforms and *E.coli*. In addition, complete physico-chemical analysis of raw and filtered waters was carried out once a month. Engineering data such as rate of filtration and filter loss of head were observed to assess the progress of filter run.

5.3 Performance Observations

The significant observations on raw water quality and the performance of the four village demonstration plants are briefly discussed below :

5.3.1 Borujwada (Maharashtra)

The characteristics of raw water from river Kolar, which is subject to seasonal floods are given in Table 14. The river water turbidity varied from as low as 2 NTU to a maxium of 440 NTU (Fig. 19-A, 19-B, 19-C and 19-D). However the infiltered water had a uniformly low turbidity and it was all the time below 5 NTU. Soonafter commissioning the plant, the infiltered water had a bacterial count even higher than that of river water for a few weeks. Lateron the quality improved and there was a considerable reduction in coliform group of bacteria. There was also a significant reduction in organic pollution determined as COD. The results have clearly

Table 14 – Water Quality Characteristics (Range) Borujwada

Parameters	Raw Water	Infiltered Water	Filter 1	Filter 2
Turbidity NTU	1.2 – 440	0.35 – 3.5	0.20 – 1.2	0.18 – 1.4
pH	7.8 – 8.9	7.7 – 8.7	7.8 – 8.8	7.7 – 8.8
Conductivity μmho/cm	200 – 650	350 – 630	310 – 640	340 – 620
Total Alkalinity as $CaCO_3$	101 – 258	164 – 265	154 – 256	160 – 257
Dissolved solids	108 – 495	121 – 495	145 – 397	158 – 480
Total Hardness as $CaCO_3$	96 – 216	116 – 216	112 – 206	116 – 204
Calcium Hardness as $CaCO_3$	22 – 116	22.0 – 130	38.0 – 116	38 – 104
Chlorides as Cl	1.0 – 35.0	7.0 – 36.0	7.0 – 35.5	7.5 – 35.0
Sulphates as SO_4	3.0 – 15.5	2.0 – 9.0	2.0 – 9.0	2.0 – 9.0
Phosphates (Ortho) as PO_4	Traces – 0.14	Traces – 0.07	Traces – 0.07	Traces – 0.12
Iron (Total) as Fe	0.06 – 8.2	Traces – 0.23	Traces – 0.08	Traces – 0.05
Nitrate as NO_3	Traces – 6.6	0.27 – 8.0	Traces – 15.5	Traces – 6.6
Chemical Oxygen Demand	Traces – 30.9	Traces – 4.5	Traces – 5.6	Traces – 6.8
Dissolved Oxygen	3.1 – 11.2	0.8 – 9.5	0.5 – 9.5	2.2 – 9.1
Chlorine Demand (1 hr)	0.18 – 8.6	0.14 – 1.49	0.15 – 1.24	0.10 – 1.28
Total Organic Carbon as C	5.2 – 23.4	6.4 – 24.5	5.3 – 25.4	5.9 – 25.3

All values except pH are expressed as mg/l

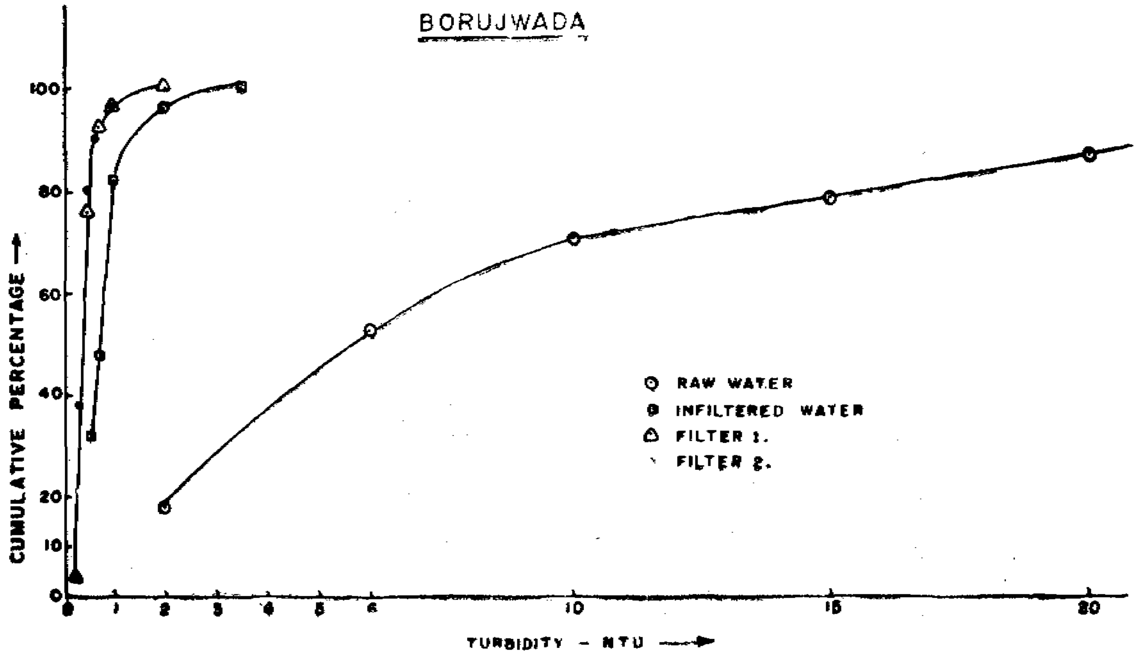


Fig. 19 (A) – Frequency Distribution of Turbidity Values – Borujwada

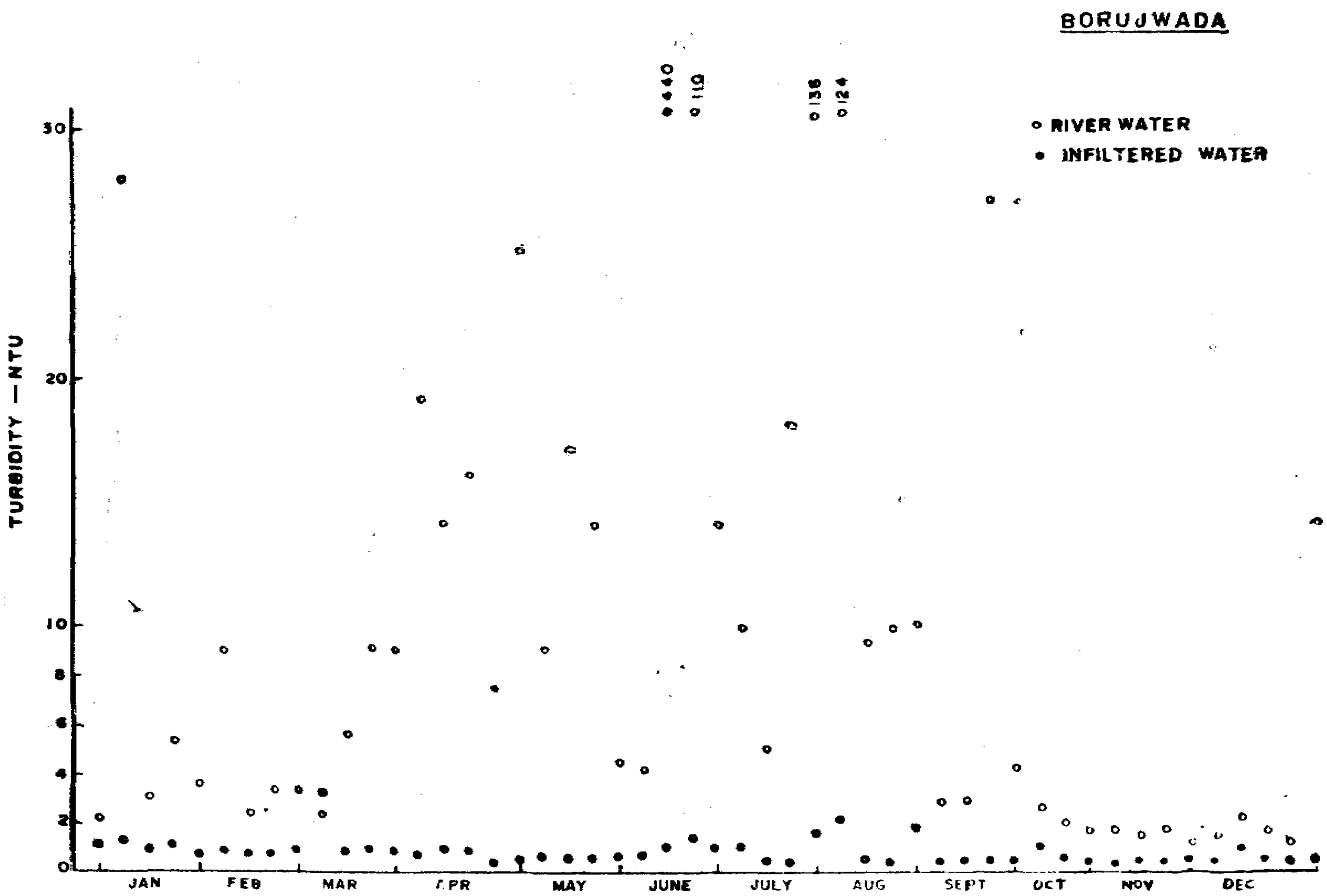


Fig. 19 (B) – Turbidity Reduction in Infiltration Gallery – Borujwada

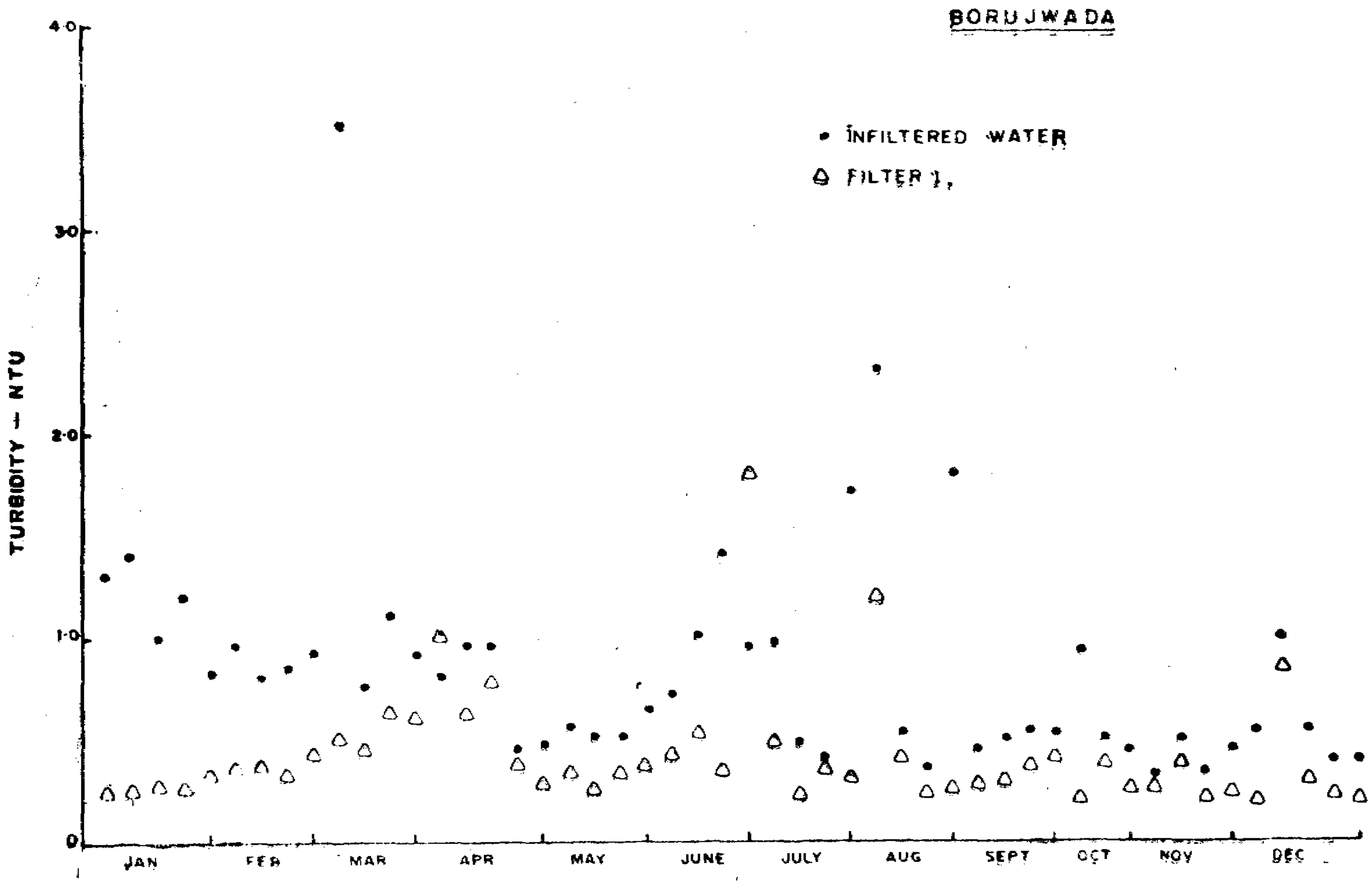


Fig. 19 (C) – Turbidity Removal by Slow Sand Filters – Borujwada

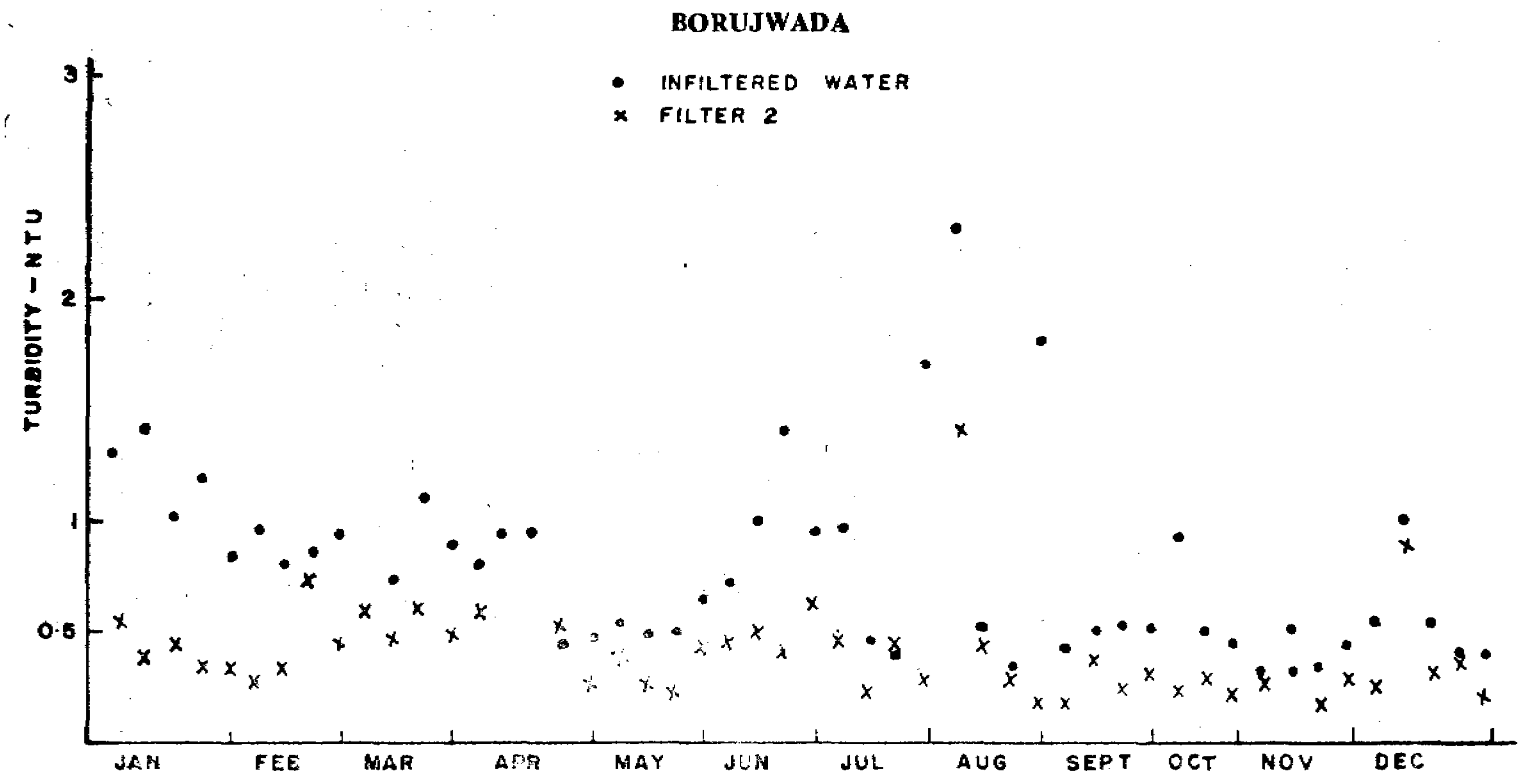


Fig. 19 (D) – Turbidity Removal by Slow Sand Filters – Borujwada

shown that pre-treatment by infiltration gallery can be very effective. There are several instances in India were infiltration galleries provide the only treatment for river waters prior to terminal disinfection. They require minimum operation and maintenance and when conditions such as grain size and thickness of river bed strata are favourable can prove a simple and effective filtration method.

In view of the uniformly good quality of pre-filtered water, the filters were operated at 0.15 m/hr. The turbidity of filtered water was most of the time below 1 NTU. The COD value of raw water varied from less than 1.0 mg/l to 31.0 mg/l and the overall reduction was upto 86 per cent (Table 15). The filter run was quite long and the filters were cleaned only twice during a period of 15 months.

The bacteriological efficiency of the filters has been quite satisfactory. The results are presented in Fig. 20-A, 20-B, 20-C and 20-D. One of the filters, however, was giving a filtrate of poor quality for some time. This was investigated in detail by collecting filtrate samples immediately from the outlet pipe and from the weir chamber. It was found from the results that the filtered water leaving the filter was negative for *E. coli.* but positive at the weir chamber, thereby clearly indicating entry of extraneous pollution into the pipe line. This has since been rectified.

5.3.2 Abub Shahar (Haryana)

The source of raw water is Bhakra canal fed by the Bhakra dam. The raw water quality parameters are summarised in Table 16. The raw water turibidity has been exceptionally good and always less than 10.0 NTU. Plain sedimentation in summer storage tanks further improved the quality and slow sand filtration served as a final polishing step. The filtered water turbidity was always less than 1.0 NTU (Table 17).

The pollution level, both chemical and bacteriological has also been quite low. This was further reduced due to filtration. The filtered water was, for most part of the time, negative for *E. coli* as well as coliforms (Figures 21-A, 21-B, 21-C and 21-D). There was no significant change in the dissolved inorganic constituents between the influent and the filtered water. This observation confirms the findings of the applied research carried out in Phase I of the project.

5.3.3 Kamayagoundanpatti (Tamil Nadu)

The quality of raw water and its variation during the period of study are presented in Table 18. The source of water being an upland river, the turbidity was fairly low throughout the study. There was further improvement in quality due to plain sedimentation and horizontal flow prefiltration. Turibidity removal in the pre-filters has not been significant. As the filter media used in the pre filter was rather fine, rapid clogging occurred resulting in overflow and short circuiting of settled water. Studies to assess the efficiency of pre-filter by changing the size and grading of filter media could not be undertaken due to difficulties in procuring readily coarse media at a reasonable cost. The filtrate turbidity for the year 1979 was less than 3.0 units expressed as ppm SiO_2. From November 1979 the turbidity measurements were made using Hach Turbidimeter-model 2100 and during the whole year the filtered water turbidity remained below 1.0 NTU (Table 19).

The pollution level in raw water measured as COD has been quite low (less than 12 mg/l) and the average removal efficiency due to slow sand filtration was 47.5 per cent (Table 20). As for bacteriological quality, the coliform count of raw water was below 10,000 MPN/100 ml with more than 60 per cent samples having a value in the range 200-2000 (Fig. 22-A). The filtrate quality was quite satisfactory with 70-90 per cent of the samples being negative for *E. coli* (Figs. 22-B, 22-C and 22-D).

During the period of evaluation which lasted for more than 18 months, the filters were cleaned at an average interval of one month.

