PROCEEDINGS OF THE WORKSHOP ON SANITARY PROTECTION AND UPGRADATION OF TRADITIONAL SURFACE WATER SOURCES FOR DOMESTIC CONSUMPTION

Project Sponsored by

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Organised by

DEPARTMENT OF SANITARY ENGINEERING
ALL INDIA INSTITUTE OF HYGIENE AND
PUBLIC HEALTH, CALCUTTA

In Collaboration with

WATER AID, UK & MANDRA UNNAYAN SAMSAD

Proceedings Of The Workshop On Sanitary Protection And Upgradation of Traditional Surface Water Sources for Domestic Consumption —A Project Sponsored by UNICEF

17th To 18th August
1992

HELD AT
AIIH&PH AUDITORIUM
CALCUTTA

Organised by

Department Of Sanitary Engineering
All India Institute Of Hygiene And Public Health
Calcutta

In Collaboration With
Water Aid & Mandra Unnayan Samsad

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Foreword

The surface water sources are generally not explored properly for rural water supply since it involves adequate treatment and as such cost prohibitive. Most of the surface water sources in the rural areas like rivers, ponds, canals are grossly polluted and hence unfit for drinking. As such, most community water supply schemes in the rural areas are based on ground water sources. Villagers do, however, use water from surface sources like ponds etc. for most of their domestic use like bathing, washing of utensils and clothing, cooking etc. In times of water scarcity during the dry months they even drink these waters. The use of polluted surface water for domestic use is the main factor behind the endemicity of many water borne diseases and frequent epidemics of gastro-enteritis in the rural areas.

The present project which was undertaken by the Department of Sanitary Engineering in collaboration with the Department of Biochemistry and Nutrition, was sponsored by the UNICEF under the aegis of Ministry of Rural Development, Government of India. Under the project low cost models for the upgradation of quality of the traditional surface water were tried in a number of villages with active participation of the community. The findings of the study were discussed in this Workshop organised by the Department of Sanitary Engineering in collaboration with the Mandra Unnayan Samsad, under the sponsorship of WATER AID, U.K. on 17-18 August, 1992 at the All India Institute of Hygiene and Public Health, Calcutta.

I take this opportunity, for acknowledging with grateful thanks, the financial assistance provided by the UNICEF towards publication of the proceedings. I hope the proceedings would be useful for the participants of the Workshop in particular, and public health engineers and other professionals working with the government organisations, Panchayats and NGOs in general.

A.I.I.H.&P.H.,
Calcutta
30th March, 1993

Prof. **K. J. Nath**
Director

WORKSHOP ON "SANITARY PROTECTION AND UPGRADATION OF TRADITIONAL SURFACE WATER SOURCES FOR DOMESTIC CONSUMPTION"

17TH - 18TH AUGUST, 1992
All INDIA INSTITUTE OF HYGIENE & PUBLIC HEALTH, CALCUTTA

PROGRAMME

INAUGURAL SESSION

17.8.92 (Monday) :

10.00 a.m.	:	Welcome Address Prof. B. N. Ghosh, *Director, A.I.I.H. & P.H.*
10.10 a.m.	:	Workshop Objective Prof. K. J. Nath, *Head, Deptt. of Sanitary Engineering, A.I.I.H. & P.H.*
10.20 a.m.	:	Special Address Prof. S. Ramachandran, *Consulting Engineer, Water Aid, India*
10.30 a.m.	:	Inaugural Address Dr. Ambarish Mukherjee, *Minister-in-Charge of Environment and Forests,* *Government of West Bengal.*
10.40 a.m.	:	Presidential Address Mr. Gautam Deb, *Minister-in-Charge of Public Health Engineering,* *Government of West Bengal.*
10.50 a.m.	:	Special Guest Address Dr. Manas Bhuniya, *Member of Legislative Assembly,* *West Bengal.*
11.00 a.m.	:	Vote of Thanks Prof. A. K. Adhya, *Deptt. of Sanitary Engg. A.I.I.H. & P.H.*
11.05 a.m.	:	Tea Break

WORKSHOP ON "SANITARY PROTECTION AND UPGRADATION OF TRADITIONAL SURFACE WATER SOURCES FOR DOMESTIC CONSUMPTION"

17TH - 18TH AUGUST, 1992
ALL INDIA INSTITUTE OF HYGIENE & PUBLIC HEALTH, CALCUTTA

PROGRAMME

TECHNICAL SESSIONS

17.8.92 (Monday) :

11.30 — 13.30	—	Session I Presentation of the Theme Paper Prof. K.J. Nath & Mr. A.Majumdar. Chairperson Mr. Sekhar Bagchi
13.30 — 14.00	—	Lunch
14.00 — 15.30		Session II "Case Presentation by the NGOs" Chairperson Mr. P.R. Michael
15.30 — 15.45	—	Tea Break
15.45 — 17.45	—	Session III "Institutional and Organisational Aspects of Water Aid Projects" Chairperson Prof. S.Ramachandran.

FIELD VISIT

18.8.92 (Tuesday) :

07.00 - 13.00	—	Field visit to Rural Water Treatment Plant at Mandra
13.00 - 14.00	—	Lunch
14.00 - 16.00	—	Wrap - up and Valedictory Session at Mandra.

1. *Workshop Background*

In India, massive programmes have been taken up to supply adequate safe water to the villagers. Rajiv Gandhi National Drinking Water Mission achieved remarkable success in targetoriented rural water supply programme mobilising administrators, planners, engineers, scientists, people and Governmental and Non-Governmental Organisations(NGO). The International agency UNICEF also played a creditable role in the rural water supply programme. The task of supplying safe adequate water to the villagers is no doubt stupendous. The success of the rural water supply programme need sustained concerted effort and the Rajiv Gandhi National Drinking Water Mission is exerting all out effort to achieve it.

In rural areas of West Bengal, villagers mostly use tubewell (ground) water for drinking purposes. However, they generally depend upon the traditional surface water for washing, bathing and other domestic purposes including cooking. Most surface water sources like ponds, canals, rivers etc. are highly polluted and faecally contaminated. This has been one of the key factors behind the unabated endemicity of water and excreta borne diseases such as diarrhoea, enteric fever etc. and recurrent epidemics of such diseases in the rural areas. As such, the morbidity pattern of the villagers with respect to water borne diseases could not be improved significantly by providing tubewells for drinking water alone. A study was undertaken by the All India Institute of Hygiene & Public Health (AIIH&PH), Calcutta, under the sponsorship of the Ministry of Rural Development, GOI and funded by the UNICEF to develop an appropriate technology for upgradation of traditional surface water quality so as to make the water suitable for domestic usage pattern of the villagers and thereby ultimately to reduce the morbidity of the water borne diseases of the rural community. Technologies, so developed, have an inbuilt capacity for further quality upgradation so as to supplement drinking water supply, in times of scarcity. These could also be used as an alternative source of Community Water supply, in areas where ground water sources might be unsuitable for drinking, as in the case of Arsenic contamination in some parts of West Bengal.

An appropriate technology need to be socially acceptable, financially affordable and technically feasible. To keep the capital cost at the minimum level low cost technologies should be used with locally available materials. Equipments and plants installed under such a programme should be simple and easy to operate and maintain by the village level caretakers who should be given necessary training.

Under the study undertaken by AIIH&PH in Hooghly District of West Bengal, it was demonstrated that a simple and cost effective technology for upgradation of water drawn from traditional surface water sources in the villages (rivers, canals, ponds) could be developed by using horizontal roughing filters/slow sand filters. With appropriate training and awareness campaign among the villagers it was possible to successfully operate and maintain such a plant by village level caretakers under the management of a village based NGO. The experience gathered in Hooghly district is supported by the findings in other parts of the world in the use of such technologies. As such, it was felt that at this juncture it would be appropriate to organise a workshop to

(i) Disseminate the information and knowledge gathered through study.

(ii) Share experience and exchange views on various technical, managerial and socio-economic issues involved in the promotion of these technologies.

Under this background the present workshop was organised by AIIH&PH and Mandra Unnayan Samsad with financial support from Water Aid.

2. *Objective of the Workshop*

To discuss in-depth the various technical and socio-economic issues involved for the conservation and utilisation of traditional surface water sources on the basis of the findings of the study carried out in West Bengal (AIIH&PH, MRD, UNICEF) and other case studies in various parts of the world and to draw up recommendations for promotion of such technologies for supplementing community water supply in rural areas.

3. *Methodology*

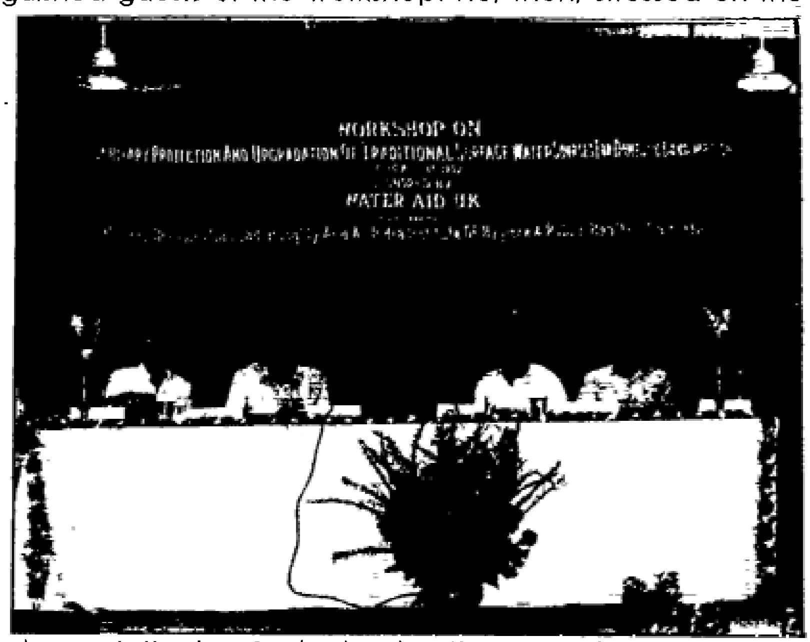
The discussions and interactions in the workshop centred on the Theme Paper presented by the Resource Persons of AIIH&PH based on their case studies in the district of Hooghly, West Bengal. The presentation was further supported by the case study findings in a number of studies in different countries which were circulated among the participants (given in Annexure. I). A field visit was also organised for the participants to inspect the experimental plant constructed in Hooghly district. After a thorough discussion and interaction between the Resource Group and the participants which included NGO leaders, public health engineers and community water supply experts, recommendations were formulated for promotion of such technologies for upgradation of quality of traditional surface water sources and their use as a supplementary/alternative source of community water supply in the rural areas.

4. *Participants*

Participants included public health engineers, community water supply experts and leaders of NGOs from a number of states, viz., Himachal Pradesh, Orissa, Tamil Nadu and West Bengal. A detailed list of the participants is given in Annexure-II.

5. *Inaugural Session*

Prof. B. N. Ghosh, Director of All India Institute of Hygiene and Public Health, Calcutta, in his Address, welcomed all the participants and distinguished guests of the workshop. He, then, stressed on the need of such type of workshops and training programmes involving the voluntary organisations. He also advocated for multidisciplinary approach involving all the relevant departments engaged in Water and Sanitation (WATSAN) programme.



While highlighting the objectives of the workshop, Prof. K. J. Nath, Professor of Environmental Sanitation and Head of the Department of Sanitary Engineering, stressed on the need for sanitary protection and quality upgradation of traditional surface water sources in the rural areas. He mentioned that gross pollution of traditional surface water sources like the ponds which are extensively used by the villagers for domestic use is the key factor behind the unabated endemicity of diarrhoeal diseases. He also mentioned a few methodologies which have been found to be appropriate under different standards of raw water quality of the sources and emphasized the need for utilisation of NGOs for implementation of such programmes in wider rural areas of the country.

Prof. S. Ramachandran, Country Representative, Water Aid, New Delhi, in his address highlighted the activities of Water Aid in rural areas and discussed the essential role of voluntary organisations in water supply and sanitation programme of the country. He briefly narrated how Water Aid is working in some specific areas with limited resources but with active participation of the people.

Dr. Ambarish Mukherjee, Hon'ble Minister-in-Charge of Forests and Environment, Govt. of West Bengal, in his inaugural address, spoke on the need of safe water supply in rural areas. He also added that sanitation improvement programme must go hand in hand with water supply programme. He advocated installation of AIIH&PH model filters for upgradation of traditional water sources, with active participation of the people. He also emphasized that scientists and engineers must work for the development of low cost technologies for environmental protection in the rural areas.

Dr. Manas Bhuniya, Member of Legislative Assembly, West Bengal, in his speech, welcomed such low cost technologies for purifying traditional surface water sources in rural areas of West Bengal. He also stressed on the involvement of NGOs and Govt. organisations to implement more of such programmes in areas of the state where drinking water is found to be inadequate or where the quality of ground water is doubtful.

Mr. Gautam Deb, Hon'ble Minister-in-Charge of Public Health Engineering, Govt. of West Bengal who presided over the inaugural session highlighted the activities of Public Health Engineering Department in water supply programme of the state. He also spoke on the role of three–tier Panchayat system in Public Health Engineering programme. The Hon'ble Minister stressed on the need for peoples' involvement in planning, implementation and operation & maintenance of rural water supply programme; accordingly people needed to be motivated effectively. He emphasized the role of voluntary organisations in such motivation and health education programmes. He appreciated the need for quality upgradation of surface water sources in rural areas and ensured government support for the same.

Prof. A. K. Adhya, Professor of Sanitary Engineering, AIIH&PH, proposed the vote of thanks to the guests, participants and organisers of the workshop.

6. *Technical Session I*

In the first Technical Session the Theme Paper on "Sanitary protection and quality upgradation of traditional surface water sources in Rural Bengal" was presented jointly by Prof. K. J. Nath, Head of the Department of Sanitary Engineering, AIIH&PH and Mr. Arunabha Majumdar, Associate Professor of Environmental Sanitation, Department of Sanitary Engineeding, AIIH&PH, Calcutta. Prof. Nath highlighted the basic issues of community health and environmental protection in the rural areas emphasising therein the urgent need of conservation, utilisation and quality upgradation of the traditional surface water sources like ponds, canals, rivers, etc. in the rural areas of the country. He explained to the participants the present water use patterns of the rural population and showed that a major portion of the domestic requirement of water of the rural population was drawn from the traditional surface water sources, largely from the ponds. It was stated from the experience of the AIIH&PH study in Hooghly district of West Bengal that the quality of such surface water sources like ponds was extremely poor as indicated by the very high faecal coliform count, in most water samples collected from them. The knowledge, attitude and practice survey conducted by AIIH&PH

in the study areas showed that in the beginning of the project the level of awareness amongst the rural community about water quality and its relation with health was rather poor. However, with adequate mass awareness campaign and training of village level caretakers it was possible to make the villagers aware of the basic issues of water quality and health, and with the help of an active NGO, the effective operation and maintenance of the low cost treatment plant for treatment of pond water was carried out very successfully. Prof. Nath also explained the various components of low cost treatment plant for upgradation of pond water which can be operated with human power only and no external energy was required. In the paper it was shown how effectively the villagers adopted the technology including regular disinfection. Mr. Arunabha Majumdar highlighted the technical aspects of operation & maintenance including cleaning of the filters. He also discussed various cost parameters including capital cost and operation & maintenance cost of different plants for various sources like rivers, ponds and canals. He explained that domestic treatment units at a very cheap cost could also be installed in rural households for treatment of water collected from ponds, etc. The details of the Theme Paper were also included (*vide supra*). At the conclusion of the presentation, the paper was discussed amongst the participants and the resource group. The delegates showed keen interest for adoption of the methodologies for upgradation of surface water in areas where extraction of ground water was problematic. There was, however, some doubt in the minds of a few representatives of NGO's as to whether this technology could be a cost effective substitute for a tubewell. Prof. Nath explained that traditional surface water sources could not be a total alternative to handpump tubewells in areas where ground water was easily extractable and there was no quality problem. However, even in such areas people were using water of traditional surface water sources for domestic uses like cooking, washing of utensils etc. As such there was a need for upgradation of quality of the same to safeguard community health. Moreover, it was also pointed out that in areas where ground water was having quality problems like in parts of West Bengal where ground has been contaminated with Arsenic or in the coastal areas where ground water is saline, use of surface water with appropriate treatment could alleviate the water scarcity problem of the people to a large extent.

The Technical Session I was chaired by Mr. S. Bagchi, Chief Engineer, West Bengal Public Health Engineering Department. In his concluding remarks, Mr. Bagchi said that such appropriate technologies should be implemented in areas where there were problem of ground water extraction, quality or otherwise and Public Health Engineering Department would like to provide all support to the NGOs and Panchayats for implementation of such programmes.

7. *Technical Session II*

In the Technical Session II the representatives of various NGOs from different parts of the country highlighted the various issues related to the problems of rural water supply in their areas. Some representatives of NGO's from West Bengal pointed out that in Southern Bengal where the ground water was mostly saline, the use of surface water should be advocated. However the utilisation of traditional surface water sources should also include scientific rain water harvesting by way of digging ponds of adequate capacity and taking necessary measures for prevention of seepage loss and evaporation. Since the AIIH&PH model needed perennial ponds, the system would not work if ponds go dry during the summer months; hence the need for scientific rain water harvesting. While agreeing with the suggestion of the participant, Mr. Majumdar of AIIH&PH, informed that while the Mandra Model was suited for perennial ponds, there were other systems which could be used for tapping sub- surface water from below the beds of rivers or canals. At this juncture, Prof. Nath intervened to suggest that we must have a rational water resource management policy which could include conjunctive use of both surface water and ground water. However, the present study was applicable to those surface water sources which were presently being used extensively by the rural community for various domestic purposes, but in an extremely contaminated form. As such, improvement of quality of water from these sources should be a priority from the point of view of community health. However, it was agreed by all that in areas where ground water could not be used, supply from surface water sources needed to be augmented by rain water harvesting, etc.

