IMPLEMENTATION MANUAL
on
National Rural Water Quality Monitoring & Surveillance Programme

सत्यमेव जयते

Rajiv Gandhi National Drinking Water Mission
Department of Drinking Water Supply
Ministry of Rural Development
Government of India

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FOREWORD

The Department of Drinking Water Supply has been making efforts to ensure supply of safe drinking water to the rural masses. Safe drinking water implies that the quality of water supply is taken care of by the suppliers and beneficiaries get potable water. However, there has been no institutionalized mechanism for monitoring and surveillance of water quality. Apart from bacteriological contamination, chemical quality problems have been making the task of the water suppliers difficult in many States of the country. As water supply in rural areas is heavily dependent on ground water, excessive extraction of ground water has resulted in depleted ground water tables intensifying the water quality problem.

Though the Government has been endeavouring to tackle the situation by taking both preventive and remedial measures, the scenario in the country still demands Water Quality Monitoring & Surveillance systems. Establishment of district level Water Quality Testing Laboratories has not been able to make a heavy dent on the critical situation, as lack of manpower and infrastructure coupled with resource constraints, has been a major obstacle for water quality monitoring.

The initiative taken by the Government for promoting community participation in rural water supply systems has to be extended to water quality monitoring and surveillance and it has been decided to establish community based Water Quality Monitoring & Surveillance system. On the recommendation of National Workshop on Water Quality Monitoring & Surveillance held on 7-9th August, 1997, an Implementation Manual for WQM&S in the country has been got prepared for operationalising WQM&S programmes, by AIIH&PH whose expertise and experience in the water quality monitoring is immense. The monitoring of water quality has been identified as one of the thrust areas for this Department and it is proposed to launch water quality monitoring programme by adopting catchment area approach involving various grassroot level educational and technical institutions by utilizing their existing resources and strengthening them by providing additional financial resources.

This Manual prepared in a very simple, easily understandable language containing pictorial presentations is meant to be used not only at grassroot level but also at district and State level and will give the requisite guidance to the implementing agencies and the VWSCs/communities for successful implementation of this programme.

I am privileged to present this Manual to the community, all sector partners and implementers in this field.

(V.K. Duggal)

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PREFACE

Water is one of the five elements of creation of life on Earth. Chemical composition of this natural resource is subject to both geological and anthropogenic interferences with the result that water of pristine purity is a rare commodity.

While quality control at the production stage is usually adequate in the case of manufactured items, quality of public water supply is to be ensured through a comprehensive process, involving treatment, distribution, sanitary surveys and preventive and remedial action. Following the 73rd and 74th Constitutional Amendments, rural drinking water is one of the 29 subjects for transfer to Panchayati Raj. In villages, water is still perceived as a natural resource and drinking water quality control, therefore, incorporates broader issues of accessibility, sustainability, community partcipation, human resource development and affordability.

Prior to launching of Rajiv Gandhi National Drinking Water Mission (RGNDWM) in 1986, monitoring of drinking water sources in rural India was done on an ad-hoc basis. A systematic approach to water quality monitoring in rural areas was initiated by RGNDWM. This involved grants for setting up of district level water quality testing laboratories in each State, building up a country-wide database on rural drinking water quality and generating awareness amongst rural masses about importance of water quality and its relationship to health.

A National Workshop on Water Quality Monitoring and Surveillance in rural areas was organized in 1997 by the RGNDWM in collaboration with the Ministry of Health and Family Welfare, which was sponsored by the UNICEF and WHO. Some of the relevant recommendations of the Workshop were:

i) *Drinking Water Quality Control and Surveillance (DWQC&S) should be accorded a high priority, and suitable institutional mechanisms at national, State, district, block and panchayat level should be developed,*

ii) *Panchayats and the community should be involved in water quality surveillance by Department of Health,*

iii) *Appropriate linkage between DWQC&S and Central and State Pollution Control Boards should be developed.*

Based on the recommendations of the Workshop, it was decided to institutionalize community based water quality monitoring and surveillance programme involving Panchayati Raj Institutions, rural water supply agencies, public health authorities, training institutions, R&D organizations etc. A pilot study was conducted in four districts in India for institutionalizing the monitoring & surveillance programme. Based on findings of the pilot study, a community based water quality monitoring and surveillance programme is proposed to be launched. NICD has agreed to collaborate in the programme as the National Referral Institute.

All India Institute of Hygiene and Public Health were approached for preparation of an Implementation Manual to guide implementers of the programme at the cutting edge level. The Institute deserves commendation for coming out with this Manual, which is written in a simple language with pictorial representations to facilitate easy grasp. I hope the Manual will provide qualitative executive bite to implementation of the proposed community based rural water quality monitoring and surveillance programme.

(Rakesh Behari)

Date : 24.11.04

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ANNEXURE

CHAPTER – 1

INTRODUCTION

1.1 General considerations

Man's requirement of water for drinking purposes score over all other uses of water. The mean daily intake of water by man is estimated to be 3.1 percent of the body weight. Thus, water for drinking and culinary purposes must not contain harmful substances that causes adverse physiological effects but at the same time, should be aesthetically acceptable to the consumer. Such water is termed as 'safe water' signifying that its consumption in any desirable amount will not impair health; rather promote the health of the community. The safe water must be free from bacteriological & chemical contamination and must be good for house-keeping, palatable and odour free.

Unfortunately, water of aforesaid definition is a rare commodity in major part of our country, particularly in rural areas where 70% of our population live. However, to promote and protect the health of the rural population, Govt. of India during the seventh five-year plan period embarked upon an ambitious programme of providing safe drinking water facilities to the entire rural population through the Department of Rural Development, Ministry of Agriculture to give a fillip and to facilitate improved and effective implementation and cost effectiveness of ongoing programmes and to tackle problems associated with quantity and quality of drinking water supply on a long term basis.

During the last few decades the national policies have shown increasing emphasis on rural water supply and sanitation. In terms of physical progress, the achievements have been remarkable, and most of the problem villages are now covered with an optimum supply of water. Unfortunately, however, such progress has not been seen to be translated into health benefits, and water borne diseases continue to be the dominant cause of morbidity and mortality in many parts of India. The reasons are fairly obvious: though water is being supplied, its potability is not being ensured. The lack of Water Quality Surveillance (hereafter referred to as WQS) in rural areas is acutely brought into focus during the episodes of waterborne epidemics.

1.2. Concept & components of Water Quality Surveillance

The precise meaning of 'surveillance' in relation to the control of drinking water quality is not always clear. As used here, it means the keeping of a careful watch at all times, from the public health point of view, over the safety and acceptability of drinking water supplies. Surveillance requires a continuous and systematic programme of sanitary inspection and water quality testing, carried out at different points of the water distribution system. A surveillance programme aims at ensuring a consistently acceptable level of drinking water quality, if it is to be fully effective, may also require legislation supported by regulatory standards and codes of practice along with institutional arrangement. Each component of the drinking water system such as source, treatment,storage and distribution must function at their optimum efficiency and without any risk of failure.The essential part of the surveillance is to have properly equipped laboratory facilities with properly trained manpower.

The key elements of a surveillance programme should include : -

- *Monitoring*
- *Sanitary survey*
- *Data processing*
- *Evaluation*
- *Remedial and preventive action, and*
- *Institutional analysis*

Monitoring

Monitoring involves the laboratory and / or spot testing of water samples collected from different locations in the water supply system including sources, water treatment plants, distribution system and house reservoirs.

Sanitary survey

This is on-site inspection and assessment of all conditions, applications and practices in the water supply system that are prone to develop health hazard to the consumers. Sanitary survey is not an alternative to water quality analysis but is an important component of such analysis in the overall quality control programme.

Data processing & evaluation

This involves processing of a large number of data generated in course of monitoring and sanitary survey to elicit precise information to be utilized for decision making to improve the management and operational components of the surveillance programme.

Remedial & preventive action

Remedial action entails a series of exercises to be carried out to rectify sanitary deficiency upon detection. The evaluator should be extremely cautious in interpreting the relative effect of the identified deficiency on the safety of the supply and kind of corrective and preventive measures needed. Remedial and preventive action may be repairing and upgrading, spot source protection, checking of chlrine dosage and application, use of alternative safe sources etc.

Institutional analysis

Institutional examination of water supply system is a scrutiny of operation and management of the relevant functions like defective design, poor maintenance, ineffective supervision, inadequate training or personnel, lack of inter-sectoral coordination, etc. which may lead to deficiency in the water supply system.

1.3 Present Status of Rural Water Quality Monitoring & Surveillance

In India, financial and technical support to the urban and rural water supply systems are provided by the Central Government through the Ministries of Urban Development & Poverty Alleviation and Rural Development respectively. However, planning, designing, construction and operation & maintenance including laboratory process control etc. are undertaken by the Public Health Engineering Department / Rural Development Department / Panchayati Raj Department and Water Supply & Drainage Boards of the respective State Governments. The metropolitan cities have their own water supply system and water testing laboratories that are parts of water supply facilities for process control and monitoring of the water quality. But institutional framework for water quality surveillance programme incorporating different components like continuous monitoring, sanitary survey, data processing and evaluation and inter-sectoral coordination is extremely inadequate in the peri-urban and rural areas. Unfortunately, the utility and importance of this vital function in the overall management of drinking water supply system is often not realised by the concerned authorities and beneficiaries as well. Administrative limitations, lack of governmental and political support and on top of it the public apathy are the primary factors behind the low priority so far accorded to these essential functions.

The problems of undertaking WQS in rural India can be summarized as follows : -

- *Resource constraint, both in terms of manpower and infrastructure, is a major obstacle.*
- *There has traditionally been an urban emphasis in the developments in the Water Supply sector.*

- *The state / district level water testing laboratories are in no position to take the task of routinely monitoring the rural water sources. They can at the most play useful role in crisis situations like water - borne epidemics.*
- *No system of WQS exists at the village / block level in most cases.*
- *Water supply is a political issue and people even in remotest rural areas perceive it as a demand. Water quality monitoring, however, as yet is not the felt need of the people.*

However, during the last decade, considerable progress has been made in rural water supply sector in the country. Department of Drinking Water Supply, MRD, GOI is providing support to the state governments in the matter of setting up district/ state level laboratories for water quality monitoring. In some states water quality monitoring at village level has made impressive progress.

1.4 Recommended approach on National Water Quality Monitoring & Surveillance

Even though the coverage has been impressive over the last decade, various studies indicate that there is no institutionalized quality monitoring and surveillance system in the country. This is going to be critical to the entire water supply sector in the future owing to increase in pollution and depletion of water resources. The National Workshop held on 7-9 August, 1997 recommended that there is a need to institutionalize water quality monitoring and surveillance systems in the country. Establishing of water quality labs could be only one of the components of the programme. A 'Catchment Area Approach' would be adopted by involving various grass root level educational and technical institutions by utilizing existing resources and strengthening them by providing additional financial resources to these institutions. This may be implemented at three levels consisting of a nodal unit at the top level catchment like a premier technical institution, university etc, intermediary level units like district laboratories, polytechnics etc. and grass-root level units like (+2) level education institutions, labs, etc. Activities related to preliminary water testing etc. could be carried out at the grass-root level itself and more complicated cases could be referred to higher levels in such a way that only focused cases of complex nature and of value and utility at state level reach the nodal unit. The nodal units will be networked with the state headquarters (PHED). 100% funding, as per the approved norms, would be provided to the states for strengthening water quality monitoring facilities, based on projects received from the state Governments. Restructuring the state PHEDs with the required grant-in-aid support, to bring in the much missed link up with the health authorities will also be attempted as a part of institutionalizing the monitoring system. Health department officials will be increasingly involved in the surveillance activity.

DRINKING WATER QUALITY

2.1. General Consideration

2.1.1. Absolutely pure water is rarely found in nature. The impurities occur in three progressively finer states – suspended, colloidal and dissolved. These may be present also in floating state. These impurities can basically be categorised according to their sizes, as presented in figure – 2.1.

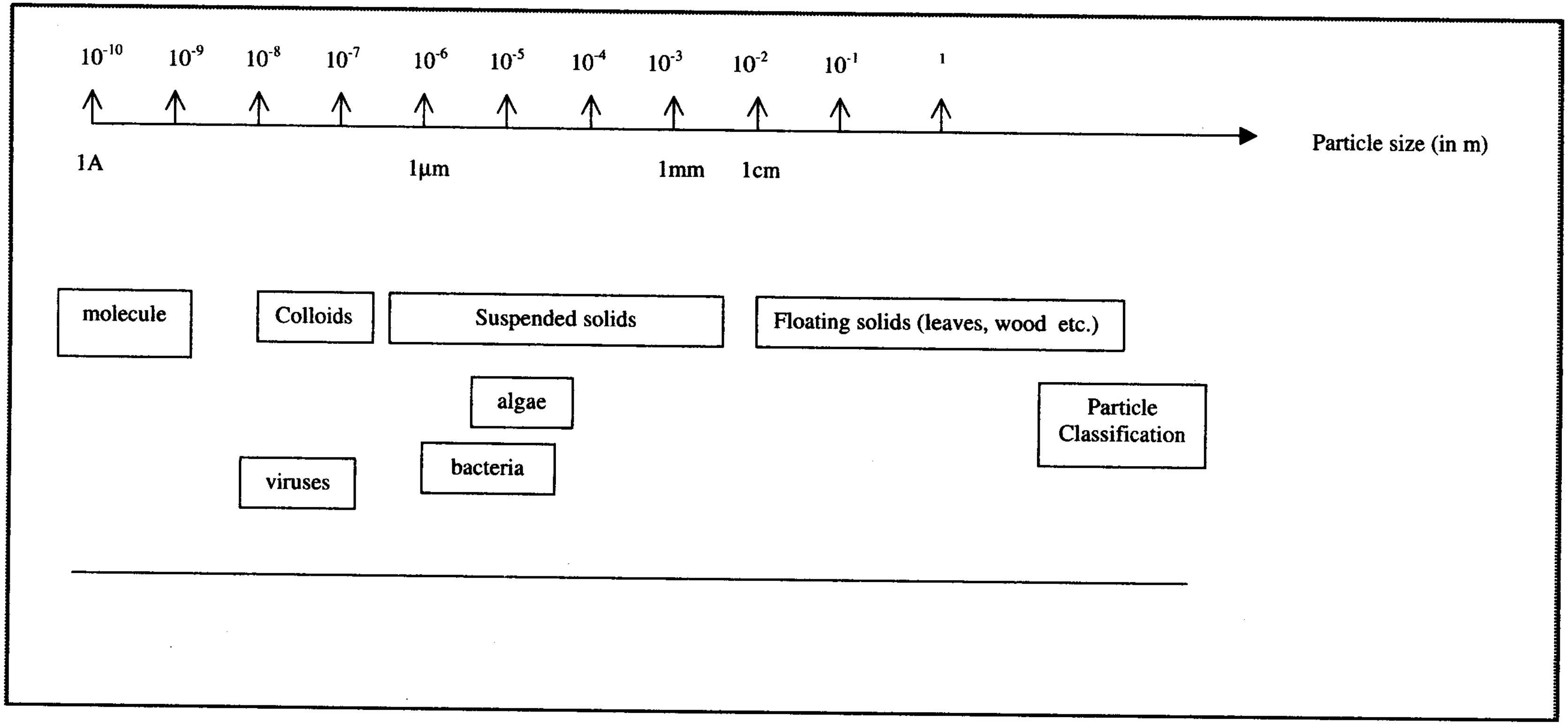
2.1.2. Although appearance, taste and odour are useful indicators of the quality of drinking water, suitability in terms of public health is determined by microbiological, physical, chemical and radiological characteristics. Of these, the most important is microbiological quality. Also a number of chemical contaminants (both inorganic and organic) may be found in water. Both bacteriological and chemical contamination of drinking water cause deleterious effect on human health.

2.1.3. The drinking water should be

- Free from pathogenic (disease causing) organisms
- Clear and transparent
- Not saline (salty)
- Free from offensive taste and smell
- Free from chemical contaminations that may have adverse effects on human health
- Free from chemicals that may cause corrosion to pipe and appurtenances or stains clothes / utensils etc.

2.1.4. Water quality standards are broadly classified into microbiological, chemical, physical and radiological characteristics.

Fig. 2.1. : Particle Size



2.2. Microbiological Aspects

2.2.1. The major interest of Public Health Authorities in classifying and issuing standards in the identification, quantification, and evaluation of microorganisms connected with water borne diseases and in general are limited to Bacteria, Viruses, Protozoa and Helminths. There are indeed microbiological contaminants associated with undesirable tastes and odours or reasons for treatment problems of drinking water, such as algae and fungi but since they are not causes of water borne diseases, get very little importance from the public health point of view.