5.3.4 Pothunuru (Andhra Pradesh)

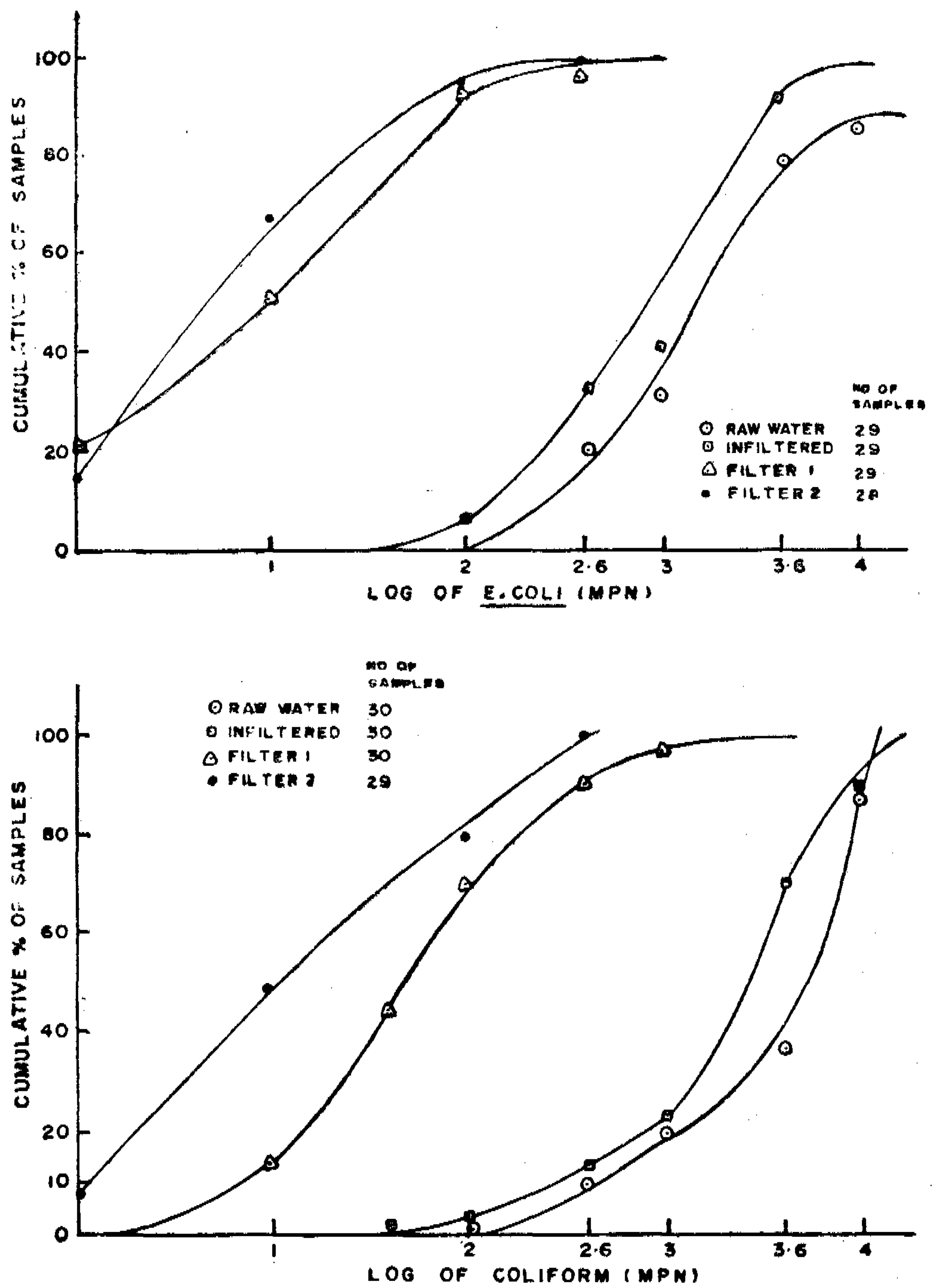
Data on water quality characteristics, both raw and filtered, are presented in Table 21. Because of storage, the raw water turbidity was low. The bacteriological quality of filtered water has been quite satisfactory (Table 22). The canal

Table 15 – Reduction in Chemical Oxygen Demand (COD) – Borujwada

Sr. No.	Raw Water	Infiltered Water	Filter 1	Filter 2
1	3.0	1.1	ND	ND
2	5.1	3.1	1.6	1.6
3	5.5	4.5	3.1	ND
4	6.2	1.2	ND	ND
5	2.6	ND	ND	1.1
6	3.1	ND	ND	ND
7	3.2	2.1	1.4	1.1
8	4.1	1.1	ND	1.1
9	6.8	ND	ND	–
10	2.7	ND	ND	ND
11	3.3	1.3	2.2	Scraped
12	8.4	3.2	1.6	1.2
13	8.8	1.9	1.1	ND
14	5.8	1.9	1.3	1.1
15	9.8	1.3	1.1	ND
16	10.3	ND	ND	ND
17	4.4	1.2	1.4	1.2
18	8.7	4.0	5.6	6.8
19	30.9	3.2	2.9	2.9
20	14.1	ND	ND	1.1
21	6.1	2.4	2.4	2.0
22	4.2	1.2	ND	ND
23	2.7	ND	1.2	ND
24	4.8	ND	ND	ND
25	12.8	2.8	ND	1.4
26	11.6	3.0	2.0	1.8
27	3.6	ND	ND	1.4
28	6.4	3.6	ND	ND
29	3.0	2.0	1.6	1.6
30	ND	1.1	ND	1.7
31	2.0	1.8	ND	ND
32	4.8	ND	ND	ND
33	ND	ND	ND	ND
34	2.8	2.4	ND	1.2
35	5.2	1.2	2.0	1.2
36	4.7	ND	ND	ND
37	4.2	1.5	1.5	1.5
38	4.8	1.4	1.7	ND
39	4.5	ND	ND	ND
40	ND	ND	ND	ND
41	4.8	2.1	3.1	1.0
42	2.4	ND	ND	ND
43	1.6	ND	ND	ND
44	18.8	ND	ND	ND

ND :–Not Detectable All values are expressed as mg/l.

1. Average COD removal in infiltration = 77.6 per cent
2. –do– by F1 compared to infiltered water 32.7 per cent
3. –do– by F2 –do– 41.1 ,,
4. –do– by F1 compared to river water 85.00 ,,
5. –do– by F2 –do– 86.9 ,,



FREQUENCY DISTRIBUTION OF COLIFORM & E-COLI IN RAW, INFILTERED AND FILTERED WATERS - BORUJWADA

Fig. 20 (A)

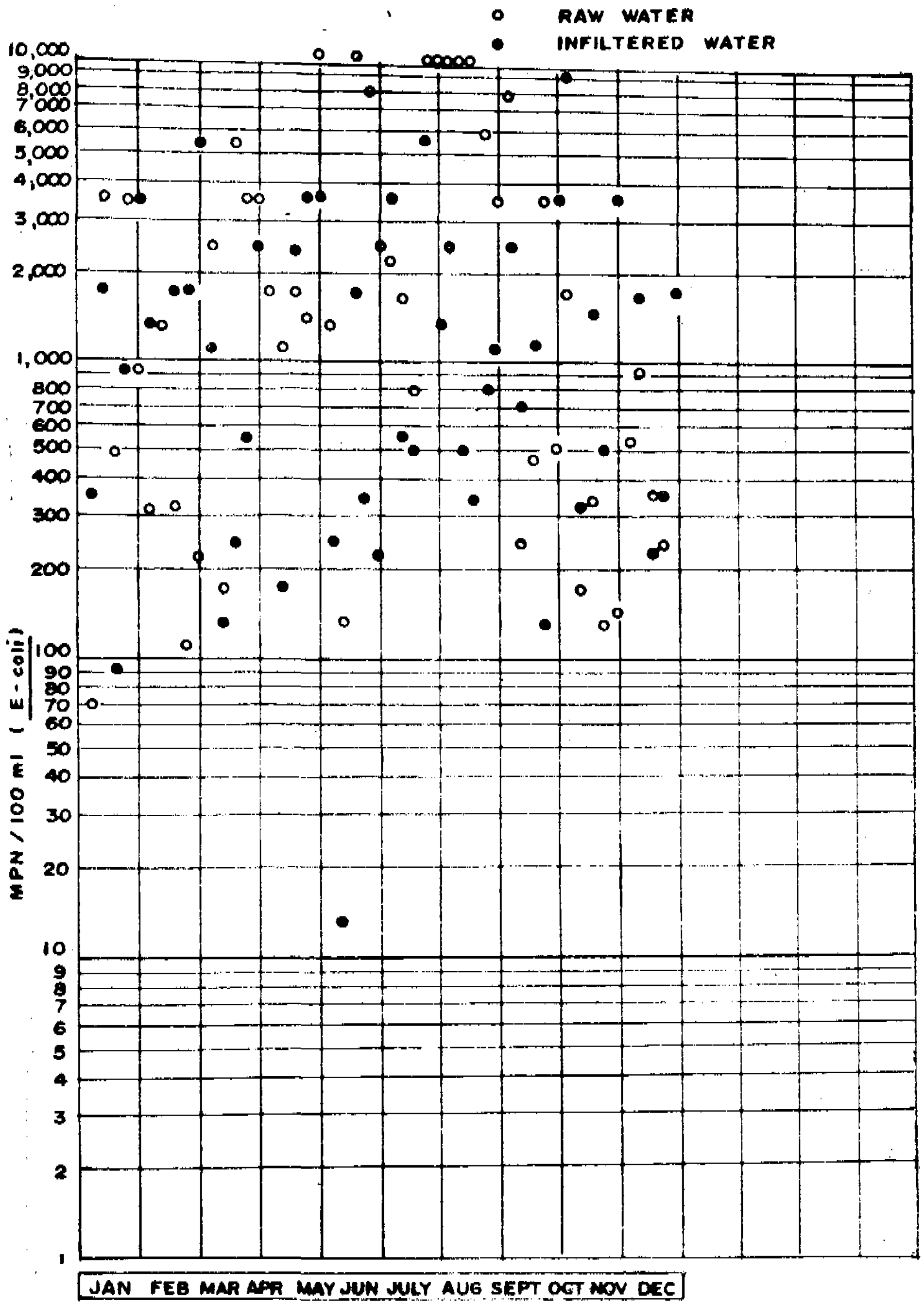


Fig. 20 (B) – *E. coli* Variation in Raw and Infiltered Waters – Borujwada

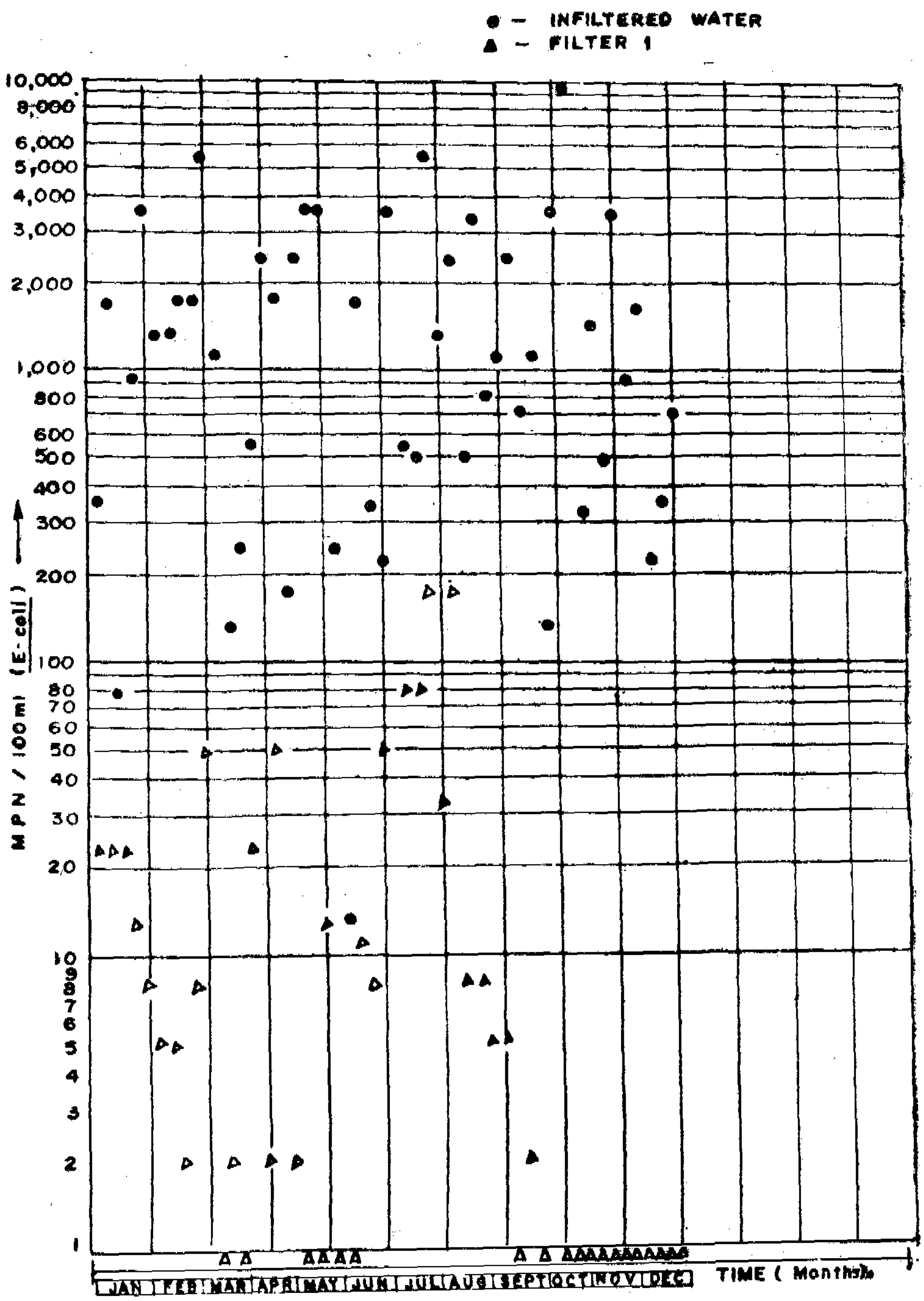


Fig. 20 (C) – *E. coli* Variation in Infiltered Water and Filtrate – Borujwada

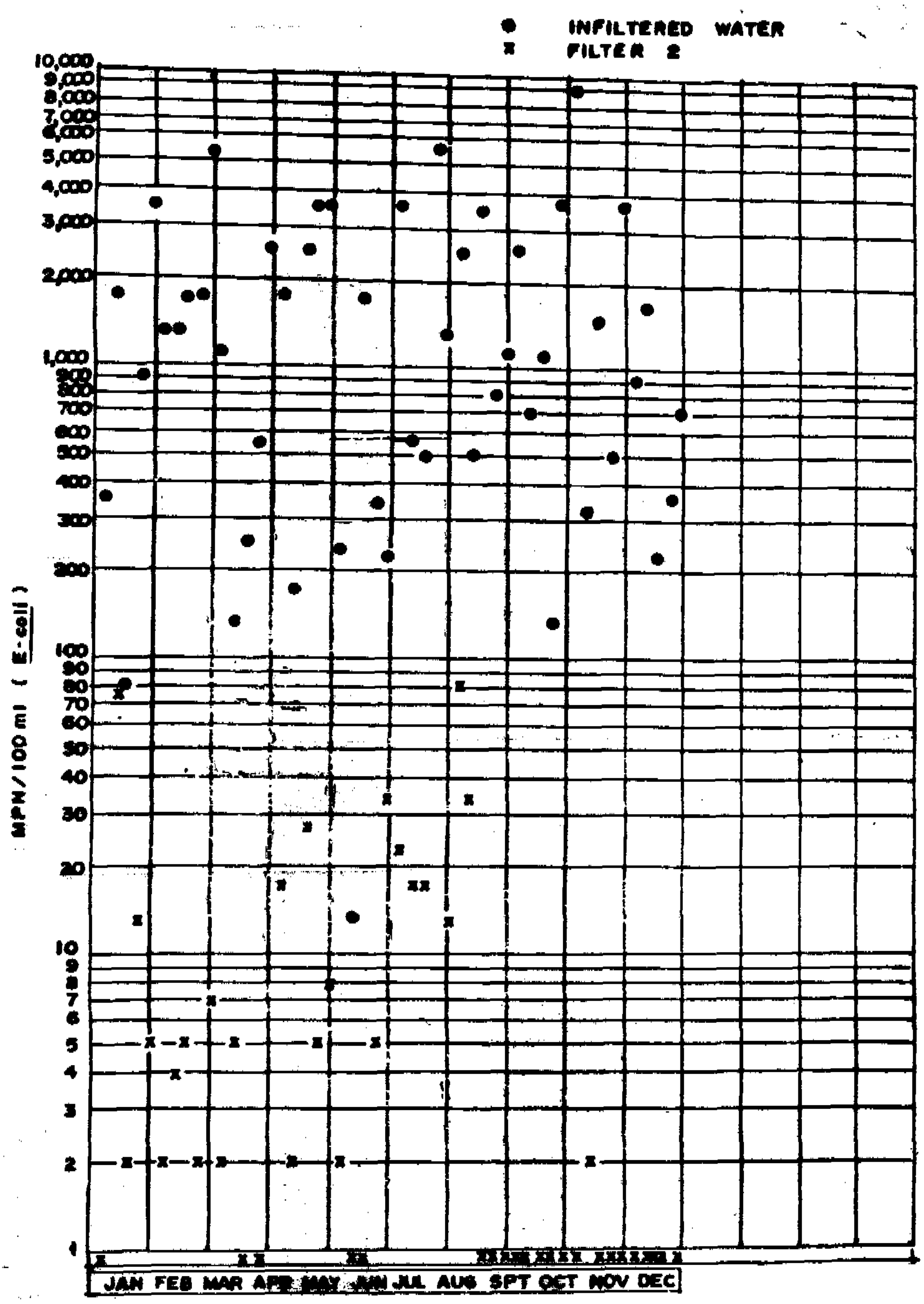


Fig. 20 (D) – *E. coli* Variation in Infiltered Water and Filtrate – Borujwada

Table 16 – Water Quality Characteristics (Range) – Abub Shahar

Parametres	Raw Water	Settled Water	Filter 1	Filter 2
Temperature°C	14 – 30	15 – 33	19.5 – 32	14 – 32
Conductivity μ mho/cm	158 – 220	150 – 220	150 – 220	150 – 220
pH	6.3 – 9.0	6.3 – 8.6	6.4 – 8.4	6.5 – 8.4
Turbidity (NTU)	0.3 – 7.4	0.2 – 1.9	0.15 – 0.43	0.16 – 0.6
Dissolved solids	84 – 262	87 – 135	80 – 148	86 – 140
Total Alkalinity as $CaCO_3$	55 – 72	54 – 74	52 – 72	52 – 72
Total Hardness as $CaCO_3$	54 – 104	56 – 96	56 – 98	56 – 102
Ca Hardness as $CaCO_3$	44 – 70	44 – 66	44 – 68	44 – 64
Magnesium as Mg	3.9 – 8.7	3.9 – 8.7	4.9 – 7.8	3.9 – 9.2
Chloride as Cl	4 – 16	4 – 8	4 – 8	4 – 8
Sulphate as SO_4	20 – 33	20 – 33	20 – 34	20 – 33
Iron (total) as Fe	0.05 – 0.12	0.05 – 0.1	0.05 – 0.1	0.05 – 0.1
Fluoride as F	0.04 – 0.2	0.15 – 0.2	0.15 – 0.2	0.15 – 0.2
C. O. D.	2.0 – 9.0	2.6 – 9.0	1.0 – 5.4	1.0 – 8.0
Chlorine Demand	0.15 – 0.4	0.15 – 0.38	0.2 – 0.38	0.15 – 0.38

All values except pH are expressed as mg/l.

Table 17 - Turbidity Removal Efficiency – Abub Shahar

Month	TURBIDITY (NTU)			
	Raw Water	Settled Water	Filtrate 1	Filtrate 2
July' 79	4.5	1.5	0.25	0.6
August	0.85	0.8	0.25	Scraped
September	1.4	1.2	0.17	0.16
October	7.4	……………Power failure……………		
November	0.8	1.5	0.2	0.3
December	1.2	1.2	Not in operation	0.2
Jan.' 80	2.5	1.1	0.43	0.56
February	0.3	0.2	0.17	0.17
March	1.0	0.9	0.15	0.45
April	1.5	1.5	0.26	Not in operation
May	0.58	0.85	0.2	0.23
June	0.7	0.60	0.17	0.16
July	1.0	0.8	0.13	0.1
August	1.5	1.1	0.23	0.25
September	3.6	0.8	No sample	0.15
November	1.6	1.9	0.15	0.2
December	1.6	1.6	Scraped	0.2

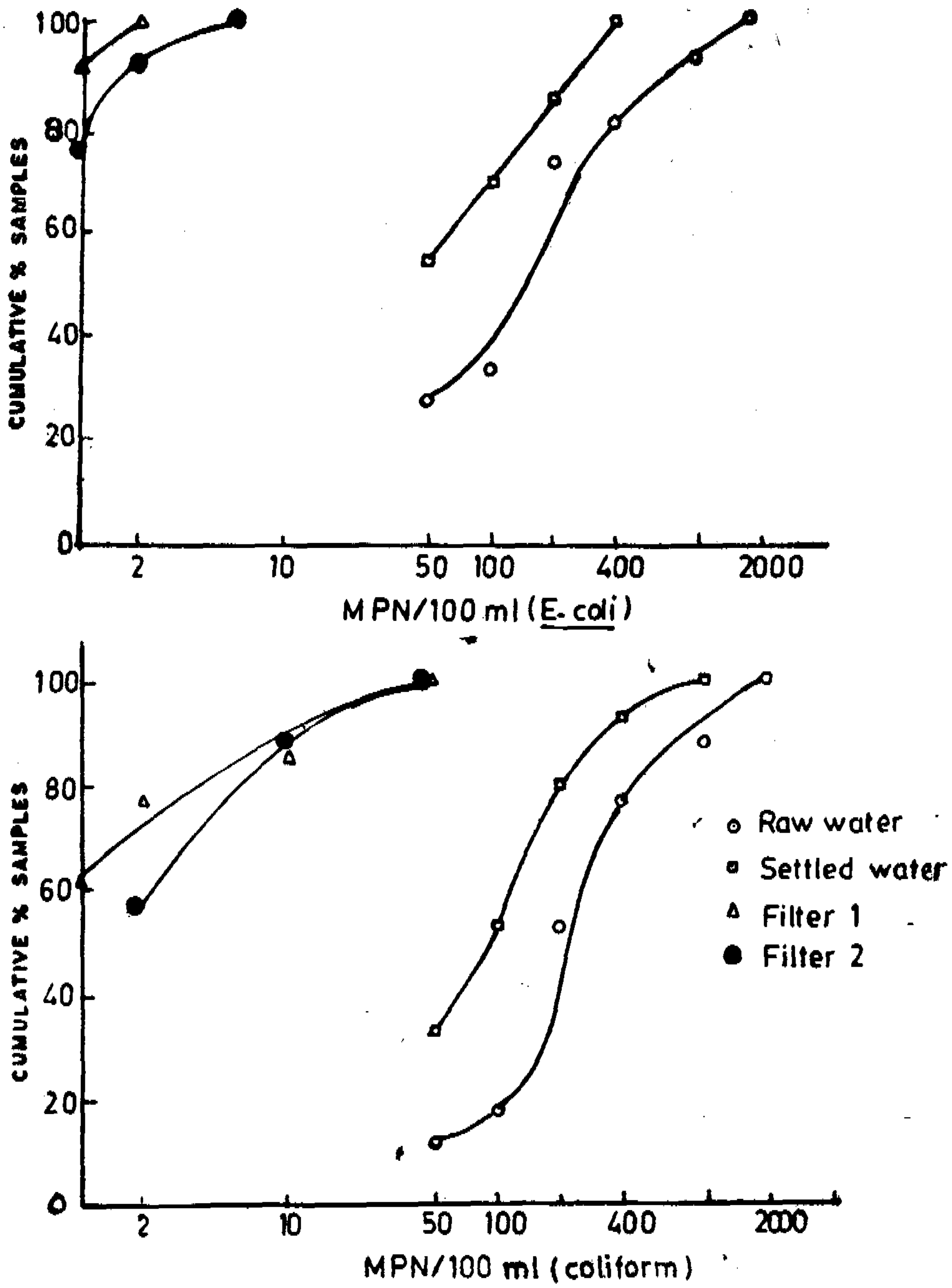


Fig. 21 (A)–Frequency Distribution of Coliform and *E. coli* in Raw, Settled and Filtered Waters – Abub Shahar