Some representatives raised the question of Arsenic contamination of ground water in some districts of West Bengal and they felt that the present technology should be used to provide alternate sources of water to the villagers. The State Govt. was urged to take urgent action in this regard. Participating in the discussion representatives of some of the NGO's pointed out that while addressing the problem of water quality in the rural areas, we must also educate the people about personal hygiene and other health issues. An integrated approach towards health, water and sanitation was suggested. More effective collaboration between the NGOs, Village Panchayats and the Public Health Engineering Departments for solving the problems of rural water supply and sanitation was suggested by the Leaders of NGOs. The Session II was Chaired by Mr. P. R. Michael, South India Representative, Water Aid.

8. *Technical Session III*

The third Technical Session was devoted to the institutional and organisational aspects of the NGO's and the supportive role of Water Aid in their programmes. Prof. S. Ramachandran, Country Representative, Water Aid, chaired the session and discussed with the participants regarding the activities of Water Aid and how Water Aid could support the programme of the NGO's in the field of rural water supply and sanitation. He appreciated the project implemented by Mandra Unnayan Samsad in collaboration with the AIIH&PH for the sanitary protection and upgradation of Pond water and informed the participants that Water Aid was prepared to support such projects in other parts of West Bengal in particular and the country in general. Prof. Nath opined that the Mandra experience had been on a limited scale and it was necessary to have further projects to test its replicability on a larger scale.

9. *Field Visit*

On 18th August 1992 the delegates were taken for a field visit to Mandra. The delegates were shown the pilot plant of horizontal roughing filter and slow sand filter and functioning of the same. The detailed technical aspects of the plant were explained by Mr. A. Mazumdar of AIIH&PH.

The delegates interviewed some of the villagers who were regularly using the treated water. The delegates appreciated the efforts taken by the AIIH&PH for installation of such types of treatment systems for upgradation of pond water.

10. *Wrap-up Session*

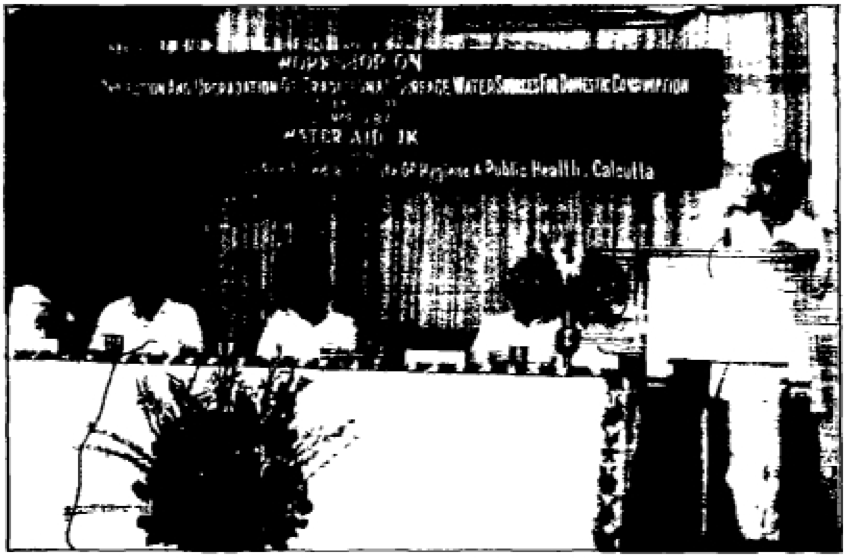
A wrap-up session was organised in the latter half of the day. Mr. P.R.Michael, Country Representative (South India) presided over the session. Prof. Ramachandran enquired about the reaction of the delegates on the field visit.

It was the general consensus that similar ventures in other areas would necessitate extensive mass awareness as had been done at Mandra. Everybody agreed about the technical and financial viability of the programme and showed their willingness to replicate the same in their respective areas.

The session was over with the vote of thanks offered by Prof. S. Ramachandran on behalf of Water Aid and by Mr. T. P. Bhattacherjee on behalf of the host organisation, Mandra Unnayan Samsad.

11. *Exhibition*

An exhibition depicting the essential features of the Community Based Rural Water Supply System in the Mandra village, executed and operated as a joint collaborative project of AIIH&PH & Mandra Unnayan Samsad, was organised during the Workshop.



Mr. Goutam Deb, Hon'ble Minister (PHE, Govt. of West Bengal) delivering the Presidential Address at the inaugural session of the Workshop : sitting on his right Prof. S. Ramachandran, Prof. B. N. Ghosh, Dr. Manas Bhuniya, Dr. Ambarish Mukherjee and Prof. K. J. Nath

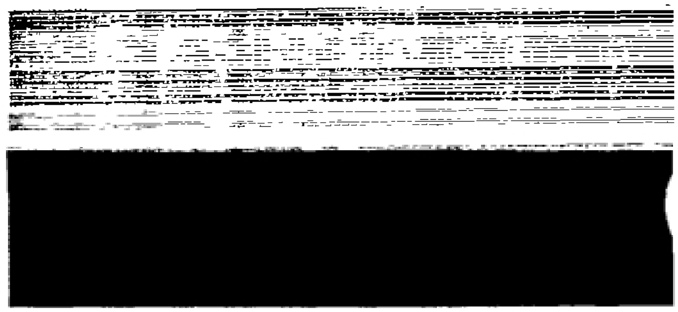
Panel Speakers and a section of participants during a technical session

Field Demonstration Of HRF & SSF at village Mandra, Hooghly

Intake Chamber for HRF & SSF Model – Using Traditional Surface Water (pond)

Water Treatment Plant (HRF & SSF) at village Mandra, Hooghly

Disinfection with bleaching powder



Treated Water from HRF being utilised for bathing and washing

Top view of HRF & SSF

THEME PAPER

Sanitary Protection And Quality Upgradation Of Traditional Surface Water Sources In Rural Bengal

Prof. K. J. Nath *, Mr. A. Majumder and **, Mr. S. Lahiri ***

1. *Introduction*

Majority of the rural population in different districts of West Bengal, India, use considerable amount of traditional surface water for day-to-day activities. However most of the traditional surface water sources e.g. ponds, lakes, rivers, etc. are highly polluted and faecally contaminated. This has been one of the key factors behind the unabating endemicity of water and excreta- borne diseases, such as diarrhoea, dysentery, enteric fever etc. and recurrent epidemics of such diseases in rural areas. As such, the morbidity of the villagers with respect to water borne diseases could not be improved significantly by providing tubewells for drinking water alone.

In order to develop appropriate methodology for upgradation of traditional surface water quality so as to make the water suitable for domestic uses by the villagers and thereby of the rural community, a study was undertaken by the All India Institute of Hygiene and Public Health, during 1989-91 under the aegis of Ministry of Rural Development, Government of India and sponsorship of UNICEF.

The essential feature of the present study includes baseline date collection; knowledge, attitude and practice survey; selection of appropriate technology for upgradation of water quality, cost benefit analysis and performance evaluation. Furthermore, quality improvement of traditional surface water through small household installation has also been studied.

2. *Appropriate Technology Selection*

The term "appropriate technology" is often used synonymously, although mistakenly, with "low cost technology" in the context of water supply and sanitation for developing countries. To be appropriate, a technology must be socially acceptable, affordable and manageable. The overall considerations of appropriate technology design should be simplicity, reliability and durability.

Different appropriate methodologies were selected for upgrading the quality of surface water. The provision of water with improved clarity at a point of delivery which eliminates the necessity of the recipient entering the surface source to collect water would be sufficient justification for such system.

River water is found to be one of the major surface water sources in rural West Bengal. The turbidity of the river water varies with season and high turbidity could be observed during rains.

Usually high turbidity in river water necessitates addition of chemicals (coagulant) for removal. However, the process needs meticulous operation and maintenance with constant monitoring and therefore the process is not generally encouraged in rural water supply. Accordingly, method of prologed storage with plain sedimentation and slow sand filtration was selected for treating river water.

Again, some of the rivers become dry during summer months. In order to select appropriate technology in that type of situation under situ filter was adopted to be installed below river bed.

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* Prof. & Head, Department of Sanitary Engineering & Environmental Sanitation, All India Institute of Hygiene and Public Health, Calcutta.

** Associate Prof. Department of Sanitary Engineering, All India Institute of Hygiene and Public Health, Calcutta.

*** Project Officer, Department of Sanitary Engineering, All India Institute of Hygine and Public Health, Calcutta

Ponds are abundantly available in villages, however some ponds become dry in summer months. Two appropriate methodologies for treatment of pond was tried in two different rural areas under study. A slow sand filter with double action single operation handpump was selected in one study area whereas a combined horizontal flow roughing filter and slow sand filter was considered for treatment of a pond water with high turbidity in the other study area.Table 1, depicts the criteria adopted for source specific Table-1 technology selection.

Table - 1
Criteria for Source Specific Technology Selection.

	Criteria	Source	Purification methodology
a.	High turbid water (Perennial Source) Highly Polluted.	River (Ganga)	Prolonged storage-Plain Sedimentation – Slow Sand Filtration – Disinfection.
b.	Medium turbid water, Highly Polluted (Perennial source)	Pond	Horizontal Roughing Filtration – Slow Sand Filtration – Disinfection
c.	Low turbid water (Perennial source)	Pond	Slow Sand Filtration – Disinfection.
d.	Medium turbid water (Water source drying in summer condition)	River (Saraswati)	Under Situ – Filtration – Disinfection.

3. *Existing status of water quality*

Almost all the surface water sources in rural areas are contaminated and unsafe for domestic use. However, these water sources are used by the villagers indiscriminately for various domestic uses except drinking. The situation was also true in case of the present study areas. All the surface water sources were found to contain high faecal contamination. The turbidity goes high specially in river waters. However, the quality of surface waters indicated favourable acceptance for domestic use provided appropriate purification methodology is applied.

The chemical and bacteriological quality of various surface water sources in study areas are furnished below :

Chemical and Bacteriological quality of river Ganga water at Belur, Howraah.

Parameters

a)	PH	7.3	–	7.4
b)	E. C. (u ohms/cu)	540	–	580
c)	Turbidity (JTU)	50	–	600
d)	Alkalinity (mg/1) as $CaCO_3$	160	–	180
e)	Chloride (mg/1) as Cl	70	–	80
f)	Hardness (mg/1) as $CaCO_3$	160	–	170
g)	Iron (mg/1) as Fe	1.2	–	1.8
h)	MPN of Coliforms/100 ml.	3500	–	4000
i)	MPN of Faecal coliform/100 ml	3500	–	2500

Chemical and Bacteriological quality of pond water at Mandra, Hooghly.

Parameters

a)	pH	7.30	–	7.75
b)	E. C. (U mohs/cm)	950	–	1220
c)	Turbidity (JTU)	50	–	70
d)	Alkalinity (mg/1) as $CaCO_3$	200	–	220
e)	Cholorids (mg/1) as Cl	90	–	110
f)	Hardness (mg/1) as $CaCO_3$	150	–	205
g)	Iron (mg/1) as Fe	0.7	–	0.9
h)	MPN of Coliform/100 ml	4500	–	6000
i)	MPN of faecal	3000	–	4000

Chemical and Bacteriological quality of rural water at Singur, Hooghly,

Parameters

a)	pH	7.80	–	7.92
b)	E. C. (U mohs/cm)	750	–	900
c)	Turbidity (JTU)	10	–	35
d)	Alkalinity (mg/1) as $CaCO_3$	180	–	205
e)	Cholorids (mg/1) as Cl	40	–	50
f)	Hardness (mg/1) as $CaCO_3$	150	–	180
g)	Iron (mg/1) as Fe	0.42	–	0.63
h)	MPN of Coliform/100 ml	1600	–	1800
i)	MPN of faecal coliform/100 ml.	500	–	1000

4. *Health Status Of Study Area*

Epidemiological study was conducted in Singur and Mandra areas during six months before the installation of new treatment models. The study in Singur depicts that about 45% of the population surveyed suffered from water & sanitation borne diseases as per details given below.

Epidemiological study data of Singur, Hooghly.

Total population surveyed : 582

	Type of Disease	Occurance rate (%)
a)	Diarrhoea	10.65
b)	Dysentery	6.36
c)	Gastro-Enteritis	1.72
d)	Cholera	Nil
e)	Enteric fever	0.17
f)	Worm infection	23.44
g)	Infective hepatitis	Nil
h)	Poliomyelitis	2.33

Similar epidemiological study was conducted at Mandra. Hooghly for a period of six months and it was found that about 65% of the population suffered from water and sanitation borne diseases in the area. The disease-wise data are furnished below.

Epidemiological data of Mandra, Hooghly

Type of Disease		Occurance of Rate (%)
a)	Diarrhoea	18.09
b)	Dysentery	10.58
c)	Gastro-Eneritis	3.48
d)	Cholera	Nil
e)	Enteric fever	5.76
f)	Worm infection	26.94
g)	Infective hepatitis	0.13
h)	Poliomyelitis	0.04

5. *Knowledge, Attitude And Practice Survey*

Before installation of water treatment unit at Mandra the research group organised mass awareness campaign programmes on 26th August, 1989 and Knowledge, Attitude and Practice(KAP) survey was conducted later in collaboration with Mandra Unnayan Samsad. In the mass awareness campaign programme both men and womenfolk of the villages participated. Audio-visual aid was utilised to create interest amongst the villagers. Moreover, different household disinfection techniques were shown in the programme.

During the implementation of the experimental water treatment plants, peoples participation was utilised fully in collaboration with Mandra Unnayan Samsad.

Knowledge, Attitude and Practice survey was also conducted in different villages of Mandra area as a baseline survey. The said survey was repeated in due course of time with the further input of mass awareness campaign. The summary result of the KAP survey is furnished below :

5.1 Village : Mandra.

Total no. of households surveyed in the area - 129

Total population surveyed - 746

5.1.1 Water Usage Pattern (in percentage of population)

	Dugwell	H.P	River	Canal	Pond
Drinking	0.78	98.44	–	0.78	–
Cooking	1.55	45.74	–	–	52.71
Washing Utensils	0.78	2.32	1.55	9.30	86.05
Washing Clothes	0.78	–	1.55	6.98	90.69
Bathing	0.78	7.75	–	3.10	88.37

5.1.2 Per captia water demand (in litres)

Usage	Minimum	Maximum
Drinking	3	4
Cooking	7	8
Washing Utensils	5	6
Washing Clothes	6	7
Bathings	20	25
Others	5	10
Total :	**46**	**60**

5.1.3 Collection and storage

a) 96.12% of the women population collect water, while 10.07% children and only 9.30% of adult men participate in collecting water.

b) 98.44% of the population use metal containers for collecting water, while 22.48% use earthen containers and 10.07% use plastic containers.

c) 83.72% store the water in the same pot used for collecting water, while the rest transfer it to another pot.

d) 62.02% keep the stored water covered, while the rest do not cover the stored water.

5.1.4 Treatment (Purification) and handling of water

a) 0.78% treat the water before drinking by using camphor and boiling, while the rest do not make any treatment before drinking.

b) 75.97% pour out the water from the vessels, while 18.60% use accessory utensils to take out the water and 5.43% simply immerse their hands to take water out.

c) 89.92% of the population are eager to have their own package household treatment unit. 0.78% do not want it, while 9.30% did not give their opinion in this matter.

5.1.5 Some relevant data

a) Average volume of water collected per household per day for drinking and cooking purposes = 39.67 litres.

b) Average distance of source of drinking water from the house = 81.41 meters.

c) Average time spent in collection of water = 14.48 min/bucket.

5.1.6 Difficulties experienced by the people in collection of water

a) 46.51% complain of bodyache.

b) 70.54% complain of exhaustion.

c) 34.88% complain that the handpump is too far away

d) 53.48% complain that they have to wait for a long time for the collection.

e) 12.0% also complain that the use of handpump is monopolised by a few people of the area.

5.1.7 Personal opinion regarding water related health hazards

a) 100% of the population are aware that unsafe water causes health problems.

b) 60% of the population are indifferent about their personel hygiene.

5.1.8 100% of the villagers welcomed the decision of installation of experimental water treatment unit for treatment pond water in the area.

Similarly, the research group conducted the knowledge, attitude and practice survey in singur area with active help and cooperation of Rural Health Unit and Training Centre of All India Institute of Hygiene and Public Health at Singur. The survey was conducted to arrive at the baseline status of the villagers related to knowledge, attitude and practice for water supply and sanitation. The summary result of K.A.P. survey for Singur area is furnished in the next page.

5.2 *Village : Singur*

Total no. of families surveyed = 101

Total population surveyed = 746

5.2.1 Water usage pattern (in percentage of population)

	Dugwell	H.P	W.S. Tap	River	Canal	Pond
Drinking	–	96.04	1.98	–	–	1.98
Cooking	0.99	76.24	3.96	0.99	0.99	16.83
Washing Utensils	2.97	19.80	11.88	0.99	0.99	63.37
Washing Clothes	1.98	19.80	5.94	0.99	0.99	70.30
Bathing	–	52.48	15.84	0.99	0.99	29.70

5.2.2. Collection and storage

a) 99.01% of the women population collect water, while 3.96% of adult men and 0.96% of children participate in collecting water.

b) 96.04% of the population use metal containers for collecting water, while 4.96% use earthen containers and 1.98% use plastic containers.

c) 77.23% stire the water in the same pot used for collecting water, while the rest transfer it to another pot.

d) 57.43% keep the stored water covered, while the rest do not cover the stored water.

5.2.3 Treatment (purification) and handling of water

a) 1.98% treat the water before drinking by boiling, while rest (98.02% do not make any treatment before drinking.

b) 80.20% pour out the water from the vessels, while 8.91% use accessory utensils to take out the water and 10.89% simply immerse their hand to take water out.

c) 80.20% of the population are eager to have their own package household treatment unit while rest (19.80%) do not want it.

5.2.4 Some relevant data

a) Average volume of water collected per household per day for drinking and cooking purposes = 29.61% litres.

b) Average distance of source of drinking water from the house = 65.39 metres.

c) Average time spent in collection of water = 14.68 min/bucket

d) 49.5% villagers rinse their utensils in safe water.

5.2.5 Difficulties experienced by the people in collection of water

a) 1.98% complain of bodyache

b) 38.61% complain of exhaustion

c) 38.61% complain that the handpump is far away.

d) 25.74% complain that away have to wait for a long time for the collection.