2.2.2. Indicator organisms

It is not practicable to test the water for all organisms that it might possibly contain. Instead, the water is examined for a specific type of bacteria that originates in large numbers from human and animal excreta and whose presence in the water is indicative of fecal contamination. Such indicative bacteria must be specifically faecal and not free-living. An indicator organism should always :

- Be present when the pathogenic organism of concern is present, and absent from clean, uncontaminated water
- Be present in faecal material in large numbers
- Be able to respond to natural environmental conditions and to treatment processes in a manner similar to the pathogens of interest
- Be easy to isolate, identify, and enumerate
- Have a high ratio of indicator / pathogen
- Come from the same source as that of the pathogen

Table – 2.1 : Recommended Standards for Bacteriological Quality

Organism	Unit Standards	Recommended	Remarks
A. Piped water supplies			
A.1. Treated water entering the distribution system			
Faecal coliforms	Number / 100 ml	0	
Coliform organisms	Number / 100 ml	0	Turbidity < 2.5 NTU, for disinfection with chlorine, pH preferably <8.0, free chlorine residual 0.2-0.5 mg/l following 30 minutes (minimum) contact time
A.2. Untreated water entering the distribution system			
Faecal coliforms	Number / 100 ml	0	
Coliform organisms	Number / 100 ml	0	In 95% of samples examined throughout the year - in the case of large supplies when sufficient samples are examined
Coliform organisms	Number / 100 ml	3	In all occasional sample, but not in consecutive samples
A.3. Water in the distribution system			
Faecal colifirms	Number / 100 ml	0	
Coliform organisms	Number / 100 ml	0	In 95% of samples examined throughout the year in the case of large supplies when sufficient samples are examined
Coliform organisms	Number / 100 ml	3	In all occasional sample, but not in consecutive samples
B. Unpiped water supplies			
Faecal colifirms	Number / 100 ml	0	
Coliform organisms	Number / 100 ml	10	Should not occur repeatedly, if occurrence is frequent and if sanitary protection cannot be improved an alternative source must be found if possible
C. Emergency water supplies			
Faecal colifirms	Number / 100 ml	0	
Coliform organisms	Number / 100 ml	0	Advise public to boil water in case of failure to meet guideline values

Total coliforms, faecal coliforms, E. coli, fecal streptococci, enterococci and heterotrophic plate count (HPC) are some of the microorganisms selected to be indicators. However, total coliforms are the most commonly used indicator. Faecal coliforms and HPC are also used frequently. There are two methods of conducting tests on the levels of faecal coli and faecal streptococci in water : the multiple tube method for establishing the most probable number (MPN), and the membrane filtration method. Where possible, examination for both fecal coli and faecal streptococci should be made. This will provide an important check on the validity of the results. It will also give a basis for computing the ratio at which the two species of bacteria are present. From this, a tentative conclusion can be obtained whether the faecal pollution is of animal or human origin.

Table 2.1 depicts recommended standard for bacteriological quality of different water supplies.

2.3. Chemical Aspects

2.3.1. Several of the inorganic elements for which standards have been made are recognised to be essential elements in human nutrition. Standards are divided in two parts for the chemicals (both inorganic and organic) one is Desirable limit and other is maximum permissible limit for rejection.

Table 2.2 BIS Standard : IS-10500-1991

Test Characteristics For Drinking Water

Sl. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the Absence of Alternate Source	Remarks
(1)	(2)	(3)	(4)	(5)
Essential Characteristics				
1.	Colour, Hazen units, Max	5	25	Extended to 25 only if toxic substances are not suspected, in absence of alternate source
2.	Odour	Unobjectionable	-	a. Test cold and when heated b. Test at several dilutions
3.	Taste	Agreeable	-	Test to be conducted only after safety has been established
4.	Turbidity NTU, Max	5	10	-
5.	pH value	6.5 to 8.5	No relaxation	-

Sl. No.	Substance or Characteristic	Requirement (Desirable Limit) Alternate Source	Permissible Limit in the Absence of	Remarks
(1)	(2)	(3)	(4)	(5)
6.	Total hardness (as $CaCO_3$) mg/l, Max	300	600	-
7.	Iron (as Fe) mg/l Max	0.3	1.0	-
8.	Chloride (as Cl) mg/l, Max	250	1000	-
9.	Residual, free chlorine, mg/l, Min.	0.2	-	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be Min. 0.5 mg/l
Desirable Characteristics				
10.	Dissolved solids mg/l, Max	500	2000	-
11.	Calcium (as Ca) mg/l, Max	75	200	-
12.	Copper (as Cu) mg/l, Max	0.05	1.5	-
13.	Manganese (as Mn), Max	0.1	0.3	-
14.	Sulphate (as SO_4), Max	200	400	May be extended up to 400 provided (as Mg) does not exceed 30
15.	Nitrate (as NO_3) mg/l, Max	45	100	-
16.	Fluoride (as F) mg/l, Max	1.0	1.5	-
17.	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	0.002	-
18.	Mercury (as Hg) mg/l, Max	0.001	No relaxation	To be tested when pollution is suspected
19.	Cadmium (as Cd) mg/l, Max	0.01	No relaxation	To be tested when pollution is suspected
20.	Selenium (as Se) mg/l, Max	0.01	No relaxation	To be tested when pollution is suspected
21.	Arsenic (as As) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
22.	Cyanide (as CN) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
23.	Lead (as Pb) mg/l, Max	0.05	No relaxation	To be tested when pollution / plumbosolvency is suspected
24.	Zinc (as Zn) mg/l, Max	5	15	To be tested when pollution is suspected
25.	Anionic detergents (as MBAS) mg/l, Max	0.2	1.0	To be tested when pollution is suspected
26.	Chromium (as Cr^{6+}) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
27.	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	-	-	-
28.	Mineral oil mg/l, Max	0.01	0.03	To be tested when pollution is suspected
29.	Pesticides mg/l, Max	Absent	0.001	-
30.	Radioactive materials :			
	a. Alpha emitters Bq/l, Max	-	0.1	-
	b. Beta emitters pci/l, Max	-	1	-
31.	Alkalinity mg/l, Max	200	600	-
32.	Aluminlum (as Al) mg/l, Max	0.03	0.2	-
33.	Boron, mg/l, Max	1	5	-

Tables – 2.2 summarize various standards for chemical substances as per BIS (both health-related and non-health related). However, water quality standards recommended by various agencies are furnished as annex I to IV. These chemicals enter the aquatic environment through geological weathering, soil leaching, mining, agriculture, and industrial discharges.

Arsenic at concentrations above 0.05 mg/l leads to adverse health effects.

Fluorides at levels above 1.5 mg/l have been reported to cause mottling of teeth.

Elevated concentrations of nitrate (>10 mg/l as N) cause methemoglobinemia in infants. High levels of nitrates are found in groundwaters.

Cadmium, chromium, lead and mercury even at low concentrations can be toxic. They tend to accumulate in the food chain and lead to biomagnification.

Aluminum compounds are used in water treatment plants as coagulants. Water containing 0.2 mg/l of aluminum (or more) is not suitable for use by kidney dialysis patients.

Both iron and manganese at high concentrations cause stains in laundry and plumbing fixtures and impart undesirable tastes to beverages. Presence of iron in water may result in undesirable growth of iron bacteria in distribution systems and can block pipes.

Total dissolved solids (TDS) in raw water are mainly due to sodium bicarbonate, chloride, calcium, and magnesium bicarbonates and sulphates. High TDS causes unacceptable taste in water. Taste thresholds vary widely depending on the type of dissolved solids present.

Thousands of individual organic compounds enter water bodies as a result of human activities. These compounds have significantly different physical, chemical and toxicological properties. Monitoring every individual component is not feasible. However, it is possible to select priority organic pollutants based on their prevalence, toxicity and other properties. Mineral oil, petroleum products, phenols, pesticides, polychlorinated biphenyls (PCBs) and surfactants are example of such classes of compounds. However, these compounds are not universally monitored, because their determination requires sophisticated instrumentation and highly trained personnel. In the future, much effort will be needed in monitoring these classes of compounds because they are becoming widespread and have adverse effects on human and aquatic environment.

2.4. Aesthetic Acceptability Aspects

2.4.1. Though in setting up water quality standards parameters those are capable of producing direct health impact should get priority, the drinking water should as well be acceptable in appearance, taste and odour. There are number of water constituents (some of them are mentioned in table 2.2) that are of no direct consequence to health at the concentrations at which they normally occur in water but may be objectionable to consumers for various reasons as discussed below.

2.4.2. Physical Parameters

i) Colour

Colour in water can be caused by humic and peaty materials and by naturally occurring metallic salts, usually of iron and manganese. It may also result from the contamination of the water source with industrial effluents and may as well be the hazardous. The source of colour in a water supply should be investigated, particularly if a substantial change takes place.

ii) Taste and Odour

Taste and odour are subjective tests, which rely upon description rather than quantitative results. Tastes tend to be closely related to odours, although there are certain non-volatile substances, such as sodium chloride, which give rise to tastes without causing odours.

Usually, the presence of an odour suggests higher than normal biological activity. Organic compounds, inorganic chemicals, oil and gas can impart odour to water although an odour does not automatically indicate the presence of harmful substances. Taste and odour may also develop during storage and distribution. An unusual taste or odour might be an indication of the presence of potentially harmful substances.

Chlorination may produce chlorine residues that are perceptible by the consumers, but lowering the chlorine dose to overcome taste and odour problems must not compromise the microbiological safety of the water.

iii) Temperature

As water temperature increases the rate of chemical reactions generally increases together with the evaporation and volatisation of substances from the water. Increased temperature also decrease the solubility of gases in the water, such as O_2, CO_2, N_2, CH_4 and others. The metabolic rate of aquatic organisms is also related to temperature and in warm waters, respiration rates increase leading to increased oxygen consumption and increased decomposition of organic matter. Growth rates of bacteria also increase leading to increased turbidity, when nutrient conditions are suitable. Subsequently high water temperature may increase taste, odour, colour and corrosion problems. Moreover, cool water is generally more palatable than warm water.

iv) Turbidity

Turbidity is an indication of the clarity of a water and is defined as the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a sample of water.

Turbidity in drinking water is caused by particulate matter that may be present as a consequence of inadequate treatment or from resuspension of sediment in the distribution system. It may also be due to the presence of inorganic particulate matter in some ground waters.

High levels of turbidity can protect microorganisms from the effects of disinfection and can stimulate bacterial growth. In all cases where water is disinfected, therefore, the turbidity must be low so that disinfection can be effective.

2.4.3. Chemical Parameters

i) Aluminium

The presence of aluminium at concentrations in excess of 0.2 mg/l often leads to consumer complaints as a result of deposition of aluminium hydroxide floc in distribution systems and the exacerbation of discoloration of water by iron; concentrations between 0.1 and 0.2 mg/l may give rise to these problems in some circumstances.

Aluminium (as Al) beyond 0.03 mg/l in drinking water has a cumulative effect on human health causing dementia.

ii) Ammonia

Ammonia occurs naturally in water bodies arising from the breakdown of nitrogeneous organic and inorganic matter in soil and water, excretion by biota, reduction of nitrogen gas in water by micro-organisms and from gas exchange with the atmosphere. It is also discharged into water bodies by some industrial processes. Unpolluted water contain small amounts of ammonic and ammonic compounds, usually less than 0.1 mg/l as nitrogen.

The threshold odour concentration of ammonia at alkaline pH is approximately 1.5 mg/l, and a taste threshold of 35 mg/l has been proposed for the ammonium cation.

iii) Chloride

Most chlorine occurs as chloride in solution. High concentrations of chloride can make waters unpalatable and therefore unfit for drinking or livestock watering.

Taste thresholds for the chloride anion depend on the associated cation and are in the range of 200-300 mg/l for sodium, potassium, and calcium chloride. Consumers can become accustomed to concentrations in excess of 250 mg/l.

iv) Copper

The presence of copper in water supply may interfere with the intended domestic uses of the water. Copper in public water supplies increases the corrosion of galvanized iron and steel fittings. Staining of laundry and sanitary ware occurs at copper concentrations above 1 mg/l. At levels above 5 mg/l, it also imparts a colour and an undesirable bitter taste to water.

v) Hardness

The hardness of water depends mainly on the presence of dissolved calcium and magnesium salts. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. The taste threshold for the calcium ion is in the range 100-300 mg/l depending on the associated anion, and the taste threshold for magnesium is probably less than that for calcium. In some instances, a water hardness in excess of 500 mg/l is tolerated by consumers.

Depending on the interaction of other factors, such as pH and alkalinity, water with a hardness above approximately 200 mg/l may cause scale deposition in the distribution system and will result in excessive soap consumption and subsequent "scum" formation. On heating, hard waters form deposits of calcium carbonate scale. Soft water, with a hardness of less than 100 mg/l, may, on the other hand, have a low buffer capacity and so be more corrosive for water pipes.

vi) Hydrogen Sulphide

The taste and odour thresholds of hydrogen sulphide in water are estimated to be between 0.05 and 0.1 mg/l. The "rotten eggs" odour of hydrogen sulphide is particularly noticeable in some ground waters and in stagnant drinking water in the distribution system, as a result of oxygen depletion and the subsequent reduction of sulfate by bacterial activity.

Sulphide is oxidized rapidly to sulfate in well aerated water, and hydrogen sulphide levels in oxygenated water supplies are normally very low. The presence of hydrogen sulfide in drinking water can be easily detected by the consumer and requires immediate corrective action.

vii) Iron

Anaerobic ground water may contain ferrous iron at concentrations of up to several milligrams per litre without discoloration or turbidity in the water when directly pumped from a well. On exposure to the atmosphere, however, the ferrous iron oxidises to ferric iron, giving an objectionable reddish brown colour to the water.

Iron also promotes the growth of "iron bacteria", which derive their energy from the oxidation of ferrous iron to ferric iron and in the process deposit a slimy coating on the piping.

At levels above 0.3 mg/l, iron stains laundry and plumbing fixtures. There is usually no noticeable taste at iron concentrations below 0.3 mg/l, although turbidity and colour may develop. Iron concentrations of 1-3 mg/l can be acceptable for people drinking anaerobic well water.

viii) Manganese

Although manganese concentrations below 0.1 mg/l are usually acceptable to consumers, this may vary with local circumstances. At levels exceeding 0.1 mg/l, manganese in water supplies stains sanitary ware and laundry and causes an undesirable taste in beverages. The presence of manganese in drinking water, like that of iron, may lead to the accumulation of deposits in the distribution system. Even at a concentration of 0.02 mg/l, manganese will often from a coating on pipes, which may slough off as a black precipitate. In addition, certain nuisance organisms concentrate manganese and give rise to taste, odour, and turbidity problems in distributed water.

Although concentrations below 0.1 mg/l are usually acceptable to consumers, this may vary with local circumstances.

ix) pH

Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. For effective disinfection with chlorine, the pH should preferably be less than 8. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. Failure to do so can result in the contamination of drinking water and in adverse effect on its taste, odour, and appearance.

The optimum pH required will vary in different supplies according to the composition of the water and the nature of the construction materials used in the distribution system, but it is often in the range 6.5-9.5. Extreme values of pH can result from accidental spills, treatment breakdowns, and insufficiently cured cement mortar pipe linings.

x) Sodium

The taste threshold concentration of sodium in water depends on the associated anion and the temperature of the solution. At room temperature, the average taste threshold for sodium is about 200 mg/l.

xi) Sulphate

The presence of sulphate in drinking water can cause noticeable taste. Taste impairment varies with the nature of the associated action; taste thresholds have been found to range from 250 mg/l for sodium sulphate to 1000 mg/l for calcium sulphate. It is generally considered that taste impairment is minimal at levels below 250 mg/l.

It has also been found that addition of calcium and magnesium sulphate (but not sodium sulphate) to distilled water improves the taste; optional taste was recorded at 270 and 90 mg/l for the two compounds, respectively.

xii) Total Dissolved Solids

Total dissolved solids (TDS) can have an important effect on the taste of drinking water. The palatability of water with a TDS level of less than 600 mg/l is generally considered to be good; drinking water becomes increasingly unpalatable at TDS levels greater than 1200 mg/l. Water with extremely low concentrations of TDS may be unacceptable because of its flat, insipid taste.

The presence of high levels of TDS may also be objectionable to consumers owing to excessive scaling in water pipes, beaters, boilers, and household appliances. Water with concentrations of TDS below 1000 mg/l is usually acceptable to consumers, although acceptability may vary according to local circumstances.

xiii) Zinc

Zinc imparts an undesirable astringent taste to water. Tests indicate a taste threshold concentration of 4 mg/l (as zinc sulfate). Water containing zinc at concentrations in excess of 5 mg/l may appear opalescent and develop a greasy film on boiling, although these effects may also be noticeable at concentrations as low as 3 mg/l. Although drinking water seldom contains zinc at concentrations above 0.1 mg/l, levels in tap water can be considerably higher because of the zinc used in plumbing materials.

2.5. Radiological Aspects

2.5.1. Many waters contain trace amounts of radioactivity caused by naturally occurring radioactive isotopes of elements such as potassium (40 K). In granite areas water can contain trace amounts of radium. Usually, the levels of natural radioactivity found in drinking water are too low to constitute a health risk.

2.5.2. The standards recommended take account of both naturally occurring radioactivity and any radioactivity that may reach the water sources as a result of human activities. From a radiological point of view, they represent a value below which water can be considered potable without any further radiological examination.

The guideline values are specified assuming that only the most toxic radionuclides likely to be present in significant quantities, namely, 90 Sr and/ or 226 Ra contribute to the gross radioactivity of the drinking water.

2.6. Guideline Values for Traditional Surface Water Sources

Traditional surface water sources like the ponds, dugwells, springs, etc. are often grossly contaminated with Faecal Coliform Count exceeding 1000 / 100 ml. In Chapter – 7 of this manual a number of measures for sanitary protection and quality upgradation for such sources have been recommended. It may be difficult to make the Bacteriological Quality of these sources conform to the above standards. It is recommended that ponds and other surface water sources which could be used for domestic purposes other than drinking should have Faecal Coliform Count less than 200 / 100 ml and the same for protected dugwells and springs should be less than 50 / 100 ml.

CHAPTER – 3

EPIDEMIOLOGICAL & HEALTH ASPECTS OF WATER QUALITY

3.1 General Considerations

The health status of an individual, a community or a nation is determined by the interplay and integration of two ecological universes - the internal environment of man himself and the external environment which surrounds him. The external environment consists of 3 major components - physical, biological and social, all of which are closely related. The physical environment encompasses the non-living things and physical forces affecting man, e.g. water, air, ventilation, light, noise, climate etc. The biologic environment includes the living things of the plant and animal kingdom. The social environment comprises a complex interplay of factors and conditions such as cultural values, customs, habits, beliefs, attitudes, economic status, occupation, religion, social and political organization.

It is well known today that a disease is caused due to a disturbance in the delicate balance between man and his environment. Of the three ecological factors (agent, host and environment) responsible for diseases, the disease agent is usually identified with the help of laboratory diagnosis; the host is available for study; but the environment from which the patient comes is largely unknown. Yet frequently, the key to the nature, occurrence, prevention and control of disease lies in the environment. Without this knowledge, this key may not be available to the physician who desires to cure disease, prevent or control it. This chapter will deal with one of such environmental factors which is responsible for transmission of many diseases in man.