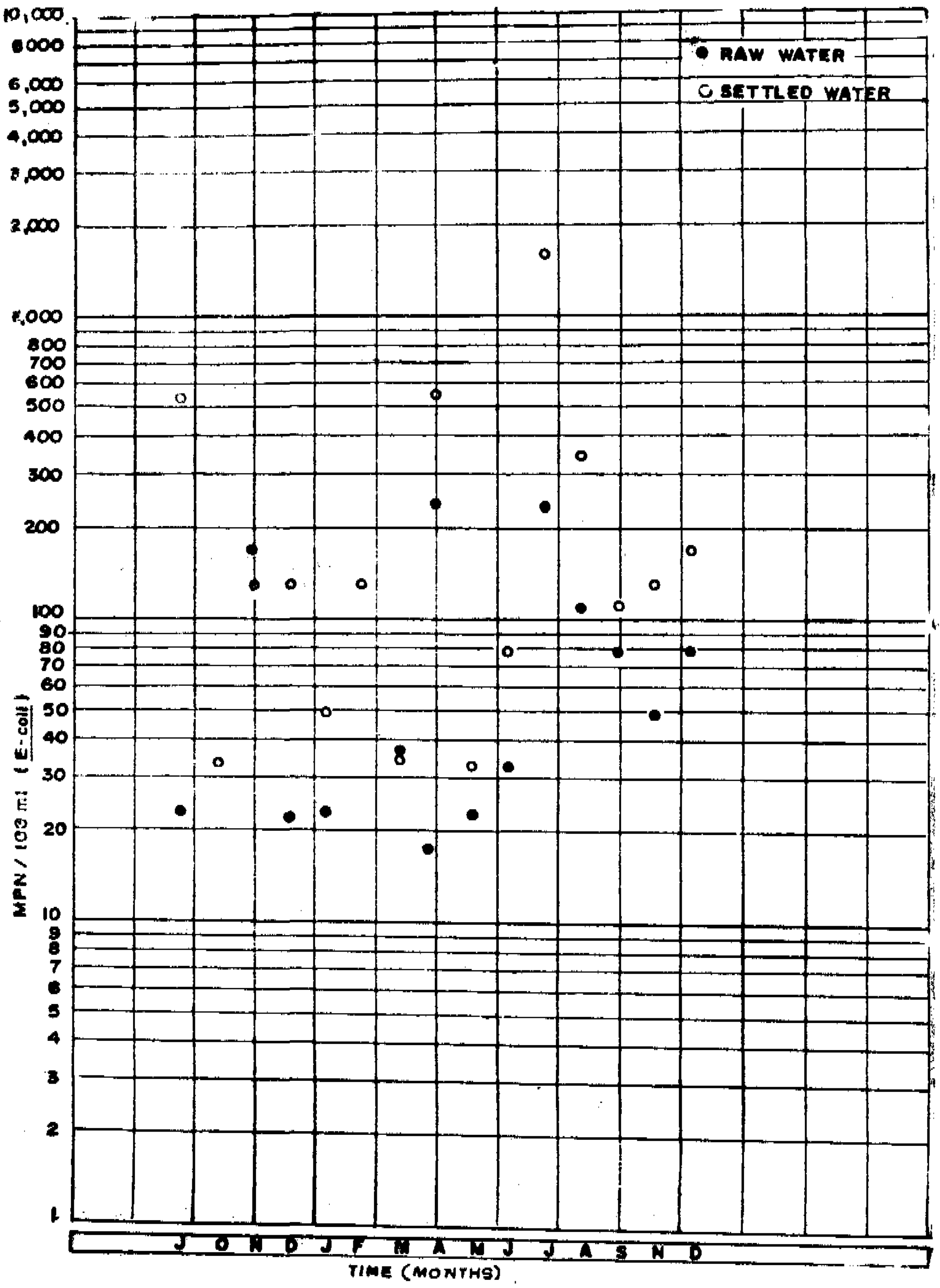


Fig. 21 (B) - *E. coli* Variation in Raw and Settled Waters-Abub Shahar

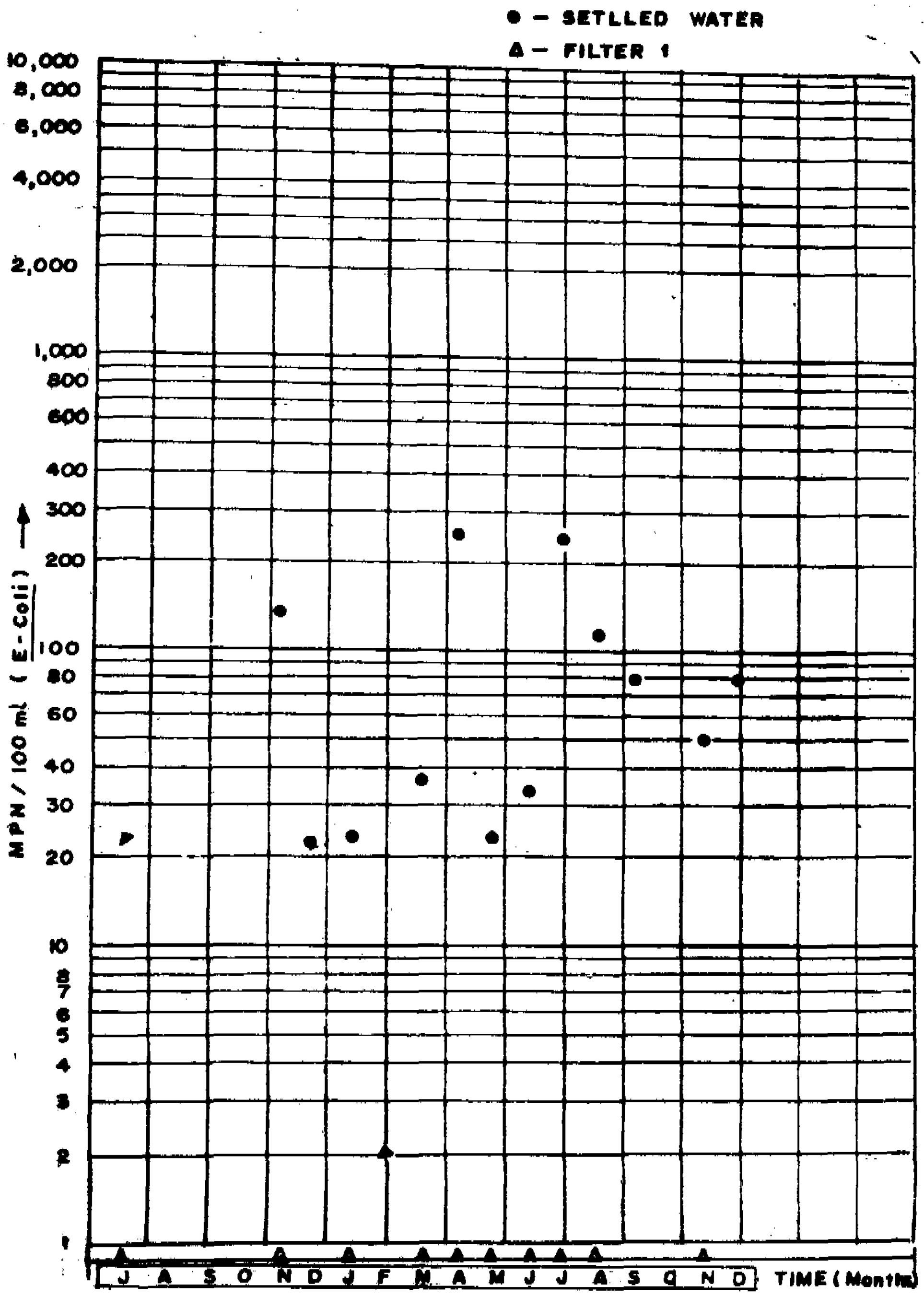


Fig. 21 (C) – *E. coli* Variation in Infiltered Water and Filtered Waters – Abub Shahar

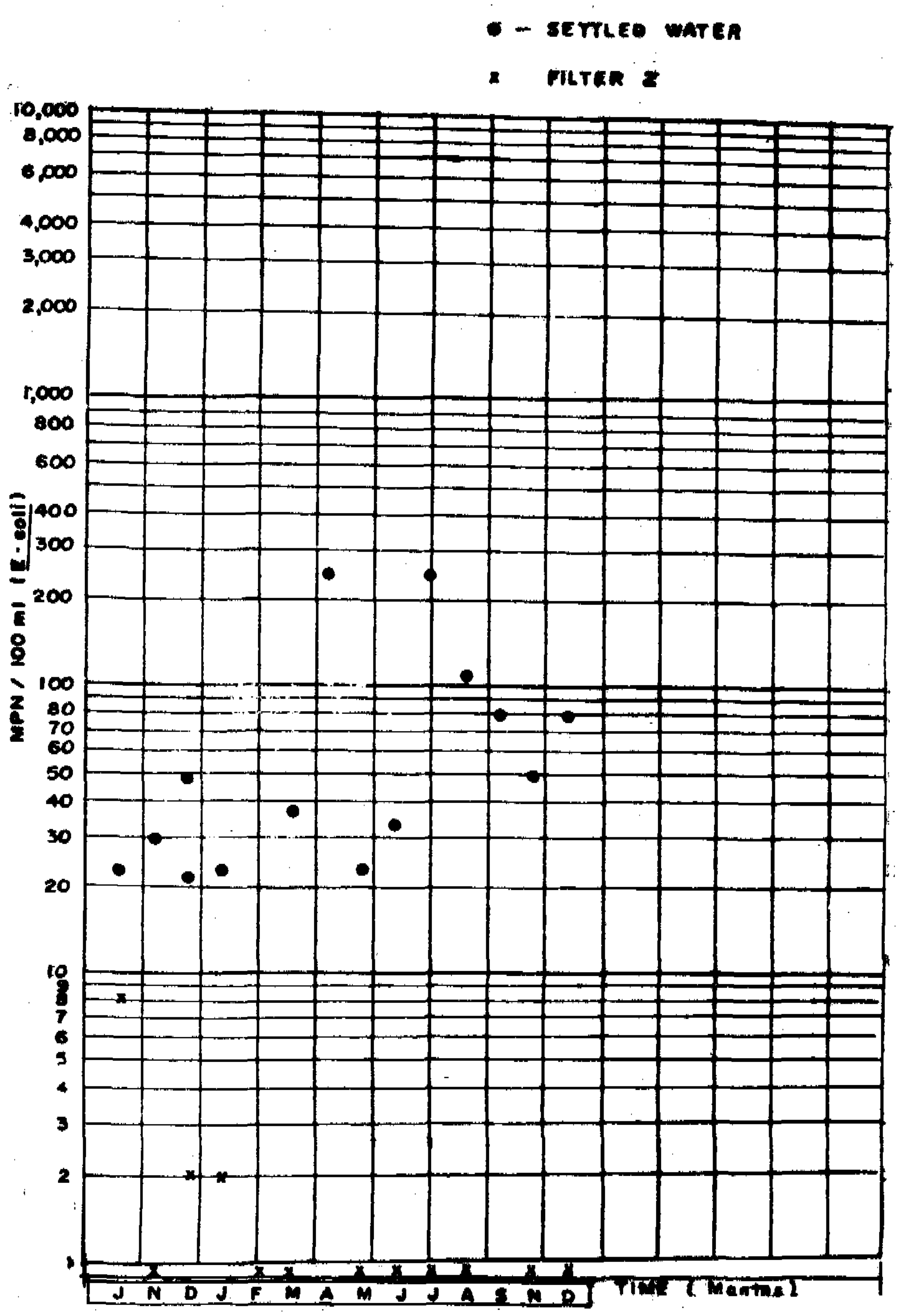


Fig. 21 (D) – *E. coli* Variation in Settled and Filtered Waters – Abub Shahar

Table 18 – Water Quality Characteristics (Range) – Kamayagoundanpatti

Parameters	Raw Water	Settled & prefiltered water	Filter 1	Filter 2
pH	7.5 – 8.6	7.5 – 8.2	7.5 – 8.5	7.5 – 8.5
Turbidity NTU	2.5 – 41.0	3.2 – 35.0	0.5 – 2.0	0.4 – 3.0
Total solids	182 – 518	162 – 514	114 – 488	130 – 502
Dissolved solids	122 – 380	125 – 492	98 – 402	116 – 496
Total alkalinity as $CaCO_3$	134 – 324	134 – 340	134 – 330	136 – 380
Total hardness as $CaCO_3$	100 – 263	104 – 286	94 – 254	102 – 290
Carbonate hardness as $CaCO_3$	100 – 263	104 – 286	94 – 254	102 – 290
Calcium as $CaCO_3$	56 – 122	54 – 132	56 – 90	54 – 138
Magnesium as $CaCO_3$	44 – 153	45 – 178	34 – 164	45 – 162
Chlorides as Cl	1.4 – 28	1.3 – 21	1.3 – 20	1.3 – 19
Sulphates as SO_4	4.0 – 16.8	4 – 15.2	3.2 – 12.8	3.8 – 13.2
Iron (Total) as Fe	0.3 – 2.4	0.2 – 2.4	0.08 – 0.7	0.1 – 0.5
COD	2.4 – 12	Traces – 12.0	Traces – 10.0	Traces – 6.0
Fluoride as F	0.5 – 1.4	0.4 – 1.4	0.4 – 1.4	0.2 – 1.4

All values except pH are expressed as mg/l

Table 19 – Turbidity Removal Efficiency – Kamayagoundanpatti

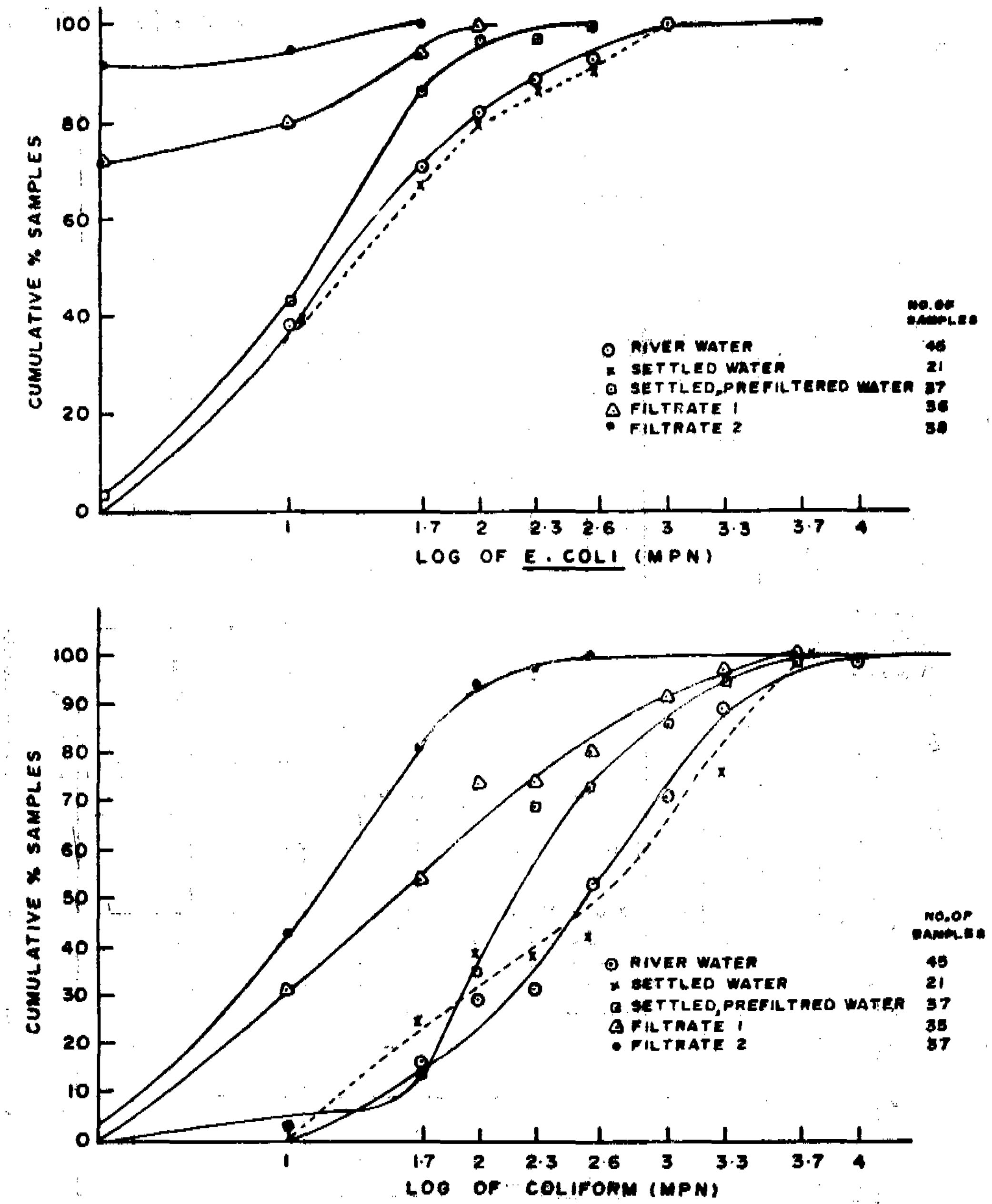
Month	TURBIDITY – NTU				
	Raw Water	Settled Water	Settled & Pre-filtered water	Filtrate 1	Filtrate 2
March '79	3.7	–	6	–	1.0
April	4.3	8	3.5	2.2	2.2
May	11.2	8	7.8	4.2	1.7
June	24.0	8	6.3	3.0	2.5
July	22.0	–	5.0	2.2	2.2
August	28.5	–	19.0	2.7	2.7
September	17.3	–	15.0	3.0	2.7
October	18.0	16	16.0	5.7	3.2
November	8.5	8	3.6	1.7	1.7
December	7.6	5.5	5.0	1.0	1.0
January '80	6.0	4.0	4.0	0.7	1.0
February	2.3	3.3	2.9	0.8	0.5
March	5.0	3.5	2.3	0.6	0.5
April	1.8	1.5	1.5	0.7	0.8
May	8.5	–	–	0.6	0.4
August	3.5	3.5	3.5	1.0	0.7
November	3.0	2.5	2.5	–	0.5
December	4.0	2.7	1.7	0.5	0.6

Table 20 – Reduction in Chemical Oxygen Demand (COD) – Kamayagoundanpatti

S. No.	Raw Water	Settled and prefiltered water	Filter 1	Filter 2
1	2.4	2.0	1.5	1.5
2	4.5	4.5	3.3	3.7
3	8.0	8.0	6.0	6.0
4	4.8	4.5	4.5	4.2
5	–	–	–	–
6	12.0	12.0	10.0	4.0
7	4.0	3.0	2.0	3.0
8	4.5	2.9	1.5	–
9	4.5	2.9	1.5	1.5
10	11.6	7.7	5.2	5.1
11	8.6	7.4	–	6.4
12	5.0	N. D.	N. D.	N. D.
13	3.7	–	N. D.	N. D.

N.D. :– Not Detectable, All values are expressed as mg/l.