5.2.6 Personal opinion regarding water related health hazards

a) 97.03% of the population are aware that unsafe water causes health problems.

b) 70% of the population are indifferent about their personal hygene.

6. *Horizontal Roughing Filter (HRF)*

In developing countries, slow sand filteration is commonly considered as an appropriate water treatment process. But HRF acts both as filteration and sedimentation unit and has remarkable potentiality to improve bacteriological quality of the water. The removal of suspended solid by the process of filteration and sedimentation is so significant that the efficiency of such solids removal may be compared with chemical coagulation and flocculation. In case of small installation where often high suspended solids are required to be removed HRF may be considered to be appropriate. Moreover, when often slow sand filters are overloaded with suspended solids thereby causing unacceptable short filter runs, a pretreatment of raw water by HRF may be considered to be appropriate.

7. *Case Study on Horizontal Roughing Filter : (Mandra Village, Dist. Hooghly)*

A Horizontal roughing filter was installed at Mandra Village, in the District of Hooghly of West Bengal State of India in 1990 in order to upgrade the quality of traditional surface water (pond). The HRF was succeeded by slow sand filter in order to pgrade the quality as per drinking standard. The pilot plant was designed to serve a population of 300.

7.1 Source :

A pond which receives from time to time overflow from an adjacent irrigation canal was selected as a perennial raw water source for water supply. The pond also receives polluted surface run off and faecal contamination.

7.2 Raw Water Quality :

The raw quality is shown in Table - 2 below.

Table – 2
Raw Water Quality

	Maximum	Minimum	Average
Turbidity (JTU)	70	50	60
PH	7.8	7.3	7.55
EC (umhos/cm)	1220	950	1085
Alkalinity (mg/1) as $CaCO_3$	220	200	210
Hardness (mg/1) as $CaCO_3$	205	150	178
Chloride (mg/1) as Cl	110	90	100
Iron (mg/1) as Fe	0.9	0.7	0.8
Total Coliform /100 ml	6000	4500	5200
Faecal Coliform /100 ml	4000	3000	3500

7.3 Intake

An intake well with prefabricated earthenware rounds was installed in the pond. The intake was fitted with pipe and was connected with handpump to feed raw water in the HRF. The hand pump could draw 20-25 Lts. per minute as per standard human operation.

7.4 Constructional features

Three inter-connected compartments were constructed for the HRF in which 15 mm, 10 mm and 5mm size gravel was packed in first, second and third compartments respectively. The filter lengths for above mentioned sizes of media are 2 metres each for the first two comparments and 1 metre for the rest. The cross- sectional area of the HRF was kept as 1.0(W) x 1.1(D). The HRF treats 12000 Lts/day, operating 12 hours per day, which means a rate of filtration of about 1 Cu.M/h. Cleaning interval was 180 days on an average.

The partition walls of the HRF compartments were constructed without providing cement sand mortar for the vertical joints of the bricks. This enabled horizontal movement of water particles through the partition walls. A bed slope of 1% has been provided in the HRF in order to take care of head loss through gravel media. An under drainage system in three HRF compartments has also been provided for cleaning HRF.

7.5 *Inlet and Outlet Chambers :*

Both the inlet and outlet chambers of size 0.6 m(L) X I m (W) X 1.1 m(D) have been provided. A tap connection has been provided from outlet chamber for use by the villagers except for drinking.

7.6 *Slow-Sand Filter :*

A Slow Sand Filter has been provided to 67% of H. R. filtered water to improve its quality further. A SSF Surface area of 4.2 sq.m. has been installed adjacent to HRF, to keep the rate of filtration as 190 Lt/hr/m2. The SSF has a capacity to treat 800 Lts/hr. of water.

The detailed specification of the filter media of SSF are presented below :-

Total gravel media Thickness	250	mm
Top layer (0.7 to 1.4 mm) gravel	I50	mm
2nd layer (2 to 5 mm) gravel	100	mm
3rd layer (6 to 12 mm) gravel	I50	mm
Bottom layer (18 to 36 mm) gravel	I50	mm
Total Thickness of Sand media	500	mm
Effective size (D10)	0.23	mm
Uniformity Coefficient (D60/D10)	2.2	mm

7.7 *Treated Water Quality :*

The average chemical, bacteriological quality of water at different units are presented below.

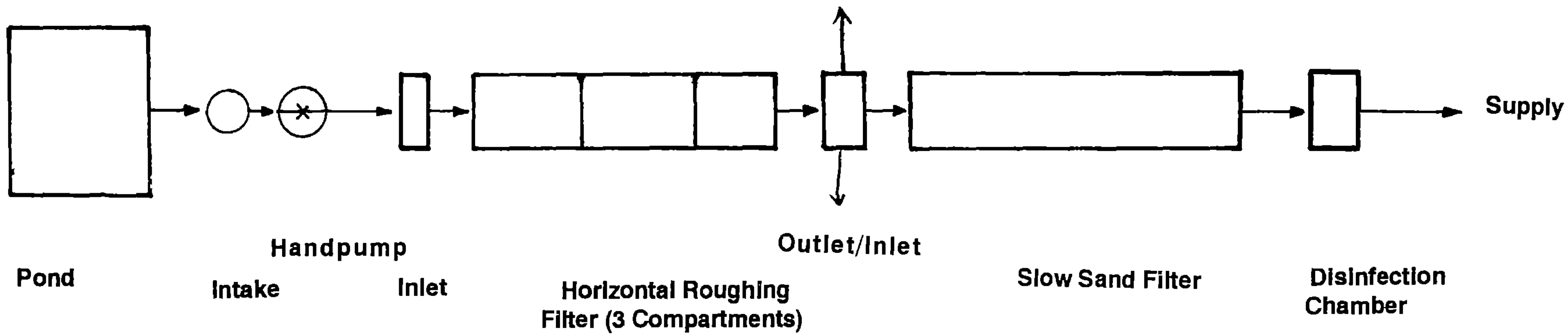
Treated Water Quality

	Pond Water	Treated Water of HRF	Treated Water of SSF
pH	7.5	7.5	7.5
E.C. (umhos /cm)	1100	1000	920
Turbidity (JTU)	60	5	1.0
Alkalinity (mg/1) as $CaCO_3$	210	205	200
Hardness (mg/1) as $CaCO_3$	175	170	170
Chloride (mg/1) as Cl	100	98	96
Iron (mg/1) as Fe	0.8	Nil	Nil
Total Coliform /100 ml	5250	180	Nil
Faecal Coliform /100 ml	3500	90 **	Nil *

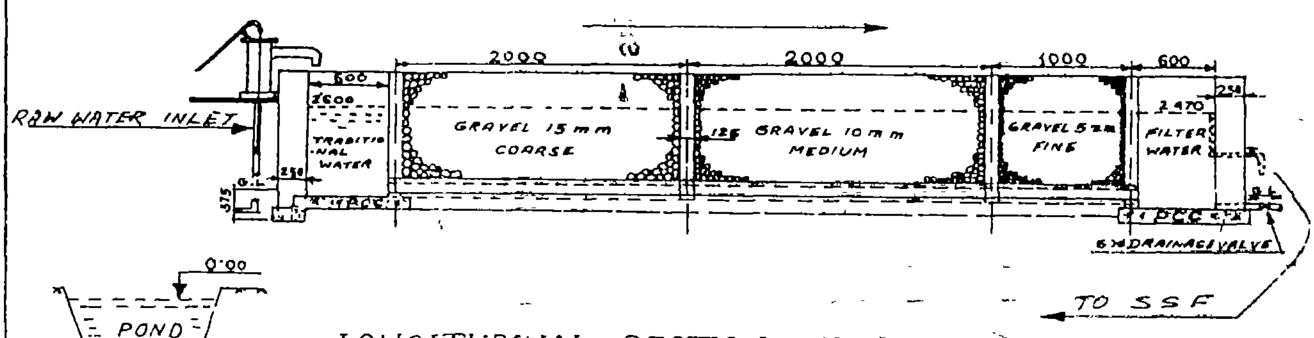
* After chlorination and without chlorination 6/100 ml

** could be brought down to nil by adequate chlorination.

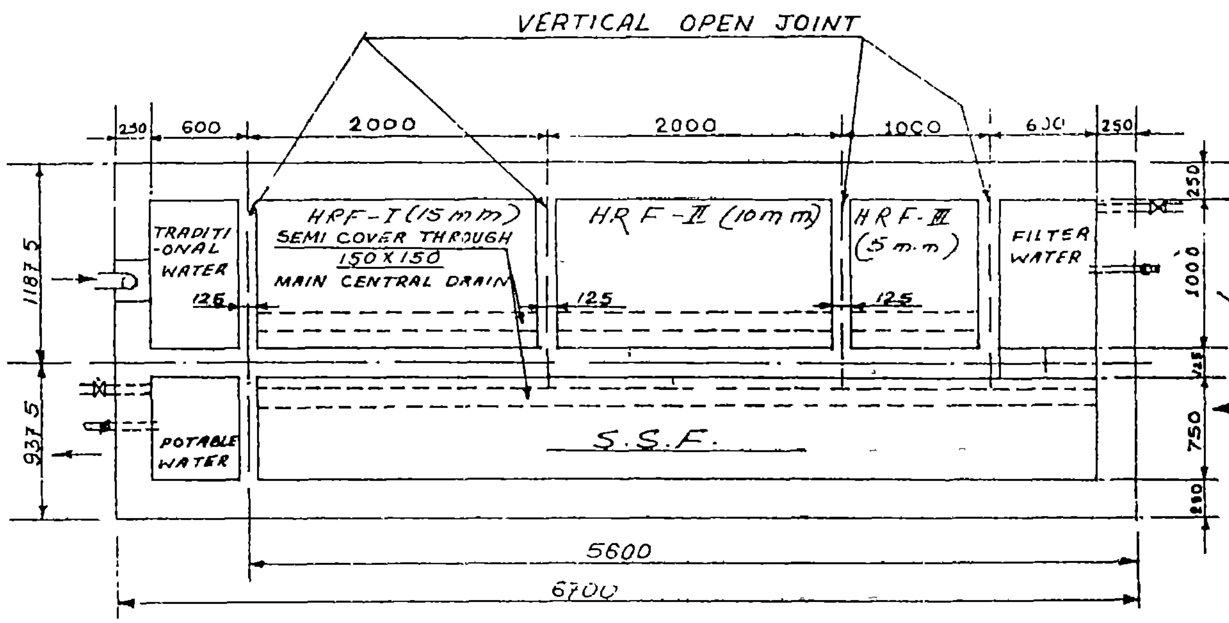
Treatment Process Diagram (Fig.1)



Horizontal Flow Roughing Filters and Slow Sand Filter at Mandra, Hooghly



LONGITUDINAL SECTION OF H.R.F



PLAN

7.8 *Performance*

HRF Performance :-

Excellent performance of HRF may be noticed for removal of suspended solids in different compartments packed with gravel. The field performance of the HRF indicates that on an average 50% of the suspended solids are retained in the first compartment having 15 mm. gravel. In the second compartment 10 mm. gravel media arrest 30% of the suspended solids. The major amount of the remaining suspended solids are arrested in the third compartment with 5 mm. gravel size. The study, therefore, indicates that filter load (gm/1) is highest in the first compartment. Thus it can be stated that higher the media size higher would be the filter load.

SSF Performance :

The performance of SSF indicates that the length of the filter run (days) varies with suspended solids loading on the SSF. Field study indicates that for SSF inlet water turbidity of 10 JTU, the interval of filter cleaning is 90 days. This is found to be 30 days for inlet water turbidity 30 JTU.

7.9 *Operation and Manitenance*

The HRF need to be cleaned thoroughly before starting filter operation. The HRF unit should be filled with water at a low flow rate (preferably 0.5 to 1 m/h.) upto the effluent weir level (or out let level) and thereafter water should be drained off from all the compartments by opening the drainge valve. The procedure should be repeated at least three times. This would help in washing out dust particles from the compartments. Unless these dust particales are not properly cleaned, the particales would accumulate in the fine gravel compartment resulting in increasing the initial filter resistance.

As HRF acts as a physical filter, intermittent operation is possible without marked deterioration of the filtrates. Hence HRF can be well operated with fitting hand pump for feeding raw water at the inlet. In the rural situation, when HRF is not operated in the night time, no adverse impact on the quality of the filtrate is noticeable in day time.

However, it is recommended to operate HRF as continuously as possible.

Recording of filter resistance is extremely important during the running of HRF. On an average for 5 m media travel length 20 cm. head loss would be allowed at the end of the filter run. The filter need to be cleaned when such head loss is reached. Usually flushing out of water from the compartment would enable the accumulated suspended solids to be removed from the HRF. The process need to be repeated at least thrice. However, manual cleaning of filter media may be necessary in case the suspended solids and organic mass are sticked with gravel media.

The interval of cleaning may vary from 100 to 180 days depending upon suspended solids in the pond (average 50 mg/1.) and allowable filter load (10 to 20 gm/1.). Accumulation of higher quantity of suspended solids in the rainy season may be considered.

However, frequent hydraulic cleaning to restore filter efficiency is advisable with village level community management system.

Village caretakers are to be trained for maintenance of the plant.

Mass awarenes camps are to arranged for the beneficiaries.

Regular disinfection of water is necessary after HRF/SSF if such water is used for domestic purposes.

7.10 Cost Analysis

The salient features of cost analysis is presented below.

No. of beneficiaries	300
Capacity of the experimental Water Treatment Unit	12000 Lits/day.

Capital Cost :

Cost of construction	Rs.	35000.00	($ 1166)
Capital cost of investment/person	Rs.	116.00	($ 3.89)
Capital cost of investment/Lit. Capacity of the Plant	Rs.	2.29	($ .09)

(The cost could be lowered by about 20% if voluntary services of the villagers could be utilised.)

Operation and Maintenance Cost :

O & m Cost/Year (amortization cost included)	Rs.	5700.00	($ 190)
Production cost : Per day/1000 Lt.	Rs.	1.30	($ .04)

7.11 Relative Cost Comparison :

The cost of construction as well as operation and maintenance of HRF-SSF rural model need to be compared with the conventional water treatment plants purifying surface water for drinking purpose. From the available cost data of large scale (Conventional) Municipal Water Treatment Plants : Coagulation / RSF) and using the scale up factor of 3 for equivalent capacity conventional water treatment plant, the capital cost investment per liter capacity of the plant would be Rs.3.39 ($ 0.12) whereas for the present HRF-SSF model the capital cost investment per liter capacity of the plant is Rs. 2.29 ($ 0.09)

The production cost of 1000 liters of drinking water in case of equivalent conventional water treatment plant would be Rs. 3.57 ($ 0.12), as against the presnt HRF-SSF model costing Rs. 1.30 ($ .04).

The performance of HRF-SSF model plant indicate that it is not inferior to conventional type water treatment plant with the added advantage of requiring no energy and less skill and man power for operation and maintenance.

Performance of HRF in Mandra village indicated that for removal of turbidity of more than 50 NTU from surface water sources, HRF may be considered as an appropriate alternative to coagulation - flocculation - sedimentation. The constructional cost of conventional pre-treatment units is likely to be much higher than the cost of construction of HRF. The treatment cost of 1000 liters though HRF only has been found to be Rs. 0.75 ($ 0.03) whereas such cost for clariflocculator would be Rs. 2.00 ($ 0.07)

It is reported by IRCWD (No. 06/86) that in Tanzania the construction costs of a pre-treatment unit with a daily capacity of 440 m3/d, composed of a baffled tank (detention time 20 min) used as a flocculator, and a horizontal flow sedimentation tank (overflow rate lm/h, detention time 2hr.) were estimated as US $ 20,000 ($ 46/m3/d). As against this, the cost of construction of experimental 12m3/d capacity HRF unit at Mandra Village in India was US $ 500 which means an unit cost of US $ 41/m3/d. If scale- up factor is used so as to compare 12m3/d capacity flocculator - horizontal flow sedimentation tank of Tanzania model, it is certain that difference of cost would be wider in favour of HRF.

The above cost analysis indicated that HRF may be considered as an appropriate and cost effective technology for the rural community for treatment and upgradation of traditional surface water.

8. *Slow Sand Filter With Double Action Single Operation (DASO) Handpump : (Singur, Dist. Hooghly)*

A traditional surface water purification model has been developed at Rural Health Unit and Training Centre of AIIH&PH (Singur, District Hooghly). A protected big pond which contains sufficient water throughout the year, has been chosen as source of water supply. The treatment unit comprises a slow sand filter with inlet and outlet arrangement. The unique feature of this particular model is the double action single operation handpump fitted with the model plant. The users draw water by pressing the handpump. The amount of filter water deplenished from the model plant due to the drawal of water by the users are simultaneously replenished from pond water by single operation handpumps.

8.1 Basic Infomation

The experimental SSF with double action single operation (DASO) handpump has been installed for a beneficiary population of 225.

Population to be served	–	225	
Per capita water supply	–	40	Lt/day.
Total amount of water required treatment	–	9000	Lt/day.
The duration for which the plant would remain in operation	–	15	hr.
Hence desired capacity of the filter unit	–	600	Lt/hr.
Considered filtration rate of SSF	–	200	Lt/hr.
Hence area of SSF	–	3	m^2

8.2 Slow Sand Filter

SSF is the low cost as well as simplest method of effective purification process which can be adopted in small scale and large scale rural supply system. The removal of impurities from the water is brought about by a combination of different process such as sedimentation, absorption, straining and most importantly biochemical and microbial action.

The dimension of the SSF and Filter media details are furnished below

SSF

Length	=	2.00 m.
Breadth	=	1.50 m.
S.W.D.	=	1.15 m.

Filter Media

Gravel media thickness	=	200 mm.
Sand media thickness	=	600 mm
Effective size of sand (D_{10})	=	0.24 mm
Uniformity coefficient of sand (U)	=	2.1

A few centimetre of top layer of sand requires to be cleaned once in three months. However, the top layer of the sand should be replaced with new sand of same grade and size.

8.3 *Disinfection*

A disinfection unit has been provided with the model plant so that users can draw disinfected filtered water. Bleaching powder solution is kept in the dozer tank which has a regulatory outlet for optimum dose to be added with the filtered water.