Poor environmental sanitation and unsafe drinking water has been one of the major health problems in India. Water & sanitation related infections and the diseases of the alimentary tract constitute 60% to 80% of the illness. Many of them, such as diarrhoea, dysentry, typhoid fever, intestinal helminthiasis, jaundice, cholera are endemic in India, particularly in the rural areas. Health linkages with water and environmental sanitation has been depicted in Figure No. 3.1.

Inspite of significant progress in scientific and technical fields there is no significant change in the situation since attainment of independence. While the rural areas continue to be in-sanitary, rapid industrialization and associated growth of the urban population during the last 25 to 30 years have adversely affected the environmental sanitation of the major cities. Though substantial progress has been achieved in the in the sector of community water supply, health benefits have not been commensurate with the investment made, primarily because of the following factors : -

- Community water supply projects have not been integrated with hygiene, education and sanitation.
- Water quality surveillance has been totally neglected.
- Lack of participation of the community / beneficiaries.

The diseases related to water supply and sanitation are numerous and the relationships are sometimes complex.

3.2 Water Related Infections

A water-related disease is one that is in some gross way related to water in the environment or to impurities within water. Water-related diseases may be divided into those caused by a biological agent of disease (a pathogen) (Table 3.1) and those caused by some toxic chemical substances (Table 3.3) in water. The first group may be called the water-related infections and may include some of the greatest causes of disease and death in the developing countries (for instance diarrhoeal diseases and malaria). The second group includes diseases such as fluorosis (linked to high fluoride levels in drinking water) and infantile methemoglobinemia (related to high nitrate levels in drinking water). These chemistry related diseases are overwhelmingly overshadowed by the water related infections in the developing countries, but some of them are slowly gaining importance in India, particularly due to industrial developments.

Transmission Routes

The water-related infections are so described because of their transmission routes. There are four transmission routes that are water related. These are shown in Table 3.2 along with the relationship with the environmental strategies for disease control that are appropriate to each route. The four routes are :

3.2.1 Water-borne route

Truly water-borne transmission occurs when the pathogen is in water that is drunk by a person or animal that may then become infected. Potentially water-borne diseases include the classical infections, notably cholera and typhoid, but also include a wide range of other diseases, such as infective hepatitis, and some diarrhoeas and dysenteries.

HEALTH LINKAGES

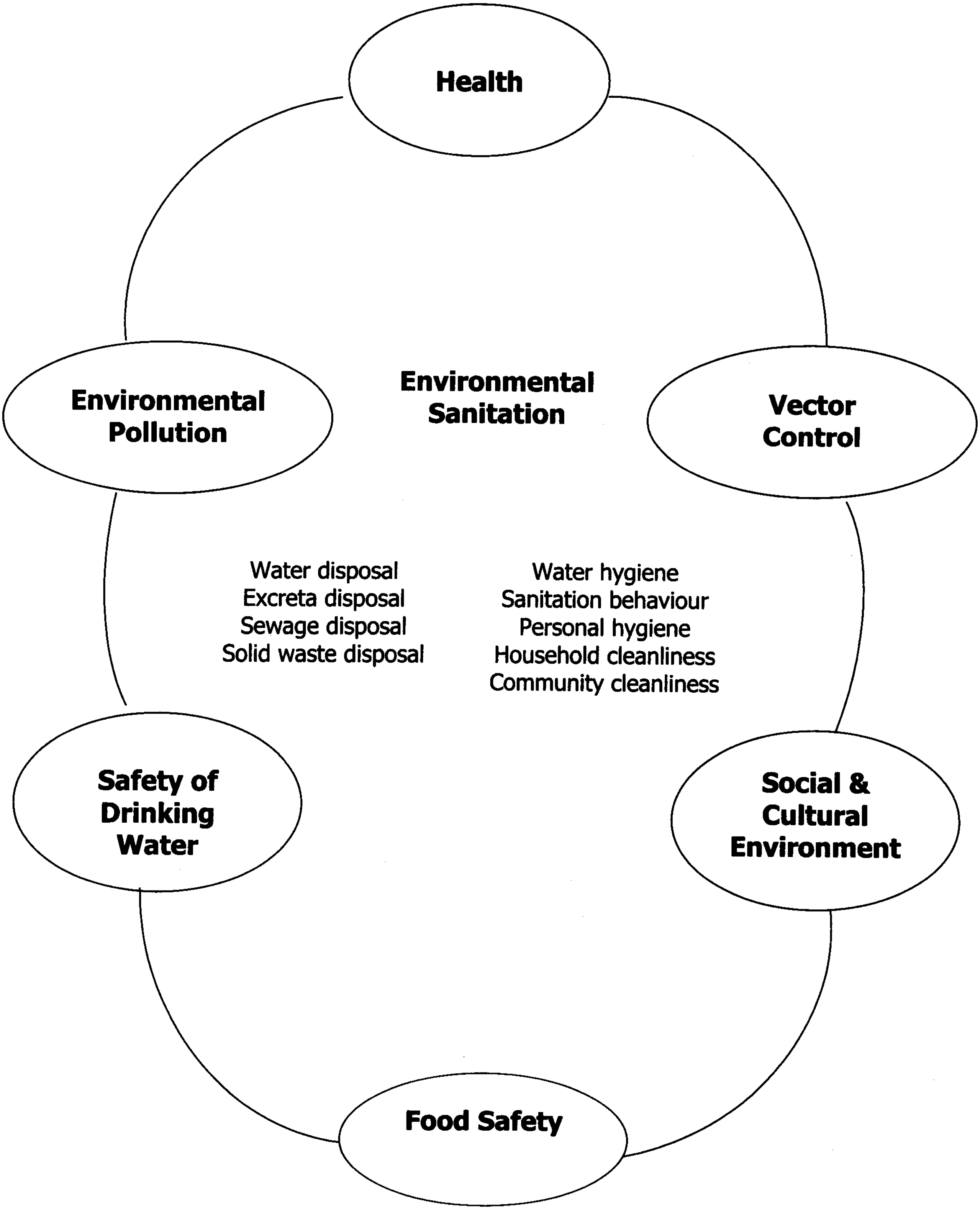


Fig No. 3.1

3.2.2 Water-washed route

There are many infections of the intestinal tract and of the skin that, may be significantly reduced following improvements in the domestic and personal hygiene. These improvements in hygiene often depend upon increased availability of water and the use for hygienic purposes of increased volumes of water. They may, therefore, be described as water-washed diseases and they depend on the quantity of water used, rather than its quality.

The important types of water-washed infections are those of the skin or eyes. Bacterial skin sepsis, scabies, and fungal infections of the skin are extremely prevalent in many hot climates, and eye infections such as trachoma are also common and may lead to blindness.

3.2.3 Water-based route

A water-based disease is one in which the pathogen spends a part of its life-cycle in a water snail or other aquatic animal. All these diseases are due to infection by parasitic worms (helminths) which depend on aquatic intermediate hosts to complete their life-cycles. The degree of sickness depends upon the number of adult worms that are infecting the patient and so the importance of the disease must be measured in terms of the intensity of infection as well as the number of people infected. Important examples are schistosomiasis and Guinea worm.

3.2.4 Insect vector route

The fourth route is via insects that either breed in water or bite near water. Malaria, yellow fever, dengue and onchocerciasis (river blindness), for example, are transmitted by insects that breed in water another example West African trypanosomiasis (Gambian sleeping sickness) is transmitted by the riverine tsetse fly *(Glossina spp.)* which bites near water.

3.3 Excreta-Related Infections

An excreta-related infection is one related to human excreta (meaning urine and faeces). Only two transmission mechanisms are excreta related :

3.3.1 Transmission via infected excreta

The pathogen is released into the environment in the faeces or urine of an infected individual.

3.3.2 Transmission by an excreta-related insect vector

An insect that visits excreta to breed or feed may mechanically carry excreted pathogens to food or an insect vector of a non-excreted pathogen may preferentially breed in faecally polluted sites.

All excreta-related infections except one are also excreted infections, i.e., they are shed in the urine or feces of an infected individual. The one clear exception is *Bancroftian filariasis,* which in some parts of the world is transmitted by members of the *Culex pipiens* group of mosquitoes that breed in sewage and other heavily polluted waters. All excreta-related infections are also water related except for the hook-worm *Strongyloides* and the beef and pork tapeworms. Several water-related infections are not excreta related (e.g., skin infections, trachoma, Guinea worm and malaria).

3.4 Water and Excreta Related Infections

The water and excreta related classifications are overlapping in that many water-related infections are excreta related and most excreta-related infections are water related. In this section, therefore, the water and excreta-related infections are brought together in groups having similar epidemiological features and are tabulated in a way that highlights their amenability to prevention through interventions in water supply, excreta disposal, or hygienic behaviour. The groupings considered are :

- The diarrhoea-causing infections and enteric fevers
- Poliomyelitis and hepatitis A
- Worms with no intermediate host
- Worms with intermediate stages in the pig or cow
- Worms with aquatic intermediate stages
- Water borne re-infection
- Skin and eye infections and louse-borne infections
- The infections transmitted by water-related insects

3.4.1 The Diarrhoea-Causing Infections and Enteric Fevers

They are the most important group of water and excreta-related infections. Diarrhoeal diseases are caused by a variety of excreta viruses, bacteria, and protozoa. In all cases transmission is fecal-oral and both water-borne and water-washed modes of transmission occur.

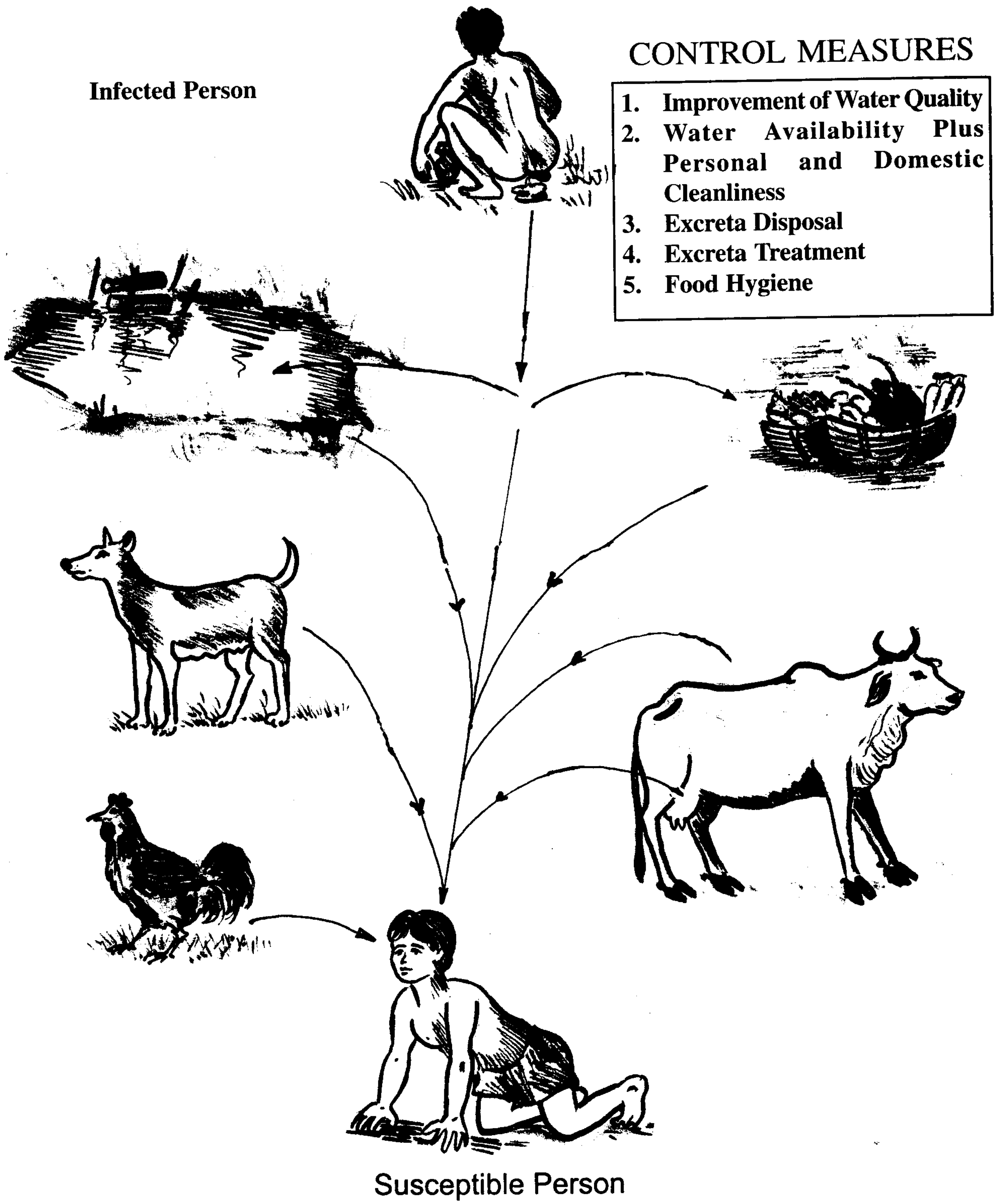


Figure 3.2

The Transmission and Control of Diarrhoeal Diseases and Enteric Fevers

Figure 3.2 represents the major transmission routes for diarrhoeal diseases and enteric fevers (typhoid and paratyphoid) and indicated the modes of action of several strategies for interrupting transmission.

3.4.2 Poliomyelitis and Hepatitis A & e

Poliomyelitis and hepatitis A & e are entirely different infections but they have several epidemiological features in common. Transmission is fecal-oral; infective doses are probably low. Figure 3.3 represents the major transmission routes for poliovirus and hepatitis A virus and indicates the modes of action of several strategies for interrupting transmission.

3.4.3 Worms with No Intermediate Host

Several excreted helminths that infect humans have no obligatory intermediate host. The adult worms live in the human intestine, and their eggs or larvae are passed in the faeces (or, if not actually in faeces, then at least via the anus). The eggs of Ascaris and Trichuris must remain in a suitable environment (usually warm, moist soil) for 5-6 weeks before they become infectious. Re-infection is then oral, by ingesting food or dirt contaminated by infective eggs. The eggs of the hookworms also develop in warm, moist soil. After one week or more infective larvae are formed that cause reinfection by penetrating the unbroken skin, usually of the foot. Figure 3.4 describes the transmission routes and control measures for these common intestinal worms.

3.4.4 Worms with Intermediate Stages in the Pig or Cow

The beef and pork tapeworms *(Taenia saginata and T. solium)* are parasites with life-cycles that are theoretically easy to interrupt through correct management of human faeces. The adult worms live only in the intestine of humans. Egg, usually contained in worm segments, are passed anally and usually in the faeces. These eggs must be eaten by a cow or pig *(for T. saginata and T. solium respectively)* following which they hatch and form encysted larvae in the muscle, tongue, liver, or other sites. Humans are reinfected by eating inadequately cooked beef or pork containing cysts. Transmission and control of these tapeworms are described in Figure 3.5.

3.4.5 Worms with Aquatic Intermediate Hosts

A fascinating array of worms infect humans only having passed through developmental stages in one or more aquatic hosts (in other words they are water based).