1. Average COD removal in settled & prefiltered water – 18.62 %
2. Average COD removal by F1 compared to settled and prefiltered water – 35.34 %
3. Average COD removal by F2 compared to settled and prefiltered water – 35.52 %
4. Average COD removal by F1 compared to raw water – 47.38 %
5. Average COD removal by F2 compared to raw water – 47.53 %



FREQUENCY DISTRIBUTION OF COLIFORM & E.COLI IN RAW, SETTLED, PREFILTERED & FILTERED WATERS (K G PATTI)

Fig. - 22 (A)

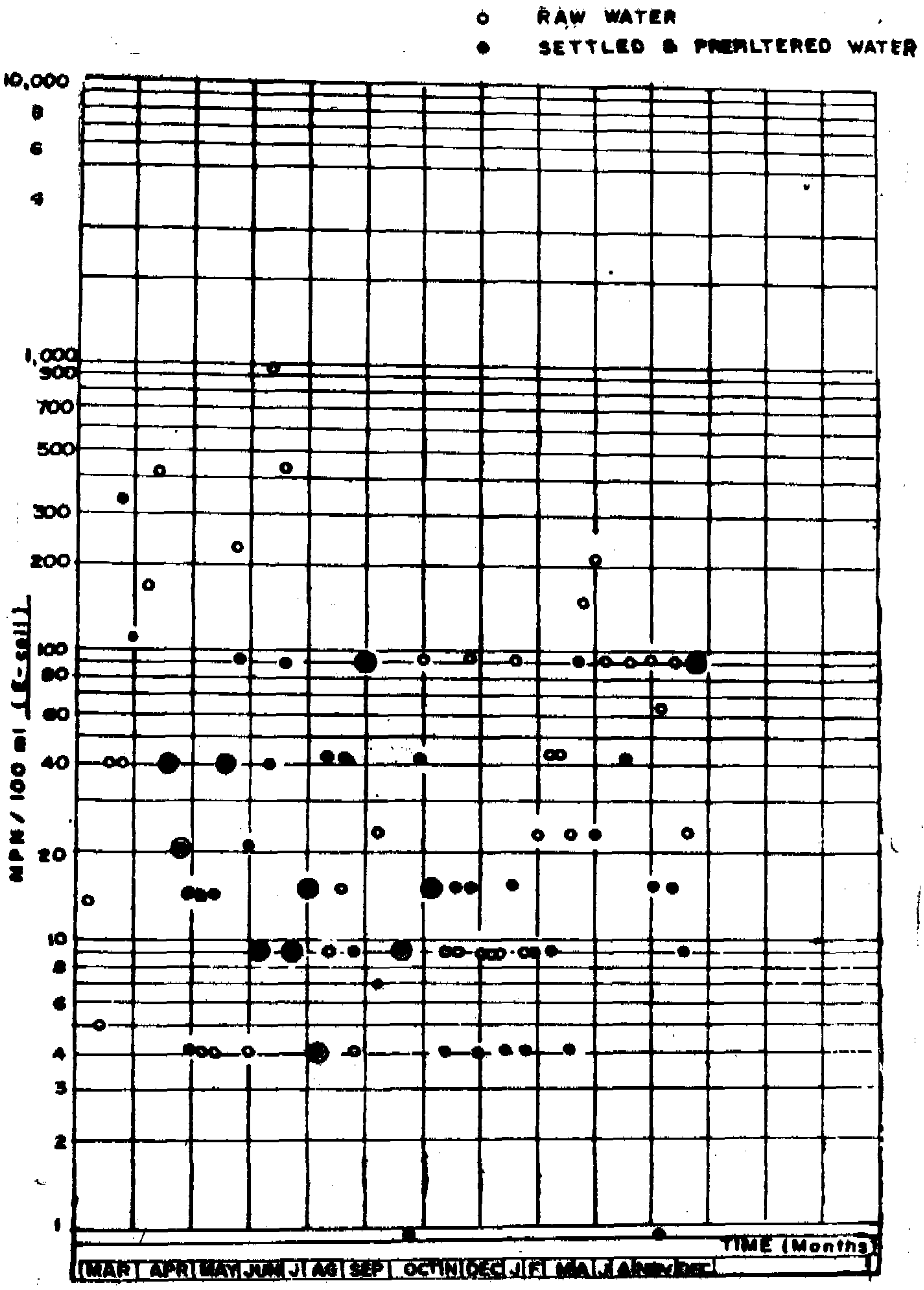


Fig. 22 (B)-*E. coli* Variation in Raw and Settled and Prefiltered Waters-Kamayagoundanpatti

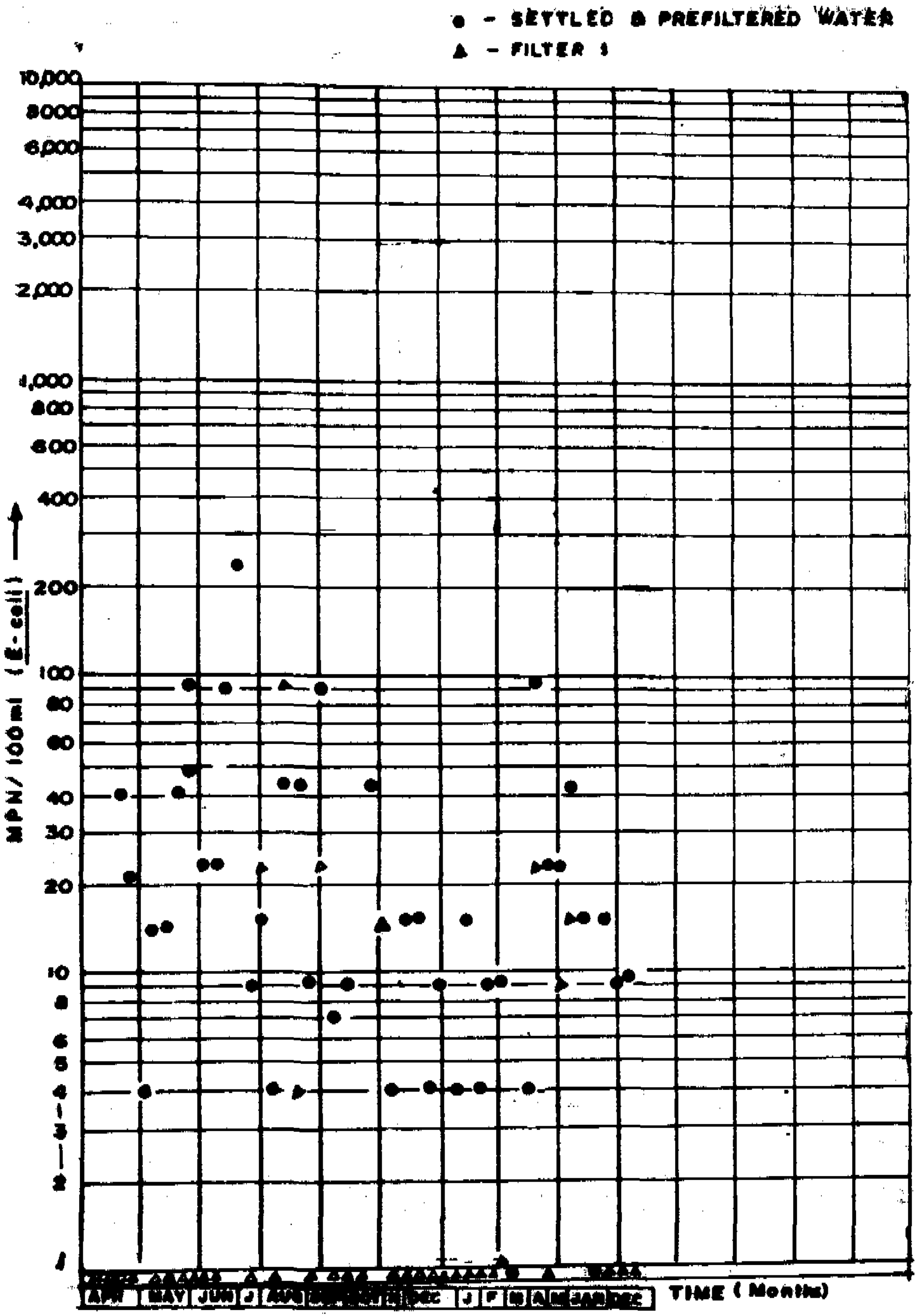


Fig. 22 (C)-*E. coli* Variation in Settled and Prefiltered Water and Filtrate – Kamayagoundanpatti

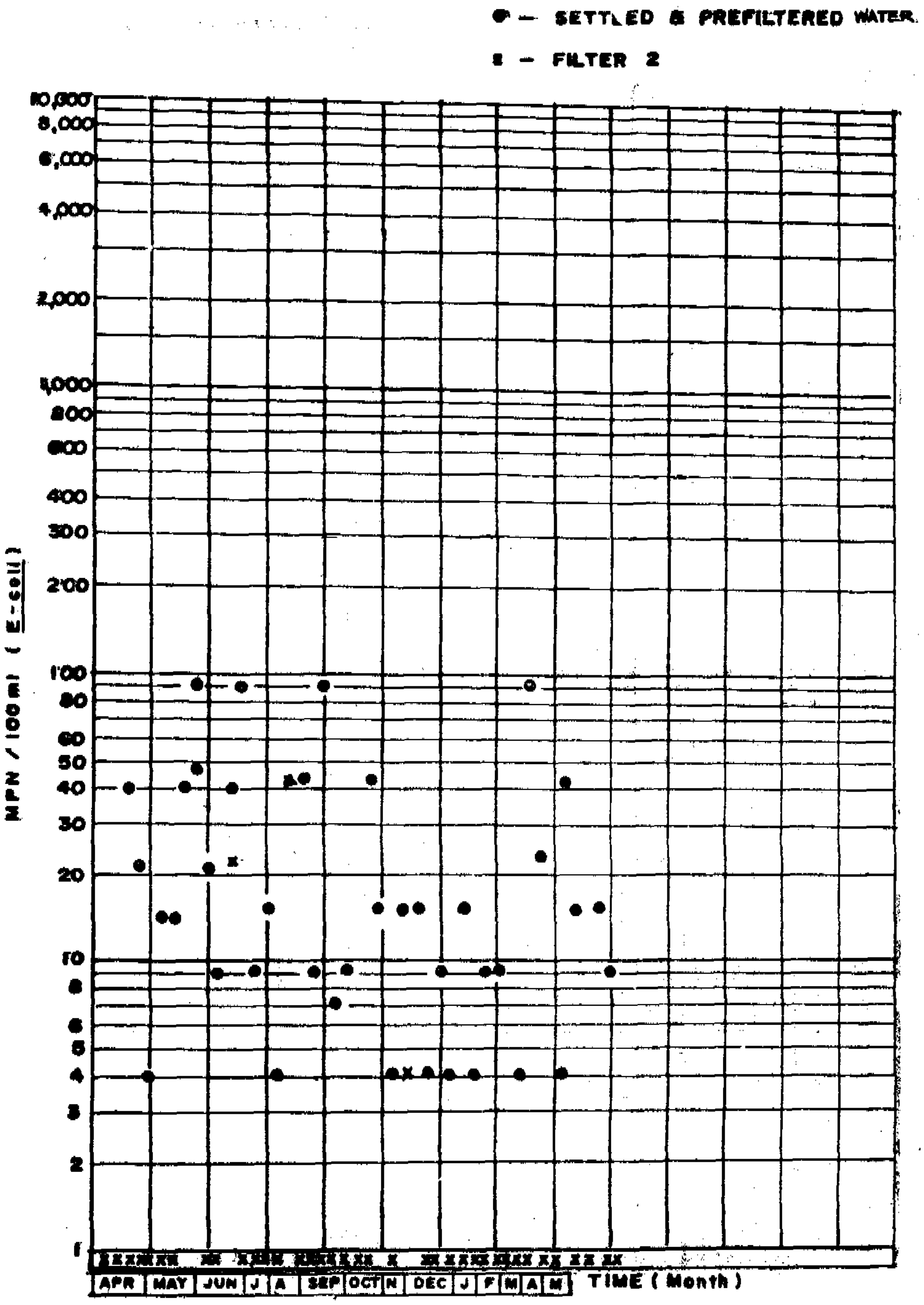


Fig. 22 (D) - *E. coli* Variation in Settled and Prefiltered Water and Filtrate– Kamayagoudanpatti

Table 21 – Water Quality Characteristics (Range) – Pothunuru

Parameters	Raw Water	Filtered Water
Turbidity (NTU)	5.0–13.0	< 1–5.0
pH	7.2–8.3	7.5–8.1
Total alkalinity as $CaCO_3$	100–126	98–146
Dissolved solids	145–234	125–230
Total hardness as $CaCO_3$	78–98	72–98
Calcium as Ca	19.2–24.8	21.6–26.4
Magnesium as Mg	5.8–11.6	3.8–10.2
Chlorides as Cl	27.0–35.0	27.0–38.0
Sulphates as SO_4	2.0–11.2	2.0–11.0
Nitrates as NO_3	Traces–0.21	Traces–0.33
C. O. D.	4.0–20.0	Traces–13.0

All values except pH are expressed as mg/l

Table 22 – Bacteriological Performance of filters – Pothunuru

Sr. No.	Coliforms	Fecal coliforms	*E. coli*
	MPN/100 ml.		
Raw Water			
1	4600	4600	930
2	240	93	15
3	2400	1100	210
4	4600	240	240
Filtered Water			
Before Disinfection			
1	240	21	15
2	4	Nil	Nil
3	9	9	4
4	240	23	23
After Disinfection			
1	–	–	–
2	4	Nil	Nil
3	Nil	Nil	Nil
4	Nil	Nil	Nil

feeding raw water to the summer storage tanks remained closed for nearly 3 months for desilting operation due to which the plant also was shut down temporarily.

5.4 Operation and Maintenance of VDPs – Some Observations

The field evaluation of demonstration plants designed to cover a wide spectrum of local conditions brought to focus a number of aspects related to the design, construction, operation and maintenance of slow sand filters at village level. These are briefly discussed below :

- While designing village level slow sand filters, the layout of the plant should be arranged compact to facilitate the daily routine by the operators especially where extremes of weather conditions are experienced (eg) common switch room for raw and filtered water pumps.
- In one of the demonstration plants, it was found that the filtered water from one of the units was getting contaminated between the filter outlet and the weir chamber. Corrective measures in such cases become cumbersome and expensive. It is therefore very essential that before commissioning a new plant the filter box along with the associated pipe lines and valves are carefully tested for water tightness to prevent leaks and possible contamination by ground water.
- During initial commissioning of the plant, clean water is often not available for back filling. In such cases, a satisfactory alternative is to use raw water for which a temporary pipe line should be laid to the filter outlet chamber right at the construction stage.
- Filtering to waste during initial ripening period, which often takes 4–5 weeks, may not always be practical. In such cases, the supply can be started after

a few days provided adequate chlorination is ensured.

- When the supernatent is to be drained out before cleaning a filter, the drain valve should be opened gradually to avoid scouring of the sand bed around the drain out chamber.

- Frequent interruptions in electric power supply affect the normal operation of village level slow sand filters. On such occasions, declining rate operation of filters can provide a satisfactory solution. Where power cuts are frequent, adequate precaution should be taken at the design stage itself by providing standby generator.

- Plankton growth and development of molluscs and aquatic weeds in raw water storage tanks or on filters do not pose any serious problems in the performance of the filters or their operation and maintenance. With experience a care taker can even predict such problems and arrange for cleaning the filters, if necessary, prematurely. Filter cleaning could be done with local labour in a few hours time.

- Association and involvement of even an unskilled local person right from the initial stages of filter construction, as was done in Borujwada, facilitates successful training of caretaker (s) effective operation and maintenance of the filter plant when handedover to the local body.

- In the case of Borujwada plant which is the smallest of the four demonstration plants and designed for a population of only 1300 persons, the operation and maintenance is looked after by a local operator trained on the plant. The recurring expenditure including the salary of the caretaker is met from the interest amount derived from a long term fixed deposit of Rs. 50,000/- which was made available as IRC contribution for the construction of the plant. The income and resources of the village being very meagre, this arrangement has not only provided a satisfactory solution but also ensured continued use and upkeep of the facility.

5.5 Conclusions

- The performance of village demonstration plants has established the efficacy of slow sand filters as a reliable and effective means of water purification.

- For raw waters of varying turbidity such as encountered in Borujwada, river bed filtration (infiltration gallery) has proved a simple and efficient method of pre-treatment before slow sand filtration. River water turbidity of as high as 500 NTU could be reduced to a uniformly low level of less than 5 NTU. In addition, there is a considerable reduction in coliform bacteria and COD.

- The village level slow sand filters, operated at normal filtration rates and with widely differing conditions of raw water quality, produce a filtrate of turbidity less than 1 NTU with *E. coli* removal as high as 90 per cent.

- Depending on the initial concentration, an overall COD removal of 45-80 per cent is brought about by slow sand filtration.

- The field observations, in general, confirm the results of applied research carried out in the first phase of the programme.

6. HEALTH EDUCATION EXTENSION IN PROJECT VILLAGES

6.1 Introduction

It is increasingly recognised that health benefits from improved water supply will not automatically follow unless a desirable change in the knowledge, attitude and practice (KAP) of the user community is brought about. All water-borne diseases can also be transmitted by any route which permits faecal material to reach man such as by contaminated food. Therefore, provision of safe water supply alone by itself can not control water-borne diseases, unless the personal and domestic hygiene status is simultaneously improved. It is against this background that a programme of health education extension has been integrated as an important activity of the second phase of the Slow Sand Filtration project.

6.2 Objectives

General

The general objectives of the programme were :

To evolve a methodology of assessing the impact of health education in preparing the community for effective utilization of improved water supply.

To study the impact of improved water supply on the health status of the community with special reference to child population (< 5 years).

To document, monitor and evaluate all aspects of educational programme relating to water and sanitation with a view to utilising the experience and knowledge in future projects.

Specific

To undertake a study of the concerned community with a view to assess its resources, potentials and educational needs. To develop suitable educational aids and materials for use in the community

To educate the community on the accpptance of improved water supply for drinking purposes.

To assess the extent to which the community has used the improved water supply for drinking purposes.

To identify the problems (financial and others) faced by the people in *utilising* improved water supply.

To help people of the project villages to acquire adequate knowledge regarding general health, environmental sanitation, selected communicable diseases and availability of health facilities.

To assess the impact of the entire process of health education and improved water supyly on the health of the people, their knowledge, attitude and practice.

To prepare a set of educational aids relating to water, personal hygiene and enviromental sanitation which can serve as a model for rural water supply programmes.

6.3 Salient Features

The strategy for the education and participation activities was developed by the Central Health Education Bureau (CHEB)* in close cooperation with NEERI, which performed the overall coordination of the national programme as well as with the State Health Education Bureaus in the four participating states of Andhra Pradesh, Haryana, Maharashtra and Tamil Nadu.

The whole programme was divided into five phases : Preparatory phase, Planning phase, Implementation phase, Evaluation phase and Report writing phase.

The preparatory phase consisted of orientation of the staff concerned, the formation of advisory and planning committees at state, district and project level and collection of field data from existing records and through standar-

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* The technical wing of the Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India.

dized questionnaires. During planning phase specific local programmes were developed to suit the needs of the community, responsibilities were divided and specific aids were prepared. In the implementation phase, local staff and leadership were trained, mass and group meetings were organised to attain the "satisfaction of the dissatisfied". Additional information on health, water and sanitation conditions and water quality was collected. Periodic and terminal evaluation of the programme was carried out to assess the impact of health education activities.

6.4 Methodology

A uniform methodology was followed in all the project villages, except for some minor changes to suit the local conditions and needs.

6.4.1 Diagnosis

In order to achieve an effective integration of health extension activities with water supply through slow sand filtration, it is a pre-requisite to diagnose the health education needs of the community and to prepare an appropriate design and implementation strategy for the field delivery system. The required information was collected through personal interviews and from available records.

The village :- General information about the village viz., location, area, demographic details, caste structure, socio-economic conditions, leadership pattern, occupation, welfare organisations, attitude of the community towards government programmes, educational facilities and other amenities available etc., were collected through a village information schedule (Appendix II).

The family :- Information regarding the families, viz. number of persons, age, sex, educational background, income, sanitation facilities, hygienic habits, demand for drinking water, present source (s) of drinking water, their knowledge, attitude and practice about various diseases, family welfare programme etc., was collected through personal interviews with each family and noted in family health survey schedule (Appendix III).

Educational diagnosis :- This information was collected from randomly selected 20 adult males and 20 adult females from the village. This was intended to bring out their present knowledge on various diseases, their causes and symptoms and also other aspects of general health hygiene. The data were recorded on educational diagnosis schedule (Appendix IV). Scrutiny and analysis of data thus collected, identified the problems that existed in the communities; viz. unsafe drinking water, scarcity of drinking water in summer months, unhygiene methods of storage, handling and use of water, unsatisfactory disposal of and solid wastes, absence of latrines, fly nuisance, lack of medical facilities, non-availability of electricity, etc.

In village Borujwada, stool analysis of the entire population was done by NEERI and found that 70.0 per cent of the people suffered from enteric parasites.

6.4.2 Formation of activity groups

State Level Committee :- This committee was formed to render necessary co-operation and assistance to the respective departments for effective implementation of the project. Heads of Public Health Engineering Departments, State Health Education Bureaus; Director, NEERI; and Director, CHEB were members of this group.

Advisory Committee :- This committee was formed at the district level to advise on effective implementation of the health education programme in the project villages. The following were the members :

1. President of Zilla Parishad
2. Chief Executive Officer of Zilla Parishad
3. District Health Officer
4. Director, NEERI
5. Director, CHEB
6. Public Health Engineer

The members of this committee were so chosen as to command and mobilize necessary help and co-operation from their respective departments for periodic review of the activities and proper implementation of the programme.

Planning and Steering Committee

This committee was formed at the block level for effective planning, implementation, evaluation and follow up of the health education programme at the village level. The following members formed the committee :

1. Chairman of the Panchayat Samiti
2. Block Development Officer
3. Medical Officer-in-charge of the Primary Health Centre
4. Panchayat Samiti Member from project village
5. Divisional Sanitary Inspector
6. Public Health Engineer
7. Epidemiologist
8. Research Officer from CHEB
9. Head of the Village Panchayat

This committee was to involve the concerned local agencies and oversee the day today activities in the village.

Village Health Committee

A welfare-cum-health committee was formed at the village level to review and implement the health education activities among the target population. The formal and informal leaders and head of the village and other prominent citizens of the locality constituted this committee.

6.4.3 *Orientation training of field workers*

Orientation training of the community health workers of the village, village head (Sarpanch) informal and formal leaders of the village and the extension staff of the Primary Health Centre was arranged to prepare them to undertake the field work in educating the community. They were trained 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.

A resource book "Health Guide to Workers" was prepared by Haryana state health education bureau to make the training interesting and meaningful.

Panchayat Samiti :- Non-governmental body of representatives of a group of panchayats comprising a block.

At Nagpur, for the village Borujwada, the training programme was organised for six days, 12-17 June, 1978. Seven persons attended the training. Water in relation to diseases, worm infestations, communicable diseases, water supply and purification, environmental sanitation and personal hygiene were some of the topics discussed during the training course. The participants were also told about health education service activities for the village, development of educational aids etc. A detailed course content of the training programme is given in Appendix V.

In all the project villages, lectures for the training course were delivered in local language by specialists in the respective fields and were supported by practical demonstrations and group discussions, with the aid of charts, models, slides, movie films, flash-cards and blackboard.

Before and after the training course, the trainee were subjected to written tests to assess their scientific knowledge related to health aspects before and after the training. The proforma/questionnaire used for this purpose in given as Appendix VI.

6.4.4 *Inter-agency meeting*

A meeting of representatives of the four participating states was arranged at Nagpur during 5-7 July 1978, to facilitate effective coordination and ensure uniformity in the implementation of health education programme in the participating states. Public Health Engineers, Medical Officers and health education field staff from all the four states participated in the meeting.