8.4 *Water Quality*

The Chemical and Bacteriological quality of treated water is as follows

1. pH	:	8.00	–	8.05
2. Turbidity (JTU)	:	2.00	–	6.00
3. Alkalinity (mg/1) as $CaCO_3$	:	192	–	220
4. Chloride (mg/1) as Cl	:	30	–	42
5. Hardness (mg/1) as $CaCO_3$	:	120	–	180
6. Iron (mg/1) as Fe	:	0.16	–	0.36
7. Total Coliforms/100 ml (Before chlorination)	:	35	–	180
8. Total Coliforms/100 ml (After chlorination)	:	Nil		

The Chemical and Bacteriological quality of raw (pond) water is presented below

1. pH	:	7.80	–	7.92
2. Turbidity (JTU)	:	10	–	35
3. Alkalinity (mg/1) as $CaCO_3$	:	180	–	205
4. Chloride (mg/1) as Cl	:	40	–	50
5. Hardness (mg/1) as $CaCO_3$	:	150	–	180
6. Iron (mg/1) as Fe	:	0.42	–	0.63
7. Total Coliforms/100 ml	:	1600	–	1800

8.5 *Cost Analysis*

No. of beneficiaries	=	250	
Capacity of the experimental water treatment model plant	=	9,000	Lt/day.

Capital Cost

Cost of construction	=	Rs.	20,000.00
Capital investment/person	=	Rs.	80.00
Capital investment/Lt. of treatment capacity of plant	=	Rs.	2.22

If voluntary services rendered by the villagers are considered, the cost of construction would be reduced further.

Operation and maintenance cost

(Based on yearly requirement)

1.	Cost of bleaching powder 15 kg. @ Rs.10/- per kg.	=	Rs.	150.00
2.	Cost of renewable top layer of sand of SSF 0.75 m^3 @ Rs.160/- per m^3	=	Rs.	120.00
3.	General maintenance of structure, plumbing etc. L. S. Rs. 50/- per month	=	Rs.	600.00
4.	Honorarium of the village caretaker Rs. 50/- per month	=	Rs.	600.00
5.	Cost of amortization (15 years @ 10% interest)	=	Rs.	3109.00
	O & M Cost per year	=	Rs.	4579.00
	O & M Cost per month	=	Rs.	381.58
	Water production Cost per 1000 Lt.	=	Rs.	1.39

9. *Low Cost River Water Treatment Plant at Belur, Howrah*

An experimental water treatment plant has been introduced at Belur, Dist. Howrah with the concept of large scale rural water supply system from traditional surface water source. An existing pond adjacent to the treatment plant site has been selected to be used for long storage of Ganga river water which flows close to the site also. Investigation of the quality of water reveals that the turbidity of Ganga water could be reduced extensively by providing adequate detention time in the existing pond. The initial long storage of raw water in the pond reduces turbidity.

The experimental plant consists of plant sedimentation, slow sand filtration, clear water reservoir and disinfection.

9.1 *Basic Information*

The plant has been designed for a population of 1500 to be supplied with 120 lpcd. The capacity of the treatment plant is 2,00,000 lt/day keeping additional 10% capacity for future need. The equivalent population based on rural water supply (40 lpcd) may be considered as 5,000.

In order to cope with the peak requirement and future demand the plant has been designed to treat 4,00,000 lts/day maximum.

9.2 *The Following Treatment Plant Units Have Been Constructed*

9.2.1 Inlet Channel

Raw water from the existing pond is pumped in the inlet channel @ 8.5 M^3/hr. Two pumps each of 8.5 m^3 /hr. capacity of 9 M. total head are kept (one working and one standby) at raw water pumping station. At the time of peak demand, both the pumps will work together for short duration as required. There is an arrangement of flow measurement at inlet with V-Notch Weir flow indicating device.

9.2.2 Settling Tank

Two settling tank each of 4 hours detention period have been provided and each is designed for a flow of 8.5 m3/hr. The settling tanks are constructed by providing earth embankment and brick flat pitching with cement pointing. Suitable inlet and outlet arrangements have been kept in the settling tanks with 0.6 M. walkway all round. The settling tanks remove suspended solids which escape out from pond. Normally one settling tank will work except during peak period when both the settling tanks shall work for short duration only. The settling tanks have also been provided with dewatering arrangement for periodical cleaning.

9.2.3 Slow Sand Filter

Two slow sand filters each of 8.5 m^3/hr. capacity having a surface area of 49.5 m^2 have been provided. The walls of the filters are of brick masonry and the floor slab has been kept as 2.3 M with free board of 0.3 M. of graded gravel and 0.9 M. of sand. The effective size of sand is 0.22 mm and uniformity coefficient is 2. The under-drainage channel running longitudinally along each filter has open jointed 80 mm dia. P.V.C. pipe shrouded with gravel packing. There is an arrangement of inlet controller-cum-rate setler so that the filtered water supply remain unchanged inspite of losses occurring in the filter bed. Suitable arrangements for isolation of each bed with top and bottom entry of settled water has been kept. Filters are capable of taking 20% overload and shall also cater for peak period load during short duration. Dewatering arrangement for emptying each slow sand filter has also been kept with pumping arrangement draining out into the pond.

9.2.4 Filtered Water Reservoir

An R.C.C. filtered water reservoir of 25 m^3 capacity (approx. 3 hours detention) has been provided with top cover slab. The reservoir can also be dewatered during maintenance along with slow sand filters. The reservoir is fitted with filtered rate controller as well as V-Notch.

9.2.5 Clear Water Pump House

2 Nos. clear water pumps each of 8.5 m^3/hr. capacity having a T.D.H. of 18 M. have been provided. The pumps are housed in an R.C.C. dry pit adjacent to filtered water reservoir. Suction/delivery pipes, special valves, etc. inside the pump house have been provided. For disinfection, bleaching powder solution tank and dosing equipment have been provided. Arrangement have been made for disinfection of stored water in the reservoir as well as in the delivery pipe line.

9.3 *Water Quality*

The Chemical and Bacteriological quality of treated water is as follows :

1. pH	:	7.3	–	7.4
2. E.C. (umhos/cm)	:	500	–	520
3. Turbidity (JTU Scale)	:	1.0	–	2.5
4. Alkalinity (mg/1) as $CaCO_3$	:	155	–	170
5. Chloride (mg/1) as Cl	:	30	–	35
6. Hardness (mg/1) as $CaCO_3$	:	155	–	160
7. Iron (mg/1) as Fe	:	Nil	–	0.09
8. Total Coliforms/100 ml	:	Nil		
9. Total Faecal coliforms/100 ml	:	Nil		

The Chemical and Bacteriological quality of raw (Ganga) water and pond water are presented below

			Raw Water			Pond Water		
1.	pH	:	7.3	–	7.4	7.3	–	7.4
2.	E.C. (umohs/cm)	:	540	–	580	520	–	540
3.	Turbidity (JTU)	:	50	–	600	10	–	20
4.	Alkalinity (mg/1) as $CaCO_3$	:	160	–	180	170	–	160
5.	Chloride (mg/1) as Cl	:	70	–	80	40	–	50
6.	Hardness (mg/1) as $CaCO_3$	:	160	–	170	160	–	150
7.	Iron (mg/1) as Fe	:	1.2	–	1.8	0.2	–	0.3
8.	Total Coliforms/100 ml	:	3500	–	4000	2500	–	3000
9.	Total Faecal coliforms/100 ml	:	2500	–	3500	2000	–	2500

9.4 Cost Analysis

No. of beneficiaries (present)	–	5000
No. of beneficiaries (future max) (Based on Rural Water Supply)	–	10000
Max. capacity of the expt. water treatment plant	–	400000 lt/day.

Capital cost

1.	Cost of construction of the plant	–	Rs.	3,35,000.00
2.	Inter - connection system	–	Rs.	50,000.00
3.	Electrical works	–	Rs.	15,000.00
			Rs.	4,00,000.00
	Capital cost investment/person	–	Rs.	40.00
	Capital cost investment /lt. capacity of the plant	·	Rs.	1.00

Operation and maintenance cost

(Based on yearly requirement)

1.	Cost of Bleaching powder 325 kg. @ Rs. 10/- per kg.	–	Rs.	3,250.00
2.	Cost of renewable top layer sand of SSF. 10 m^3 @ Rs. 150/- per m^3	–	Rs.	1,500.00
3.	General maintenance of the structure, equipment, plumbing etc. L.S.	–	Rs.	15,000.00
4.	Salary of the operators 3 No. X Rs. 500/- p.m. X 12 months	–	Rs.	18,000.00
5.	Electric bill	–	Rs.	46,000.00
6.	Cost of amortization (15 years @ 10% interest)	–	Rs.	48,000.00
	O & M Cost /Year	–	Rs.	1,31,750.00
	O & M Cost /month	–	Rs.	10,979.17
	Max. treatment capacity of the plant	–		400000 lt/day.
	Production cost per 1000 lt	–		0.91P

Cost Comparison

Surface water source :-

Cost of construction of 90 MLD water treatment plant	–	Rs.	1015 lakhs
Design population to be served	–		867000
Capital cost investment/person	–	Rs.	117.00
Capital cost investment/person/lt. capacity of the plant	–	Rs.	1.13

If economy of scale is considered, the capital investment for a conventional plant of equivalent size, would be more than Rs. 3.00.

O & M Cost

1.	Cost of chemical	–	Rs.	11500000.00
2.	Cost of chlorine	–	Rs.	1200000.00
3.	Cost of salary	–	Rs.	1800000.00
4.	General maintenance of the structure, equipment, pumping, media etc.	–	Rs.	2500000.00
5.	Electric bill	–	Rs.	10000000.00
6.	Cost of amortization	–	Rs.	12180000.00
			Rs.	39180000.00

Production cost per 1000 Lt.	–	Rs.	1,19

Cost Comparison

Ground water source :-

Population to be served	=	12500
Dia of deep tubewell	=	150 mm.
Depth	=	250 meter
No. of tube-well to be installed	=	2
Rate of pumping	=	50000 Lt/hr.
Supply of water	=	500000 Lt/day.

Cost of installation of 2 Nos. of tube-well including pump room construction, electrical works values etc complete	Rs.	600000.00
Capital cost investment/person	Rs.	48.00
Capital cost investment/Lt. capacity of the plant	Rs.	1.20

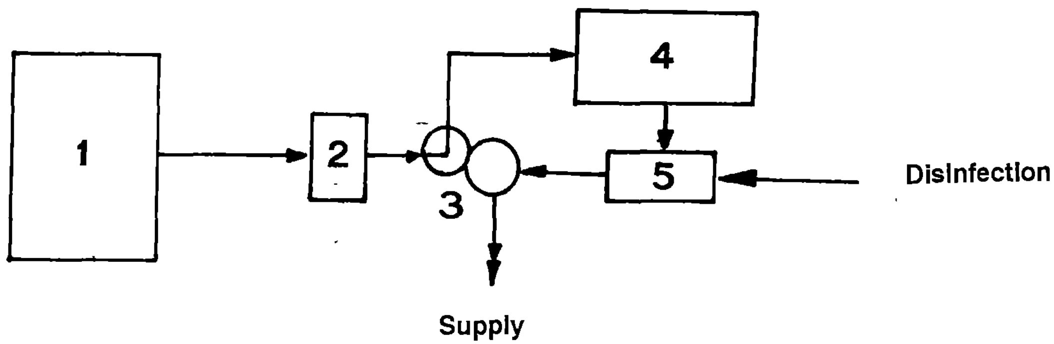
In case, iron-removal plant is required capital investment would be much higher.

O & M Cost

1.	Electricity charge	–	Rs.	50000.00
2.	Yearly general maintenance cost	–	Rs.	10000.00
3.	Salary of O & M Staff	–	Rs.	48000.00
4.	Amortization	–	Rs.	72000.00
5.	Cost of bleaching powder	–	Rs.	3600.00
			Rs.	183600.00

Supply of water	=	500000 Lt/day.
Production cost per 1000 Lt.	=	Rs. 1.00

Treatment Process Diagram



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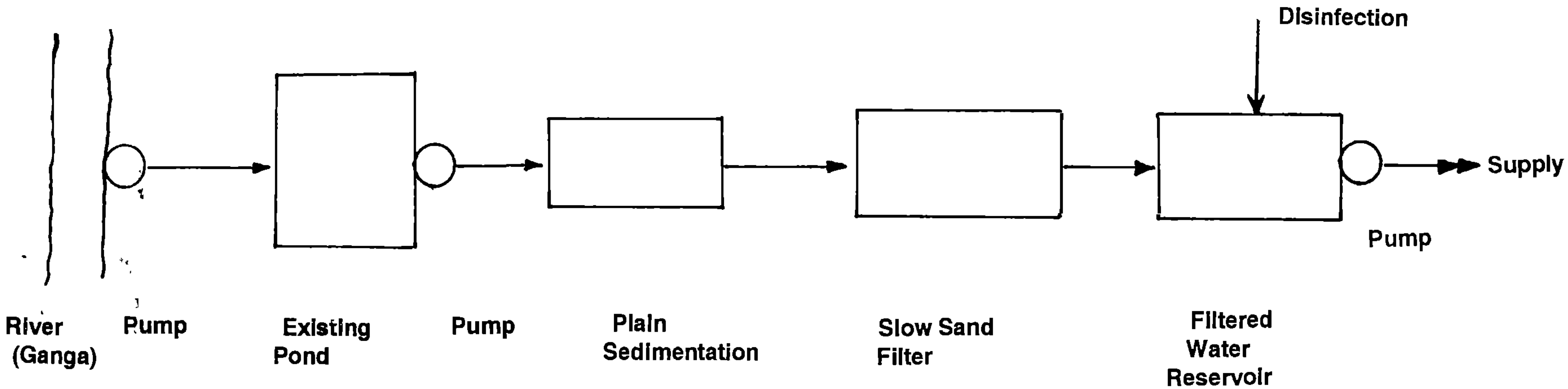
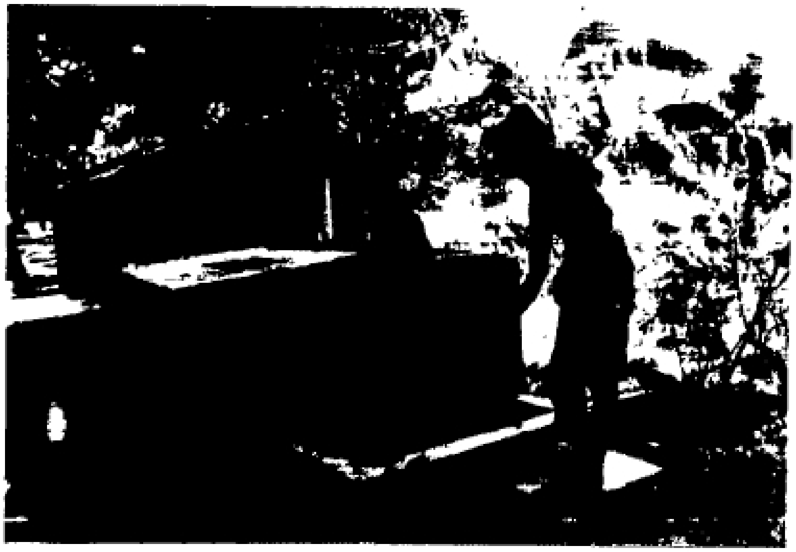
1. Existing Pond
2. Inlet Chamber
3. Double Action Single Operation Handpump
4. Slow Sand Filter
5. Outlet Chamber

Slow Sand Filter With Double Action Single Operation (DASO) Handpump at Singur, Hooghly

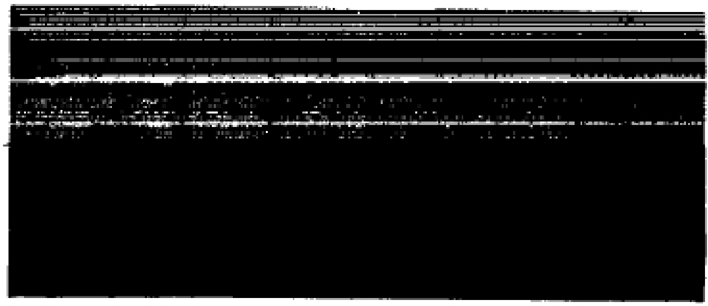
Treatment Process Diagram (Fig 2)



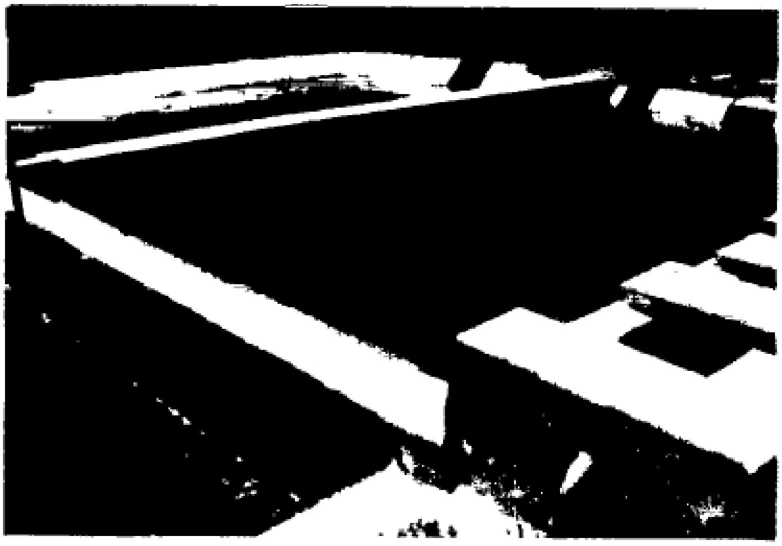
EXPERIMENTAL RIVER WATER TREATMENT PLANT AT BELUR, HOWRAH



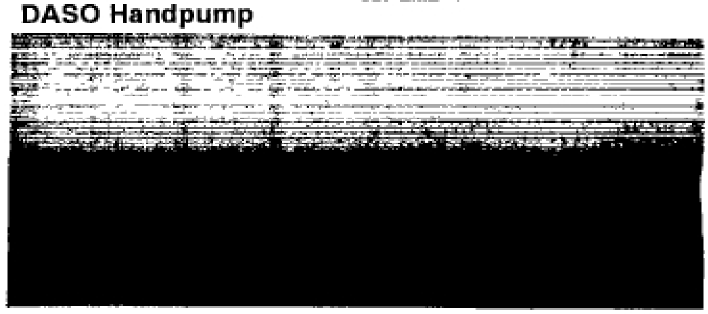
Slow Sand Filter with Double Action Single Operation (DASO) Handpump at Singur, Hooghly