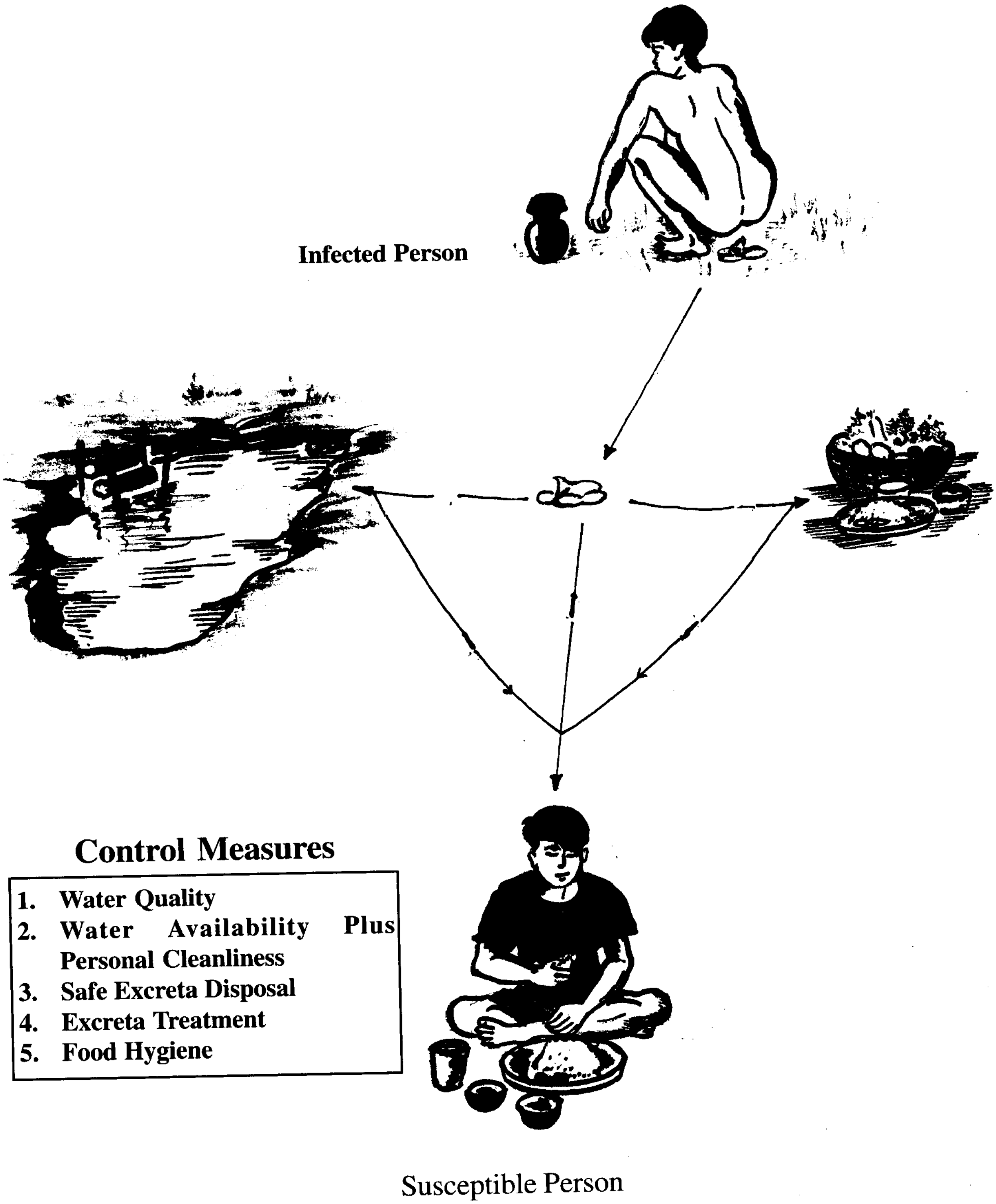


Figure 3.3

The Transmission and Control of Poliovirus and Hepatitis-A Virus

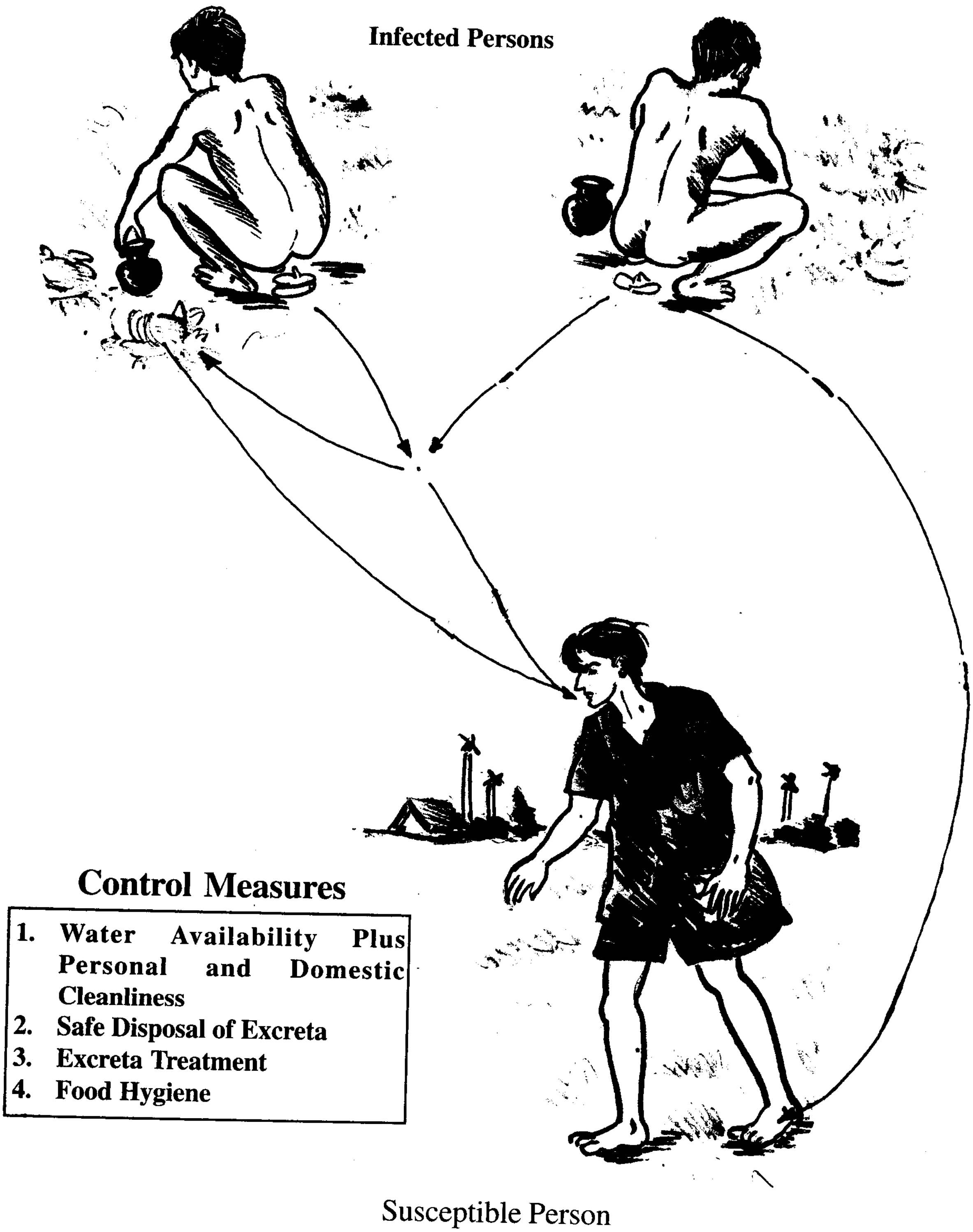


Figure 3.4

The Transmission and Control of Ascaris, Trichuris and Hookworms

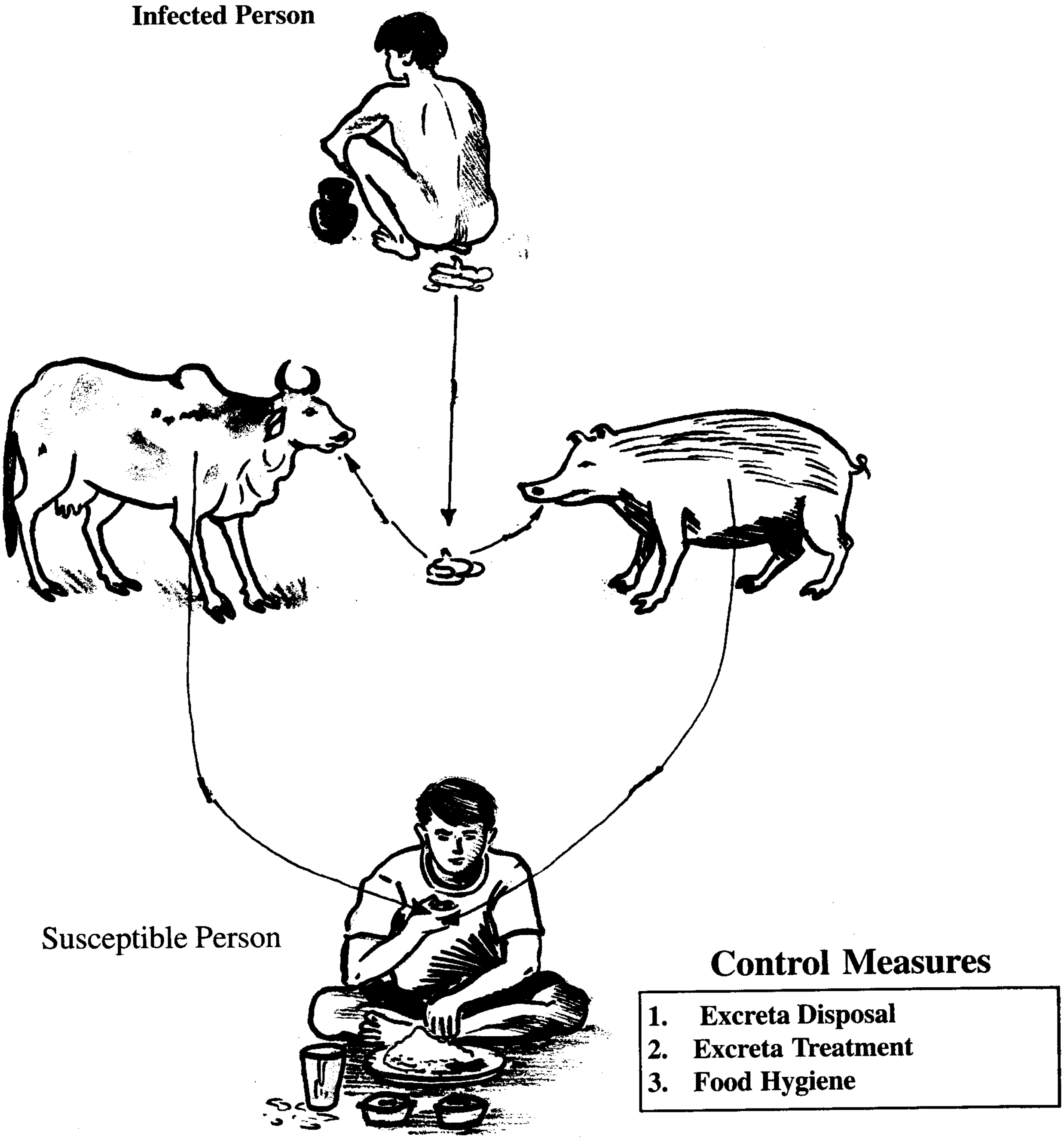


Figure 3.5

The Transmission and Control of Tapeworms

3.4.5.1 Schistosomiasis

Among them are infections like schistosomiasis infected through snails, are of major public health importance in many countries in Africa, some areas of Middle East and China but not in India.

3.4.5.2 Guinae worm infection

Guinea worm or *Dracunculus medinensis* requires an aquatic intermediate host, and re-infection in man is always water-borne. Female worms mature in the deep tissues and then migrate to lie subcutaneously in a limb. Numerous larvae develop within the body of the female which induces a blister in the skin, which breaks down. The female exposes her prolapsed uterus there and the larvae are discharged whenever water is sensed by the worm. The life cycle continues if these larvae reach water containing copepods Cyclops, which eat the larvae. Development to the third stage larvae takes place in the body of the Cyclops and these are infective to humans if ingested. Guinea worm is a unique water related infection in that it can be eradicated solely by simple improvement in community water supply (Figure 3.6)

3.4.7 Skin, Eye and Louse-Borne Infections

This mixed group of infections are not excreta related and are not water-borne but are transmitted in conditions of poor personal cleanliness (Figure 3.7).

Skin infections are extremely common and varied in the tropics. Superficial fungal infection, skin sepsis and ulcers, scabies are common. In some regions the prevalence of scabies exceeds 50% among school children. Transmission of these skin infections is by close contact; skin-to-skin or via clothes or bed linen.

Eye infection is a major public health problem in nearly all developing countries. Most serious of the common infection is trachoma, which apart from other countries, is particularly prevalent in arid areas of India. Trachoma often leads to impaired vision and sometimes to blindness. Various forms of conjunctivitis (especially acute bacteria) are also very common. Transmission is by direct eye-to-eye transfer of infective discharge by fingers, clothing or flies.

Diseases transmitted by body louse i.e. louse borne typhus caused by *Rickettsia prowazeki* and louse borne relapsing fever caused by *Borrelia recurrentis* can be reduced by controlling louse population and this can be achieved by increased body and clothes washing.

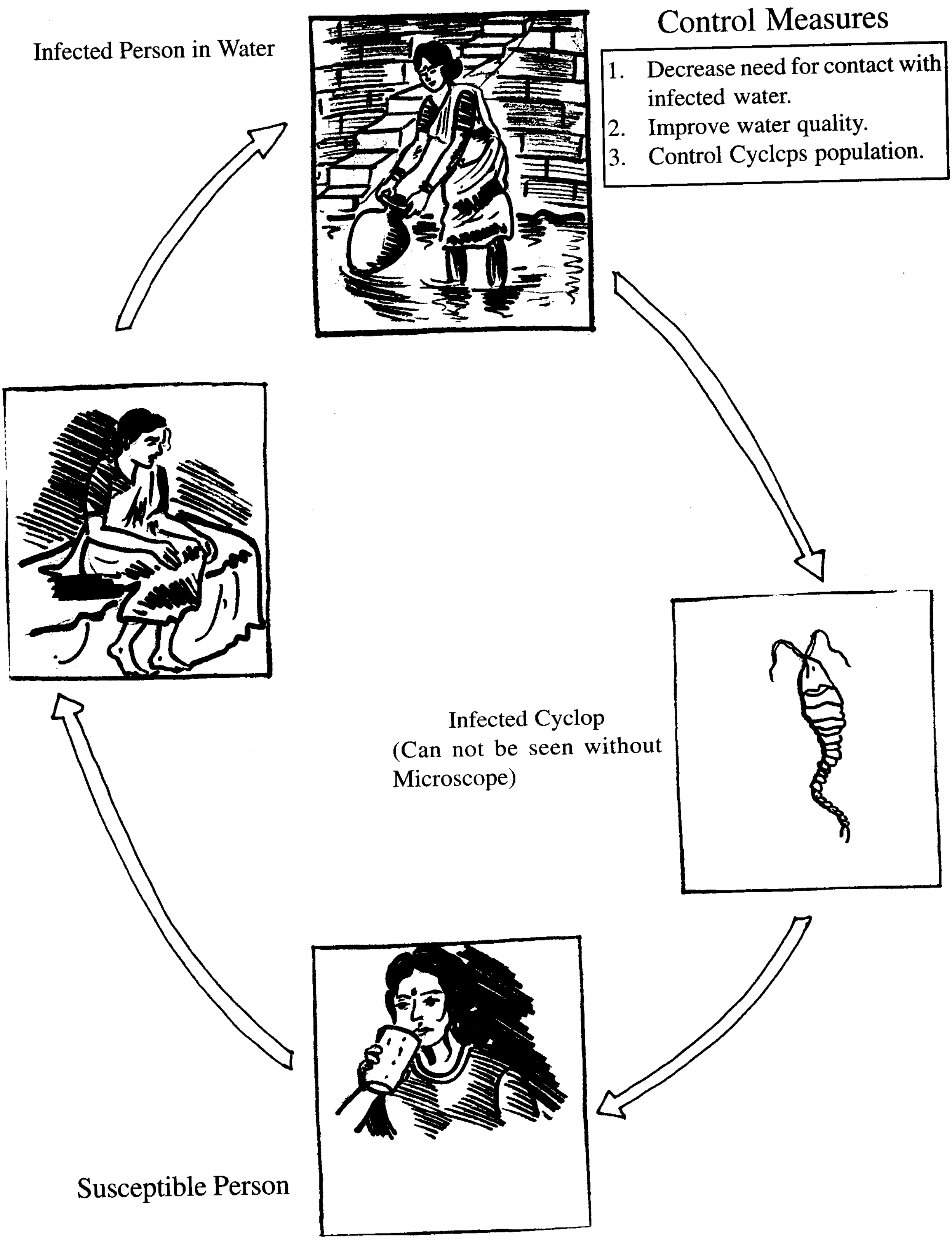


Figure 3.6

Transmission Cycle of Guinea Worm

Control Measures

1. Improve water quality.
2. Improve surface water management.
3. Decrease direct contact with infected person.
4. Improve personal hygiene

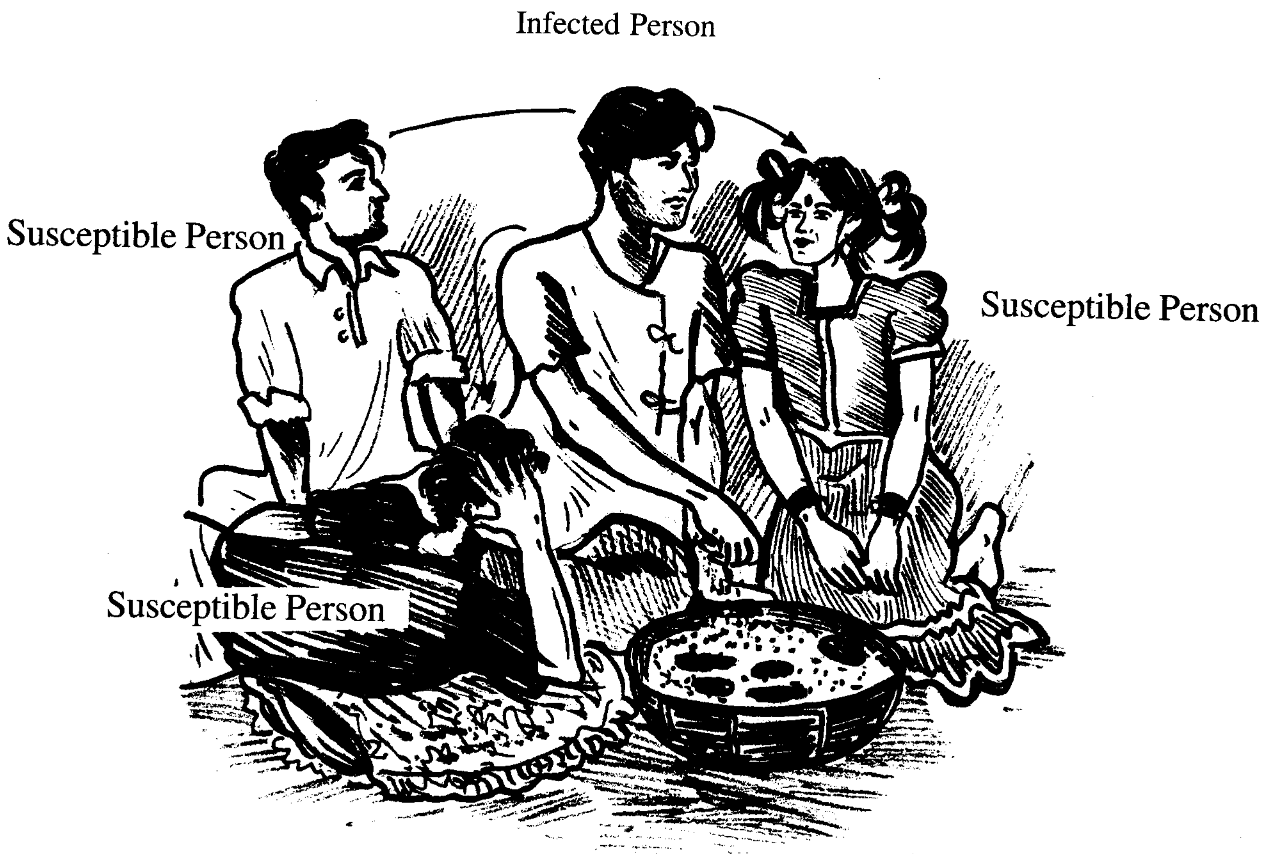


Figure 3.7

The Transmission and Control of Skin, Eye and Louse Borne Infections

3.4.8 Infections Transmitted by Water-Related Insects

A large group of infections, several of them of major international public health importance, are transmitted by flies or mosquitoes which breed in water or bite near water. Malaria, yellow fever, dengue and *Bancroftian filariasis* are most important.