6.4.5 *Educational activities*

Mass meetings :- These meetings were organised periodically and regularly in the project villages to make the villagers aware of health education and service activities which were being organised in the village with the active help of their own leaders. In these meetings, they spoke on specific topics to the community and also informed them of the type of co-operation desired from them.

Group Meetings :- The awareness created by the mass meetings were further strengthened and specific information given to the target group in every hamlet of the village through group meetings. These meetings helped the groups to clarify their doubts on various health topics. This also helped in the dissemination of the desired information and creation of a favourable social atmosphere about the programme.

Individual Contacts :- This activity helped the field staff to know their target population better and clarify their doubts and establish sound educational links. People who could not participate in the mass meetings and group meetings could also be contacted in this way.

School as a focus

All the project villages had schools and the teachers working there were also involved in educating the community. The teachers were helpful and effective in educating school children about cleanliness, personal hygiene, good habits, common diseases among children, environmental sanitation etc.

Periodic medical examination of the children was done and the defects and shortcomings pointed out to them till they were rectified. Curative medical treatment was given whenever necessary.

School premises was a good for other activities like cinema shows, meetings, exhibitions etc. (vide infra).

Doctors visit

Medical officers of primary health centres visited the project villages regularly for the benefit of the community through consultations and treatment. These visits were also used by the doctors to educate the community on various topics including the importance of protected water supply and environmental sanitation and to impress on them that cleanliness, good personal hygiene and environmental sanitation practices would pay them in the long run by way of reduced medical bills.

6.4.6. Educational aids

A variety of educational aids were prepared in local languages and used in all the project villages. Recorded dialogues, health songs, celebration of 'health day', debate and drama for children depicting health topics, were part of the campaign to educate the community. In addition, posters, pamphlets, roll charts, models, panels, flash-cards, table topics etc., were also used on various occasions.

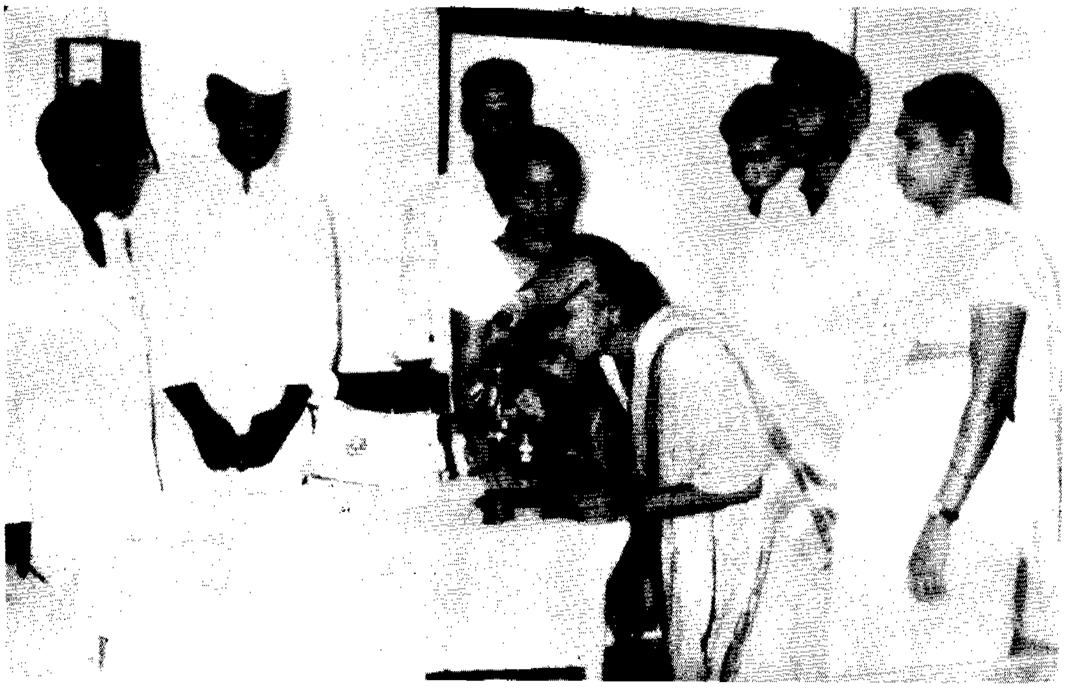
Posters :- Wall posters carrying messages (in local language) on various aspects of health (nutrition, child health, environmental hygiene etc.) and prevention of diseases like malaria, filaria, T. B., whooping cough, cholera, typhoid, jaundice, etc., were displayed prominently at a number of places in the project villages, so that the message could be picked up by the target population.

Exhibitions :- Models, charts, flash-cards, table-tops, etc., were used in these exhibitions to demonstrate the various aspects of environmental sanitation, prevention and control of diseases, water purification, personal hygiene etc. Exhibitions were well attended. In Borujwada (Nagpur) cysts and eggs of enteric parasites were demonstrated with the aid of a microscope, during one of the exhibitions.

Short slogans :- Short slogans instructing the people to use safe water for drinking and to adopt sanitation measures to keep the environment clean were displayed prominently at a number of places, including the public stand posts.

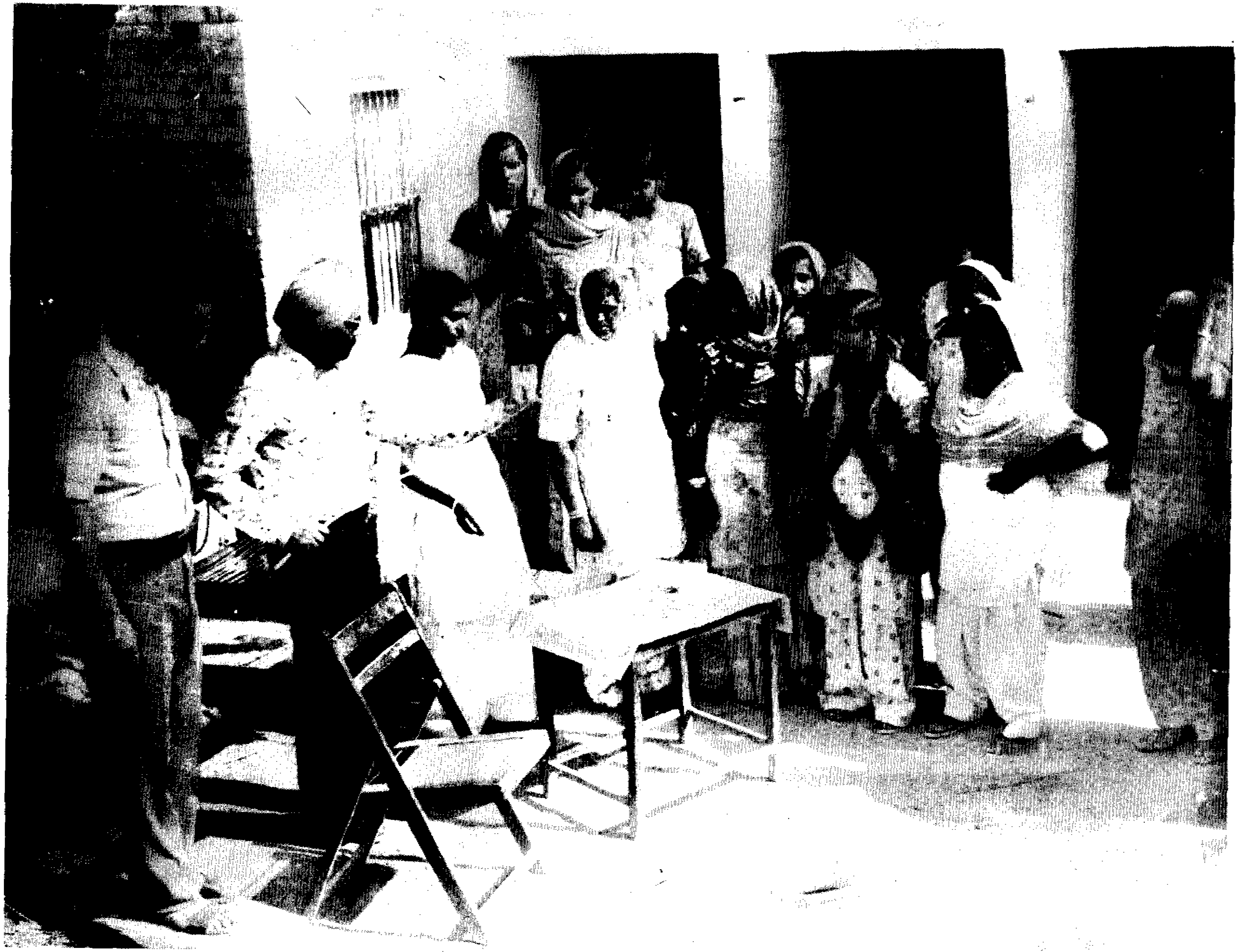
A four-line motto, in Marathi, (the local language) stressing the importance of safe drinking water, permanently installed at every public stand post was a speciality in village Borujwada. Instructions for the regular use of laterines and their advantages are also on display in this village.

Movie films :- Movie films were big attractions in every village. The films (16 mm.) were taken on loan from CHEB, Films Division, and other governmental agencies and screened in the villages. The topics covered in these films were:



Orientation training for the trainers

Participants of interagency meeting on a field visit to
project village



A group meeting on health education in progress

Health education exhibition at the
village school

Village folk at filmshow on
Importance of safe water

water-friend or foe, importance of water, cleanliness, solid wastes disposal, nutrition healthy habits, health and cleanliness in emergency, mosquito control, environmental hygiene in villages, dental care, healthy child, malaria eradication, family welfare, cholera, hookworm, filariasis etc. While screening, the scientific films were sandwitched between documentaries and feature films of entertainment value, to make the programme more attractive to the villagers. This also helped to draw the village population at one place to listen to the health education activities. Lectures in local language were invariably arranged during such assemblies to explain the scientific aspects of the films screened. All such occasions were also used to instruct the community to use safe drinking water supplied to them and to use latrines regularly, so that their environment was kept clean and germ-free.

In Borujwada, films were screened every month by NEERI, in the open air, after sunset and lectures were delivered in Marathi.

6.4.7 Support Activities

Immunization :- In all the project villages, vaccination (DPT, cholera) of children and adults was regularly done by the medical staff. During their visits, the role of immunization in the control of diseases was taught to the target population.

Morbidity data :- Every month, during their visits, the health staff in all these villages collected data on the morbidity of various diseases.

Demonstrations :- Practical demonstrations on personal hygiene, use of soakage pit, manure pits, food sanitation, safe-drinking water, pathogenic bacteria etc., were organised in all villages.

6.4.8 Evaluation

Mid-term :- Apart from the final evaluation, it was necessary to evaluate the impact of educational activities against their objectives. Randomly selected sample populations from the village were interviewed to assess their knowledge on health aspects. Their answers were recorded on a proforma designed for the purpose (Appendix VII).

Final :- Similar to the mid-term evaluation, sample populations of the villages were interviewed after the termination of the project to assess the impact of the various inputs including health education into community. The answers were recorded on a similar proforma as mentioned above (Appendix VIII).

6.5. Salient Findings

The baseline data regarding the communities' awareness of health-releated aspects and the status of water supply and sanitation before the implementation of health education programme (activity) were generally of a similar nature in all the project villages.

6.5.1 Awareness :- Health facilities were available for all the project villages though none of them had a primary health centre in the village itself. However, the communities did not fully avail of the benefit of immunization programmes, since many of them did not realise that vaccination would benefit them. The awareness of personal hygiene and clean environment was poor in most of the households, as revealed by the answers of the respondents. Most of them liked to have a better system of water supply in their village so that it would add to their convenience, while only a few realised that the new system of treatment through slow sand filters, would be much safer than the one existed. The role of drinking water in the transmission of some communicable diseases was known only to the educated few.

6.5.2 Water Supply :- A number of sources were in use for drinking water in these villages. In Borujwada, Nagpur, the major source of drinking water was a dug well. Also a perennial river flowing nearby was used for all types of washings and for drinking in summer, when the well dried up. Hand pumps were in use in a few houses only and they also dried up in summer.

In Kamayagoundanpatti, Tamil Nadu, water from dug wells, tubewells and at times from the nearby river was used for potable purposes in addition to an existing piped water supply which met only 40 per cent of the requirement of the villages.

In Pothunuru, Andhra Pradesh, the drinking water requirement was met from six village tanks while in Abub Shahar, Haryana, pond and canal water was used for drinking. Drinking water was also distributed through shall carts by private agencies.

From the above, it is obvious that safe drinking water was a bare necessity in all seasons in the project villages, and in summer, the problem was severe because of drought conditions. Inspite of such drinking water of bad or doubtful quality, most of the members of the community did not consider it necessary to boil it or carry out any treatment before use.

6.5.3 Sanitation :- It was noticed that most of the population were exposed to poor sanitation conditions. Borujwada and Abub Shahar did not have any drainage system. Surface drains existed (though partially) in Kamayagoundanpatti, but did not function satisfactorily. Pothunuru had drains only for a length of 500 meters.

Similarly, use of latrines was not common in any of the villages. Pothunuru had about 60 latrines of various kinds, but they were not kept clean due to scarcity of water for flushing. In Kamayagoundanpatti public and private latrines were in use, but the number was highly inadequate. However, well-to-do households were opting for latrines in their premises. In Borujwada, latrines were being introduced in every household as part of an integrated rural development programme at the time of initiation of this project. In Abub Shahar, even the latrines in the village were sparingly used. Obviously, the practice of open-field defecation was common in all the villages.

Composting was not practised in Pothunuru. The collected garbage and rubbish were dumped in low-lying areas. In Borujwada, garbage and dung are deposited in the allotted pits for composting, though the composting process was not carried out as per standard practice. In Abub Shahar compost pits have been made but they were not being used.

6.6 Evaluation

Evaluation of the health education activities was a continuous process and a final evaluation was done towards the end of the project period. The criteria adopted for this purpose were :

(i) Use and proper storage of treated water by the families

(ii) Regular use of sanitation facilities

(iii) Improvement in environmental and personal hygiene status

(iv) Reduction in the incidence of water-borne diseases and worm infestations

(v) Awareness of the impact of safe drinking water on their health, etc. The findings from each village are given separately as follows :

6.6.1 Borujwada (Maharashtra)

The community has accepted and is satisfied with the quality of treated water from SSF plant and use only tap water for cooking and drinking purposes. 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 health educational inputs to the community.

Latrines have been constructed and have been in use in every family. Periodical repairs were carried out as and when necessary.

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 a few cases of diarrhoea and dysentery, incidence of cholera, typhoid, jaundice etc. was not reported from this village after the SSF plant has been put to 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 of the village. 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 soak-pits are working in the village to take care of waste water from houses and public stand posts. Refuse and dung are composted in pits. Streetlights have been installed in the entire village. More people have electrified their houses. Many families have taken house connections from the water distribution system. A flourmill and a fodder-cutting plant, run with electricity have been installed in the village. A biogas plant has also been recently constructed in one of the houses. A few more families who can afford the initial expenditure are anxious to have biogas plants in their premises.

All these ultimately point out a real awakening of the village community of 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 health education in particular.

6.6.2 Kamayagoundanpatti (Tamil Nadu)

A study of the sample population at Kamayagoundanpatti revealed that due to educational inputs the knowledge and the response of the people have improved. The entire community has accepted the introduction of water supply purified through slow sand filtration. The inputs in health education has also improved the health habits of the people. Information and communication methods have shown a favourable change in attitude, knowledge and practice of the people. This has been apparent from the increase in construction of soakage pits, biogas plants and taking house connections for water supply. Study results on utilisation of water show an increase in the percentage of users of slow sand filtered water supply.

6.6.3 Pothunuru (Andhra Pradesh)

The entire community of Pothunuru has accepted the water from SSF plant and the people were also happy with the quality of water supplied. Majority of the families were using tap water for washing purposes also, while others use canal and tank water for this purpose. A few latrines have been added during the project period, indicating an increase in the awareness of the community towards sanitation and environmental hygiene. An improvement has also been observed in the status of personal hygiene of majority of the people.

The water collected from taps was found stored in clean vessels and covered properly. Awareness towards water-borne diseases also was found to have increased with reference to base-line data.

6.6.4 Abub Shahar (Haryana)

Water from the slow sand filter plant was accepted by all the members of the community. It was found that 84 per cent of the families were using only tap water while the remaining used canal water also during non-supply hours. Over 70 per cent of the respondents were aware of the ill-effects of contaminated water. About 140 families have made soakage pits for the disposal of wastewater during the project period, showing an increase in their awareness towards environmental sanitation. Most of the families were composting the solid wastes in pits allotted to them by the village panchayat. The practice of using latrine has been on the increase. The personal hygiene habits of the village people have shown improvements.

6.7 Conclusion

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 condition is a slow process. It requires sustained efforts from both the community and service agencies and effective co-ordination 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.

7. COMMUNITY PARTICIPATION

7.1 Introduction

For the success of any developmental activity aimed at improving and enhancing the socio-economic and health status of a community, public support and participation is of paramount importance. This is true also for a water supply project from its planning to implementation and continued operation and maintenance. Community participation in the four project villages where water supply with purification by slow sand filtration has been introduced is briefly discussed below :

In India water supply is primarily the responsibility of civic bodies. The initiative for provision of this basic amenity normally comes from the elected representatives of the commuiy in the form of a resolution expressing the need for protected water supply. The government executive departments implement the project in consultation with the community. Funds for rural water supply projects come mainly as grants from Govt. The contribution from beneficiary community varies depending upon local conditions and classification of the village for purposes of water supply and is usually about 10 per cent of the estimated cost of the project. The responsibility for routine operation and maintenance of the system lies with either the local body or the public health engineering department of the government/statutory body created for the purpose. The community participation aspect of the slow sand filtration project is presented against this background.

7.2 Participation in Planning & Design

During the preparatory phase of the project, formal and informal consultations were held with the elected representatives of concerned villages, prominent citizens as well as officials of government departments at district and block levels. They were apprised of the objectives and the various facets of the demonstration programme, the advantages and benefits the community would derive on its implementation, the nature and extent of participation expected from the village people and their commitment for the continued operation and maintenance of the water supply system when handed-over. Decisions regarding the source of raw water, location of treatment works including the slow sand filters and public stand posts were taken in consultation with the community and satisfying at the same time the engineering requirements.

In the case of Pothunuru, during initial consultations the Sarpanch (village head) was not in favour of installing slow sand filters for their water supply. This was due to his lack of knowledge and awareness about the advantages of the treatment system. Detailed discussions were held with the Sarpanch, other prominent citizens of the village and the local engineer, when all the doubts regarding water purification by slow sand filtration were dispelled. The merits of the system particularly in the context of favourable local conditions were explained. When the community leaders were fully convinced of the choice of the system, whole hearted support, cooperation and participation were readily forthcoming during project implementation.

In Borujwada, where a programme of contruction of sanitary- latrines in every individual house was under implementation, non-availability of adequate water in the vicinity of the house was expressed by the community. When the idea of providing piped water supply was mooted, it was enthusiastically welcomed by the whole community. While selecting the site(s) for locating the proposed slow sand filter plant, there were two options. One of the sites which was favourable from engineering considerations lay in an agricultural field owned by two villagers. When the owners were approached and explained about the benefits the whole village would get when the project is implemented, they willingly agreed to give away the land at minimal cost. Similarly the number and location of stand posts were decided with the full involvement of the village leaders.

In the Abub Shahar group of villages, the location of public stand posts was decided in a joint meeting of the health staff, engineering personnel and the village leader.

In Kamayagoundanpatti, the village leaders were fully involved in decision making with regard to the location of intake works, treatment plant and the clear water reservoir.

7.3 Participation in construction

In all the four project villages, the community participation in construction was essentially in the form of financial contribution. The construction of plants was carried out by contractors.

Village Borujwada which was awarded by Nagpur Zilla Parishad, a prize money of Rs. 10,000/- for hundred per cent coverage of the households with individual sanitary latrines, contributed that money for the water supply project. To meet its commitment of Rs. 20,000/- (10 per cent of the estimated cost of the project), it obtained a loan of Rs. 10,000/- from government. The construction of the plant was carried out by a contractor uuder the joint supervision of NEERI and Environmental Engineering Division of the Maharashtra Water Supply & Sewerage Board. One of the local residents educated upto school final was associated throughout the various stages of construction and was eventually employed as the operator for the plant. Many of the paid labour were also from the village itself.

In Abub Shahar, an amount of Rs. 20,000/- was raised by the community towards their financial contribution to the project.

The Kamayagoundanpatti panchayat (local body) obtained a loan of Rs. 3.61 lakhs (one lakh = Hundred Thousand) from the Life Insurance Corporation of India towards its share of the construction cost of the slow sand filter plant. The loan with interest was to be repaid by the panchayat from its own income by way of local taxes.

In the case of Pothunuru, the cash contribution of the gram panchayat was 20 per cent of the total cost of the water supply project.

7.4 Participation in operation and maintenance

The participation of the community in operation and maintenance of the slow sand filter plant and distribution system was realised in one form or another.

In Borujwada village, the local person associated with the construction of the plant right from the beginning and therefore familiar with the various units was appointed operator of the plant by the villagers themselves. He was given inplant training by NEERI till he was able to do the routine all by himself. The financial contribution of Rs. 50,000/- from the IRC has been kept as a long-term deposit in a bank and the interest money is utilized for meeting the expenditure on routine operation and maintenance of the plant, salary of the operator and repairs and replacements. Since the commissioning of the plant, another local person has also been trained who can look after the plant in the absence of the regular caretaker. As the water supply needs of the community are adequately met in terms of quality and quantity, a sense of responsibility and keen desire to properly operate and maintain the plant in their own interest is evident.

In Abub Shahar and Kamayagoundanpatti, the operation and maintenance of the treatment plant including pumping is looked after by the public health engineering department/water supply board in close co-ordination with the local community. The treatment plant and the distribution system in village Pothunuru are operated and maintained by the village panchayat staff.