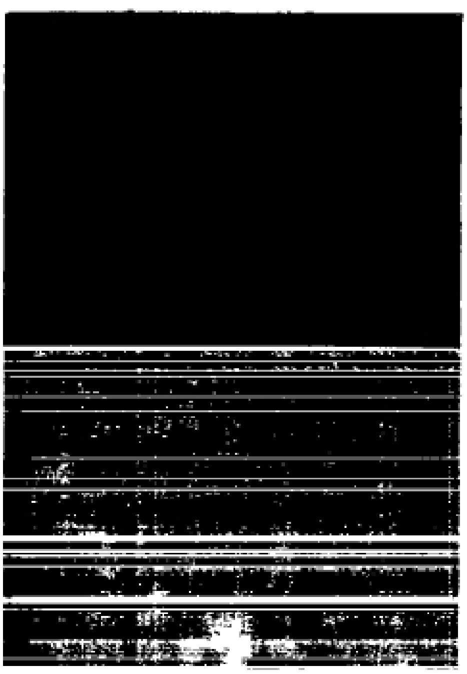


DASO Handpump

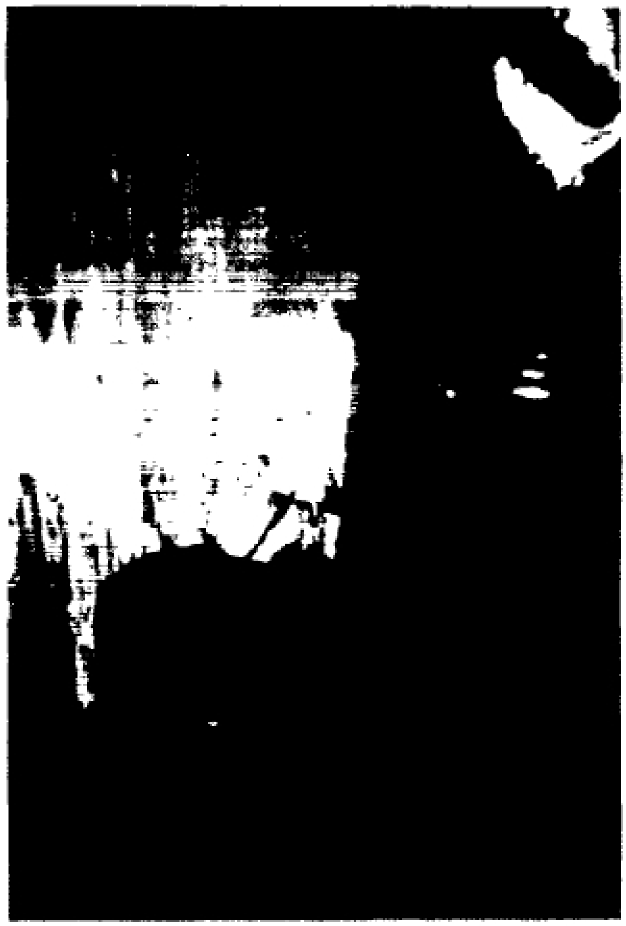


River Water Treatment Plant at Belur, Howrah





Settling tank and SSF at Belur, Howrah



Household treatment of water froın traditional surface water sources

10. *Study On Household Treatment Of Water From Traditional Surface Water Sources (Ponds/Rivers)*

10.1 Model Study In The Laboratory

Under the present project pilot scale study has been done for household water purification units. The laboratory set up model is presented. In Unit-A, pond water was stored. Alum as coagulant and lime for pH adjustment was then added for flocculation with thorough mixing. The sedimentation was then allowed for overnight settling. The effluent from the Unit-A was then filtered in Unit-B at a rate of 300 ml/min. (144 lt/hr/sq.m). The filtration rate was adjusted according to design filtration rate of slow sand filtration. The filter media was cleaned by backwashing which was done by raising the Unit-C. Bleaching powder solution was then added in the bucket which collected filtered water from Unit-C.

Filtration rate was increased in order to monitor its functioning. It was found that increase of filtration rate did not have significant impact on water quality. However, higher filtration rates in such type of instalments are not applicable.

The filter runs were dependent on the quantity of water filtered. The filter was cleaned when the same unit treated at least 3600 lts/day/sq.m. As a matter of fact, during the laboratory scale study backwashing method of cleaning was adopted at an interval of every fortnight.

Alum was used as a coagulant and jar test was carried out to determine the dosage. Following table depicts the alum dosage for various turbidity in raw water.

Alum Dosage

Raw Water Turbidity (JTU)	* Alum dose (mg/1)
45 - 60	105
61 - 100	160
101 - 150	210
151 - 200	265

* 25% pure

Control of pH by addition of lime was necessary when raw water pH was found in the range of 7.0 to 7.4. However at lower turbidity when the raw water pH was greater than 7.5 controlling of pH by addition of lime may not be required.

Water quality analysis was carried out in the Sanitary Engineering Department Laboratory regularly. Raw water and treated water quality for river and pond water are presented below.

River Water and Treated Water Quality

Parameters		River Water	Treated Water
1.	pH	7.3	7.22.
2.	EC (u mhos/cm)	520	510
3.	Turbidity (JTU)	90	2.5
4.	Alkalinity (mg/1) as $CaCO_3$	170	154
5.	Chloride (mg/1) as Cl.	74	72
6.	Hardness (mg/1) as $CaCO_3$	166	160
7.	Iron (mg/1) as Fe	1.0	0.1
8.	Total coliform/100 ml	4200	Nil *
9.	Faecal Coliform/100 ml	2800	Nil *

* After Chlorination. minimum quantity of total and faecal coliforms were 65 and 35/100 ml respectively in the treated water.

Pond Water and Treated Water Quality

Parameters		Pond Water	Treated Water
1.	pH	7.7	7.3
2.	EC (u mhos/cm)	380	370
3.	Turbidity (JTU)	50	3
4.	Alkalinity (mg/1) as $CaCO_3$	155	142
5.	Chloride (mg/1) as Cl.	64	62
6.	Hardness (mg/1) as $CaCO_3$	163	158
7.	Iron (mg/1) as Fe.	0.8	0.1
8.	Total Coliform/100 ml	2800	Nil *
9.	Faecal Coliform/100 ml	1600	Nil *

* After Chlorination. minimum quantity of faecal and total coliforms were 55 and 25/100 ml respectively in the treated water.

Laboratory study indicated that solids which are arrested at the top layer of sand media can not penetrate inside the media due to low rate of filtration. Accordingly method of scrapping and washing of top layer of sand media (2 cm) was also adopted for Unit -B. This method of cleaning would provide at least 3 to 4 weeks of filter run if used for single family.

10.2 Field Study

On the basis of findings of laboratory scale study, pilot model purification units were introduced in the village at Mandra, Mandra Unnayan Samsad provided necessary support in conducting the study in the field. Baseline data collection. KAP survey, health and nutritional study were also conducted before the commencement of the field model study. The findings of such studies have been presented in earlier para.

Following two types of household models were introduced in Mandra village.

(a) Coagulation - flocculation Sedimentation - Filtration Disinfection technique (SFD)

(b) Coagulation - flocculation Sedimentation - Disinfection technique (SD)

The criteria for selection of above two techniques are as follows :-

(a) Available turbidity of pond water.

(b) Upgradation of quality of pond water for drinking and cooking.

(c) Upgradation of quality of pond water for domestic purposes except drinking.

In order to upgrade the quality of water for drinking, field model purification units were introduced similar to laboratory model. The volume of the coagulation - flocculation - sedimentation tank (Unit -A) was 100 Lts. The opening of the tank was kept at an height 0.4H from the bottom so that at least 60 Lt. of water could be clarified from the tank.

Unit-B consists of a sand filter having 30 cm thick sand media over 15 cm thick gravel. There was a provision of constant water head of 30 cm above the sand media. The effective size of sand was 0.2 mm and uniformity coefficient was 2.5. The rate of filtration was adjusted at 600 ml/min. with the rate of filtration as 290 lt/hr/sq.m.

The operation of the model units were practised by the women members of the family. The workers were trained properly for operation and maintenance.

Initially pond water was carried by the women and stored in Unit A. After screening through clean cloth. Alum and lime packets were supplied separately for each operation of treatment of 100 Lts. of water. The alum and lime was then added in 100 Lts. of water and stirred for 60 secs rapidly and next 10 minutes slowly by a wooden spatula. The flocs thus formed were allowed to settle for a minimum period of one hour. However in some cases the flocs were allowed to settle overnight.

60% of clarified water (60 Lt) was then filtered through Unit-B and allowed to be collected in Unit -C. Bleaching powder packet which was also supplied earlier was then added in solution. A 30 minutes time was allowed further for complete disinfection. The treated water on analysis was found to be upgraded satisfactorily and conformed to drinking water quality standards. The whole operation to treat 60 Lts. of water will take approximately 2 hours time.

A summary of water quality analysis results for pond water and treated water from SFD Unit are presented below ;

Water Quality - Performance of SFD Unit in field.

Parameter		Raw Water (Pond)	Treated Water (SFD)
1.	EC (umohs/cm)	850 - 1050	780 - 890
2.	pH	7.5 - 7.9	7.4 - 7.6
3.	Turbidity (JTU)	50 - 60	3 - 5
4.	Alkalinity (mg/1) as $CaCO_3$	230 - 250	210 - 225
5.	Chloride (mg/1) as Cl.	110 -120	100 - 115
6.	Hardness (mg/1) as $CaCO_3$	195 -210	185 - 205
7.	Iron (mg/1) as Fe.	0.85	0.1 - 0.2
8.	Total Coliform/100 ml	3500	Nil *
9.	Faecal Coliform/100 ml	1800	Nil *

* After chlorination a minimum of total coliform/100 ml and faecal coliform/100 ml as 180/100 ml and 25/100 ml were detected.

SD unit (Coagulation - Flocculation - Sedimentation - Disinfection) for upgradation of pond water quality for use in domestic activities except drinking was installed also. The units were provided with an aim to distribute safe water derived from pond for use in domestic work e.g. washing of clothes, utensils etc.

The unit consisted of a circular drum of volume of 150 Lts. with a tap fitted at 0.4 H from the bottom of the drum.

The drum was filled with pond water by women after screening through clean cloth. Alum, lime and bleaching powder which was earlier supplied in packet for each operation was added. It was then stirred rapidly for 60 secs and then stirred for 10 minutes with the help of a wooden spatula. The floc thus formed was allowed to be settled overnight. The supernatant from top was collected and used for domestic purposes. The sediments then allowed to be washed out through waste water tap. The above operation, however, may be carried out twice a day by a family. The unit provided 90 Lits. of treated water in each operation. Minimum settling time of one hour was required in the drum.

The SD Unit during operation reduced the turbidity considerably. The turbidity analysis results are presented below.

Removal of Turbidity (JTU) By SD Units.

Raw water (Pond)	Treated Water (SD Unit)
30	7
40	7
50	8
60	8.5
70	10

10.3 Cost Analysis

The cost of household purification unit would be as follows :

Material	SFD Unit	SD Unit
1. Galvanised Iron	1000/-	400/-
2. Plastic	750/-	275/-
3. Earthen	–	100/-

The operational costs for SFD unit and SD Units are 15P/100 Lt and 10P/100 Lt respectively.

10.4 Mass Awareness Camp

A mass awareness camp was organised in collaboration with the NGO (Mandra Unnayan Samsad) to educate villagers on various health aspects of water supply and sanitation, sanitary protection of surface water sources, use of safe water and operation and maintenance of water supply system, and particularly about domestic storage and package purification unit. Villagers participated in the mass awareness camp with open heart and 100% supported the programme initiated under the study. The use of the package water treatment plant, developed for house use was demonstrated; the same was by and large appreciated. A majority of people however opined that the Govt. should provide subsidy to make these available at a cheaper price to the villagers.

10.5 Salient Findings

i) Performance monitoring results indicated that the household purification units are capable of reducing turbidity and bacteriological contamination from pond water. It is possible to produce safe water through such units for use in domestic purposes when operated effectively.

ii) The household units would work effectively for surface water with turbidity not greater than 70 JTU.

iii) Chlorination is essential for production of safe water through household purification units.

iv) The cost of household purification are considered to be high according to the beneficiaries except for SD unit of earthenware. A majority of people, however, opined that the Government should provide subsidy to make these available at a cheaper price to the villagers.

v) As there remains a general tendency of the villagers to use unsafe surface water for domestic purposes provision of household water purification unit for upgradation of surface water is quite justified.

vi) Villagers expressed their desire to use household purification units and participated actively in the programme.

vii) Chemicals in required quantity for each operation of the units are to be supplied by NGO/village caretaker.

viii) Sanitary protection of surface water sources are essential against point and non-point sources of pollution.

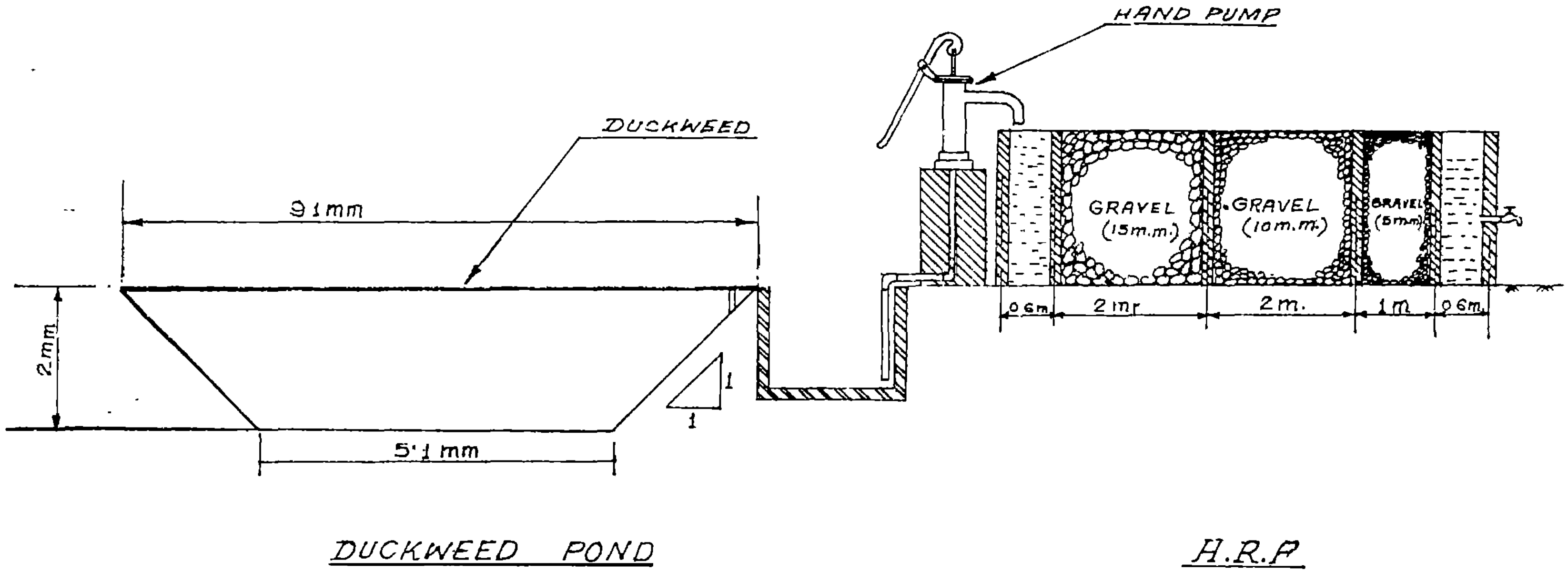
ix) Role of women are very much important for the success of such units and accordingly women are to be motivated initially by holding mass awareness camps.

x) A minimum space of 1.2 m x 1.2 m is required in the household for installation of such unit.

11. Application Of HRF In Waste Water Treatment :

As conventional waste water treatment system cannot remove faecal coliform significantly, it has now become essential to use maturation pond for providing bacteria to die away in that system so as to utilise treated effluent for sewage farming. An HRF has strong potentiality to serve the purpose.

Presently, the Sanitary Engineering Department of All India Institute of Hygiene & Public Health is studying the performance of Duckweed pond for treatment of municipal sewage. The study so far indicated that the performance of Duckweed pond which works as an anaerobic waste stabilisation pond, is excellent. It is now being considered by the Scientists/Engineers of All India Institute of Hygiene and Public Health, to utilise HRF at the end of the Duckweed pond so as to upgrade the bacteriological quality of the effluent for further utilisation in sewage farming.



SCHEMATIC DIAGRAM FOR TREATMENT OF DOMESTIC WASTE WATER BY DUCKWEED POND AND UPGRADATION OF BACTERIOLOGICAL QUALITY OF TREATED EFFLUENT BY HORIZONTAL ROUGHING FILTER

A pilot Duckweed pond of size 9.1 m x 9.1 m x 2 m with 1.1 side slope has been constructed to treat 13 m^3/day of domestic sewage with 10 days detention time. It is proposed that the HRF would work at 550 Lt/hr/m^2 loading rate. As such, 1 m^2 cross-sectional area for HRF would be required. The length of HRF of 5 meter in three compartments with 15 mm, 10 mm and 5 mm gravel size would serve the purpose. The size of HRF in that case would be 5 m(L) x 1m (W) x1 m(H).