3.5 Chemicals Causing Water Related Diseases (Table 3.3)

Arsenic

The sources of Arsenic pollution in water are generally industrial wastes, contaminating water bodies, either directly or by leaching through soil and also some agricultural insecticides. Though rare, natural arsenic pollution can occur in groundwater from arsiniferous belts in specific geomorphological conditions, as has been found in some areas of West Bengal.

The symptoms of chronic arsenic poisoning include various types of dermatological lesions, muscular weakness, paralysis of lower limbs, etc. Arsenic is a potential carcinogen and skin and lung cancer can occur after prolonged exposure.

Mercury

Mercury poisoning can occur through food and water. The source of pollution is almost exclusively industrial waste. It must be noted however, that chronic mercury poisoning is less often water borne. Industrial wastes contaminate water bodies and is taken up by phyto-planktons and zooplanktons. These are then biomagnified in fish and other sea foods, eaten by man. In organic mercury poisoning various types of neural damages occur ranging from numbness, speech impairment to paralysis and death. With inorganic mercury poisoning renal damages can occur.

Nitrates

Increase in nitrate levels in surface and groundwater is primarily due to agricultural fertilisers and manure, animal dung and other sources of nitrogenous materials in the environment. Excessive nitrates cause to infants who are particularly susceptible to asphyxiation by methemoglobinemia. Secondly, nitrites can combine with various amines in the gastrointestinal tract to form nitrosamines (particularly in low acidity conditions) some of which are carcinogenic.

Fluoride

Fluoride occurs naturally in ground water. Though most waters contain below 1 mg of fluoride per litre, there are areas that are rich in fluoride containing minerals, where fluoride content of water can be very high.

However, long term consumption of water above the permissible level can give rise to dental fluorosis, manifested by mottling of teeth and higher exposures can give rise to skeletal fluorosis, a crippling disease in which bone structure is affected.

Pesticides

Surface run-off carrying pesticides/insecticides may cause pollution of surface water sources. Pesticides may cause following deleterious effect on public health and environment.

- Residues of pesticides contribute significantly to contamination of food, water, soil, animal products and human milk and tissues.
- The ubiquitous presence of DDT and HCH in the environment.
- High body burden of DDT and HCH in the general population and reported possible risk of breast cancer among women.
- Widespread contamination of bovine milk and baby feeds with hard to degrade organochlorine pesticides.

Water supply agencies should conduct study to monitor presence of insecticides in surface water sources through research institutions. Indiscriminate disposal of hazardous and toxic chemicals and heavy metals into water and soil is causing serious contamination of surface and ground water sources. The periodic reports of contamination of water sources with chromium, cadmium, lead, mercury, etc. are of grave public health concern.

3.6 Conclusion

It is estimated that in India alone, 1.5 million children below 5 years die from diarrhoeal disease every year. Despite tremendous advances in medical knowledge and practice, morbidity and mortality due to water and excreta related communicable diseases continue to remain a heavy burden for all governments in the developing countries.

Water and sanitation has been accepted today, as a priority issue in health sector. But, it is also clear that the health impact cannot be achieved by a simplistic policy of only supplying clean water. Only carefully designed programmes that integrate water quality improvements with improvement in water availability, sanitation and hygiene education will achieve substantial reductions in the transmission of water and excreta related infections.

Table 3.1 : Environmental Classification of Water-Related Infections

Sl. No	Category	Infection	Pathogenic agent
1.	Faecal-oral (water - borne or water - wahsed)	Diarrhoeas and dysenteries Amoebic dysentery Balantidiasis Campylobacter enteritis Cholera E. coli diarrhoea Giardiasis Rotavirus diarrhoea Salmonellosis Shigellosis (Bacillary dysentery) Yersiniosis Enteric fevers Typhoid Paratyphoid Poliomyelitis Hepatitis A Hepatitis e Leptospirosis Ascariasis Trichuriasis	Protozoa Protozoa Bacteria Bacteria Bacteria Protozoa Virus Bacteria Bacteria Bacteria Bacteria Bacteria Virus Virus Virus Virus Spirochaete Helminth Helminth
2.	Water-washed Skin and eye infections Others	Infectious skin diseases Infectious eye diseases Louse-borne typhus Louse-borne relapsing fever	Fungi Virus Bacteria Ricaettsia Spirochaete
3.	Water-based Penetrating skin / Ingested	Guinea worm Schistosomiasis Clonorchiasis Diphyllobothriasis Fasciolopsiasis Paragonimiasis	Helminth Helminth Helminth Helminth Helminth Helminth
4.	Water-related insect vector Biting near water Breeding in water	Sleeping sickness Filariasis Malaria River Blindness Mosquito-borne viruses Yellow fever Dengue Encephalitis	Protozoa Helminth Protozoa Helminth Virus Virus Virus

Table 3.2 : The Four Routes of Water-Related Infection Transmission and the Preventive Strategies Appropriate to Each Route

Transmission Route	Preventive Strategy
Water - borne	Improve quality of drinking water Prevent casual use of other unimproved sources
Water - washed	Increase water quantity used Improve accessibility and reliability of domestic water supply Improve hygiene
Water - based	Decrease need for contact with infected water Control snail populations* Reduce contamination of surface water by excreta**
Water - related insect vector	Improve surface water management Destroy breeding sites of insects Decrease need to visit breeding sites Use mosquito netting

* Applies to schistosomiasis only.

** The preventive strategies appropriate to the water-based worms depend upon the precise life cycle of each and this is the only general prescription that can be given.

Table 3.3 : Inorganic chemicals causing water related diseases

Inorganic contaminant	Major source	Sphere most affected	Primary health effects
Arsenic	- Ore smelting, refining - Pesticides - Geological	- Air, Water	- Arsenic poisoning (dermatosis, keratosis, gastro-intestinal disorders, lower limb paralysis, cancer)
Fluoride	Geological	Water	Dental, skeletal and non-skeletal fluorosis
Nitrates Nitrites	Agricultural run-off Meat preservatives	- Water, Food	- Nitrates → Nitrite + Amines (in body) yield carcinogenic nitrosamines Nitrates can cause methemoglobinemia in infants.
Mercury	- Inorganic form Electrical goods Chlor-alkali industry, burning of fossil fuel - Organic form Slimicides, Fungicides	- Water, Food	- Inorganic : disorders of renal system - Organic : , disorders of CNS, numbness, impaired speech, paralysis, deformity, death.
Cadmium	- Electroplaters, battery manufacturers	- Air, Food, Water	- Cadmium fumes, joint pain, lung, kidney disease - Possibly carcinogenic, teratogenic
Lead	- Leaded gasoline, batteries - Solder, radiation shielding	- Air, Food, Water	- Impairs nervous system, red blood cell synthesis - Depends on exposure
Pesticides	Public health & agricultural use	Food, water, soil and animal products	Contamination of human milk and tissue risk of breast cancer among women

CHAPTER – 4

WATER QUALITY MONITORING

4.1. Introduction

Monitoring of water quality involves laboratory and field testing of water samples collected from various points in the water supply system including the source, water purification plants, distribution system and house reservoirs and such other consumer ends.

The objective of water quality monitoring are-

- to assess the impact of activities by man upon the quality of water and its suitability for required uses;
- to determine the quality of water in its natural state which might be available to meet the future needs;
- to keep under observation the sources and pathway of specified hazardous or harmful substances.

4.2. Location of Sampling

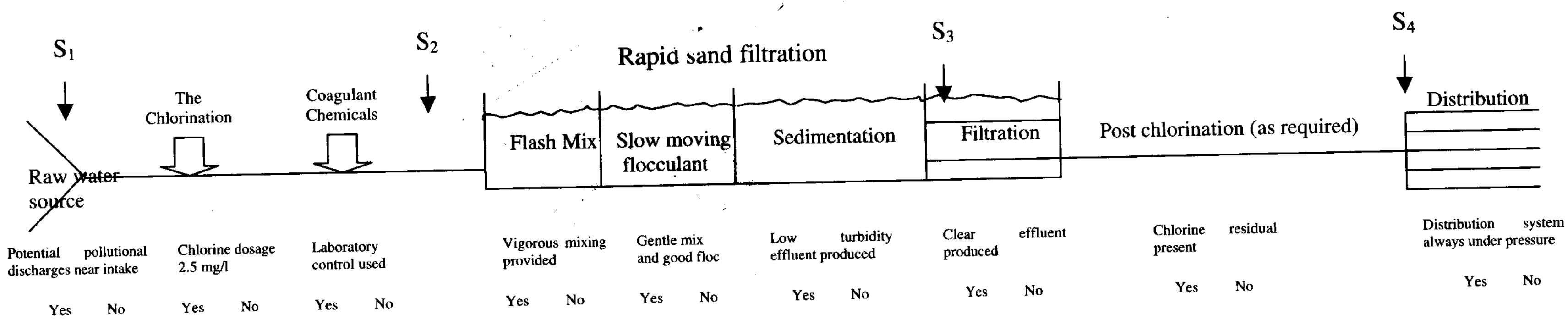
Obviously, the objective of monitoring water quality is to obtain reliable and useful data for which it is essential to take every precaution in locating the sampling spots at representative points either in the water production system (water purification plant, wells etc.) or distribution network. Collection of water sample in a surveillance programme aims at :

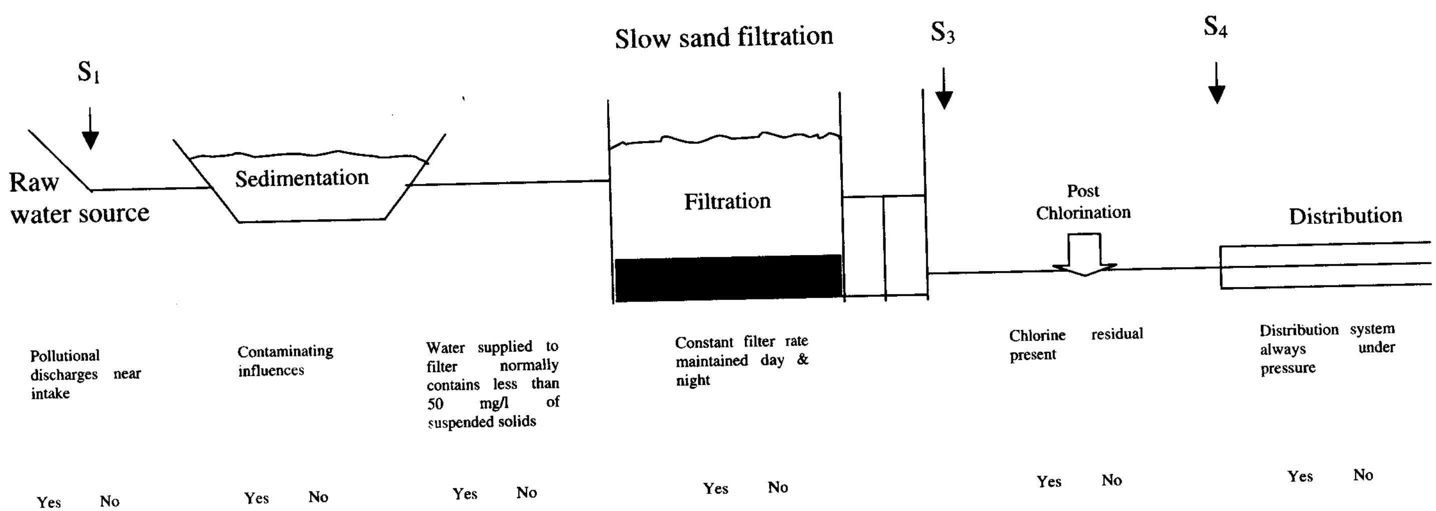
1. ascertaining the quality of water in various rural sources like tubewells, dugwells, springs, ponds, etc. or as it emanates from pipe, tap etc. to be used for drinking or other domestic purposes; and
2. examining physico-chemical and bacteriological quality to reveal whether the limit of values prescribed for different parameters have been exceeded or not.

Sampling from locations in the water treatment plants is for process control for effective performance of the treatment plant. A typical layout and location for sampling is shown in Figure 4.1.

The distribution system in a piped water supply in a rural or peri-urban system is rather simple and sampling may be done periodically in public stand posts and in selected consumer locations at random. In majority of the small water supply schemes, sampling locations recommended are the public stand posts.

Figure 4.1 : Location for sampling of surface water treatment plant





$S_1 - S_4$ = Point of sampling

In a peri-urban distribution network, on the other hand, there are house connections taking off from the submains besides public stand posts. Under such condition, sampling locations should be stand posts as well as residential taps.

In selecting sampling points, each locality should be considered individually; however, certain general criteria are usually applicable, as follows :

(a) sampling points should be selected such that the samples taken are representative of the different sources from which water enters the system;

(b) these points should include those that yield samples representative of the conditions at the most unfavourable places in the system, from the viewpoint of possible contamination (loops, reservoirs, low-pressure zones, ends of the system, etc.);

(c) sampling points should be uniformly distributed throughout the system;

(d) sampling points should be located in the three types of distribution system (open, closed and mixed) in proportion to the number of links or branches;

(e) sampling points should generally be chosen such that the samples are adequately representative of the system as a whole and its main components;

(f) sampling points should be located in such a way that water can be sampled from reserve tanks and reservoirs, etc.;

(g) in systems with more than one water source, the sampling points should be located so as to take account of the number of inhabitants served by each source;

(h) there should be at least one sampling point directly after the clean water outlet from each treatment plant.

4.3. Collection of Water Samples

The collection of water samples deserves a scrupulous care. Meaningful and reliable sampling assures correct laboratory results. For this purpose, water samples must fairly represent the body of water from which they are collected and there must not be significant change in the samples between the time of collection and conducting the water analysis. For physical analysis, ordinary care will do but for bacteriological examination, extreme care must be taken during sample collection and its preservation; chemical examination need adequate care but assessment of different parameters needs proper preservation that would be parameter specific.

4.3.1. Basic Requirements

One of the vital element in drinking water quality control is the bacteriological examination of the water. In collecting samples for bacteriological analysis, the following requirements must be fulfilled -

(a) After proper planning, sampling should be carried out ideally with adequate frequency to ensure any seasonal variations in the quality of water to be investigated.

(b) Samples should be collected, stored and despatched in suitable sterilized bottles.

(c) The volume of water to be collected should be adequate enough to permit an accurate analysis.

(d) The selection of sampling point in the water supply system should be such that the samples collected there from are as representative as possible.

(e) Utmost precaution should be taken during sampling to avoid contamination of the sample being collected.

(f) In order to prevent significant alteration in the composition of a collected sample prior to analysis, it is important to ensure that the sample is despatched to the laboratory under iced condition as soon as practicable.

(g) The details of the sample should be clearly described and the sample bottles properly labelled to avoid any error.

4.4. Type of Samples

4.4.1 Grab or Catch Samples

A sample collected at a particular time and place and would represent the composition of the sources at that time and place.

4.4.2 Composite Samples

A mixture of grab samples collected at the same sampling point at different times.

4.4.3 Integrated Samples

Mixture of grab samples collected from different points simultaneously or as nearly as possible is called integrated sample.

Generally for drinking water quality monitoring, grab samples are taken.

4.5. Sample Containers

A sample container must satisfy the following requirements -

- It should easily be freed from contamination.
- It should not change the relevant water characteristics
- It should have adequate capacity for storing the samples (required for laboratory analysis)
- It should be resistant to impact and to internal pressure which is increased by expansion of water or by release of dissolved gases at elevated temperature on storage.
- It should not make any reactions with the water.

For most purposes, 2 litres of sample water are advisable for collection assuming a margin for contingencies. Colourless or pal green bottles are preferable. Dark coloured bottles are to be avoided, except for samples for residual chlorine estimation, which should be collected separately in amber coloured glass bottles so that direct access to light is prevented to safeguard against altering the chlorine content of the samples.

For bacteriological examination, water sample should be collected in 250 ml sterilized glass bottles provided with ground glass stopper having an overlapping rim, the stopper and neck of the bottle should be protected by a paper or thin aluminium foil. The process of sterilization is carried out in an autoclave at 1kg/cm^2 pressure for 15 minutes.

In case water to be sampled contains residual chlorine, or chloramine, dechlorination is necessary during sampling for bacteriological examination .

For this purpose, before sterilization, Sodium thiosulphate ($Na_2S_2O_3 \cdot 5H_2O$) is added to the clean dry sampling bottles to neutralise these substances. 0.2 ml of 10% solution of Sodium thiosulphate is added to 250 ml bottle. The bottle is then sterilized.

4.6. Sampling Procedures

4.6.1 Sample collection for bacteriological analysis

As already discussed the sample collected must be true representative of water to be tested. A great care should be taken to ensure that no contamination takes place while collecting the sample prior to examination. The sampling bottle should be opened only when it is required for filling. The bottle should be held from the base while filling and stopper should be replaced immediately after filling. No rinsing should be done while filling. The bottle should not be filled completely. Some spaces should be left for air to facilitate shaking before analysis. After replacing the stopper, the stopper and neck of the sampling bottle should be protected by wrapping with brown paper. The following procedure should be observed while taking water samples from various sources.

(a) **Sampling from river, stream, lake, reservoir or shallow wells :** While collecting sample of water directly from a source, an effort should be made to obtain a sample which is true representative of water which is being taken for the purpose of treatment or supply as the case may be. The sample should be taken from actual draw off point with respect of distance from the bank and with respect to depth of water.