7.5 Participation in health education activities

The formal and informal leaders including the head of the village (sarpanch) and school teachers of the project villages participated in the orientation training programmes organised at the beginning of the project. In the implementation phase, they actively participated in organising health education exhibition, film shows, meetings, door to door visits etc. During mass meetings, which were held in the local languages, interesting sessions of questions and answers took place.

7.6 Conclusion

The participation of communities in the four project villages at all stages of planning and design, implementation, operation and maintenance has not only created in them a sense of pride and achievement but also has improved their knowledge regarding the role of clean water, better sanitation and personal hygiene in building up a state of positive health. The strategy for health education and community participation has adequately demonstrated that such activities should form an important ingredient in any health and social development programme for its success. The multidisciplinary approach with the beneficiary community as the target field tested in the slow sand filtration project could thus serve as a model for large scale adoption in future water supply programmes.

8. GUIDELINES FOR DESIGN & CONSTRUCTION OF SLOW SAND FILTERS FOR COMMUNITY WATER SUPPLIES IN DEVELOPING COUNTRIES

8.1 Introduction

Water supply is a capital intensive utility and the meagre resources available for it in developing countries must not be wasted on overdesigned facilities or on choice of technology that dose not match the skill level of operating and maintenance personnel. The guiding factor should be to supply water to the greatest number of people with optimal use of funds and as far as possible materials and equipment available or manufactured locally. The design should be realistic and adequate for the intended service. Applied research and field studies on village level slow sand filters described in the preceding chapters and a critical review of the traditional design practices followed in the country have resulted in the development of rational design criteria for slow sand filters. These are briefly discussed as under :

8.2 Basic Design Considerations

8.2.1 Design period

An important decision in planning a new water supply system concerns the design period. The single major constraint in the provision of water supplies in developing countries has been inadequate finances[2]. When money is scarce and interest rates are high, long-range investments are less preferred to investments that bring immediate benefits. Since there is very little economy of scale in slow sand filter construction as shown by cost analysis later, the design period should be short; for example, 10 years. This will help to optimize the long-term investment in water supply and will allow the available money to finance more new projects immediately.

8.2.2 Design Population and per-capita supply

The population to be served during the design period has to be estimated by considering all the factors governing the future growth and development of the community, transportation, agriculture, electrification, education and health services. While several methods are available for population forecasting, no single method will be uniformly applicable to all situations.

2. PINEO, C. S. & SUBRAHMANYAM, D. V. Community Water Supply and Excreta Disposal Situation in the Developing Countries – A Commentary, WHO, Geneva, Switzerland (1975).

It has been recommended[3] that there be a minimum requirement of 70 lpcd for rural communities where the supply is only through handpumps or central standposts and 90 lpcd when house service connections are contemplated. The recommended per capita rate also varies with the size of population ; 10000 (70–100 lpcd), 10000–50000 (100–125 lpcd), 50000 (125–200 lpcd).

The per capita demand multiplied by an estimate of the future population gives the total design volume. Wheh considering the design of slow sand filters, it would be more convenient to convert the daily required volume to a design flow Q, the quantity of water to be treated per hour rather than per day, because the daily requirement of water may be treated over a period of 24 hours or just a few hours, which is common in small plants. Thus, for a given daily output, the size of the plant depends on the duration of filter operation.

8.2.3 Rate of filtration

The traditional rate of filtration adopted for normal operation is 0.1 m/h (2 gph/sq. ft.). Pilot plant studies[4] have shown that it is possible to produce safe water at a rate of 0.2 m/h or even 0.3 m/h. Ofcourse, at these higher rates, the interval between filter cleanings is shortened, but the treated water quality does not deteriorate. The 0.2 m/h rate is considered a maximum desirable rate during those periods when some filters are out of service for cleaning or repairs. If only two filter units are built and the normal rate is 0.1 m/h, the overload rate with one unit out for cleaning will be 0.2 m/h, which is acceptable, but the minimum number of units should be two.

The recommendation deviates from the general practice in many states in India of providing one extra unit so that the overload filtration rate is kept to 0.1 m/h. A design that does not allow even occasional overload seems to increase the size and cost of the facility unnecessarily.

3. SUNDARESAN, B. B., KSHIRSAGAR, S. R. and PARAMASIVAM, R. ed. "Evaluation of Rural Water Supply Schemes in India" CPH&EEO, Ministry of Works & Housing, Govt. of India, New Delhi and NEERI, Nagpur (1982).
4. Slow Sand Filtration Project Report : Phase I, NEERI, Nagpur, India, (Dec. 1977).

8.2.4 Continuous versus intermittent operation

Given the daily demand, the size of a plant is governed by the effective duration of filter operation. Pilot studies[5] have shown that intermittent filter operation is not desirable. A short time after startup, the bacteriological quality of filtered water deteriorates and becomes unacceptable. Because the purification process is as much biological as physical, the biological organisms do best when conditions are nearly steady. Further, continuous operation over 24 hours obviously requires an area only one third of that needed for intermittent eight–hour operation. The savings in filter construction can pay for storage reservoirs and additional operators.

8.2.5 Number of filter beds

To ensure uninterrupted production, a minimum of two filter units should be built irrespective of the plant capacity. Three or more units may be required because the size of each unit can not exceed certain maximum practical dimensions, or three or more units may be desired simply to gain flexibility and to reduce overload on the filters that are operated when one unit is out of service for cleaning or repairs. Table 23 shows the average and overload filtration rates, depending on the number of filters.

For a given area, the cost of filter media and underdrain is practically the same for any number of filter beds. However, when the number of beds is increased, the cost of construction will increase because of increased wall length. The extra cost to be paid for higher flexibility and reliability is only a fraction of the cost of the least flexible acceptable design, which has, only two filters and may often be judged a good investment. It can also be shown that the total cost of valves, piping and control weir chambers does not necessarily increase with an increase in the number of filter units.

8.2.6 Filter shape and plant layout

Filters may be circular or rectangular. Circular filters are not economical except for

5. PARAMASIVAM, R. *et. al.* Effect of Intermittent Operation of Slow Sand Filters on Filtrate Quality, Indian J. Environ, Hlth,, **22** (2) 136–50 (1980).

Table 23 – Overload and average filtration rates

Number of Filters	Number of Operating Filters	Filtration rate m/hr.
2	2	0.100
2	1	0.200
2	0	0.000
3	3	0.100
3	2	0.150
3	1	0.300
4	4	0.100
4	3	0.133
4	2	0.200
5	5	0.100
5	4	0.125
5	3	0.166
7	7	0.100
7	6	0.116
7	5	0.140
10	10	0.100
10	9	0.111
10	8	0.124

very small installations. For a 100 m^2 plant with two filters, the diameter of each filter would be about 8 m. Two rectangular beds arranged in a row would have dimensions of about 8.16 m x 6.12 m. The common wall of the two reetangular units may offset the inherent structural advantages of the circular shape. Rectangular filter dimensions have been determined so that the wall perimeter for a given area is minimal (Table 24).

Arranging the filters in a row maximizes the number of common walls and facilitates construction, operation and maintenance. Filters arranged symmetrically in block on each side of the inlet pipe can also be attractive. Local topography and the placement of pump houses, storage, and other facilities will probably be important in determining the layout. The total area of land covered by filters is not a factor, as it is virtually the same regardless of layout.

8.2.7 Depth of filter box

The elements that determine the depth of the filter box and their suggested depths are free board (20 cm.), supernatant water reservoir (100 cm), filter sand (100 cm), supporting gravel (30 cm), and underdrainage system (20 cm), with a total depth of 270 cm. The use of proper depths for these elements can reduce the cost of the filter box considerably. It is general practice to adopt a total depth of 3-4 m for the filter box, but use of a 2.7-m box depth will reduce the cost without adversely affecting efficiency.

8.2.8 Choice of filter sand and gravel

Undue care in the selection and grading of sand for slow sand filters is neither desirable nor necessary. Use of builder grade or locally available sand can keep the cost low. Similarly, rounded gravel, which is often quite expensive and difficult to obtain, can be replaced by hard, broken stones to reduce cost.

8.3 Economic considerations

8.3.1 Minimum filter cost

The cost of a filter excluding pipes and valves is made up of two components : the total cost for floor, underdrains, sand and gravel; and the cost of walls of the filter box.

The cost in general is

$$C = K_A A + K_P P \quad \ldots (1)$$

where A is the total filter bed area in m^2, P the total wall length in m, K_A the cost per unit area of filter bed, and K_P the cost per unit length of wall.

For rectangular filters with common walls, the problem is to minimize C subject to

$$A = nlb \text{ and } P = 2nb + l(n+1) \quad \ldots (2)$$

where n is the number of filters, b is the breadth, and l is the filter length.

The term $K_A A$ is constant for any value of n and any filter shape. Hence, the minimum cost solution is the solution that minimizes P, which is

$$l^2 = \frac{2A}{n+1} \quad \ldots (3)$$

and

$$b = \frac{(n+1)l}{2n} \quad \ldots (4)$$

Table 24 – Optimal size of filter unit for a given area

Area m^2	Two Units: Length m	Two Units: Breadth m	Two Units: Perimeter m	Three Units: Length m	Three Units: Breadth m	Three Units: Perimeter m	Four Units: Length m	Four Units: Breadth m	Four Units: Perimeter m	Five Units: Length m	Five Units: Breadth m	Five Units: Perimeter m
50	5.77	4.33	34.62	5.00	3.30	40.00	4.47	2.60	44.70	4.18	2.45	48.96
100	8.16	6.12	48.96	7.07	4.67	56.56	6.32	3.95	63.20	5.77	3.47	69.24
150	10.00	7.50	60.00	8.66	5.71	69.28	7.74	4.64	77.40	7.07	4.24	84.84
200	11.54	8.66	69.24	10.00	6.60	80.00	8.94	5.58	89.40	8.16	4.90	97.92
300	14.13	10.60	84.60	12.24	8.10	97.92	10.90	6.84	109.00	10.00	6.00	120.00
400	16.32	12.24	97.92	14.14	9.34	113.12	12.64	7.90	126.40	11.54	6.92	138.48
500	18.25	13.70	109.50	15.88	10.43	126.40	14.13	8.83	141.30	12.90	7.74	154.80
600	20.00	15.00	120.00	17.31	11.43	138.48	15.48	9.67	154.80	14.14	8.48	169.70
700	21.00	16.20	129.60	18.70	12.34	149.60	16.72	10.45	167.20	15.25	9.16	183.12
800	23.10	17.33	138.60	20.00	13.20	160.00	17.87	11.17	178.70	16.32	9.80	195.84
900	24.50	18.37	147.00	21.21	14.00	169.68	18.96	11.85	189.60	17.31	10.38	207.72
1000	25.80	19.35	154.80	22.36	14.75	178.88	19.98	12.50	199.80	18.24	10.95	218.88
1200	28.30	20.22	169.80	24.50	16.16	196.00	21.90	13.68	219.00	20.00	12.00	240.00
1500	31.60	23.70	189.60	27.38	18.10	219.04	24.47	15.30	244.70	22.35	13.41	268.20
2000	36.50	27.40	219.00	31.62	20.87	232.96	28.26	17.66	282.60	25.80	15.48	309.60

The equation for b, when rearranged shows that $2nb=(n+1)l$, or the condition for minimum filter cost is to have the sum of the lengths equal to the sum of the breadths. It can be shown that this is true whether filter units are arranged in a single row or as blocks on each side of a central gallery.

The general expression for the minimum cost is found by substituting Eq 3 and 4 for Eq 1

$$C = K_A A + 2 K_P (\sqrt{2A (n+1)}) \quad \dots \quad (5)$$

A detailed cost estimate based on 1980 prices (in Nagpur, India, and excluding contractor's profit) for various materials and items of work has shown that the filter bed cost per square metre is Indian Rs. 350/- and the wall cost per metre length is Rs. 570/-.

Therefore, $K_A = 350$ and $K_P = 570$, the specific cost function (Nagpur, 1980) written in terms of area A is

$$C = 350 A + 1140 (\sqrt{2A (n+1)}) \quad \dots \quad (6)$$

Table 25 gives the cost for filters ranging in total area from 50–2000 m^2. At 0.1 m/h filtration rate and 24 hour operation, this size range corresponds to a range in production of 120 m^3/d to 4800 m^3/d. With a per capita supply at 70 lpcd, this would serve a population range from 1700 to 68000 people. A large percentage of villages and towns in India and other developing countries fall within this population range.

8.3.2 The cost of operating flexibility

The percentage increase in cost with reference to the minimum of two filter units is shown in table 26. The table of cost shows that the number of filters can be raised from two to three by spending roughly 2 to 8 per cent more money. Building five units instead of two costs roughly from 6 to 22 per cent more.

The smaller the total area, the greater the additional cost for building more than the minimum of two units. However, it would not be wise to build more units for small area, as the unit size would become too small for practical construction. Too many filters would also demand greater attention from the operator.

If it is assumed that for a given filter area, the increase in cost to provide a given number of units (against a minimum of two) will not exceed 5 per cent (based on the cost equation C = 350 A + 570 P), the lower limit ot area A can be worked out for different values of n. Based on this information and the cost figures given in Table 25, the number of units for a given area, and the cost thereof have been worked out and presented in Table 27, which can serve as a ready reference for a design engineer. It can be concluded that there is no significant cost penalty for making the number of filters greater than two in order to gain reliability and operating flexibility.

8.3.3 Economy of scale

A general cost model for the filter beds can be written

$$C = K (A)^a$$

where A is the total area of the filter beds, K(A) is the cost per unit area of filter bed construction including walls, and 'a' is the exponent that represents the economy of scale factor.

The cost data given in Table 27 have been used to determine the parameters K and 'a' of the function by the method of least squares. Slight changes in the unit cost of filter bed and box wall, from the values of 350 and 570 used to derive Table 27, do not significantly change the value of the exponent 'a'.

The resulting equation is given by

$$C = 1218 A^{0.857}$$

where A is square metres. Hence, the cost per unit area of slow sand filter is seen to be Indian Rs. 1218, and the economy of scale exponent is 0.857.

If the exponent were 1.0 the cost would vary in direct proportion to the area of the filter. If the exponent 'a' is small, there will be little additional cost for building a larger unit. If a=0, the cost is independent of size. Large economies of scale are associated with small values of the exponent. Until the exponent decreases to about 0.6 or 0.7, there is no economic incentive to overdesign. Thus, very little saving is accom-

Table 25 – Cost in Indian Rupees* for given area and number of Units

Area m²	Indian Rupees			
	Two units	Three units	Four units	Five units
50	37 234	40 300	42 980	45 407
100	62 908	67 240	71 204	74 467
150	86 700	91 990	96 618	100 859
200	109 468	115 600	120 958	125 814
300	153 336	160 816	167 198	173 400
400	195 814	204 480	212 048	218 934
500	237 414	247 048	255 540	263 236
600	278 400	288 934	298 236	306 729
700	318 872	329 872	340 304	349 378
800	359 002	371 200	381 860	391 629
900	398 780	411 716	423 072	433 400
1000	438 236	451 960	463 886	474 762
1200	516 786	531 720	544 830	556 800
1500	633 072	649 852	664 478	677 874
2000	824 830	844 188	861 082	876 472

* U. S. $ 1 = approximately Rs. 9/-

Table 26 – Percentage increase in cost of two units when a given number of filter units is provided for a given area

Area m²	Rate of Cost Increase		
	Three Units per cent	Four Units per cent	Five Units per cent
50	8.23	15.45	21.95
100	6.68	12.90	18.37
150	6.10	11.44	16.33
200	5.60	10.49	14.93
300	5.01	9.04	13.08
400	4.42	8.29	11.80
500	4.05	7.63	10.87
600	3.78	7.12	10.17
700	3.44	6.72	9.56
800	3.39	6.36	9.08
900	3.24	6.09	8.68
1000	3.13	5.85	8.33
1200	2.68	5.42	7.74
1500	2.65	4.96	7.07
2000	2.34	4.39	6.26

Table 27 – Cost of Filters for Optimum Number of Units

Area m²	Number of Units	Cost of Filters Rs.
50	2	37 234
100	2	62 908
150	2	86 700
200	2	109 468
300	3	160 816
400	3	204 480
500	3	247 048
600	3	288 934
700	3	329 872
800	3	371 200
900	3	411 716
1000	3	451 960
1200	3	571 720
1500	4	664 478
2000	4	861 082

plished by increasing the size of the project in order to provide service over a long time into the future.

8.4 Construction staging and expansion

In developing countries, the major problem in providing public water supplies has been insufficient funds. The planning problem is to find the optimal design period that minimizes present and long–range costs. It is important on national and international levels to bring safe drinking water to as many people as possible in the shortest time. The available money must be invested wisely. It would not, for example, be wise to invest money in over–designed treatment plants by building treatment capacity that would not be used for ten to twenty years, unless the extra capacity could be provided inexpensively.

There is a valid reason for building the initial plant smaller and planning for rather frequent but smaller expansions, which is contrary to traditional practice. This recommendation is based on an economic analysis of current construction costs for slow sand filters and on the balance between a lower cost yield per unit of capicity in large plants, against the cost of interest on money tied up in unused capacity. The problem simply is to find the design period that minimizes the total long–range cost of the treatment facilities. The solution to this problem has been published by several engineers, including Lauria[6].

The problem is solved by finding the design period that minimizes the present value of construction costs required to keep the system at a capacity that meets the demand over a period of time from the present into the future. The present value P of an amount of money F to be spent in n years, given a time value of money of r per cent per year (interest or discount rate). is

$$P = F/(1 + r)^n \qquad \dots(9)$$

This is equivalent to the amount of money that could be invested today at a return of r per cent per year, in order to have the amount F when it is needed after n years.

It is important to account for the time value of money in this way, not only because some agency may actually have to pay interest on it but also because money invested in one project is unavailable for investment in an alternative project that may have a real value to the economy of r per cent per year. Because of government subsidies, the actual interest rate paid on a loan may not be the correct discount rate to use in determination of a sound investment policy. In today's economy, a discount rate of 6 per cent per year is very low, and a discount rate of 12 to 15 per cent per year may not be too high.

Lauria has fitted an approximate model to the exact solution to the problem of building a new plant and then expanding it as needed in the future for the case where the demand grows linearly, that is, at a constant increment (not constant percentage) each year, and where the demand will always be satisfied. The new plant must satisfy an existing, unmet demand of people already in the village and must also serve the village for some time into the future. In Figure 23, the initial, unmet demand is labelled D_0 and

6. LAURIA, D. T. Planning for Small Water Supplies in Developing Countries. Natl. Tech. Infn. Service. PB 219 744 us Depot. of Comm. (1972)

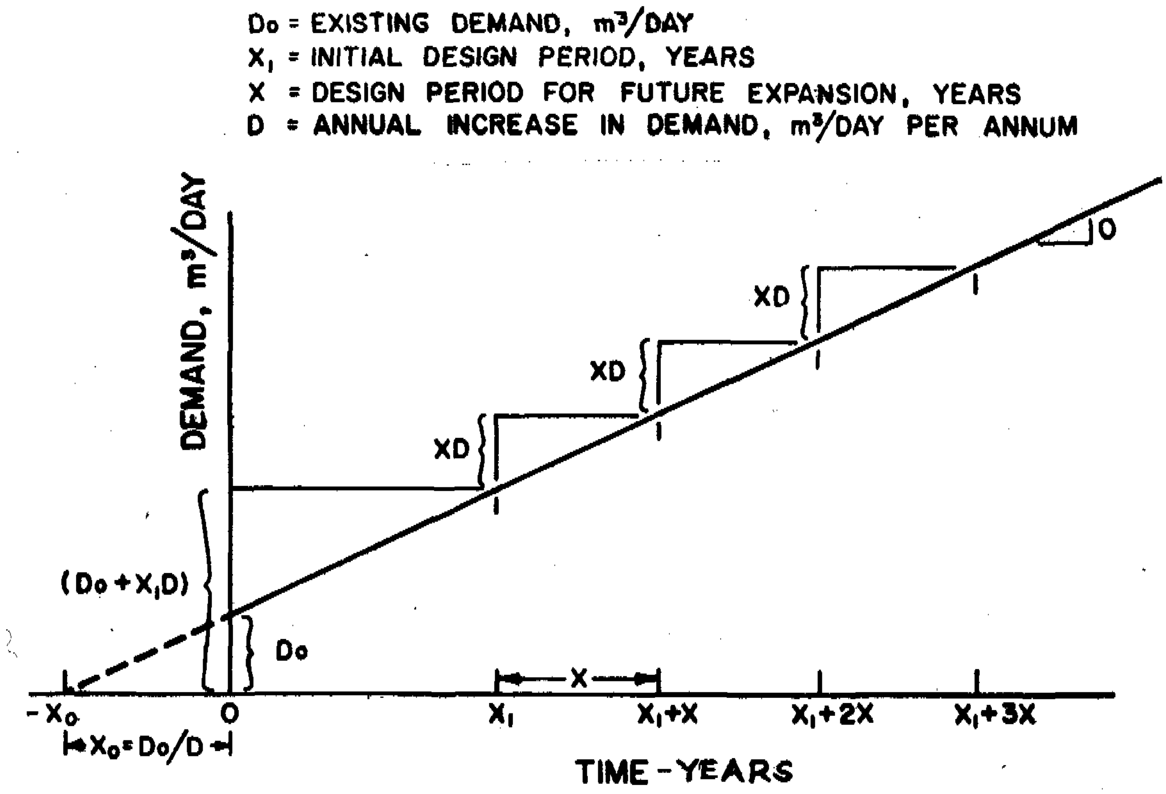


Fig. 23 – Model definition for initial construction and expansion in the case of linear growth in demand with an unsatisfied demand at time zero

the length of time the first stage will serve is X_1. At time X_1, an expansion goes into service. The expansion is of capacity XD and is adequate for X years. A second expansion of the same capcity is needed at time X_1 +X years, and so on into the future.

The size of the initial stage is $D_0 + DX_1$, where D is the annual increase in demand (for example, m^3/d per year).