12. *Conclusion*

a. Conservation and utilisation of traditional surface water sources by using low cost and simple treatment models has a tremendous potential in areas where conventional water supply systems like tubewell fitted with handpump or powerpumps, or wells fitted with powerpumps are difficult to install or are very expensive. For instance where suitable groundwater is overlaid by a rocky terrain thereby necessitating expensive drilling or where salinity or high flouride contents render the groundwater unsuitable, traditional water from large ponds or rivers or canals can be utilised to solve the drinking and domestic water supply problems. In such areas simple and low cost models of in situ treatment process as developed in Mandra or Singur are quite suitable. Many ponds are available in flat terrains of rural India, the perennial ones of which could be utilised for the purpose. Again the villages near a river or a canal may be supplied with water by installing small units of under situ upflow filter in the river beds at suitable intervals of distances along the river/canal. Both types of the models would be much more cost effective than the conventional expensive water supply systems.

b. For larger population congregation, as in peri-urban regions near a river the low cost full fledged treatment models as installed in Belur could be more cost effective than conventional full fledged treatment units.

c. The utilisation of traditional water as a complementary water supply system has also a great potential. Inspite of having tubewells the villagers have an affinity for pond water for domestic use other than drinking. If a small treatment model is installed adjacent to a pond, the villager who come to the pond, would utilise cleaner water for washing utensils or clothings or even bathing, yet would not face problems of hardness or iron of tubewell water. Disease communication links are expected to be vastly reduced particularly when washing of utensils is carried out regularly with this treated water. In a way, the villagers would be satisfied that they are using the natural traditional water.

d. It is felt that the current project is nothing but a beginning and some more models are required to be developed and studied in details. Appropriate models are required to be developed for drought prone areas, if possible. Therefore, more intensive investigations with pilot studies are required to be undertaken.

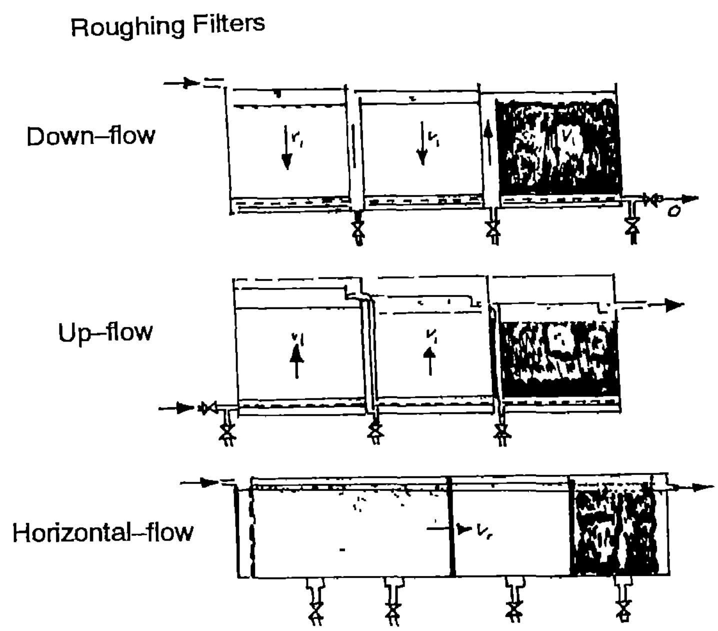
1. The decade of roughing filters - development of a rural water treatment process for developing countries.

Abstract:

Slow sand filtration applied as surface water treatment is particularly effective in improving the bacteriological water quality. However, efficient application of the treatment process requires water of low turbidity, hence pre-treatment of the surface water is usually necessary. Chemical flocculation combined with sedimentation is often inapplicable, because rural water supplies in developing countries generally face serious operational problems with chemical water treatment. Pre-filtration is a simple and efficient alternative treatment process. This paper presents the concept, field experience and promotion of HRF as a viable pre-treatment process. Roughing filters combined with slow sand filters present a reliable and sustainable treatment process, particularly appropriate for developing countries.

Roughing Filters:

Roughing filters are designed to treat surface water of high turbidity. The filter medium of roughing filters is composed of coarse (rough) material, usually gravel, ranging from 25 mm to 4



Fig–1 Layout of Roughing Filters

mm in size, installed in layers of different fractions. The water is filtered by a sequence of normally three filter fractions. Roughing filters are further sub-divided into down-, up- and horizontal flow filters (Fig. 1).

Horizontal-flow roughing filters process a much greater filter length and can handle short turbidity peaks (500 - 1000 NTU) in comparison to other roughing filter types.

HRF Technology :

HRF has received a great attention than any other pre-filtration technique as it proved to be worthy through laboratory researches and field tests. A world-wide dissemination of the horizontal-flow roughing filtration was possible due to strong involvement of IRCWD in the development and promotion of the HRF technology, since 1982.

HRF Design :

The main features of HRF are illustrated in Fig. 2. HRFs have the simplest layout of all roughing filters. The raw water runs from the inlet compartment in horizontal direction through a series of differently graded filter material seperated by perforated walls. The water level in the filter is controlled by an outlet pipe and is kept beneath the filter surface to prevent algal growth.

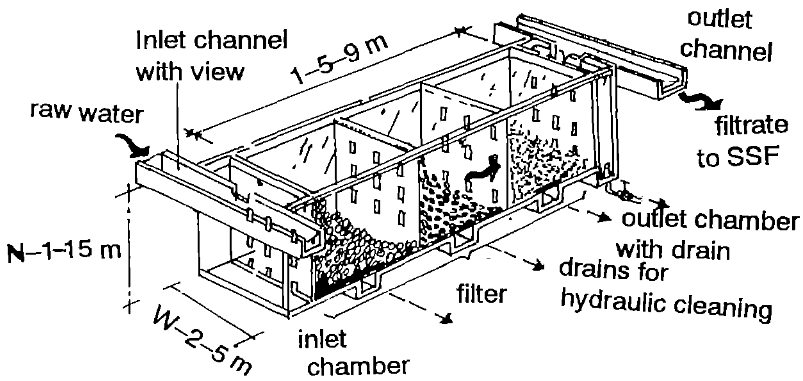


Fig 2 :- Main features of a Horizontal-Flow Roughing Filter (HRF)

The shallow filter box eases the construction of HRFs, which do not require mechanical equipment for their operation and therefore its operation and maintenance is possible at village level.

HRF Development :

The first known horizontal-flow gravel filter used in a public water supply was constructed by John Gibb at Paisley, Scotland in 1804. The treatment plant consisted of three concentric rings arranged around central tank. Later, Down-flow roughing filters were used as pre-treatment in Europe.

As time passed, the roughing filters were converted virtually into rapid or mechanical filters. Coagulation in conjunction with sedimentation and, more recently, with direct filtration replaced the pre-filter technology. In the early 1960s, the water works of Dortmund (Germany) constructed HRF for an artificial ground water recharge plant. Water works in Aesch (Switzerland) and Graz (Austria) followed the example of Dortmund with modified designs. Salient data of such plants are given in Table-1.

Table 1. Examples of roughing filters in artificial groundwater recharge plants

Plant	Country	River	Suspended solids (mg/1) Mean	Max.	Filter length (m)	Filtration rate(m/h)
Dortmund	W.Germany	Ruhr	8	20	50-70	10
Aesch	Switzerland	Birs	7	40	15	5-8
Graz	Austria	Andritzbach	5	20	10	4-14

Field Experience (A Case Study):

The treatment plant of La Javeriana in Cali, Colombia consists of an intake filter, two HRF and two SSF units. The respective filtration rates amount to 4.7, 1.2 and 0.15 m/h. The plant has a capacity of 260 m3/day. The variation of the different water quality parameters and their respective reduction by the different stages is summarized in Table-2.

Table 2. Water-quality improvement by the different treatment stages for the treatment plant La Javerlana, Call [18] (Number of samples = 24–26 ; suspended solid concentration and apparent colour recorded with HACH test kit DREL 5)

	Raw water	Intake filter	Effluent of HRF	SSF
Turbidity (NTU)	22–17.2	12–9.5	4.4–3.0	2.6–1.9
Suspended solids (mg/1)	49–41	27–19	11–7	7.5–4.9
Apparent colour (CU)	132–113	79–53	34–20	22–17
Faecal coliforms (100 ml)	4800–2400	2400–1600	295–300	3.9–6.6

The gradual reduction of turbidity, apparent colour and faecal coliforms through the different treatment stages are illustrated in Fig 3. The gradual improvement of these three parameters indicates that there is a development of biochemical processes in different filters.

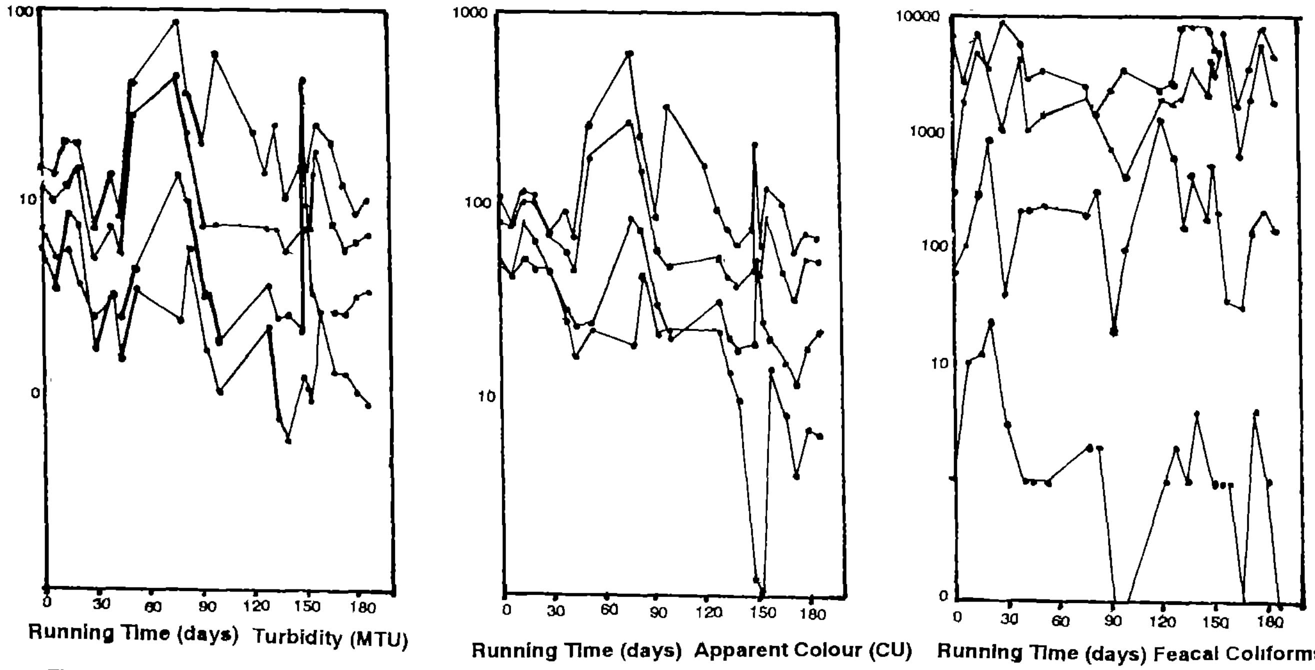


Fig. 3. Reduction in turbidity apparent colour and faecal Coliforms by the different treatment stages at La Javeriana Treatment Plant

Limitations of HRF Technology :

— HRF treatment process requires relatively a large installation and can therefore hardly be applied in large urban water-supply schemes. So, it has to be predominantly designed for rural water supplies.

— HRFs operate at relatively small filtration rates asking for large installations.

— Again, large installations consequently higher the specific construction costs per m^3 design capacity.

— The initial cost of HRF construction is higher than those required for the construction of flocculation/sedimentation tanks. However, the operation and maintenance cost is lower for the HRF.

— Filter regeneration by fast drainage is not yet fully explored.

HRF Promotion :

In 1986, the IRCWD-managed HRF project has entered in its last phase, which involved the promotion and dissemination of the HRF technology. This technology has spread to more than 20 countries in the past four years (Fig.4). According to IRCWD, over 60 HRF plants have been constructed during this period. However, new approaches and designs developed by the local engineers were collected by IRCWD and the information were passed on to other cooperation partners through the HRF Filter Newsletter.

One of such treatment schemes is illustrated in Fig.5. Twenty liters of gravel and ten litres of sand used as filter material are able to transform contaminated turbid surface water into 30 litres of quality drinking water. Thus, such plants can be a benefit for those who are still lacking a safe and reliable water supply.

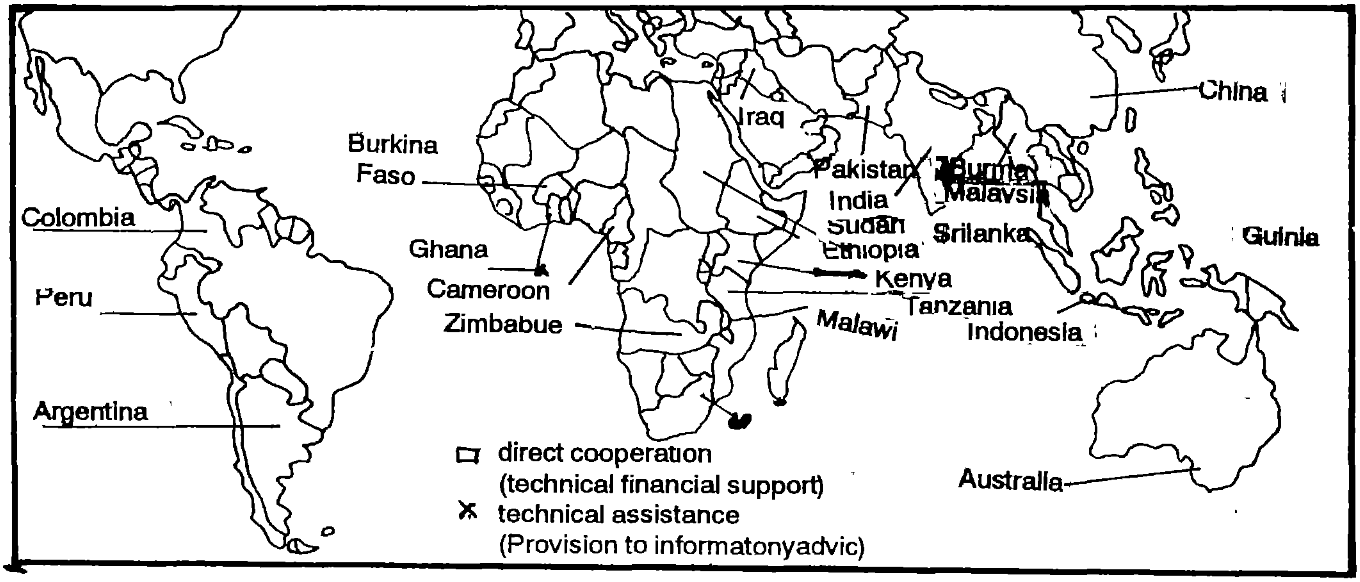


Fig.4 Geographical distribution of the HRF demonstration project.

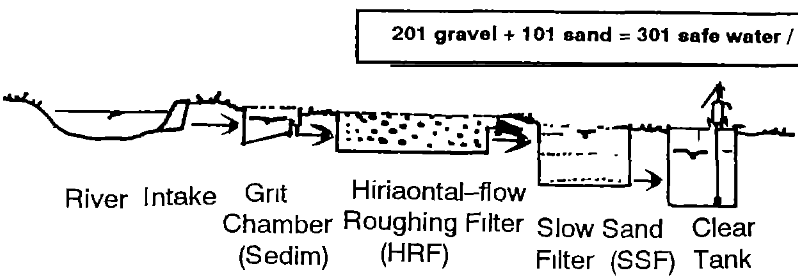


Fig.5 Scheme of a self-reliant water treatment plant

by :
M. Wegelin, R. Schertenleib and M. Boller.

2. Institutional And Organisational Aspects In The Implementation Of A Self-help Water Supply Project.

The case of Maji Kumase/Ghana

Introduction:

In developing countries, rural water supply schemes are still a complex issue as very often they are found to be collapsed just after a few years of commissioning due to lack of community participation. To overcome this problem one must involve the project beneficiaries and consider seriously the mass-awareness level, their willingness to accept the project, their economic standard, tradition and priorities and their unity and communal spirit.

Mafi Kumase self-help community water supply is one of the successful community based-projects in Ghana, which has a 7 Km. distribution network and is provided with SSF/HRF treatment technology. The project was initiated and implemented when the Town Development Committee (TDC) and the Youth Association (MA KAYA) felt, in 1986, that the Government would not help much regarding supply of safe water. The community had a high rate of guinea worm infection but within 4 years, the mentioned project has contributed to the successful eradication of guinea worm in the community.

Design:

The design phase began with the involvement of the community in providing reliable data and information as the basis for the project design. Technical cooperation provided basis for project implementation. The design data are furnished in Table-I.

The construction was undertaken in 2 stages. In Stage 1, the treatment plant was constructed at the end of which there was a drive for public collection. Training and selection of Caretakers nominated by each village was also a part of this stage.

In Stage 2, the reservoir and distribution lines were constructed. (Fig.1)

Financing :

The financial support for the project was provided by Caritas Switzerland, the Protestant Church Association, Swiss Development Corporation and some Swiss individual sympathizers in addition to local financing.