Samples are taken by holding the bottle in the hand near its base and plunging its neck downward below the surface. The bottle should then be turned until the neck point slightly upward, the mouth being directed towards the current. In case of reservoir where there is no current, it should be created artificially by pushing the bottle horizontally forward in a direction away from the hand. In case it is difficult to take sample by hand, weight should be attached to the base of the bottle which is lowered into the water. Special type of apparatus is also available which arranges the mechanical removal of stopper of sampling bottle below the surface at a required depth.

(b) Sampling of Hand pump Water : For collection of water sample from a hand pump, water should be pumped for about five minutes before filling the sample bottle.

(c) Sampling of water from a tap on distribution : For taking sample of water from a tap on distribution system, make sure that the tap selected for water sample is located on the service pipe connected with the main and not the one served from storage tank. Before taking the sample, clean the tap, sterilise it by heating with spirit lamp, open it fully and allow the water to run for 3 to 4 minutes or more to allow clearing of service pipe. Then adjust the flow of the tap to fill the bottle without splashing. The taps which are leaking allowing the water to flow over the outside should not be used for taking samples. In case it is necessary to use a particular leaking tap as a sampling point, carry out the repair of the tap first.

In open distribution systems sampling is necessary (Figure 4.2) :

A. *At the clean-water outlet from the treatment plant; this serves to check the effectiveness of the water treatment and to indicate the quality of the water entering the distribution system;*

B. *At a point such that samples are representative of the water in the chief main;*

C. *At a point such that samples are representative of the water in the branches of the chief main;*

D. *At a point such that samples are representative of the water at the end of the system.*

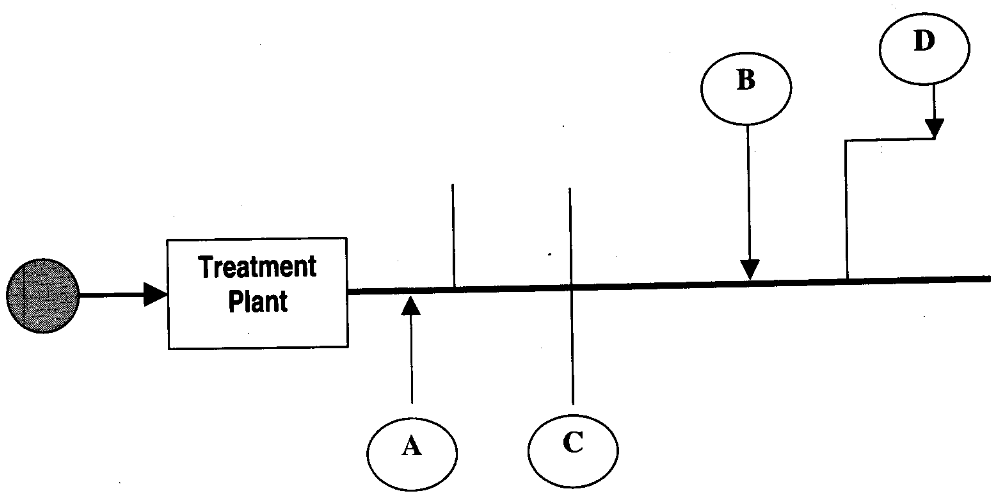


Figure. 4.2 : Open Distribution System

4.6.2 Data Relative to Samples

It is very important that all samples are properly labelled and complete and accurate data is supplied along with sample. If the samples are required to be carried for long distance for examination, the bottles should be properly packed, with separate compartment for each bottle to ensure safety in transit.

1. Name and address of person / agency requesting the examination
2. Date and time of collection
3. Purpose of examination
4. Sampling point and its location (well, stream, river, house tap etc.)
5. Exact place and depth below surface from where sample taken
6. Particulars of recent rainfall, if any, at the time of sample collection
7. Odour and taste of water after rainfall or under any particular circumstances
8. Complaint from consumers, if so, nature of complaint.
9. Surroundings : Proximity to drains, cess pools, cattle sheds, grave yards, cremation grounds, bathing ghats, manure heaps or any source of pollution.
10. Treatment and sterilization methods, if any, particulars of treatment, chemical dose and point of application etc.
11. If sampling is from a **well or a bore well :**
    - (a) Depth of well and water surface from ground level.
    - (b) Whether covered or uncovered, nature, material and construction of cover.
    - (c) Whether newly constructed or with recent alterations.
    - (d) Height and condition of parapet and apron.
    - (e) Construction :
        - *i. Bricks set dry or in cement, whether plastered inside and whether puddled outside the lining,*
        - *ii. Depth of lining*
        - *iii. Method of pumping or other means of raising water.*
    - (f) Any discoloration of sides of well or other visible indications of pollution.
    - (g) Nature of sub-soil and water bearing strata.
    - (h) Proximity of drains, cess pools or other possible sources of pollution and distance from the source.
    - (i) Whether water is clear it flows out of the tube well and remains clear when exposed to atmosphere for 4-6 hours or becomes discoloured or turbid.

12. If sampling is from a **river or stream :**
    (a) Nature of flow, whether flood or common.
    (b) Level of water whether above or below normal
    (c) Depth below surface at which sample was taken
    (d) Whether sample was taken from middle or side
    (e) Condition of weather, particulars of rainfall or flood
    (f) Any possible source of pollution upstream and distance from point of sampling, such as bathing ghat, boat jetty, burial ground and sewer outfall etc.
13. If sampling is from a **spring :**
    (a) Nature of stratum from which water drawn.
    (b) Whether sample is taken from the spring itself or from a collecting chamber; if from a chamber, indicate construction of chamber.
14. If sampling is from **tanks, impounded reservoir or lakes :**
    (a) Source of input i.e. rain, stream or a channel etc.
    (b) Characteristics of catchment area whether restricted, protected or not.
    (c) Type and extent of weed growth
    (d) Size and number of reservoirs
    (e) Whether covered or open
    (f) Date of last cleaning

The above particulars should be indicated in the forwarding letter to be sent to the testing agency and at the same time it should be written on the label of the bottle or on an appropriate tag for identification and convenience of the person conducting the test in the laboratory even at some later date. This would eliminate the chance of any confusion or mistake. A suggested form to accompany water samples is shown in Figure 4.3.

Fig. 4.3 : Suggested Form to Accompany Water Samples

Water Quality Control Programme

[Name of body responsible ______________]
Sample Code No. ______________

Sampling Data

Locality : ______________
Sample Site : ______________
Place : ______________
Source : ______________
Sender : ______________
Date of Collection : ______________
Hour of Collection : ______________
Date of Analysis : ______________
Time of Analysis : ______________
Residual Chlorine : ______________ mg/l
Appearance :

Signature of Sender   Signature of Analyst

Copies of this section sent to the laboratory

Sample Data

Sample Code No. : ______________
Locality : ______________
Sample Site : ______________
Place : ______________
Source : ______________
Residual Chlorine : ______________
Date of Sampling : ______________
Time of Sampling : ______________
Sender : ______________

Section detached and stuck to the sample

The particulars should bear the date and the name in block letters of the person collecting the sample.

4.6.3 Preservation and Storage of Samples

It is recommended that the sample should be examined preferably within one hour after collection but this period, in no case should exceed 24 hours. Efforts should be made to keep the temperature of the sample as close as possible to that of the source of water. It is considered necessary to preserve the sample in ice until analysis of the sample (if the sample cannot be analysed within 24 hours). For bacteriological analysis, sample is unfit for analysis after 72 hours.

When the waters have high coliform count originally, icing of sample is not necessary if the object of analysis is only to detect pollution. However, if the object is an accurate examination of coliforms, icing of water samples is considered necessary.

4.6.4 Details of Sampling of Water for Testing of Various Parameters

I. General Variables

i. **Temperature -** Temperature should be measured *in situ,* using a thermometer. As temperature has an influence on so many others aquatic variables and processes, it is important to always include it in a sampling regime and to take and record at the time of collecting water samples.

ii. **Turbidity -** It is best to measure turbidity in the field, but samples can be stored in the dark for not more than 24 hours. Settling during storage and changes in pH leading to precipitation, can affect the results during storage.

iii. **pH -** Ideally, pH should be determined *in situ*, or immediately after the sample is taken, as so many natural factors can influence it. As pH is temperature dependant the water temperature must also be measured in order to determine pH accurately.

II. Inorganic Variables

i) **Hardness** - Samples for Hardness determination must be filtered but not preserved. If during storage a Calcium carbonate sediment appears, it must be dissolved with small volume of hydrochloric acid (1 : 1) after decanting the clear liquid above the sediment.

ii) **Ammonia** - Samples intended for the determination of ammonia should be analysed within 24 hours. If this is not possible the sample can be deep frozen or pressured with 0.8 ml of Sulphuric acid for each litre of sample and then stored at 4°C. Prior to analysis any acid used as preservation should be neutralised.

iii) **Nitrate and Nitrite** - Samples taken for determination of nitrate and / or nitrite should be collected in glass or polyethylene bottles and filtered and analysed immediately. If this is not possible 2-4 ml of chloroform per litre can be added to the sample to retard bacterial decomposition. The sample can be cooled and then stored at 3-4°C.

III. Major Ions

i. **Sodium -** Samples for sodium analysis should be stored in polyethylene bottles to avoid potential leaching from glass containers. Samples should be analysed as soon as possible because prolonged storage in polyethylene containers can lead to evaporation losses through the container walls and lid. Filtration may be needed if the sample contains solid material.

ii. **Potassium -** Same as (i)

iii. **Calcium -** Samples for calcium analysis should be collected in plastic or boro-silicate glass bottles without a preservation. They should be analysed immediately, as soon as possible, after collection and filtration. If any calcium carbonate precipitate forms after filtration and during storage, it must be redissolved with hydrochloric acid or nitric acid and then neutralised before analysis.

iv. **Magnesium** - Samples for magnesium analysis should be collected in plastic or borosilicate glass containers without preservative.

v. **Chloride** - Samples for chloride determination need no preservation or special treatment and can be stored at room temperature.

vi. **Sulphate** - Samples for Sulphate analysis, may be collected in glass or plastic container and can be stored in the refrigeration for upto 7 days, although when intended for analysis soon after collection they may be stored at room temperature. Prolonged storage should be avoided if the samples contains polluted water.

IV. Other Inorganic Variables

i. **Sulphide** - Sulphide determination should be done immediately after sampling. If it is not possible, the sample should be fixed with cadmium acetate or zinc acetate, after which it can be stored upto three days in the dark. During sampling, aeration of the sample must be prevented.

ii. **Fluoride** - Water samples for fluoride determination do not usually require any preservation and can be analysed upto several days following collection. Storage in polyethylene containers is recommended.

iii. **Cyanide** - Samples for cyanide determination must be analysed as soon as possible since it is a highly active and unstable variable. If necessary, samples collection in polyethylene bottles can be preserved with sufficient sodium hydroxide to raise the pH to 11 or more and then stored at above 4°C.

iv. **Arsenic** - Water samples for Arsenic determination should be preserved if not analysed soon after sampling. Water samples in polyethylene bottles may be preserved by adding conc. Hydrochloric Acid (12N) @1ml/lit of sample

V. Metals

i. Samples for metal analysis are usually pretreated by acidification prior to transportation to the laboratory to suppress hydrolysis, sorption and other processes, which affect concentration. However, such preservation techniques destroy the equilibrium of the different forms of the metals, and can be used only for determination of total concentrations. For determination of dissolved metals, it is recommended that the samples are filtered through 0.45 μm pore diameter membrane filters. The filtered sample should be acidified for preservation. Removal of particulate matter by filtration prevents dissolution or description of trace metals from the particulate phase to the dissolved phase within the sample. A very high degree of cleanliness in sample handling at all stages of collection and analysis is necessary to avoid contamination and incorrect results.

VI. Organic Contaminants

i. **Mineral Oil and Petroleum Products** - As oil can be biochemically oxidised very easily, it is necessary to extract it from the sample immediately after sampling with Carbon tetrachloride or trichlorotrifluoroethane. The extract can then be stored in a cool, dark place for several months.

ii. **Phenols** - Samples, particularly if required for the determination of volatile phenols, must not be stored for long periods and ideally, determination should be carried out within four hours. If this is not possible, samples can be preserved with sodium hydroxide and can be stored for 3-4 days at 2-4°C.

4.7. Frequency of Sampling

The frequency of sampling is generally determined by the population served, size and type of the system. In urban areas where the system is complex and the population served is high the frequency of sampling is necessarily high.

Sampling frequency for rural and peri-urban systems however, varies depending upon the source and type of systems. Properly developed spring, shallow and deep tube wells, provided with sanitary protection should provide good quality water constantly and thus reduce the sampling frequency. In streams and rivers where the flow is low in summer, there is a greater risk of contamination, and immediately following monsoon there is likelihood of greater pollution due to surface run off. Hence, it would be prudent to sample during summer / dry season and again during the onset of monsoon / flood.

Based on sanitary surveys, it is possible to identify rural water supply systems into high risk and low risk zones. Sampling should be more frequent in high risk areas compared to low risk areas.

Suggested frequency of sampling and analysis of water supplies is indicated in **Table – 4.1.**

Table 4.1 : Suggested Frequency of Sampling and Analysis of Water Supplies

Source and Mode of Supply	Minimum Frequency of Sampling and Analysis		Remarks
	Bacteriological	*Physical / Chemical*	
Ground Water :			
Open wells for community supply	Every 7 days	Once initially then 4 times yearly	Pollution usually expected to occur
Covered dug wells and shallow tube wells with hand pumps	Every fortnight	Once initially then 4 times yearly	Situations requiring testing; change in environmental conditions, outbreak of waterborne disease; or increase in incidence of waterborne diseases
Deep tubewells with hand-pumps	Once initially, thereafter as situation demands	Once initially, then 4 times yearly	Situation requiring testing : change in environmental conditions, outbreak of waterborne disease or increase in incidence of waterborne diseases
Wells and piped supplies	Once initially, thereafter as situation demands	.. Once initially, then 4 timesyearly .. Test weekly for residual chlorine if water is chlorinated	Situations requiring testing: change in environmental conditions, outbreak of waterborne disease or increase in incidence of waterborne diseases
Springs and piped supplies	Once initially, thereafter as situation demands	.. Once initially then 4 times yearly. .. Test weekly for residual chlorine if water is chlorinated	Situations requiring testing : change in environmental conditions, outbreak of waterborne disease or increase in incidence of waterborne diseases.
Surface water and Rain water:			
Filtered and/or chlorinated and piped supplies	Once monthly	.. Once initially then 4 times yearly .. Residual chlorine test daily	Increase frequency of bacteriological test if situation demands.
Community rainwater collection system	Sanitary protection measures; bacteriological testing only if situation demands	Not needed	—

CHAPTER – 5

LABORATORY INFRASTRUCTURE

5.1. General Considerations

Laboratory control in water quality management is indispensable. A well arranged and adequately equipped analytical laboratory with competent analysts is an important and indeed an integral part of any water quality monitoring and surveillance programme. The results of laboratory analysis performed on representative samples of water are also essential for the evaluation of the efficiency of the operations of purification plants. It is therefore essential that the analytical determinations of different physical, chemical, biological and bacteriological parameters must be carried out most efficiently and accurately. However, the laboratory infrastructure needed shall necessarily depend upon the level of analysis desired, location and other support facilities available.

5.2. Location of Laboratory Facilities

The organisational pattern adopted for water quality monitoring and surveillance would decide the location of laboratory facilities. However, a three tier structure of laboratory facilities, as shown below, is recommended by WHO and may be adopted with necessary modifications:

Level – I
(Village Level) ... Water analysis section may be attached to primary rural health centres mainly for bacteriological analysis of samples collected from villages through community volunteers. The responsibility of collection and analysis of sample could also be entrusted to the plus two schools (with science stream) located in the village. In addition, Field kits for both chemical and bacteriological analysis of water should be provided at village level.

Level – II
(District Level) ... There should be water testing laboratory in each district under PHD / PHED and mobile laboratory in hilly and difficult areas with facilities for chemical and bacteriological examination of water and to oversee chemical analysis of samples from villages and small towns.

Level – III
(State Level) ... Chemical and bacteriological analysis of water samples collected at random.

... Special analysis for metals, pesticides and organics.

... Analytical quality control.

... Data analysis and information transfer.

... Assist district level laboratories.

... Policy planning and formulation at state level for rural water supply system.

... Policy formulation.

... Budget calculation / requirement allocation of funds

5.3. Laboratory Staff

The most important need of a water testing laboratory is competent individuals to be in charge of the analytical work. The person to whom the laboratory functions are to be entrusted upon, must be interested in the job, ready to learn and able to receive the required specialised instructions. However, the staffing pattern in village, district, state and national level will depend upon the local situation. Personnel needed at different levels, as recommended by WHO is rational as indicated below :

Village Level

Trained Person for Operation of Water Testing Field Kit	...	1
Sample Collector	...	1

District Level

Senior Chemist	...	1
Chemist	...	1
Bacteriologist	...	1
Analyst	...	1
Sample Collector	...	1
Laboratory Attendant	...	1
Data Entry Operators	...	2

State Level

Chief Chemist	...	1
Chemist	...	2
Bacteriologist	...	2
Laboratory Technician	...	2
Analyst	...	4
Sample Collector	...	4
Laboratory Attendant	...	2
Senior System Analyst	...	1

National Level - Water Quality Surveillance

Director Senior Chemist Senior Bacteriologist Computer Programmers System Analysts	All the post to be made available to National Referral Institute

5.4. Specification for the Laboratory Space and Other Infrastructural Requirements

Planning of Laboratory Facilities

Physical Facilities

The design of the laboratory depends on the volume of analytical work required to be done. In deciding the requirement of space, due attention should be given to space needed for permanently installed equipments and smooth performance of analytical work by the laboratory personnel. Necessary provision for future expansion should also be kept in view.

Location

The laboratory should be so located as to have easy access and adequate natural lighting (preferably north light) and ventilation.