The exact solution to this problem[7] can be found by using Lauria's approximate solution

$$X_1 = \frac{2.6\,(1-a)^{1.12}}{r} + \frac{0.3\,(1-a)\,(D_0/D)^{0.85}}{\sqrt{r}} \qquad \dots (10)$$

where 'a' is the economy of scale exponent of Eq. 8 and 'r' is the discount rate of Eq. 9 X_1, D_0 and D are defined above. Note $D_0 / D = X_0$.

7. THOMAS, R. H. Discussion of Time Capacity Expansion of Waste Treatment System. *Jour. Sani. Engg. Div. ASCE.*, **96**, SA 4 (August 1970).

The exact solution is more explicitly dependent on the growth rate D than this approximating function, which is accurate enough to be useful.

Solving this equation for a variety of values of D_0, D, and 'r' shows that the initial design period X_1 should be less than the 20 to 30 years commonly estimated by water supply agencies in the past. For example, if $D = 2.5$, $D_0 = 50$, $r = 0.08$ (8 per cent per year), and 'a' = 0.857, X_1 will be about 6 years. Figures 24 and 25 show other results.

Eq. 10 shows how little incentive there is to overdesign. Note that X_1 approaches zero when the exponent a approaches unity. For slow sand filters, 'a' is so close to unity that the value of X_1 will always be small, regardless of the values used for other variables. Higher interest rates also make X_1 smaller, and a faster rate of growth in demand (larger D) will reduce the time before expansion.

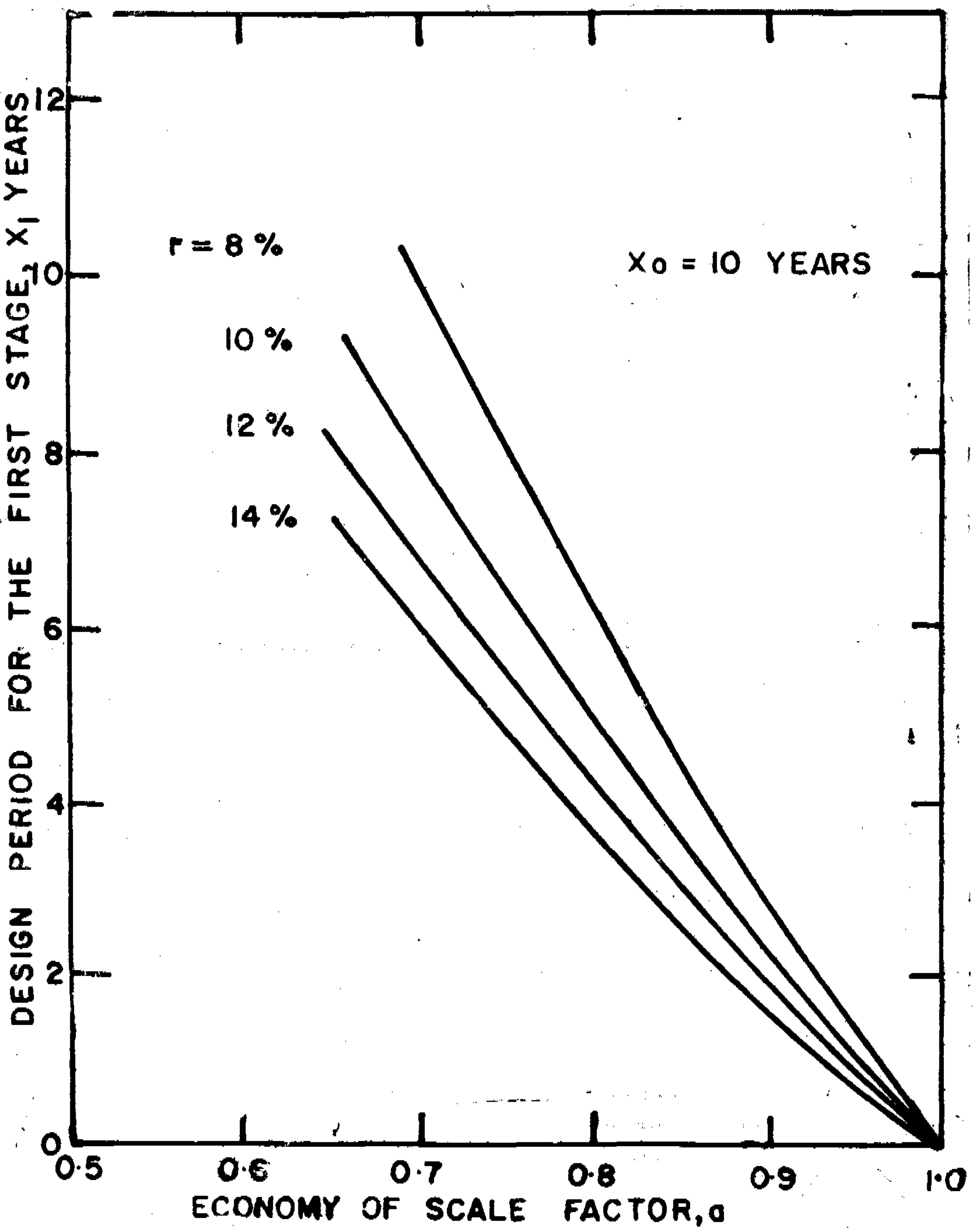


Fig. 24 – Design period of the first stage when there is an unsatisfied initial demand and Xo = 10 years. Calculated using Lauria's approximation.

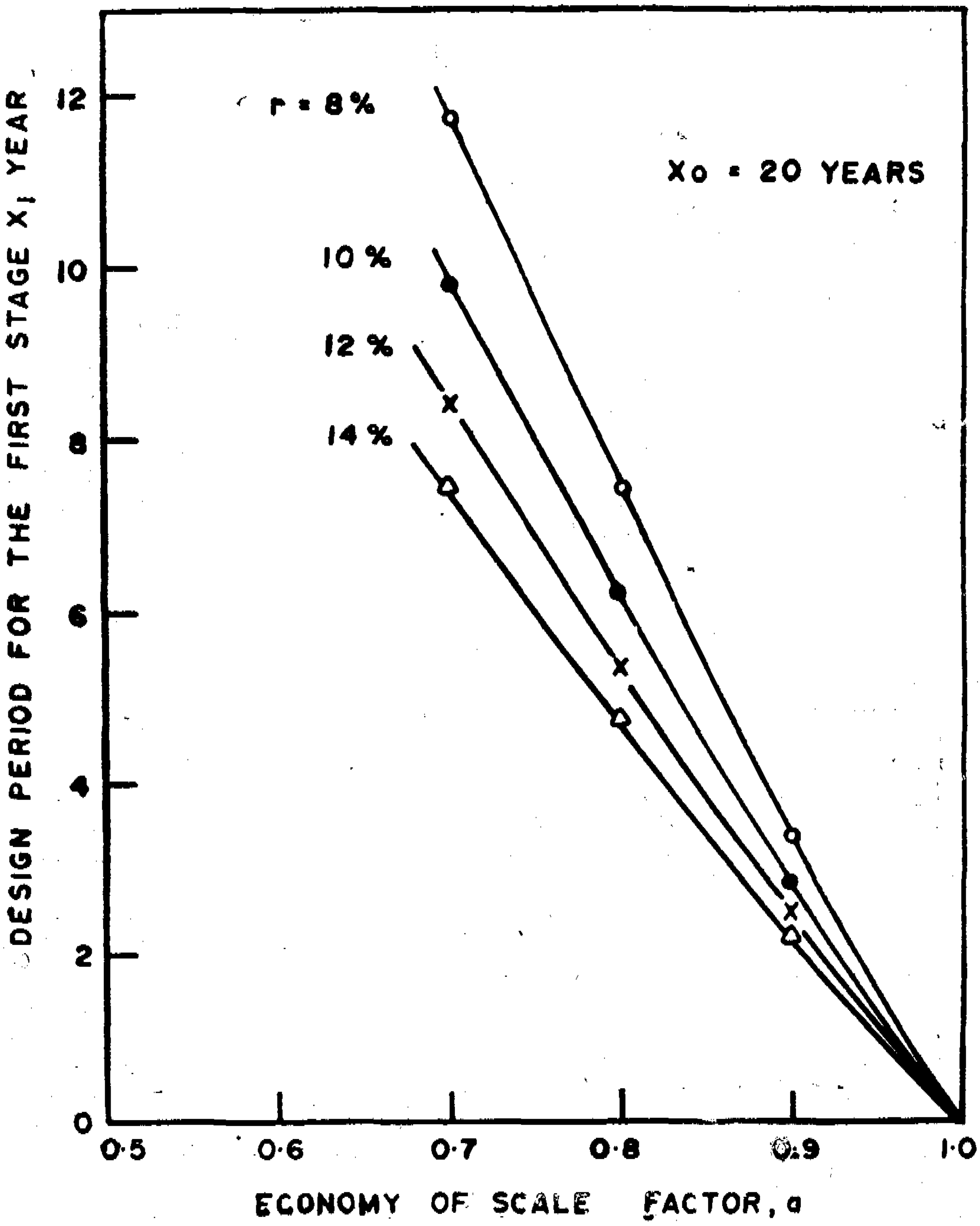


Fig. 25 – Design period of the first stage when there is an unsatisfied initial demand and Xo = 20 years. Calculated using Lauria's approximation.

The inescapable conclusion is that planning should be for frequent and fairly small expansions. The commonly used design periods of 20 to 30 years tie up scarce resources unproductively. The cheapest way to bring safe water to a large number of villages is to construct several plants that are expected to serve upto 10 years before thay are expanded.

The values calculated from Eq. 10 are useful approximations of the exact solution, which Lauria has called the optimal solution. This solution is optimal in the real sense only in so far as the model from which it is calculated reflects all the important features of the decision making problem. In this problem, there are practical, logistic reasons for not accepting the calculated values as optimal in the real sense; for example, those shown in Figures 24 and 25. As a practical matter, no orgnization would want to organize an expansion every two or three years and no treatment plant operator would want to have his operation interrupted by construction every few years. The model does not incorporate these realities, nor does it include the cost of periodic design and other administrative costs.

Inspite of these imperfections, the model gives good advice : No matter how small the economy of scale factor 'a', or how low the interest rate 'r', or how long the backlog of unmet demand X_0, the design period of the first stage should not be longer than 10 years. Design periods shorter than 10 years are economical if just construction costs are considered. Although the numerical values calculated from these models are only guidelines, they should be taken seriously as good advice in favour of short design periods.

8.5 Future expansion

Expansion of existing plants can also be calculated by using Lauria's approximation Eq. 10 and setting $X_0 = 0$. This assumes, of course, that the expansion is timed so that there will not be a new unmet demand before the expansion goes into service. The model for the design life of an expansion is:

$$X = \frac{2.6\,(1 - a)^{1.12}}{r} \qquad \ldots (11)$$

It is clear that even for low discount rates the period between expansions should be short (about five years). As a practical matter, some engineers and administrators will think that five years is too short, considering the usual time lags in arranging financing and other logistics of constuction. Nevertheless, it is clear that frequent expansion is the best economic policy. There should be no great difficulty at the regional or national level to program one or two expansions when the initial stage has already been built.

8.6 Uncertainty

In a given village, there will be uncertainty about the rate of population growth and the actual maximum average and peak filtration rates. These two factors determine the actual time between filter expansions and the size of the first installation and subsequent additional stages.

This uncertainty is not damaging since the decision about what capacity to install will be made thousands of times, and overestimates at some plants will be cancelled by underestimates at others. There is no penalty for the under-estimate because there is no substantial economy of scale savings.

8.7 The case for standardization

Because there are virtually no savings available through economy of scale, savings should be sought elsewhere. The first method, which has been employed for some time, involves careful hydraulic and structural designing to minimize materials. The second method standardizes the design (comparable to the standardization of water heaters and automobiles). A small number of models (capacities and layout) would be available, and one would be selected to fit a particular situation best. A detailed design would not be made for each village; rather, a selection would be made from a catalogue of already optimized design.

Prefabrication of components would be possible since there would be a limited number of sizes available. Wall slabs might be precast, just as building slabs are precast. Pipes could be precut and partially fitted at the factory. Economies from this kind of mass production are as high as 30 per cent on some components. The savings arise from reduced wastage of cement and other materials, fabrication by crews that have gained efficiency by repeated practice, and more precise design of all components.

Standardization and prefabrication are subjects for future research. The number of villages having a given range of population at the present time and 10 years in the future needs to be tallied; then the best sizes for installation can be determined, and detailed optimal plans can be made. Precise construction details, as well as careful study of prefabrication methods, are needed at this stage.

Summary

In the light of the findings of applied research and experiences with full scale village level slow sand filters, the traditional design and economies of filter construction have been reviewed. Rational design guidelines have been proposed. A model for filter construction has been developed and optimal filter dimensions and number of units for a given area to gain flexibility and reliability in operation have been worked out. It has been shown that there is no economy of scale in slow sand filter construction and that at the national level, it would be more advantageous to adopt a strategy that provides for system expansion at frequent intervals (10 years) than to plan for large initial works. The guidelines should prove useful to water supply planners at national level and design engineers at local level.

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(v) White, Dr. A. T.
" Community Participation "

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(ii) Raman, A., Gurdeep Singh & Nagpal, J. L.
Observations on Design & Construction Aspect of Slow Sand Filtration Demonstration Plant at Abub Shahar, Haryana.

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APPENDIX I

QUESTIONNAIRE ON SLOW SAND FILTRATION

1.	Location, year of construction and capacity.	:	
2.	Population served		
3.	Source of raw water*	:	River Impounded Reservoir/lake Any other
4.	Data on raw water quality if available	:	Please furnish in enclosed proforma.
5.	Type of pre-treatment, if any*	:	Plain sedimentation Extended settling Roughing Filtration Coagulation and Sedimentation. Any other.
6.	Number and size of filters	:	
7.	Normal and maximum (design) rate of filtration.	:	......................m/hr. .... gph/sq. ft.
8.	Specifications of filter media	:	**Sand** Depth m. E. S. mm U. C. **Gravel** Grading Depth
9.	Type of under drains with* details, if available	:	Brick under drains Pipe under drains Any other.
10.	Permissible headloss	:	.... m.
11.	Frequency of cleaning (Scraping) of filter bed	:	.... days.
12.	Performance data, if available	:	Filtered water turbidity...... Bacteriological quality......
13.	Difficulties, if any, in operation and maintenance*	:	a) Short runs due to excessive algal growth. b) Production of tastes and odours in the effluent. c) Underloading/over loading of filters d) Scraping and cleaning of sand. e) Availability and procurement of sand.
14.	Proposal, if any, to abandon the existing slow sand filters indicating reasons	:	
15.	Published information, internal reports etc.	:	

* Please strike out whatever is not applicable.

APPENDIX II

VILLAGE INFORMATION SCHEDULE

A. Topographic Characteristics

1. Name of the village.
2. Area in Square Km.
3. Provision of electricity.
4. Approachability : a) Kutcha/Pucca
   b) Whether approachable during rainy season– Yes/No
   c) Remarks, if any.
5. Map of the village showing :
   a) Geographical boundaries;
   b) Administrative boundaries;
   c) Sub-Divisions of the village;
   d) Important roads and streets;
   e) Common meeting places (Chaupals, Baithaks, Temples, Baratghars, etc.)
   f) Location of school;
   g) Community water sources (pond, river, wells, taps etc.)
   h) Community latrines, if any;
   i) Houses of the member of panchayat etc.
6. No. of sub-divisions of the village with names of the sub-divisions and no. of families residing.

Name of sub-division. *No. of families.*

B. Demographic and Social Characteristics–

1. a) Total population b) Reference period.
   i) Male ii) Female
   iii) Children below 15 years of age
   iv) Children below 6 years of age
   c) Total No. of families
   d) Type of families : i) Joint No.
   ii) Nuclear No.

	1974	1975	1976	1977
2. a) No. of births during the year–				
b) No. of deaths during the year (Mention source of information).				

3. Different caste groups (like Rajputs, Jats, Ahirs, Harijan etc).

a) *Caste* *No. of families*

b) Religion (like Hindu, Muslim, Sikh, Christian etc.)

Religion *No. of families*

4. *Occupation* *No. of families*

a) Agricultural

i) Land Lords.

ii) Cultivators.

iii) Labourers

b) Non-Agricultural

i) Business (specify)

ii) Service (specify – Civil, Defence, Police, Private, etc).

No. of families

iii) Labour. *No. of families*

5. Literacy

	Read & Write	Primary & below.	Middle & below.	High School & below.	Above High School	Total
No. of literate persons (if available)						
No. of those who could be involved in welfare activities (if available)						

6. General economic status of the community members :

7. Leadership :

a) Formal leaders

i) *Names of Panchayat Members* *Caste* *Profession*

ii) Days of the month when panchayat meets.

iii) *a)* Funds available with the Panchayat
b) Estimated annual revenues.

iv) Nature of activities on which panchayat has been spending money.

v) General functioning of the panchayat.
a) Whether meets regularly Yes/No.
b) At what frequency the Panchayat meets in a month. 1/2/3/4 specify

b) Names of the informal leaders (like leaders who have been defeated in last panchayat elections, caste–leaders, numberdars, social workers, religious leaders, retired Govt. servants – civil, defence, police – and other influential persons including the local banks agent and innovators – those who are always willing to adopt new practices and retired school teachers residing in the villages).

Name *Caste* *Address* *When available (Time)*

c) Group Dynamics

Information on the following points may be collected

i) Major influential groups and their inter-connections–Caste groups, occupation groups, neighbourhood groups, playgroups.
ii) Faction groups and names and addresses of their important leaders;
iii) News carriers, innovators and their role in introducing changes in the village community.

iv) Integrating factors of the community like common-interest, security, respect etc.

v) Disintegrating factors like personal and caste rivalries.

vi) Accepted role of the local organisations in mobilising resources for health programmes.

vii) Influence of outside organisations and leaders on the community in respect of health and welfare programme.

d) Names of local teachers and their address :

e) Names of local 'dais' and their addresses :

f) Name and address of the village chowkidar :

g) i) Names of the nearest post office.
ii) Its distance from the village Km.
iii) Name of the postmaster
iv) Frequency of delivery of post in the village.
v) Name of the postman visiting the village :

h) Names of governmental agencies under whose jurisdiction this village comes :

Name	*Address*	*Distance from village*
i) Primary Health Centre/sub-centre		
ii) Community Development.		
iii) Revenue Department.		
iv) Block Education Officer.		

i) Any other health welfare agency working in the village
Please give the name and nature of their functions :-

j) Names of the 'Health', Development and Revenue staff visiting the village :-

Name	*Headquarter*	*Frequency of visit per month*
V. L. W.		
B. H. W.		
S. I.		
H. I.		
Vaccinator		
A. N. M.		
L. H. V.		
Patwari		
Gram Sachive		
Others		

8. Welfare organisations in the village (like Welfare Associations, Youth club Mahila Mandal, Balwari, Drama Club, Bhajan Mandal)

Name of the organisation	*Office bearers/members*

9. Educational Institutions

a)

Educational Instt. in the village.	*No. of teachers*	*No. of students.*	*Distance from the village*

b) Nearest Institution for further education like middle school, high school, college.

Institution	*Distance from the village*

c) Information about the local school :-

Provision of :

i) Urinals Yes/No

ii) Latrine Yes/No Type of latrines Dry/Hand flushed.

iii) Whether water available in or near the latrine and urinals. Yes/No
If yes, give brief description

iv) Sources of drinking water : Well / tap / river / hand pump / other.

v) Quality of water for each source : Hard/soft.

vi) How water is stored in the school : pitchers/buckets/other utensils.

vii) Whether it is covered ? Yes/No
If yes how ?

viii) How water is taken out from the vessel, when it is stored.

ix) Mode of drinking water by the students (with hands/glass/same glass etc.)

x) Whether dust bins are provided in the school ? Yes/No

xi) Whether electricity is available in the school ? Yes/No

xii) Any other concerned information :

10. Channels of communication :

a) Major communicators (like persons who give the news, innovators etc.)

b) Communication Media :

i) *News Paper* *Language* *Circulation*

ii) Radios/Transistors (indicate approximate No.)

iii) Others (Specify) –

iv) Traditional channels (like 'monyadi', nautanki, katha Mandli, drama and song parties etc.)
Please mention frequency of each such channel being used in the village.

v) Common meeting places including shops (baithaks, chaupal, school, temple, barat chars etc.)

vi) Community fairs and festivals;

vii) Nearest market – mention name and distance from the village.

11. Environmental Sanitation :

a) Sources of water being used by the community for drinking, bathing, washing, for animals(like ponds, river, shallow-wells, deep-well, tube-wells, taps etc.) Give information about No. of sources of each type and the purposes these are being used, their sanitary condition and quality of water from each source. Whether chlorination of drinking water is done ? If so, how often, method being used for chlorination and who does the chlorination, mode of drawing water, its transportation and storage in general. Any other relevant information :

b) Methods of waste water disposal from individual house and from streets.

c) Methods of garbage and refuse disposal used by individual family and the community.

d) Methods used for disposal of animal dung by individual family and the community in general.

e) Methods used for disposal of human-excreta (sanitary latrine, open field defecation, dry latrine).

12. 1. Previous experiences of the people regarding the welfare programmes in general and health programmes in specific :-

2. Community attitude towards :

a) Government programmes	Favourable/neutral/unfavourable
b) Social welfare programme	-do-
c) Community organisation	-do-
d) Local leadership	-do-
e) Community and national uplift.	-do-
f) Personal and family uplift.	-do-

3. Factor in favours and against the past health programme (Please mention them clearly)

4. Status of village in respect of various health programmes run by the Primary Health Centre (data should be collected regarding the village only).