Benefits :

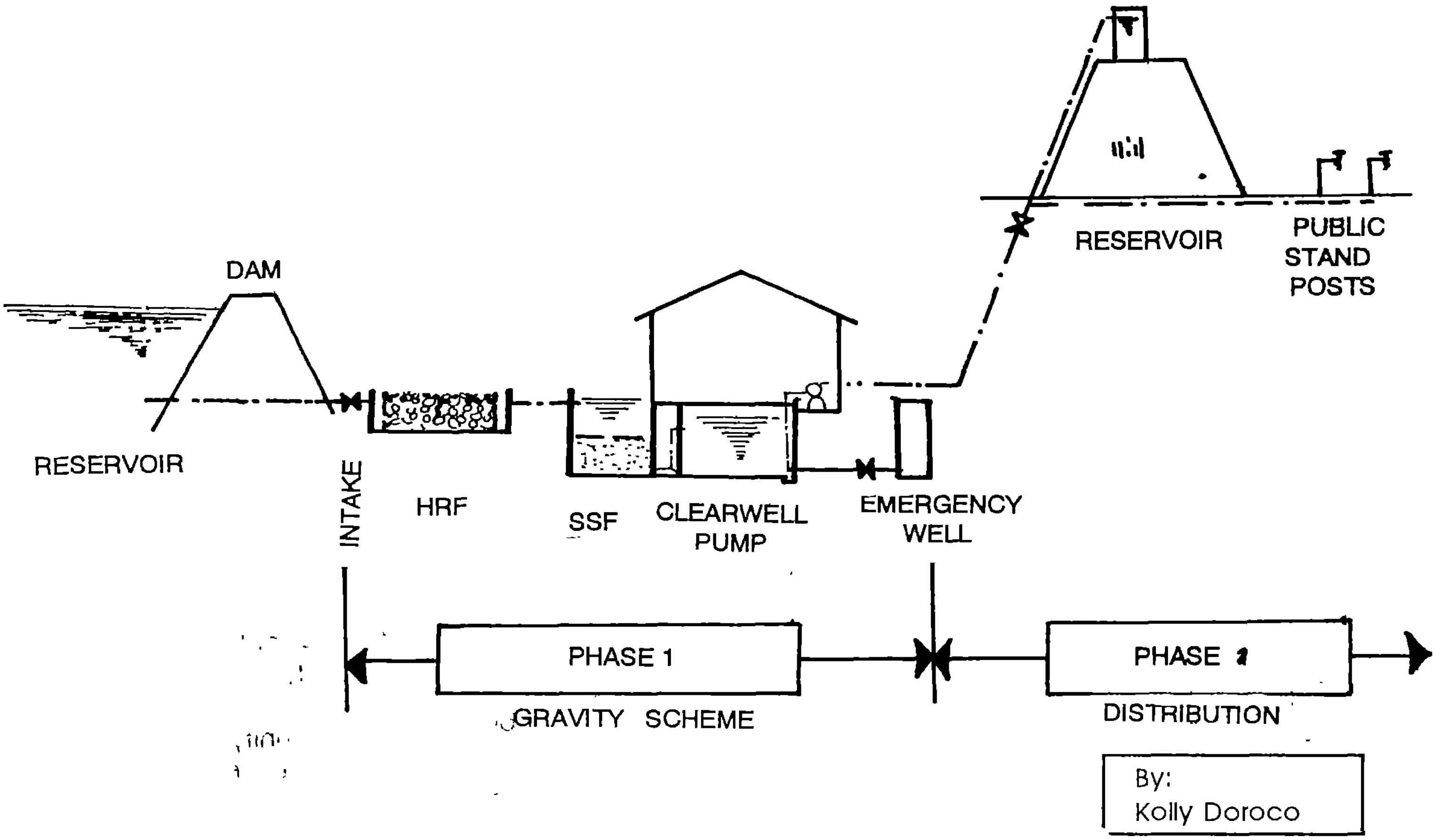
The benefits of the project included guinea worm eradication, economic benefits like small-scale stone cracking industries and some social benefits due to close relationship of the people which developed during sharing of responsibilities for running of the project in the community.

Finally, the use of simple engineering concepts (HRF/SSF Technology) combined with community involvement has led to great health and economic benefits to improve the quality of the life of the poor rural people who are often the forgotten in the developing countries.

TABLE — 1

MAFI KUMASE WATER SUPPLY SYSTEM

Population	:	3,500
Raw Water Source	:	Reservoir (Dam embankment)
Design Capacity	:	75 m3 / day
Raw Water Quality	:	Turbidity 50 - 100 NTU
Source pollution	:	Guinea worm, Bilharzia and diarrhoeal diseases prevalent
Filtration rate	:	HRF V = 1.0 m/h
		SSF V = 0.2 m/h
Pumping Head	:	45m, alternating electro driven pumps



3. The Treatment And Operational Performance of Roughing Filters In Tanzania.

Abstract :

In this paper, the treatment and operational performances of three full-scale Horizontal-flow Roughing Filter plants and extrapolated data from one pilot plant in Tanzania are described. The studies reported were conducted by the University of Dar-es-Salaam between 1989 and 1991. Mean apparent colour, turbidity and faecal coliform removals of 77 - 28%, 60 - 40% and 97 - 66%, respectively were observed. With the exception of the intermittently operated HRF unit, the performance compares favourably with data reported from elsewhere in the literature. The studies showed that socio-economic and technical factors associated with attitudes, revenue collection mechanisms, health education, awareness of up-to-date guidelines and the general motivation status of the caretakers and important factors in ensuring successful operation and maintenance of HRF plants.

Introduction :

In Tanzania, to date, the application of Roughing Filters (RF) and specifically Horizontal Roughing Filters (HRF) is still confined to rural (small scale) plants. Big rural water supply schemes provided with slow sand filters (SSF) without any form of pre-treatment are yet to adopt the bio-physical system of Roughing Filters.

A study conducted by the University of Dar-es-Salaam (UDSM) on the quality of surface water in Tanzania indicated that the majority would need pre-treatment prior to slow sand filtration and later it was established by the UDSM that RF represent the most reliable option. However both the HRF and the Downflow Roughing Filters (DRF) were found to be equally well. Now, three HRF/SSF plants have been constructed in Tanzania (Fig. 1).

Design :

Table-1 gives a complete summary of the main design features of both the HRF and SSF units of the three main drinking water treatment plants under discussion.

Treatment Performance :

The treatment performance of the HRF units of the three working plants in Tanzania were compared on the basis of the two to three months of data collection done at each plant.

The results of treatment performance based on turbidity, apparent colour and faecal coliform were —

- The mean turbidity removal of the HRF unit was in the range of 60–40%.
- The mean apparent colour removal of HRF observed was in the range of 77–28%.
- The mean bacteriological quality removal of HRF observed lies in the range of 97–66%.

The data for the three working plants and one pilot plant are presented in Table-1 & 2.

Thus, the treatment performance of HRF plants has been proven to be good even under intermittent operational conditions. While the physical removal of impurities in HRF is good, the improvement of bacteriological quality has been found to be exemplary in most cases.

Proper design of the under-drainage systems of HRF is necessary in order to ensure that no chance of short-circuiting is allowed.

Therefore, one can safely apply HRF as a sole filtration unit in rural areas of developing countries to get safe water.

Table 1. The Main Characteristics of the HRF / SSF Treatment Plants.

FEATURE	KASOTE	MLANGALI	TAGAMENDA
1. Location	. 80 Km from Sumbawanga town.	. 40 km from Municipality of Mbeya	. Within the periphery of of Iringa Municipality
2. Ownership	. Villagers of Kasote	. Villagers of Mlangali 1989	. TANESCO (Private)
3. Commissioned	. 1985	. 1989	. 1984
4. Funding	. NORAD / Tanzania Govt.	. DANIDA / Tanzania Govt	. TANESCO
5. Water Source	. River Kapondwe	. River Msimbizi	. River Little Ruaha.
6. Design Capacity (m^3/d)	. 150.6 (2001)	. 86.4 (2004)	. 51.1 (2002)
7. Operation mode	. Continuous (hydram)	. Continuous (Gravity)	. Declining rate (Pumped)
8. Number of Units	. 2 HRF and 2 SSF	. 2 HRF and 2 SSF	. 1 HRF and 1 SSF
9. HRF media length (m)	. 12.0	. 9.0	. 7.95
10. Coarse, medium and fine media diameter (mm)	. (32–16), (16–8) & (8–4)	. (25–15), (15–7) & (6–4)	. (50–30), (30–15) & (15–1)
11. Design HRF rate (m/h)	. 1.0	. 1.0	. $<$ 2.0
12. HRF underdrainage system	. Perforated pipes	. Perforated pipes	. None
13. Design SSF rate (m/h)	. 0.2	. 0.1	. $<$ 0.2
14. SSF media d_{eff}	. 0.25	. 0.25	. 0.20

Table 2 : Treatment Performance

	Plant	Parameter	Mean/Average HRF Inlet	Mean/Average HRF Outlet	% Removal	Remarks
1.	Kasote	. Turbidity (JTU)	50 (300–5)	< 5* (7.5–5)	—	* < 5 JTU, Not detectable
		. Apparent Colour (mg. Pt./1)	9.2 (20–5)	5.4 (10–5)	41.3	—
		. Faecal Coliforms	175 (260–85)	7** (27–2)	96	** Excluding 24/02/80 data
2.	Tagamenda (After Rehabilitation)	. Turbidity (NTU)	45.4 (78–25)	26.9 (52–9)	40.7	—
		. Apparent Colour (mg.pt/1)	134* (> 150–125)	97 (150–80)	27.6	* Assume that > 150 = 175
		. Faecal Coliforms (No./100 ml)	640 (3300–150)	215 (760–20)	66.4	—
3.	Mlangali	. Turbidity (NTU)	230 (780–43) *	103 (330–17)	55	14.2.91, Intake after rain = 2690 NTU
		. Apparent Colour (mg. Pt./1)	189.2 (400–25)	66.2 (250–15)	65	—
		. Faecal coliforms (No/100 ml)	1144 (8200–30)	149 (580–0)	87	—
4.	Wanging'ombe HRF pilot (Extrapolated to full scale)	. Turbidity (NTU)	41.7 (170–2)	16.7 (127–2)	60	—
		. Apparent colour (mg. pt./1)	69.6 (> 150–35)	16.3 (41–2)	77	—
		. Faecal Coliforms (No./100 ml)	79 (280–1)	2 (8–0)	97	—

Note : Figure in brackets (a – b) = Ranged from "a" to "b"

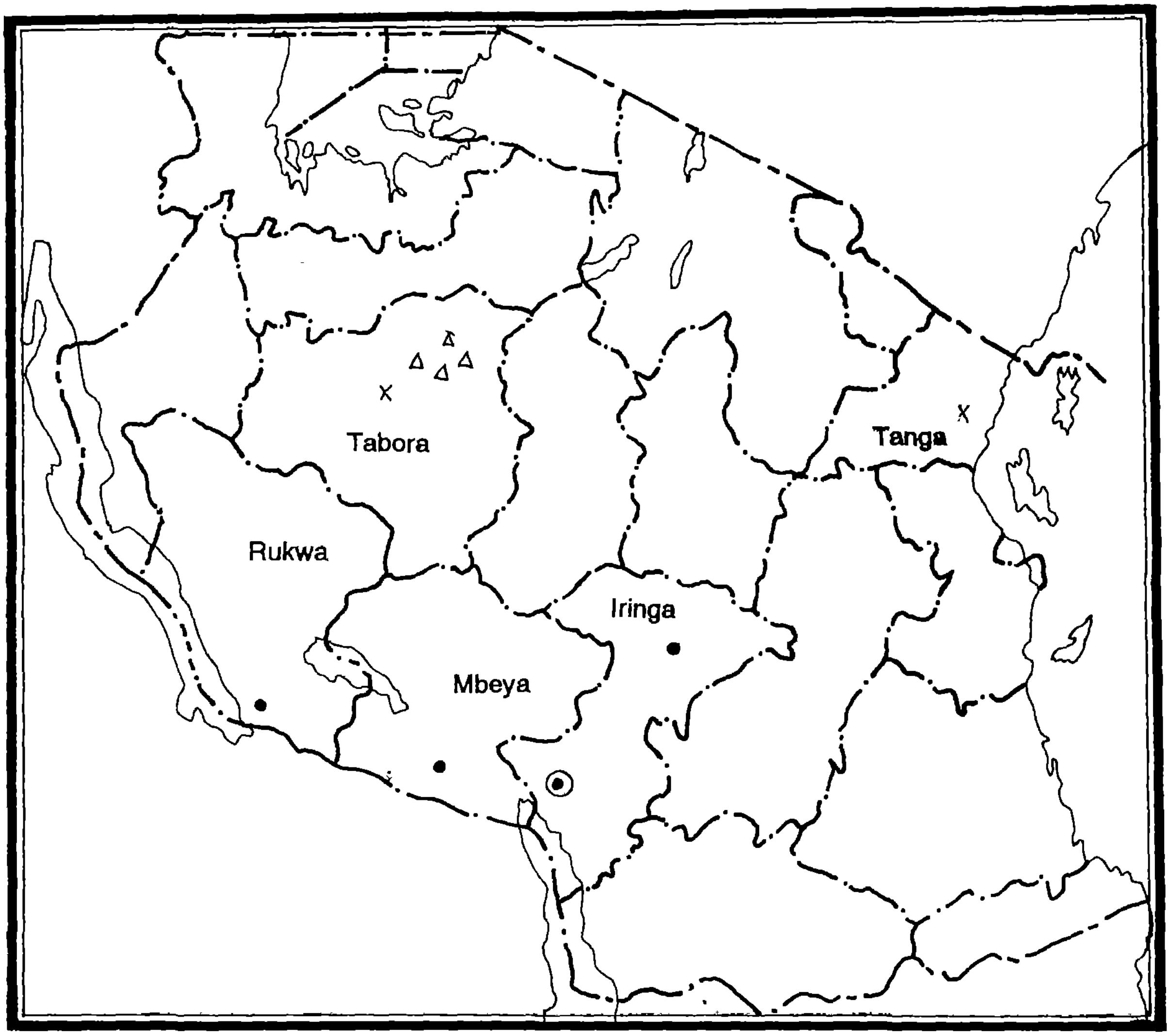


Fig. 1 The Location of the HRF and SSF plants in Tanzania

Legend :

- Existing HRF/SSF plants
- HRF Pilot plant
- x Chemically pretreated SSF plants
- Δ Abandoned SSF plants

by :
Dr. T.S.A. Mbwette

4. The Application And Observation Of Horizontal-flow Roughing Filtration In Rural Water Plants In China.

Abstract

Since 1988, three HRF/SSF demonstration water plants have been constructed in the rural areas of Zhejiang, China. To fit the local conditions, some modifications have been made on the drainage system, inlet and outlet chambers, sedimentation tank and fast-opening valve. Two years of operation have shown that HRF water pre-treatment results are good. HRF combined with SSF is an appropriate process for rural water supply where surface water is used. The paper also discusses the pre-treatment efficiency of HRF, the factors influencing HRF efficiency, the role of sedimentation tank, the water treatment efficiency of SSF as well as the economic assessment of the HRF process.

Introduction

Conventional water treatments by small water plants in rural areas often yield unsatisfactory water quality due to lack of qualified personnel to ensure reliable application of the process, shortage of chemical supply and unbearable costs for operation and maintenance. Therefore, a few years ago, the HRF process was recommended in the field of rural water treatment only after laboratory investigations of the process by the International Reference Centre for Waste Disposal(IRCWD) and field test in Tanzania. Combined with SSF, HRF is regarded as a promising water pre-treatment method suitable for rural water supply in developing countries.

The general features of the three water plants, viz., Jin Xing water plant (in Deqing Country), Chen Zhuan water plant (in Tongziang Country) and Heng Shen water plant (in Sheng Country), are given in Table I, while the raw water data is listed in Table - 2.

Table 1. The General Features of the Demonstration Water Plants

Plant Name	JinXing (Deqing)	Chen Zhuang (Tongxiang)	Heng Shan (Sheng)
Topography	plain	plain	hill
Population	1630	1240	293
Water source	river	river	reservoir
Water demand (m^3/day)	187	184	34
Construction period	Oct. 1988–June 89	March 1989–Oct. 89	Aug. 1990–Oct. 90
Technology process		river → pump stage → sloping-tube sedimentation → HRF → SSF →clear water tank→water tower(pump stage)→ distribution pipe→ users	reservoir → HRF →SSF → clear water tank→ distribution pipe→ users
Water supply system		pumping scheme	gravity scheme
The technology in Jin Xing and CHen Zuang are the same.			

Table 2. Raw Water Features

Parameter	Jin Xing	Chen Zhuang	Heng Shan
Turbidity (NTU)	15–180 (43.9)	35–120	turbidity :
Suspended solids (mg/1)	7–209 (42.0)	27–80 (50.9)	dry season
Filtrability (ml/3 min.)	47–142 (94)	78–100 (91)	20 (TU)
Settleable solids	the values are below graduated line		rainy season
	(settled after 24 hours)		3–20 (TU)
C.O.D. (mg/L)	2.3–6.6 (4.0)	3.5–7.7 (5.2)	after rain storms
NH3–N (mg/L)	0.64–2.94 (1.57)	0.41–2.66 (1.25)	50–100 (TU)
Coliform group (MNP No/100 ml)	920 –> 1600	33 – > 1600	

The results of the settleable solids in Jin Xing and Chen Zhuang are the same.

Design of HRF

The design parameters of three HRF demonstration water plants are listed below in Table-3.

Table 3. Main Design Parameters and Dimensions

Parameter	Jin Xing	ChenZhuang	HengShan
Water demand (L/cd)	80	80	80
Population in 15 years	1630	1240	293
Daily operation hours	18.7	18	24
Number of units	2	2	1
Design capacity (m^3/h.unit)	5	5	1.4
Filtration rate (m/h)	1.0	0.75	0.75
Cross-section area (m2)	5	6.667	1.867
HRF chambers	3	3	3
Filter (m)	1.5	1.5	1.2
Filter width (m)	3.333	4.445	1.556
Filter length (m)/gravel size (m/m)			
coarse gravel	3/dg 16–32	3/dg 30–50	2/dg 16–32
medium gravel	2/dg 8–16	2/dg 15–30	1/dg 8–16
fine gravel	1/dg 4–8	1/dg 8–20	1/dg 4–8
Inlet chamber length (m)	0.6	0.6	a group of distribution water pipes perforated
Outlet chamber length (m)	0.6	0.6	a group of collecting water pipes perforated

Drainage System

A drainage trough on the HRF floor was constructed with perforated covers on the top and side walls of the trough. Perforated branch pipes which were connected with hydraulic claening efficiency and further prevent water short- circuiting.(Fig.1).

New design pratice, in recent years, trends to reduce filter lengths. The practice in Jin Xing and Chen Zhuang has proved that, because of the efficient hydraulic cleaning, silt accumulation in the HRF is not serious and therefore, it is possible to shorten the length of the HRF. Accordingly, the HRF in Heng Shen was constructed with 3 filter chambers.The inlet and outlet chambers were omitted as the turbidity of raw water in Heng Shen was not high and a screen was used to retain floating matters from going into inlet mouth. So, two groups of perforated plastic pipes were inserted vertically in the 1st gravel chamber and in the outlet of the 3rd chamber (Fig.2). The pipes were surrounded by some big gravels.