Floor Space

As guideline, a laboratory to be manned by one person should have a minimum floor space of 6 m x 6 m. Additional 3 m x 3 m area should be provided for each additional worker.

However, a minimum floor space required is 80 m^2 The width of walk ways between rows of tables should be at least 1m, preferably 1.2 m. The total floor space requirement for a work room should be computed by accounting for space requirement for all equipments and their placement and the number of staff working in the room. A tentative estimate of the space requirement is given in table 5.1.

Walls

The walls should be finished smooth in bright colours and should be of sufficient thickness to provide built-in cabinets. The wall space and offsets should be convenient to locate cabinets, benches etc. along side without any loss of floor space.

Lighting

All work room in the laboratory including passages should be well lighted. The window area in terms of floor area should not be less than 20% and all windows fitted with transparent glass panels. Long windows rather than broad windows are preferred for greater depth of light penetration in the room. North-South facing is preferred for elimination of glare on work tables. Provision of adequate artificial lighting to supplement day light should be provided for uniform lighting with minimum shadow effect. Adequate number of plug points should be provided for extra lighting if and when needed.

Power Supply

Adequate electric power supply should be ensured by providing both single and three phase A. C. lines. It is also recommended to provide a suitable generator to ensure uninterrupted supply of power during load shedding periods to prevent spoiling of chemical and bacteriological tests. It is also advisable to provide voltage stabilizers to protect costly equipments from damage due to wide fluctuation in line voltage.

Floor

Floors should be smooth but not slippery and should be easy to clean. Concrete flooring with terrozo finish and daddoing upto window sill is recommended.

Work Tables and Benches

A provision of 10 m^2 space of work table and benches per worker is adequate. The working tables and the benches should be located along the walls. Tables located in any other position should have a clear gangway of not less than 1m between adjacent rows. The wall side tables are generally 60 to 75 cm. wide and centre tables are designed 140 cm wide to facilitate work space on both sides. The height of the table should be 90 to 95 cm for working in standing posture and 75 to 80 cm working in sitting posture. Table tops should be covered with black acid resistant glossy sheets. A separate table of size 120 cm X 60 cm with stool should be provided for analytical balance. Adequate number of high stools should be provided along with working tables and benches.

Reagent Cabinets and Cupboards

These should be provided in adequate number and size for storing chemicals and reagents and should be provided with sliding glass panels. The laboratory tables should be provided with cupboards and open glass shelves on the top.

Plumbing

Plumbing should be well designed to ensure sufficient water supply to both tables sink and separate sinks. The table sinks should be provided with goose-neck taps extending high enough above the table to permit 1 litre cylinders. Separate sinks of adequate size and depth located at suitable points should also be provided for washing of glasswares. Plumbing to sinks and wash basins should be of proper design and of non-corrosive material like PVC, especially for waste water line.

Electrical Installation

Electrical plugs should be provided at all benches and work tables and the locations of all electrically operated equipments. Use of long extension lines should be avoided as far as possible inside the laboratory.

Fuel Gas Supply

Provision for supply of illuminating gas for operation of burners should be made and gas taps at suitable intervals should be provided on all benches and work tables. Natural gas, tank gas or bio-gas if available, can be used provided proper kind of burners are available.

Balance Room

The analytical balance placed on a small table to be used in sitting position should be provided in separate cubicle or enclosure in the laboratory.

Media Preparation and Sterilization Room

For bacteriological analysis additional facilities for media preparation, centrifuging, sterilization by autoclaving etc. are essential and a separate room for accommodating these facilities needs to be provided. This room, however, should be attached to the laboratory and located within easy reach of the analyst.

Equipments

An important problem for water quality monitoring and surveillance laboratory is the selection of equipments.

In planning, the fundamental needs for laboratory equipment, the matter of reference to standard text books and current periodicals pertaining to the science of water analysis need not be over looked.

The principal items of chemicals, equipments and sundry articles for the proposed laboratories are given in table 5.2. The list is not exhaustive but covers major requirements.

All equipments need certain amount of maintenance care. Periodic servicing of equipments and checking for their efficiency will save the damage of equipments and prevent faulty analyses leading to wrong inference.

A stock register for all equipments, chemicals and glasswares must be maintained in all laboratories and kept upto date.

Table 5.1 Tentative estimate for the space required for the laboratory

			Area in Sq. Meters
1.	Physical, Chemical and bacteriological testing laboratory	...	50
2.	Store Room	...	10
3.	Office Room	...	20
	Total :	...	**80**

In case a new building is to be constructed, then a land area of about 120 sq. mts. is to be acquired at a suitable location.

Table 5.2 Suggestive List of laboratory equipment, chemicals and glassware's for District Water Quality testing Laboratory.

A. List of Instruments:

Sl.No.	Item	Specification	No. Required
1.	Monopan balance	Cap. 200gms. Tarring device accuracy - 0.001 gm	1
2.	pH meter	Digital display, Auto buffer, pH range 0 - 14	1
3.	Conductivity meter	Direct reading, Digital display	1
4.	Nephelometer (Turbidimeter)	Direct reading, Range —— 0 – 100 & 100 – 1000	1
5.	Spectrophotometer	Visible range	1
6.	Refrigerator	Cap. 295 litres	1
7.	Voltage Stabilizer	To be specified in terms of the instrument with which is to be used	4
8.	Hot plate	1500 /2000 watts, big size	2
9.	Heating Mantle	Capacity – 1 litre	1
10.	Steam Bath (electrical)	With 12 openings with lid	1
11.	Hot air oven	Memest type. Inner chamber of Aluminum, big size with four shelves	1
12.	Bacteriological Incubator	Temperature control device – Range : 0-50°C	1
13.	Autoclave	Medium size – Steel cabinet – 15 Atm. Pressure	1
14.	Magnetic stirrer	With speed control device and Taflon paddle	2
15.	Microscope	Binocular 10X, 5X	1
16.	Vacuum Pump	1 H.P. capacity	1
17.	Water Bath (thermostatic)	44°C ± 0.25°C	1
18.	Typewriter	Standard type	1
19.	Room Cooler	1.5 ton	1
20.	Distillation Still	Stainless steel capacity 5 litre / hour	1
21.	Ion Meter	Specific electrodes to be chosen as per water quality problems prevalent	1
22.	Computer with printer and other accessories	Pentium – IV, Standard	1

B. List of Glassware's

Sl.No.	Item
1.	Conical flask — Cap. 100ml (12 Nos), 250ml(50Nos), 500ml(24 Nos), 1000ml(12 Nos)
2.	Beaker — Cap. 50ml(12 Nos.), 100ml(24 Nos), 250ml(24 Nos), 500ml(24 Nos), 1 lit(12 Nos), 2 lit. (6 Nos)
3.	Pipette (bulb) — Cap. 5ml(12 Nos), 10ml(12 Nos), 25ml(12 Nos), 50ml(6 Nos).
4.	Pipette (graduated) — Cap. 1ml(12 Nos), 2ml(12 Nos), 5ml(12 Nos), 10ml, 20ml(12 Nos), 25ml(6Nos).
5.	Burette — Cap. 10ml(6Nos), 25ml(12 Nos), 50ml(12 Nos), 100ml(6Nos).
6.	Burette (Automatic) — Cap. 50ml(3 Nos).
7.	Measuring cylinder (graduated) — Cap. 10ml(6Nos), 25ml (6Nos), 50ml (6Nos), 100ml (6Nos), 250ml (6Nos), 500ml (6Nos), 1 lit(3Nos).
8.	Measuring Flask — Cap. 10ml(24Nos), 25ml(24Nos), 50ml(12Nos), 100ml(12Nos), 250ml(12Nos), 500ml (12Nos) & 1 lit (6Nos).
9.	Flask (flat bottom) — Cap. 100ml(6 nos.) 1 lit., (6 nos.) 2 lit., (3 nos.) 4 lit (2 nos.).
10	Desiccators — Small (6Nos)& Big(3Nos)
11.	Reagent bottle (ground glass stopper) — Cap. 500ml(36Nos), 1 lit. (36Nos), 2 lit(24Nos).
12.	Sample bottle (glass) — Cap. 250ml (24 nos.) 500ml (24 nos.), 1 lit. (24 nos.)
13.	Sample bottle (Polythene) — Cap. 100ml (24 nos.), 250ml(50Nos), 500ml(50Nos), 1 lit(24Nos)., 2 lit(24Nos).
14.	Test tube (Rimless) Borosil (Size : 6" x ¾")
15.	Durham tube — 1" X 3/8" X 5/16", 3" X 1/16"
16.	Flask (round bottom) — Cap. 250ml(12Nos), 500ml (6 nos._), 1 lit.(3 nos.)
17.	Filter Funnel - 3" dia. (12Nos), 4" dia(12Nos)., 5" dia(24Nos).
18.	Porcelain dish — Cap. 95ml (3nos.), 50ml.(3nos.)
19.	Nessler tube (polished bottom) with stand Cap. - 50ml (12 nos.), 100ml (12 nos.)
20.	Glass rod (5kg)
21.	Glass bead (2kg)
22.	Glass tube (assorted) (5 kg)
23.	Thermometer — 10°C – 110°C (12Nos), 10°C – 250°C(12Nos).
24.	Wash bottle (Polythene) — 1 lit. (6 nos.)
25.	Separating Funnel — Cap. 250ml (2 nos.), 500ml (2 nos.), 1000ml (2 nos.)
26.	Petri dishes dia. 4" and 6".(6nos. each)
27.	Dropping bottle.
28.	Glass slide 3" X 1" X 2mm
29.	Cover slip (round)
30.	Arsenic generator and absorption Tube, (All glass with standard joint).

C. List of Miscellaneous Items

1. Burette stand with clamp(6Nos)
2. Burner (gas) (6Nos)
3. Clamp holder
4. Centrifuge machine, medium size
5. Filter paper, Whatman nos. 1, 40, 41.
6. Funnel support
7. Jar brush
8. Motor and Pestle (Glass or Porcelain)
9. Rubber tubing (assorted dia.)
10. Spatula, medium and big
11. Test tube support
12. Plastic Carboys - Cap. 1 lit. (25Nos), 2 lit. (50Nos), 5 lit. (25Nos), 10 lit(12Nos)., 20 lit. (6Nos), 50 lit(3Nos)
13. Rubber Stopper (assorted)
14. Ice box (Thermocol) (3Nos)
15. Cotton, absorbent & non-absorbent (2 kg)
16. Gas Cylinder (2Nos)
17. Tripod stand (12Nos)
18. Iron ring with clamp(12Nos)
19. Heating mantle (loose) (6Nos)
20. Blotting paper (100 sheets)
21. Physical balance with Weight box (1No)
22. Wire gauze with asbestos centre 6" X 6". (12Nos)
23. Asbestos sheet 12" X 12" (6Nos)
24. Wash bottle, Plastic, 1 litre (6Nos)
25. Stop Watch (2Nos)
26. Glazed tile 6" X 6" (6Nos)
27. Enamel Tray 1' X 1' (3Nos)and 2' X 2' (3Nos)
28. Plastic bucket
29. Plastic mug
30. Plastic beaker 1 litre (6Nos).
31. Spirit lamp (3Nos)
32. Kerosene stove(1No)
33. Tongs 10" and 18"

34. Pinch clamp
35. Triangular file 4" and 6"
36. Cork Borer Heavy duty
37. Wire net basket 6" X 6" X 6"
38. Wire cutter (small)
39. Test tube brush
40. Pipette case, Stainless

D. List of Chemicals

1. Acetic acid, glacial (10x500 ml)
2. Alizarin Red S (1x500 g)
3. Absolute alcohol (2x500 ml)
4. Aluminium Potassium Sulphate (10x500 ml)
5. Ammonium Acetate (5x500 g)
6. Ammonium Chloride (5x500 g)
7. Ammonium Hydroxide (5x500 g)
8. Ammonium Purpurate / Muroxide (2x100 g)
9. Arsenic Trioxide (2x500 g)
10. Barium Chloride (2x 500 g)
11. Boric Acid (1x500 g)
12. Calcium Chloride (fused) (5x500 g)
13. Calcium Chloride (2x500 g)
14. Disodium Ethylenediaminetetra Acetate (EDTA) (2x500 g)
15. Erichrome Black T (5x5 g)
16. Ferrous Ammonium Sulphate (2x500 g)
17. Hydrochloric Acid (5x2.5 L)
18. Hydroxylamine Hydrochloride (5x100 g)
19. Hydrogen Peroxide (2x500 ml)
20. Electrolytic Iron (1x100 g)
21. Lead Acetate (2x500 g)
22. Methyl Orange Indicator (2x100 g)
23. Phenolphthalein Indicator (2x100 g)
24. Potassium Hydroxide (5x500 g)
25. 1-10, Phenanthroline, Monohydrate (10x10 g)

26. Potassium permanganate (2x100 g)
27. Potassium Iodide (5x100 g)
28. Potassium Chromate (5x100 g)
29. Potassium Hydrogen Phthalate (1x500 g)
30. Stannous Chloride (5x100 g)
31. Silver diethyldithiocarbamate (5x100 g)
32. Sodium Hydroxide (5x500 g)
33. Silver Nitrate (10x250 g)
34. Sodium Acetate (5x100 g)
35. Sodium Thiosulphate (5x500 g)
36. Starch (Soluble) (2x500 g)
37. Sodium Fluoride (Anhydrous) (2x500 g)
38. Sodium Arsenate (2x100 g)
39. SPADNS, Sodium 2-(parasulphophenylazo)-1,8-dihydroxy-3, 6-naphthalene disulphonate, also called 4,5-dihydroxy-3-(parasulphophenylazo)-2,7 naphthalenedisulphonic acid tri-sodium salt (1x100 g)
40. Zirconyl Oxichlorid, Octohydrate, $ZrOCl_2 . 8H_2O$ (5x100 g)
41. Sodium Sulphate (anhydrous) (2x500 g)
42. Sulphuric acid, sp. gr. 1.84 (5x2.5 L)
43. Sulphuric acid (Fuming) Oleum (5x250 g)
44. Sodium Chloride (2x500 g)
45. Potassium Dichromate (1x500 g)
46. Calcium Carbonate (anhydrous) (5x500 g)
47. Phenol, white (5x500 g)
48. Potassium Nitrate (2x500 g)
49. Sodium Sulphate, non-hydrate, $Na_2S. 9H_2O$(2x500 g)
50. pH Indicator paper, Range 2-14 with comparator (10 rolls)
51. Methylated spirit (10x500 ml)
52. MacConkey broth, dehydrated (Hi-media) (10x500 ml)
53. Peptone (1x500 g)
54. Oxgall (1x500 g)
55. Lactose (2x500 g)
56. Brillant green (2x100 g)

5.5. Mobile Water Testing Laboratory

For a facilitating effective water quality surveillance programme, especially in hilly/far flung areas, states may consider to have a mobile water testing laboratory under the control of state PHED apart from state level and district level stationary laboratory. This type of mobile laboratories might be required for areas from where water samples cannot be brought to the stationary laboratories within stipulated time. Moreover, these laboratories are very much useful for analysis & monitoring of potable water during natural disasters. Seventeen such mobile water testing laboratories have been designed and fabricated by ITRC, Lucknow during 1990. Services rendered by the mobile water testing laboratories in Rajasthan and Gujarat are noteworthy.

Services to be rendered by the mobile laboratory

- Investigation of the quality of potable water in rural areas, especially in remote areas.
- Identification of sources of contamination.
- Surveys for new potential water resources to determine their feasibility as new water sources.
- Training and demonstrations at the district level in the villages regarding water quality assessment.
- To increase mass awareness regarding water pollution, its sources and prevention, water - borne diseases, diagnostic, prophylactic and therapeutic intervention.

The mobile laboratories are fully equipped to carry out on the spot analysis of water in relation to safety of drinking water sources, specially in rural areas. The tests performed will provide information on the treatments required to make the contaminated water suitable for drinking purpose.

Laboratory Facilities

The Mobile Water testing laboratory is equipped with a small fridge, hot air oven, water bath and incubator. A small portable kit capable of measuring temperature, conductivity, pH and dissolved oxygen as well as nephelometer are provided along with a small top loading analytical balance and spectrophtometer. Filtration equipments are included for microbiological work. The storage space in drawers and cupboards is adequate for the glasswares and chemicals required for the bacteriological and chemical analyses. A large tank accommodated on the roof will provide water for the laboratory needs.

Analysis which can be performed

Conductivity, pH and temperature are measured using a small portable kit. Turbidity is measured using a nephelometer.

Spectrophotometic analysis is used for fluoride, iron, sulphate and nitrate. Alkalinity, hardness and chloride are analyzed by titration methods and residual chlorine by kit method. In addition, if required, manganese, lead, copper, chromium, ammonia, nitrite, phosphate, arsenic and cyanide may be estimated by spectrophotometic methods.

Total coliform count and faecal coliform count can be performed by the Multiple Tube Method.

Power Sources

The mobile water testing laboratory works on 220 volts AC mains supply ; 10 KVA generator; solar panel and inverter system (2 KVA) ; batteries.

5.6. State Level Laboratory

In addition to all instruments as mentioned under district level laboratory, the state level laboratory must procure modern instruments e.g. AAS, HPLC etc., for more precise tests and specialised tests as would be possible in district level laboratories.

CHAPTER - 6

SANITARY SURVEY

6.1. General Considerations

An effective drinking water quality control programme involves two equally important activities; the carrying out of sanitary survey and the sampling and analysis of water. Changes in the quality of water at various stages of supplies can help in detecting contamination and in determining whether these have arisen at the source or during the course of water treatment or in the distribution system.

Sanitary inspections, are complementary to such analysis and functions as a part of water-quality control programmes. They allow for an overall appraisal of the many factors associated with a water-supply system, including the waterworks and the distribution system. Moreover, such an appraisal may later be verified and confirmed by micro-biological analyses, which will indicate the severity of the defects. Sanitary inspections thus provide a direct method of pinpointing possible problems and source of contamination. They are also important in the prevention and control of potentially hazardous conditions, including epidemics of waterborne diseases.