	1976	1977
1. Malaria		
a) No. of blood slides collected.		
i) by active agencies.		
ii) by passive agencies.		
b) No. of cases given presumptive treatment		
i) by active agencies.		
ii) by passive agencies.		
c) No. of positive cases detected.		
d) No. of positive cases given radical treatment,		
e) No. of deaths.		
2. Smallpox		
a) No. of primary vaccinations given.		
b) No. of re-vaccinations done.		
3. M. C. H		
a) No. of pregnant mothers registered by ANM/LHV.		
b) No. of pregnant women given tetanus toxoid.		
i) first dose		
ii) second dose		
c) No. of average ante-natal visits made by ANM/LHV per ante-natal case.		
d) No. of delivery conducted by Trained staff (trained dai, ANM,LHV doctor).		
e) No. of post-natal visits made, on average, by ANM/LHV per post natal case.		
f) No. of children given primary vaccination.		
g) No. of children given DPT		
i) 1st dose		
ii) 2nd dose		
iii) 3rd dose		

	1976	1977
4) **Family Welfare :**		

a) No. of eligible couple

b) No. of vasectomies performed.

i) No. of tubectomies performed.

ii) No. of IUD inserted.

iii) No. of regular user of ' Nirodh ' registered. (the regular user is one who has drawn Nirodhs at least three time in the year)

c) No. of dissatisfied cases of sterilization and IUD at present with their names and addresses and nature of complaints.

d) Any other programme being run in the village and relevent information on above pattern may be given.

e) Names and address of medical practitioners available in the village, visiting village, around the village (Allopaths, Vaids, Hakims, Homoeopath).

Name & Qualification	*System*	*Address*

f) Health statistics of the village

a) Epidemics :

Diseases	1974 Cases deaths	1975 Cases deaths	1976 Cases deaths	1977 Cases deaths	Source of information

b) Prevalence of waterborne diseases in the village during the last three years;

Diseases	1974 Cases deaths	1975 Cases deaths	1976 Cases deaths	1977 Cases deaths	Source of information

c) Any other significant information regarding the village which may be useful.

Note : The above mentioned information may be collected through ;

a) Enquiry from influential persons of the village. (Panchayat members, numbardars, caste leaders, school teachers, retired personnel, village chowkidars and the workers of various organisations in the village etc.).

b) Records and reports available with the concerned persons of these agencies (P. H. Centre sub-centres, hospital, dispensary, block development office, Naib Tehsildar/Tehsildar Office etc.)

c) Any other known source.

General Remarks.

Signature ____________________

Date :

APPENDIX III

FAMILY HEALTH SURVEY SCHEDULE

1. Name of the interviewer 2. Name of the village 3. Date
4. a) House No. b) Household No. 5. Name of Head of Family
6. Total Income of the family per month Rs.
7. a) Name of the respondent b) Sex c) Age
   d) Education e) Religion f) Caste
8. a) Type of family Joint/Nuclear
   b) Details about the members of the family

S. No.	Name	*Relation to the head.	Age	Sex	Educa-tion.	Occupa-tion	Immunization status						Health status. ***	Remarks ****
							PV	RV	BCG	**DPT 1	2	3		

*Use these abbreviations: Son–S, Daughter–D, Son–in–law– S–in–L, Daugther–in–Law –D–in–L
**Inquire only about the children below 6 years of age
***Please mention here any permanent disability or chronic illness of the member after putting the serial No.
****Mention here any important information which was not recorded.

Present Health Status

1. Is any member of your family suffering from any sickness at present ? Yes/No.
   a) If yes please provide the following information:

Name of the patient	Since when	Disease	Signs & symp-toms	treatment† being given	By whom since when	Remarks
1.						
2.						
3.						

2. Where you and members of your family go for treatment when sick ? (PHC/Sub Centre/Hospital/Private Practitioner) (Please specify)
   a) If private practitioner please note down his name and address.
   b) Why are you not utilizing services provided by the Govt. (Please note down the reasons) (put this question if the family is not utilizing the PHC/Sub Centre/Hospital Services)

†Please specify if indegenious treatment is given, otherwise write allopathy, Homoeopathy, Vadic.

Nutrition

1. Do you give special diet to:

If yes provide this information

Group	Special diet given	reasons for giving the diet if any
a) Pregnant mothers Yes/No.		
b) Lactating mothers Yes/No.		
c) Infants during weaning Yes/No.		
d) Children between 1 Yr – 5 Yrs of age. Yes/No.		
e) During illness Yes/No.		
f) Old people		

2 a) Do you grow vegetables? Yes/No
If yes, where & what?

b) Observe if there is a place for cultivating a kitchen garden

Environmental Sanitation

1. House:

a) Type of house – kutcha/Pakka/Katcha-pakka (Pl. encircle the right answer)

b) No. of rooms

c) Whether ventilated: No. of rooms
i) Ventilated
ii) Not ventilated

d) If ventilated, please observe and record type of ventilation in each room (cross ventilated, one side ventilated, no. of windows and ventilators etc.)

e) Please observe and record whether animal shed is within the house or outside the house.

i) If within the house is it separate and away from living rooms ? Yes / No.

2. Water

a) From where do you bring water :

i) for drinking: (encircle the water source)

Personal well/tube well/tap/community well/River/pond
Any other (Specify)

Quantity of water brought daily (in bucket, pitcher, litres etc).

No. of times water is brought daily

How do you store the water for drinking?

How do you cover it?

How the water is taken out from the storing vessel for drinking ? (Observe if water is covered and a drawer is there)

Do you like the taste of water? Yes/No

Does the taste of water change during rainy season? Yes/No

Are you satisfied with the quantity of water brought daily? Yes/No

ii) For bathing (encircle the water source)

Personal well/tubewell/

Community well

River/Pond

Any other (specify)

Quantity of water brought daily

No. of times water is brought

iii) For washing:

Personal well/tubewell/tap/Community well

River/Pond/any other (Specify)

Quantity of water brought daily

No. of times water is brought daily

b) General remarks about the sources from where water is brought

c) Where do you and your family members take bath ? (If outside please specify the place)

i) Adult male	House/Outside
ii) Adult female	House/Outside
iii) Children	House/Outside

d) Where do you and your family members wash clothes
(If outside please specify the place)

i) Male House/Outside
ii) Female House/Outside

3. Disposal of Waste Water :

a) How the waste water is disposed ? (Please observe and record)

4. Disposal of solid waste :

a) Where do you throw your : i) refuse and garbage
(Please observe & record) ii) Cow dung etc.

b) Where do you and your family members go for defecation ?

i) Adult males Open/Latrine

ii) Adult Females Open/Latrine

iii) Children Male Open/Latrine

iv) Children Female Open/Latrine

v) If there is latrine observe whether it is a dry, hand flushed latrine.

vi) Please note the sanitation of the latrine (whether clean, flies are there, smell etc.)

vii) Observe the source of water used for ablution

viii) How do you and your family members clean themselves after defecation (with water or otherwise)

ix) Do you and your family members wash hands after defecation ?

Adult Yes/No

Children Yes/No

If yes, with what (earth, ash soap etc.) specify.

Adults

Children

(Please mention the source of water being used for washing hands)

5. There is a scheme for providing filtered water through taps to individual families. The individual family has to spend some money for pipe line and tap to bring water to the house. Do you like to have filtered water ? Yes/No

If no, please give reasons :

FAMILY WELFARE :

(Fill up this proforma for every eligible couple in the family separately. The information must be had from husband or wife)

1. Name of the respondent.
2. Name of the husband/wife.
3. No. of total children born.
4. No. of living children.
5. Age of the last child.
6. Whether wife is pregnant at present (if yes how old is the pregnancy) — Yes/No
7. Where was the last child born ? If at home who conducted the delivery ? — Home/PHC/Hospital/Specify Indigenous Dai/Trained Staff/Other (Specify)
8. Did mother take Tetanus Toxoid during the last pregnancy ? If yes (Please mark) — Yes/No

   1st *2nd*

   (The interviewer should verify this information from secondary data)
9. Do you or your spouse practice any methods of contraception ? — Yes/No

   a) i) If yes, which methods (specify)

   ii) Are you satisfied with the method ? — Yes/No

   iii) If no please give reasons.

   b) If no why not. Please mention the reasons.
10. Do you know the places where facilities for family welfare are available. Please specify.
11. Remarks :

Investigator :

APPENDIX–IV

SCHEDULE FOR EDUCATIONAL DIAGNOSIS OF THE COMMUNITY

Date

1. House No. 2. Name of the respondent Age

Sex Edu. Caste

3. What are the signs and symptoms, causes, mode of spread, treatment and prevention of the following diseases :

S. No.	Disease	Signs and Symptoms	Causes	Mode of spread	Treatment*	Prevention	Remarks
a)	Diarrhoea						
b)	Dysentery						
c)	Cholera						
d)	Worms Infestation (specify)						
e)	Typhoid						
f)	Whooping cough						
g)	Tetanus						
h)	Diphtheria						
i)	T. B.						
j)	Sore eye						
k)	Trachoma						
l)	Cataract						
m)	Itching						
n)	Boils						
o)	Malaria						
p)	Filaria						
q)	Any other						

* Please specify if some indigenous treatment is given, otherwise mention the system Allopathy, Homoeopathy, Hikmat, Unani, Ayurveda etc.

4. Nutrition

a) What are the food items which help an infant to grow healthier which may be given to infant while weaning :

b) What are food articles which help the child (Below 6 years) to grow healthier ?

c) What special food should be given, if any, to a pregnant mother so that health of the mother improves ?

d) What food should be given to a lactating mother so that both mother and the infant grow healthier ?

e) What food should be given in sickness to :

i) an infant

ii) a child

iii) an adult

iv) an old person

APPENDIX–V

TIME TABLE AND COURSE CONTENTS FOR THE ORIENTATION TRAINING PROGRAMME FOR HEALTH EXTENSION STAFF

Place : Primary Health Centre, Kalmeshwar
Period : 12th June 1978 to 17th June, 1978.

Day & Time	Topic	Contents
Monday 12th June 1978 1 hr.	Introduction to the Course	Aim of the course, contents, methodology etc.
2 hrs.	Water in relation to diseases	Sources of water, what is wholesome water ? Physical, chemical, biological impurities in water with special reference to pathogens, water pollution, water quality standards, need for water treatment, nuisance causing organisms, water-borne diseases examples, role of water in transmission of diseases, Methods of breaking the transmission chains etc.
2 hrs.	Water–borne diseases	Cholera, dysentery, typhoid, infectious hepatitis, signs and symptoms, causes, diagnosis, mode of spread. Treatment and prevention, Role of health worker in prevention of these diseases.
Tuesday 13th June, 1978 2 hrs.	Worm infestations (Enteric Parasites)	Worm infestations, round worms, hook worms, pin worms & tape worms, signs and symptoms, causes, mode of spread, diagnosis, treatment and prevention.
2 hrs.	Communicable diseases	Malaria) Signs & symptoms, causes, diagnosis,mode T. B.) of spread, treatment, prevention, role of) Malaria worker in NMEP, role of health) worker in T. B. control programme.
2 hrs.	Water Supply and Purification	Components of water supply systems, general principles of purification, proposed scheme for Borujwada water supply, Methods of filtration with special emphasis on slow sand filtration, brief description of slow sand filter, chlorination, distribution, individual connections, public stand posts.
Wednesday 14th, June, 1978 2 hrs.	Environmental sanitation	a) Safe method of disposal of human excreta. Sanitary latrine construction, advantages, precautions to be taken. b) Safe methods of disposal of animal dung, garbage and refuse composting. c) Safe method of disposal of waste water, soak pit, kitchen garden etc.

1	2	3
2 hrs.	Personal Health	a) Nutritional deficiencies commonly found in children, women & men, Protein deficiency, Vitamin deficiency; treatment and prevention. b) Immunisation – DPT, TT, DT, Polio vaccine, small pox and B. C. G. What these mean, quantity of doses with interval. Precautions to be taken. Right age for immunisation. c) Exposure to heat and cold. Sun/heat stroke) signs and symptoms, precau- exposure to cold) tion and treatment.
1 hr.	Personal Hygiene	Safe methods of collection and storage of drinking water. Desirable personal hygiene habits – proper washing of hands after defecation, removing nails etc. Advantages.
Thursday 15th June, 1978 2 hrs.	Health Education	What is health education ? Methods of health education –Mass, Group and Individual. How to organise mass meetings and group discussions in the village.
2 hrs.	Health education service programme for village Borujwada.	Health education service programme. Role and responsibilities of each staff in it.
Friday 16th June, 1978 4 hrs.	Development of educational aids and talking points on different relevant topics.	1) Safe water, slow sand filtration project. Safe methods of storage and utilization of safe water. 2) Safe disposal of human excreta, animal dung, garbage, refuse – sanitary latrine, compost pit. 3) Safe disposal of wastewater – soak pit, drainage, kitchen gardening. 4) Diarrhoea, dysentery, gastro-enteritis, typhoid, cholera. 5) Malaria, T. B. exposure to heat and cold. 6) Immunisation, B. C. G., D. P. T., T. T., D. T. The participants will be divided into three groups. Each group will be required to develop talking points on the two topics and relevant aids for educating villagers. After comments from other grops and group discussions, the talking points and aids will be finalised.
2 hrs.	Leaders Orientation Training Programme	How to prepare leaders for orientation training programme – the participants will prepare an orientation training programme for local leaders of village Borujwada and present it. 1) How to indentify leaders, communication. Barriers in communication. 2) Demonstration on spread of rumours.

1	2	3
Saturday 17th June, 1978 3 hrs.	Work plan for next 6 months for village Borujwada	Work plan along with educational activities to be undertaken by each worker. Each participant will work out his/her work plan and present it to the group.
1 hr.	Records and reports	1) Records to be kept by each worker. 2) Monthly reports to be prepared by each of them. 3) Quarterly report of the project.
2 hrs.	Valedictory Session.	

Note :- 1) Lectures to be followed by group discussions, demonstrations etc. Demonstrations will be essential for Malaria, TB, Environmental sanitation etc.

2) The educational aids to be used are Black-board, charts, models. slides, films. flash cards as and when required.

APPENDIX–VI

ORIENTATION TRAINING FOR HEALTH EXTENSION STAFF

Questionnaire for Evaluation

Name of the Participant

Date

Each participant is required to answer all the questions in brief only ;

1) Write down the names of common diseases which are caused by contaminated water :

2) Mention the cause, signs and symptoms, mode of spread and prevention of the following diseases :

Disease	Cause	Signs & symptoms	Mode of spread	Preventive measures
a) Malaria				
b) T. B.				
c) Diarrhoea				
d) Dysentery				
e) Gastro–enteritis				
f) Cholera				
g) Typhoid				
h) Worm infestation : Roundworms Hookworms Pinworms Tapeworms				
i) Infective hepatitis				
j) Diphtheria				
k) Whooping cough				
l) Tetanus				
m) Polio				

3) Name the diseases which are prevented by the following vaccinations/innoculations against each of them. Also mention the number of doses recommended, interval between the doses, quantity of the dose and the best suitable age for each of them.

Vaccinations/ Innoculations	Disease/ Diseases prevented	No. of the recommended doses	Interval between doses in weeks	Quantity of the dose	Best suitable age	Contra-indications, if any
a) D. P. T.						
b) D. T.						
c) T. T.						
d) Polio						
e) Small-pox						
f) B. C. G.						
g) Cholera						

4) Mention the method of making impure water fit for drinking :

5) What do you know about health education and its methods :

6) Mention the methods of safe disposal of–

i) Human excreta

ii) Animal dung

iii) Refuse & garbage

iv) Waste water

APPENDIX-VII

SCHEDULE FOR MIDTERM EVALUATION

I. GENERAL INFORMATION

1. Project Village Block
   Distt. State

2. Date of initiation of Health Education Services Project.
   Month Year .

3. Date of completion of Slow Sand Filtration Plant.
   Month Year .

4. Date of Interview .

II. IDENTIFICATION DATA :

1. House No.

2. Respondent.
   a) Name
   b) Male/Female
   c) Age Yrs.
   d) Education ILL/P/M/H/A.
   e) Caste

III. SPECIFIC DATA.

1. (Please tick mark the source/sources of drinking water of the respondent's family:)
   River/Pond/Common well/Personal well/Personal handpump/Community hand pump/ Public tap/Personal tap/Tank/Canal.

2. (Please tick mark source/sources of water used for washing purposes)
   River/Pond/Common well/Personal handpump/Community handpump/Public tap/Personal tap/Tank/Canal.

3. If public tap, how far away it is from your house?

4. Why do you, take drinking water from other source/sources when tap water is available? (Please ask this question only to those who take drinking water from other than tap and write answer verbatim)
   a)
   b)
   c)
   d)

5. Is the quantity of water you collect from the tap daily is sufficient? (Put this question to those who take drinking water from tap). Yes/No.

6. How much time do you spend daily in collecting water from tap? minutes.

7. Do you find any difference in taste of tap water from other sources? Yes/No.

8. If yes, please specify the difference :

   a) in colour
   b) in taste
   c) in smell
   d) Others (specify)

9. (Please ask, observe and note the method of disposal of solid waste by the respondent's family.)

10. (Please ask, observe and record how the animal dung is disposed of by the family).

11. Where do you and your family members go for defecation ?

a) adult male	open field/latrine/both.
b) adult female	open field/latrine/both.
c) children male	open field/latrine/both.
d) children female	open field/latrine/both.
e) old persons	open field/latrine/both.
f) sick persons	open field/latrine/both.

12. If there is a latrine please ask, observe and record :

   a) If it is handflush or dry
   b) If it is clean or dirty
   c) If it has curtain or door or open
   d) Source of water used for ablution

13. Do you and your family members wash hands after defecation? Yes/No.

14. If yes, what material is used for washing hands after defecation by :

a) Adults	ash/ earth/soap
b) Children	ash/earth/soap
c) Sick persons	ash/earth/soap

15. Can you name diseases which are caused by contaminated water ?

   1.
   2.
   3.
   4.
   5.
   6.

16. Could you please tell the signs and symptoms, causation, mode of spread, treatment (both indigenous and modern), and prevention of the following diseases ? (Please note clearly and in short).

Disease	Sign & Symptoms	Causes	Mode of spread.	Treat-ment	Pre-vention
a) Diarrhcea					
d) Dysentery					
c) Cholera					
d) Typhoid					
e) Worm-infes-tation.					
f) Scabies & boils					
g) Jaundice					

17. Where do you and your family members go for treatment when sick?
   a) Registered/Private Medical practitioners/Allopath/Homoeopath Hakim/Unani/Vaid
   b) Govt. Institutions : Hospital/PHC/Sub-Centre/Others (Specify)
   c) Health Staff : MPW/Community Health Worker.
   d) Quacks : Wise Man/Others, (Specify)

APPENDIX-VIII

SCHEDULE FOR TERMINAL EVALUATION

I. General Information

1. Project village Block
   District State
2. Date of initiation of Health Education Service Project
   Month Year
3. Date of completion of SSF Plant
   Month Year
4. Date of interview

II. Identification Data

1. House No.
2. Respondent
   a. Name :
   b. Sex : Male/Female
   c. Age : years
   d. Education : ILL/P/M/H/A
   e. Caste
   (also mention if schedule caste)

III. Specific Data

1. Where do you and your family members go for defecation
   (Please encircle the response given)
   a) Ault male open field/latrine/both
   b) Adult female open field/latrine/both
   c) Children male open field/latrine/both
   d) Children female open field/latrine/both
2. a) Do you and your family members wash hands after defecation ?
   Yes / No
   b) If yes, what material is used for washing hands after defecation ?
   i) adult ash/earth/soap
   ii) children ash/earth/soap
3. Can you name diseases caused by contaminated water ?
   a) Diarrhoea b) Dysentery c) Gastro-enteritis
   d) Cholera e) Typhoid f) Worm-infestation
   g) Jaundice h) Scabies & Boils i) Don't know
   j) No response

4. Can you tell the signs & symptoms, cause, mode of spread, treatment and prevention of the following diseases ?

a) Diarrhoea –

– Signs & Symptoms	*C/IC/DK/NR*
– Causation	*C/IC/DK/NR*
– Mode of spread	*C/IC/DK/NR*
– Treatment	*MM/AV/H/Others*
– Prevention	*C/IC/DK/NR*

b) Dysentery –

– Signs and symptoms	*C/IC/DK/NR*
– Causation	*C/IC/DK/NR*
– Mode of spread	*C/IC/DK/NR*
– Treatment	*MM/AV/H/Others*
– Prevention	*C/IC/DK/NR*

c) Gastro–enteritis

– Signs and Symptoms	*C/IC/DK/NR*
– Causation	*C/IC/DK/NR*
– Mode of spread	*C/IC/DK/NR*
– Treatment	*MM/AV/H/U*
– Prevention	*C/IC/DK/NR*

d) Cholera

– Signs and Symptoms	*C/IC/DK/NR*
– Causation	*C/IC/DK/NR*
– Mode of spread	*C/IC/DK/NR*
– Treatment	*MM/AV/H/U*
– Prevention	*C/IC/DK/NR*

e) Typhoid

– Signs & Symptoms	*C/IC/DK/NR*
– Causation	*C/IC/DK/NR*
– Mode of spread	*C/IC/DK/NR*
– Treatment	*MM/AV/H/U*
– Prevention	*C/IC/DK/NR*

C – Correct; IC – Incorrect; DK – Don't know; NR – No response
MM – Modern Medicine; AV – Ayurvedic; H – Homoeopathy; U – Unani.

f) **Worm-infestation**

- Signs & Symptoms *C/IC/DK/NR*
- Causation *C/IC/DK/NR*
- Mode of spread *C/IC/DK/NR*
- Treatment *MM/AV/H/U*
- Prevention *C/IC/DK/NR*

g) **Jaundice**

- Signs & symptoms *C/IC/DK/NR*
- Causation *C/IC/DK/NR*
- Mode of spread *C/IC/DK/NR*
- Treatment *MM/AV/H/U*
- Prevention *C/IC/DK/NR*

h) **Scabies and Boils**

- Signs & symptoms *C/IC/DK/NR*
- Causation *C/IC/DK/NR*
- Mode of spread *C/IC/DK/NR*
- Treatment *MM/AV/H/U*
- Prevention *C/IC/DK/NR*

5. Where do you go for treatment when fall sick ?
   - Registered Medical Practitioner (Please specify the system of medicine being practised by him)
   - Hospital/PHC/Sub-Centre
   - MPW/CHV
   - Quacks

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