Instead of ball valve, which is rather expensive, fast-opening steel gate was installed in the HRF plant of Chen Zhuang that reduces the cost by about 60% - 70% (Fig.3). The efficiency of the HRF plant was found to be satisfactory as the monitoring data showed satisfactory level of suspended solid and turbidity (Fig. 4).

The monitoring results also indicates that the HRF has some ability of reducing coliform group. The average removing rate was 75.3% for Jin Xiang and 52.9% for Chen Zhuang, respectively. The effluent concentrations were reduced to about 60% and 20% for Jin Xing and Chen Zhuang respectively by HRF treatment.

Fig.5 shows that when the influent turbidity of HRF of Jin Xing is 50 NTU or below, the increasing of filtration rate has no obvious influence on the effluent turbidity. When raw water turbidity increases, the flow rate is obviously increasing and consequently the effluent will be over 10 NTU. Under similar conditions the filtration rate and raw water turbidity, compared with Chen Zhuang and Jin Xing, the effluent turbidity is obviously increasing. This might be due to the type of filter materials used. In Jin Xing the filter materials were gravel, while in Chen Zhuang filter material were broken stones. Thus, it can be concluded that under different turbidity conditions, the parameters on gravel size recommended by IRCWD are most suitable.

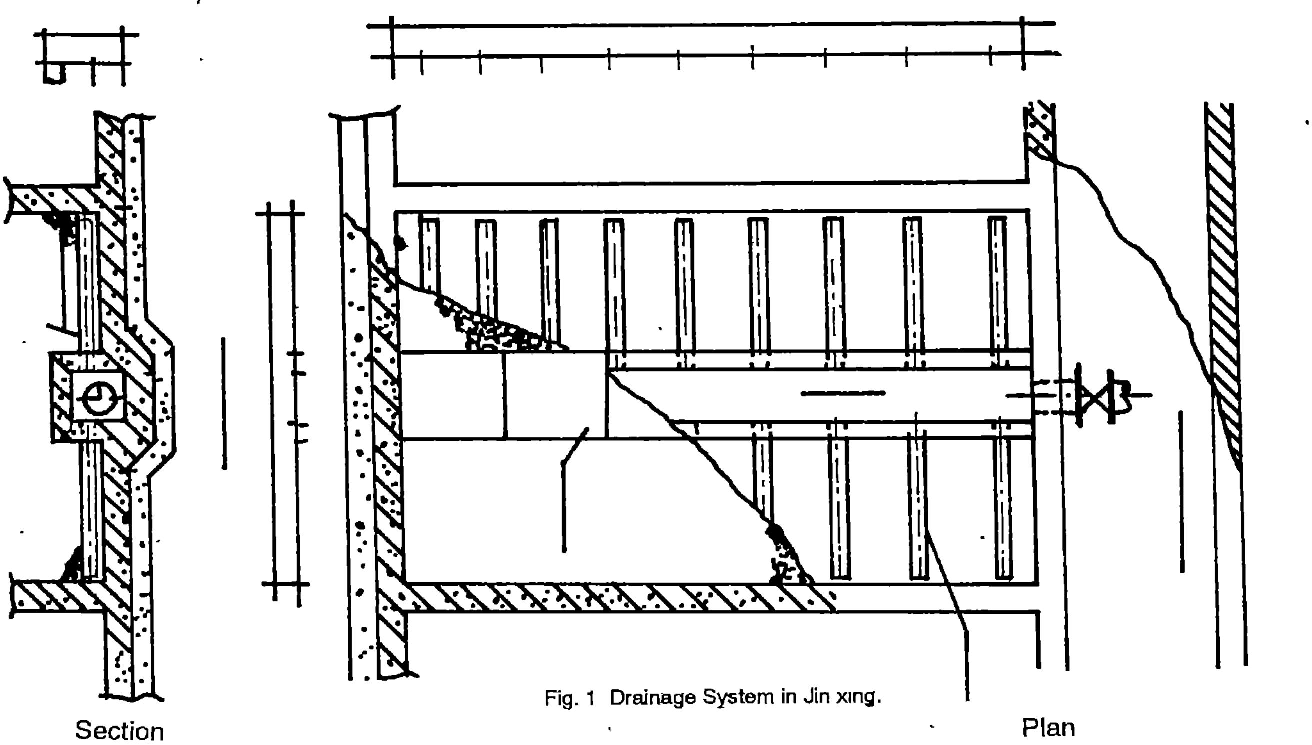


Fig. 1 Drainage System in Jin xing.

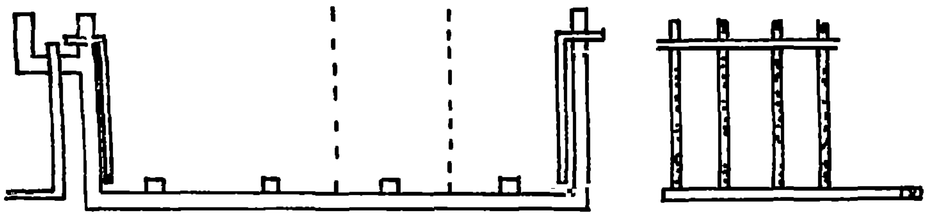


Fig : 2. Perforated pipes used for water distribution and collection

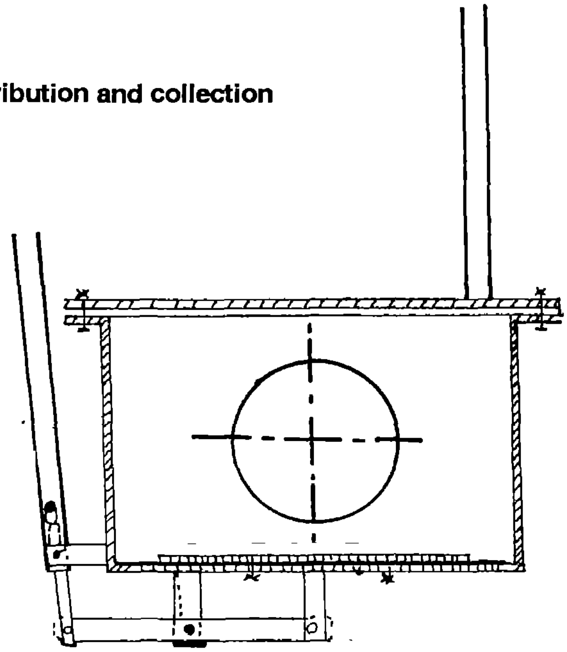
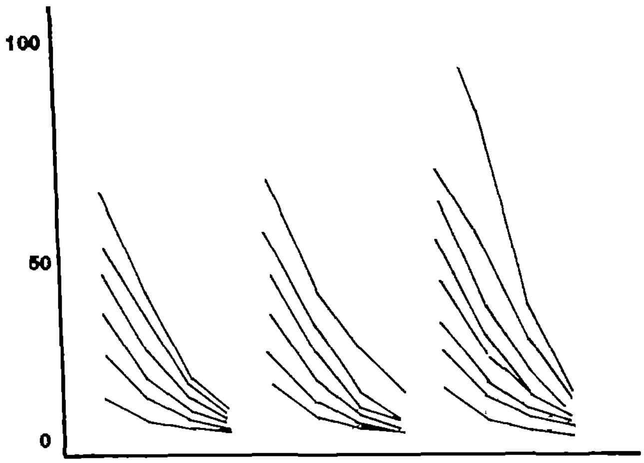


Fig : 3. Simple fast closinng gate



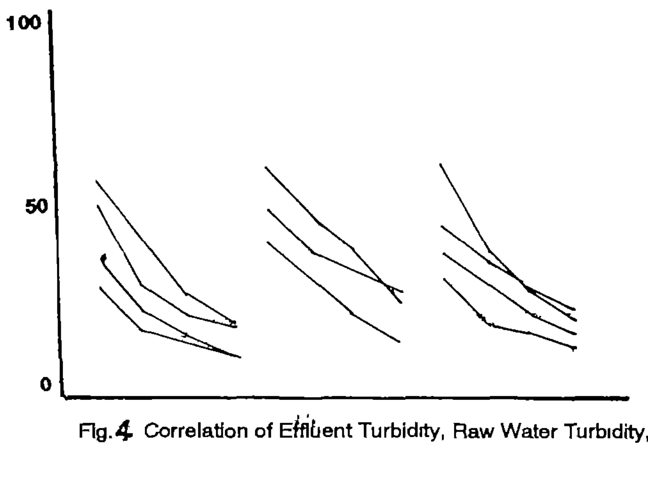


Fig. 4 Correlation of Effluent Turbidity, Raw Water Turbidity, Filtration Flow and Filteration Medium Size.

by :
Xu Xiangkuan, Shenfu Hang, Wang Mingdi,
He Shengliang, and Zhu Anli

List of Participants

Attended the workshop on "Sanitary Protection and Upgradation of Traditional Surfaces for Domestic Consumption" on 17th & 18th August, 1992.

Sl. No.	Name, Desigantion & Address
1.	Dr. Ambarish Mukherjee *Hon'ble Minister-In-Charge* *Environment and Forests* *Govt of West Bengal*
2.	Mr. Goutam Deb *Hon'ble Minister - In - Charge* *Public Health Engineering,* *Govt. of West Bengal*
3.	Dr. Manas Bhuniya *Member, Legislative Assembly* *West Bengal*
4.	Prof. S. Ramachandran *Country Representative* *Water Aid, New Delhi* *C - 3/209, Janakpuri, New Delhi*
5.	Mr. P. R. Michael *South Indian Representative* *Water Aid* *19, 5th Cross Road, Ponnagay* *Tiruchirapalli, Tamil Nadu — 620001.*
6.	Mr. S. Paramasivan *Project Officer, Water Aid* *19, 5th Cross Road, Ponnagay* *Tiruchirapalli* *Tamil Nadu — 1.*
7.	Mr. Hyacinth Vaz *Project Officer* *Water Aid, Calcutta.*
8.	Mr. M. Biswas *Project Coordinator* *28/49A, S. S. Road, Calcutta — 50*
9.	Prof. D. Mukherjee *President (IEDS)* *14/5, Sribas Datta Lane,* *Howrah — 1*
10.	Mr. Arjahan Halder *Asstt. Gen. Secretary* *Tajmahal Gram Bikaskula Kendra* *Vill -Khasikhamar* *P.O -Rameswar Nagar, Dt. Howrah* *West Bengal - 711 310*

...... contd.

Sl. No.	Name, Desigantion & Address
11.	Mr. G. Pande *President,* *United Artists' Association* *Dist. Ganjam* *Orissa — 761 026.*
12.	Mr. Kartick Pramanik *Secretary* *Vill. & P.O. Barizpur* *South 24 Parganas (s) – 743 375 W B*
13.	Mr. B. Mandal *Life Member, Akabpur Sammelani* *Vill. Akabpur, P O. Nandanghat* *Vill Akabpur, P.O. Nandanghat* *Dist. Burdwan, West Bengal – 713 515.*
14.	Mr. Dharamvir Singh *Director, Ruchi* *Shalana via Rajgarh* *Dist. Sirmur, H.P. 173 101*
15.	Mr. P.C. Mishra *Director* *Indian Institute of Youth and Development* *Kalinga, Orissa — 762 022.*
16.	Mr. S. K. Das Bera *Secretary, Chak–Kumat Milan Sangha* *Vill. Chak–Kumat, P O. Debra Bazar* *Midnapore*
17.	Mr. T. Bhattacharjee *Project Engineer-cum-Project Officer* *Mandra Unnayan Samsad* *Vill + P O. – Mandra,* *Dist – Hooghly , West Bengal – 721 301.*
18.	Mr Jaydeb Bhuniya *Coordinator of Chak – Kumat* *Milan Sangha* *Vill Chak – Kumat* *P O. Debra Bazar, Dt. Midnapore.* *West Bengal – 721 126.*
19.	Dr. R. Bera *Hony General Secretary* *Social Welfare and Relief Society* *Vill. + P O. – Khukurdah,* *Dist – Midnapore* *West Bengal – 721 424.*
20.	Ms. Sephali Bera *Member* *Social Welfare & Relief Society* *Vill + P.O – Khukurdah,* *Dist. – Midnapore* *West Bengal – 721 424*

...... contd.

Sl. No.	Name, Desigantion & Address
21.	Ms. Madhuri Hazra *Member* *Dulal Samity Samsad* *Vill + P O – Khajurdaha, Hooghly* *West Bengal – 721 149.*
22.	Mr. T. A. Bux *General Joint Secretary* *Asha Welfare Society* *Vill + P O – Ganeshnagar,* *Dist – South 24 Paraganas, West Bengal.*
23.	Prof. N. C. Naskar *President* *Sundarban A M U Samity* *Vill + P O. – Tuldi,* *South 24 Pgs, (s), West Bengal – 743 376.*
24.	Mr. D. J. Raju *President* *Society for the Welfare of* *Weaker Sections,* *At Gotal, P O – Lalusahi,* *Via – Narayanpura,* *Dist – Ganjam, Orissa – 761 212*
25.	Mr. S. K. Mukherjee *Secretary, CADS* *5/2 R B C Road, P O – Naihati,* *Dist – North 24 Parganas, West Bengal – 743 165.*
26.	Dr. B. B. Chaudhuri *Adviser* *Lutheran World Service, India,* *84, Dr Suresh Sarkar Road* *Calcutta – 700 014*
27.	Mr. A. R. Middya *General Secretary* *Malikpur Samaj Unnayan Samity,* *Vill & P O Jujersa, Dist – Howrah.* *West Bengal – 711 302.*
28.	Ms. Arati Dutta *President* *Saroj Nalini Dutta Memorial Assoc* *23/1, Ballygunge Station Road* *Calcutta – 700 019.*
29.	Ms. Jayshree Sen *General Secretary* *Saroj Nalini Dutta Memorial Assoc.* *23/1, Ballygunge Station Road* *Calcutta – 700 019.*
30.	Mr. C. R. Haldar *Secretary, Ashuralo Vivekananda Samity Sangha* *Vill Ashuralo, P.O. Sadhurhat* *24 Paragnas (S) , West Bengal.*

...... contd.

Sl. No.	Name, Desigantion & Address
31.	Mr. Sekhar Bagchi *Chief Engineer, PHED* *Govt. of West Bengal*
32.	Mr. Biswanath Pal *Hony Secretary,* *Mandra Unnayan Samsad,* *Vill + P.O. – Mandra,* *Dist. – Hooghly,* *West Bengal – 712 303.*
33.	Mr. Syamal Kanrar *Rector,* *Youth Welfare & Cultural Society* *P O. Chitrasempur, Howrah, W B.*
34.	Mr. Jayanta Roy *Project Officer* *UNICEF* *3, Sunny Park, Calcutta.*
35.	Mr. A. K. Nandi *Programme Manager* *Sarbik Gram Bikash Kendra,* *Gandhi Mission* *P O. – Daspur,* *Dist. – Midnapur,* *West Bengal – 721 211*
36.	Mr. Amulya Maity *General Secretary* *Council for Rural Welfare* *P O Sabang, Dist. – Midnapore,* *West Bengal – 721 144*
37.	Mr. C. R. Dutta *Hony Secretary* *Institute of Engineers, India, WBSC.*
38.	Mr. Sambhu Das *P.W.D.* *West Bengal*
39.	Mr. Dilip Banerjee *Vivekananda Swashthya Sansthan* *Salt Lake, Calcutta*
40.	Mr. Parasbhai Das *Executive Secretary* *Phulbani Rural Development &* *Technology Agency,* *At / P O. G. Udayagari* *Dist. – Phulbani,* *Orissa – 762 100.*
41.	Mr. Prakash Jha *At P O. – P. R. D. T. A.* *Gudayagiri, PLB Orissa – 762 100.*

...... contd.

Sl. No.	Name, Designation & Address
42.	Ms. Lutfa Khatun *Secretary* *Shatomanisha Santi Sangha* *(Mohila Samity)* *Vill Shatomonisha, P. O. Basuldanga* *South 24 Parganas.*
43.	Md. Alauddin Laskar *Member* *Institute of Ecological & Development Studies,* *14 / 5, Sribas Datta Lane* *Howrah – 711 101, West Bengal*
44.	Mr. Asim Das *Coordinator* *Unnayan, 36/1A, Garcha Road* *Calcutta – 700 019.*
45.	Dr. B. N. Ghosh *Director* *All India Institute of Hygiene &* *Public Health, Calcutta*
46	Prof. K. J. Nath *Professor & Head Deptt. of* *Sanitary Engineering* *AIIH & PH, Calcutta*
47.	Prof. A. K. Adhya *Prof of Sanitary Engineering* *AIIH & PH, Calcutta.*
48.	Shri A. Majumdar *Associate Professor* *Deptt. of Sanitary Engineering* *AIIH & PH, Calcutta*
49.	Mr D. Kahali *Demonstrator* *Deptt. of Sanitary Engineering* *AIIH & PH, Calcutta*
50.	Dr. Gautam Basu *Scientific Officer (RJNDWM)* *Deptt of Sanitary Engineering* *AIIH & PH, Calcutta*
51.	Dr. S. Bandyopadhyay *Asstt Research Officer,* *Dept of Sanitary Engineering,* *AIIH & PH, Calcutta.*
52.	Mr. Santanu Lahiri *Project Officer cum Senior,* *Instructor, ITN,* *Dept of Sanitory Engineering,* *AIIH & PH, Calcutta.*
53.	Dr. A. K. Kundu *Instructor, ITN,* *Dept. of Sanitory Engineering,* *AIIH & PH, Calcutta.*

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Editor : Prof. K. J. Nath

Persons involved in this publication :

Mr. Arunabha Majumdar
Dr. Saumitra Bandyopadhyay
Mr. Santanu Lahiri
Mr. Diptarup Kahali
Dr. Gautam Basu
Mr. Avijit Mukherjee
Mr. Gautam Dutta
Mr. Chanchal Nandi

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A HRF in use for upgradation of water quality from a traditional surface water source (pond).

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