Sanitary inspections are intended to provide a range of information and to locate potential problems. The data obtained may identify failures, anomalies, operator errors, and any deviations from normal that may affect the production and distribution of safe drinking water.

6.2. Organization

The frequency of routine sanitary inspections depends on a number of factors, such as geography, distribution of the population, access to the various localities etc., as well as on the overall development level, including facilities, number and expertise of technical staff, level of activity in surveillance programme etc.

In general, it is not possible to maintain the same level of activity in all areas of each country, and this can lead to difficulties in carrying out the programme. It may be impractical or difficult to initiate and carry out a comprehensive programme in countries that have numerous rural systems and only a few sanitary engineers or well-trained surveillance personnel. However, experience has shown that surveillance is still feasible.

For example, in a country or region where there are only a few highly trained professionals available for carrying out the control of a large number of localities, the use of less qualified technical personnel specially trained in surveillance can help. Collective training of selected groups of people has a multiplying effect so that, by means of short intensive courses, a single sanitary engineer can ultimately have a large number of auxiliary workers at his disposal

The surveillance team, under the supervision of a coordinator should be given responsibilities of gathering basic data in order to prepare inventories in the area selected. The team may well require not only specific water quality surveillance training but also training for basic data gathering because they will be required to :

i. record the population in each community, village or town;
ii. list the water sources which are being used;
iii. summarise the existing water quality data supplied by the water authority;
iv. identity existing sources for which no data is available;
v. consolidate water related epidemiological data ;
vi. watch disease outbreak and hot spots with water source and quality.

Survey or inspection should be prioritized according to the following criteria :

i. in the area selected, the inventories should be as complete as possible;
ii. the largest urban populations' sources should be dealt with first;
iii. for rural supplies the largest number of people using a source;
iv. for small rural supplies public facilities should get priority over private.

Routine inspection are visits made with a defined frequency in accordance with a previously established plan. In addition, non-routine visits by the inspector will be necessary in a typical situations, such as the introduction of a new water source and in cases of emergency.

Emergency situations calling for the urgent presence of the engineer or technician include :

(a) reports of epidemics;
(b) high turbidity caused by floods;
(c) unresolved cases where bacteriological analyses repeatedly show the presence of coliforms (specially of faecal origin) and/or excess levels of microbiological organisms and where free residual chlorine levels remain absent;
(d) the detection of any important changes that could impair drinking water quality.

Surveillance personnel for rural water-supply systems can thus be divided into two categories: inspectors for routine work and inspectors for non-routine and emergency situations. All the emergency situations are unusual and unpredictable and can involve considerable health risks for the population. Inspections in emergency situations should be conducted by a sanitary engineer or a professional with similar training. Such a person's knowledge of the possible causes of the problem will not only result in a more reliable assessment of the situation and facilitate remedial action but the most suitable way of dealing with the problem is also more likely to be found. Routine surveillance can, however, be perfectly well carried out by technical operators so long as they receive suitable training.

It should be pointed out that, in view of the responsibility which all such surveillance personnel will bear, their training must be very thorough. Ideally, training covering all aspects of water supply and distribution systems should be given in the field, under the supervision of a sanitary engineer.

Finally, it should be stressed that, while the operators carrying out routine sampling for bacteriological analysis may not have the same knowledge and training as the sanitary inspection staff, they should have a basic knowledge of the subject, and in many cases, will be able to give adequate warning of possible risks.

It is suggested that district level team for sanitary survey may be constituted by suitably inducting engineering personnel, health department personnel, laboratory representatives, members of NGO, panchayat functionaries etc.

Depending on the type and size of water supply systems, there could be widely varying intervals between inspection visits proposed. Table 6.1 shows the proposed inspection intervals / sampling frequency for various water supply arrangements.

6.3 Methodology

Sanitary inspection requires a thorough examination of the water-supply system, or at least its key points, in order to check whether the installations are satisfactory and whether the various operations are being carried out properly. The recommended method of undertaking an inspection is to follow the natural sequence, starting with the source water and its intake, and going on to treatment, disinfection, storage, distribution etc. In each case it is essential to record what has been observed on preset appropriate forms.

The procedures for carrying out sanitary survey should be formulated in such a way that the

Table – 6.1 : Sampling Frequency of Sanitary Inspection of Water Supplies

Source and Mode Supply Agency	Minimum Number of Sanitary Inspections per Year		
	By community Workers	*By Water Supply Agency*	*By Surveillance Agency*
Ground Water:			
Open wells for community supply	12	—	Once initially, thereafter as situation demands
Covered dug wells and shallow tubewells with handpumps	4	—	Once initially, thereafter as situation demands
Deep tubewells with hand pumps	4	—	Once initially, thereafter as situation demands
Wells and Piped Supplies	1	1	Once initially, thereafter once every 5 years, or as situation demands
Spring and Piped Supplies	1	1	Once initially, thereafter once every 5 years, or as situation demands
Surface water and rainwater and / or Chlorinated and Piped Supplies :			
Population up to 5000	12	2	Once initially, thereafter once every 5 years, or as situation demands
Population 5000-20000	—	24-48	Every system once a year
Community rainwater collection systems	1	—	Once initially, thereafter once a year or as situation demands

inspector can make a rapid, systematic and complete assessment of the key points of any water-supply system. He or she should be able to construct a table or form which can be put together like a jigsaw puzzle, and which will then be specific to the water-supply systems under consideration.

The observable faults in the drinking water system, which may give rise to problems of quality or continuity of supply can most readily be identified by careful on-site inspection. Every fault should be systematically listed during the sanitary survey and each point may therefore be considered as a Sanitary risk factor.

Graphical representation with marks of sanitary risk factors for various types of sources are shown in Figures – 6.1. to 6.7

Water quality problems may be associated with, and traceable to, any or all of the following —

i. poor quality source waters;
ii. poor site selection or protection;
iii. construction difficulties and
iv. structural deterioration with age.

All of the problems above should be identifiable by the comprehensive sanitary survey; A sanitary surveyor should always be on the look out for additional points of risk, not just those listed in the survey report form.

Proper detection of the faults / problems is fully dependent on the thoroughness and perspicacity of the surveyors.

The complementarity of sanitary survey and water analysis cannot be overemphasized. There are many occasions when the source of contamination cannot be detectable by sanitary inspection. In the case of ground water contamination, for example, a hand pump tubewell may appear to be in a good physical state, but the aquifer itself may be contaminated at a point remote from the tubewell. This remote contamination of the aquifer can be only detected by water analysis. Thus, the sanitary survey can provide a robust and conservation safe method of risk identification. Generally the sanitary survey reveals many of the chronic risks, of contamination, which may not be revealed by a single and costly laboratory analysis.

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **DUGWELL (Ref. Fig. 6.1)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../................../..................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?....................Sample No.................... Water Quality Acceptable/Rejectable

II. Specific Diagnostic Information for Assessment (Numerical-Legends (1-11) may be read from Fig. 6.1)	**Risk** Yes	No
1. Is there a latrine within 10m of the well?	•	•
2. Is the nearest latrine on higher ground than the well?	•	•
3. Is there any other source of pollution within 10m of the well? (e.g. animal excreta, rubbish/garbage)	•	•
4. Is the drainage poor causing stagnant water within 2m of well?	•	•
5. Is there a faulty drainage channel? Is it broken, creating ponding?	•	•
6. Is there an inadequate parapet (less than 1m) around the well which would allow surface water to enter the well?	•	•
7. Is the cement floor less than 1m wide round the well?	•	•
8. Are the walls of the well inadequately sealed at any point for 3m below ground?	•	•
9. Are there any cracks on the cement floor around the well which could permit water to enter the well?	•	•
10. Are the rope and bucket left in such a position that they may be contaminated?	•	•
11. Is the well covered (Temporarily by mosquito net etc.)	•	•

Total Score of risks ..../11

Contamination risk score: 9-11=V, high; 6-8=high; 3-5= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

(list nos 1-11)

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

Signature of Investigator ....

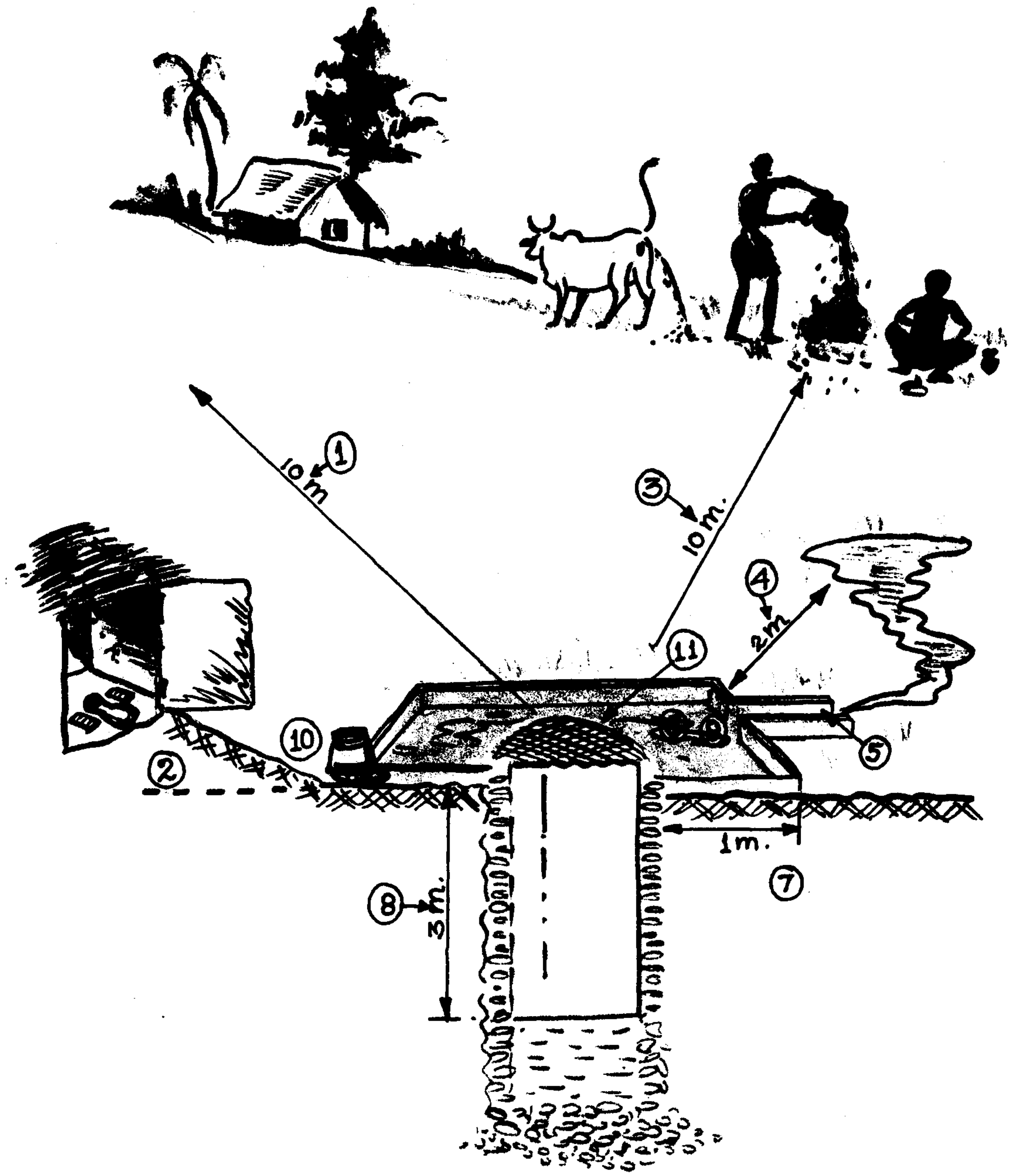


Figure - 6.1 Dugwell- Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **HANDPUMP ON DUGWELL (Ref. Fig. 6.2)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../................................/................................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?..............................Sample No.............................. Water Quality Acceptable/Rejectable

II. Specific Diagnostic Information for Assessment (Numerical-Legends may read from Fig. 6.2)

		Risk Yes	Risk No
1.	Is there a latrine within 10m of handpump?	•	•
2.	Is the nearest latrine on higher ground than the handpump?	•	•
3.	Is there any other source of pollution within 10m of the handpump? (e.g. animal excreta, rubbish)	•	•
4.	Is the drainage poor causing stagnant water within 2m of the cement floor of handpump?	•	•
5.	Is the handpump drainage channel faulty e.gs. is it broken, permitting ponding? Does it need cleaning?	•	•
6.	Is the cement floor less than 1m wide round the handpump?	•	•
7.	Is there any ponding on the cement floor around the handpump?	•	•
8.	Are there any cracks on the cement floor around the handpump?	•	•
9.	Is a bucket also in use and left in a place where it could be contaminated?	•	•
10.	Is the handpump loose at the point of attachment fo base? (which could permit water to enter the casing?	•	•
11.	Is the cover of the well insanitary?	•	•
12.	Are the walls of the well inadequately sealed at any point for 3m below ground level?	•	•

Total Score of risks ..../12

Contamination risk score: 8-12=V, high; 5-7=high; 3-4= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

(list nos 1-12)

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

Signature of Investigator ....

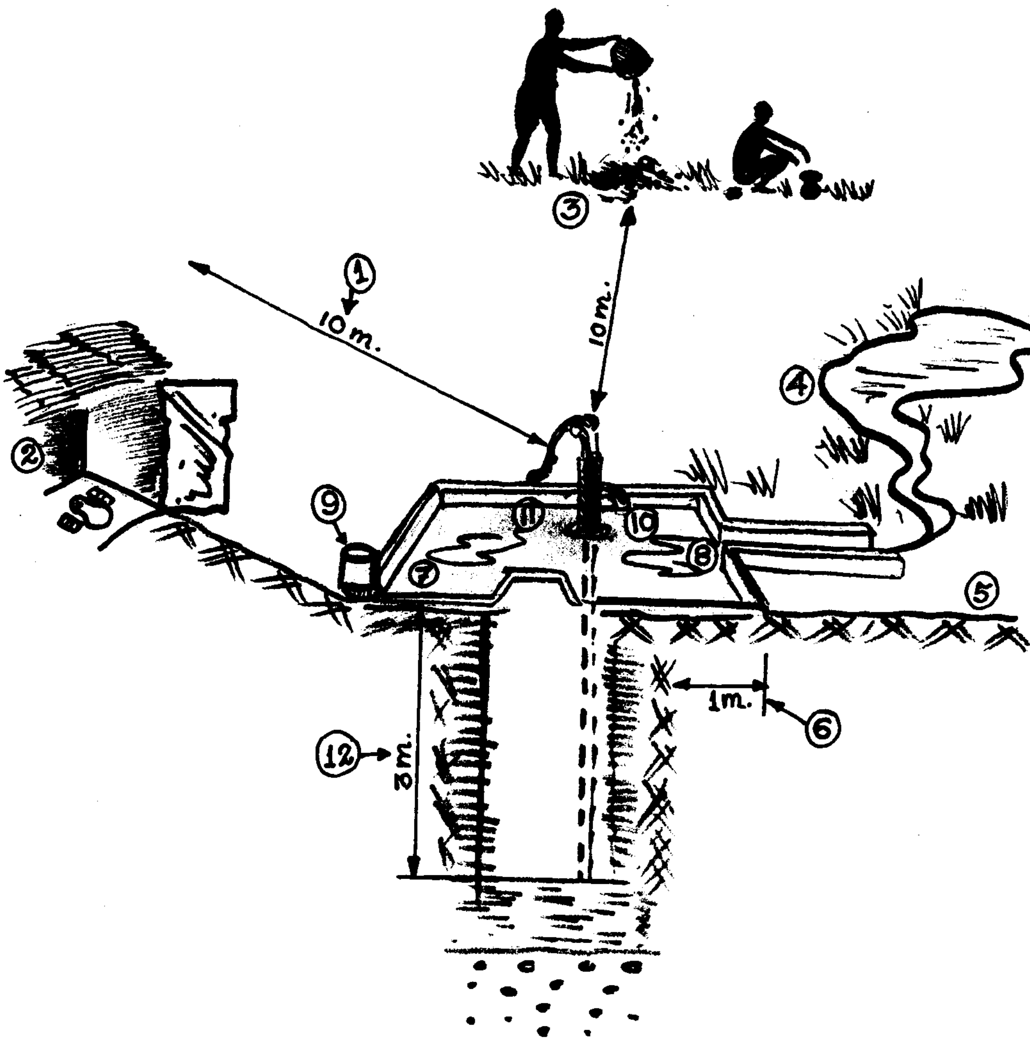


Figure - 6.2 Handpump on Dugwell- Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **SHALLOW AND DEEP HANDPUMPS (TUBEWELL) [Ref. Fig. 6.3)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../......................................./......................................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?...............................Sample No.................................. Acceptable/Rejectable — Water Quality

II. Specific Diagnostic Information for Assessment (Numerical-Legends may read from Fig. 6.3)

		Risk Yes	Risk No
1.	Is there a latrine within 10m of handpump?	•	•
2.	Is the nearest latrine on higher ground than the handpump? (a pit latrine that percolates to soil)	•	•
3.	Is there any other source of pollution within 10m of the handpump? (e.g. animal excreta, rubbish, surface water)	•	•
4.	Is there any ponding of stagnant water within 2m of the cement floor of handpump?	•	•
5.	Is the handpump drainage channel faulty? Is it broken, permitting ponding? Does it need cleaning?	•	•
6.	Is the cement floor less than 1m radius all round the handpump?	•	•
7.	Is there any ponding on the cement floor around the handpump?	•	•
8.	Are there any cracks on the cement floor around the handpump?	•	•
9.	Is priming of tubewell required during dry season?	•	•

Total Score of risks ..../9

Contamination risk score: 8-9=V, high; 5-7=high; 3-4= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

(list nos 1-9)

Signature of Investigator ....

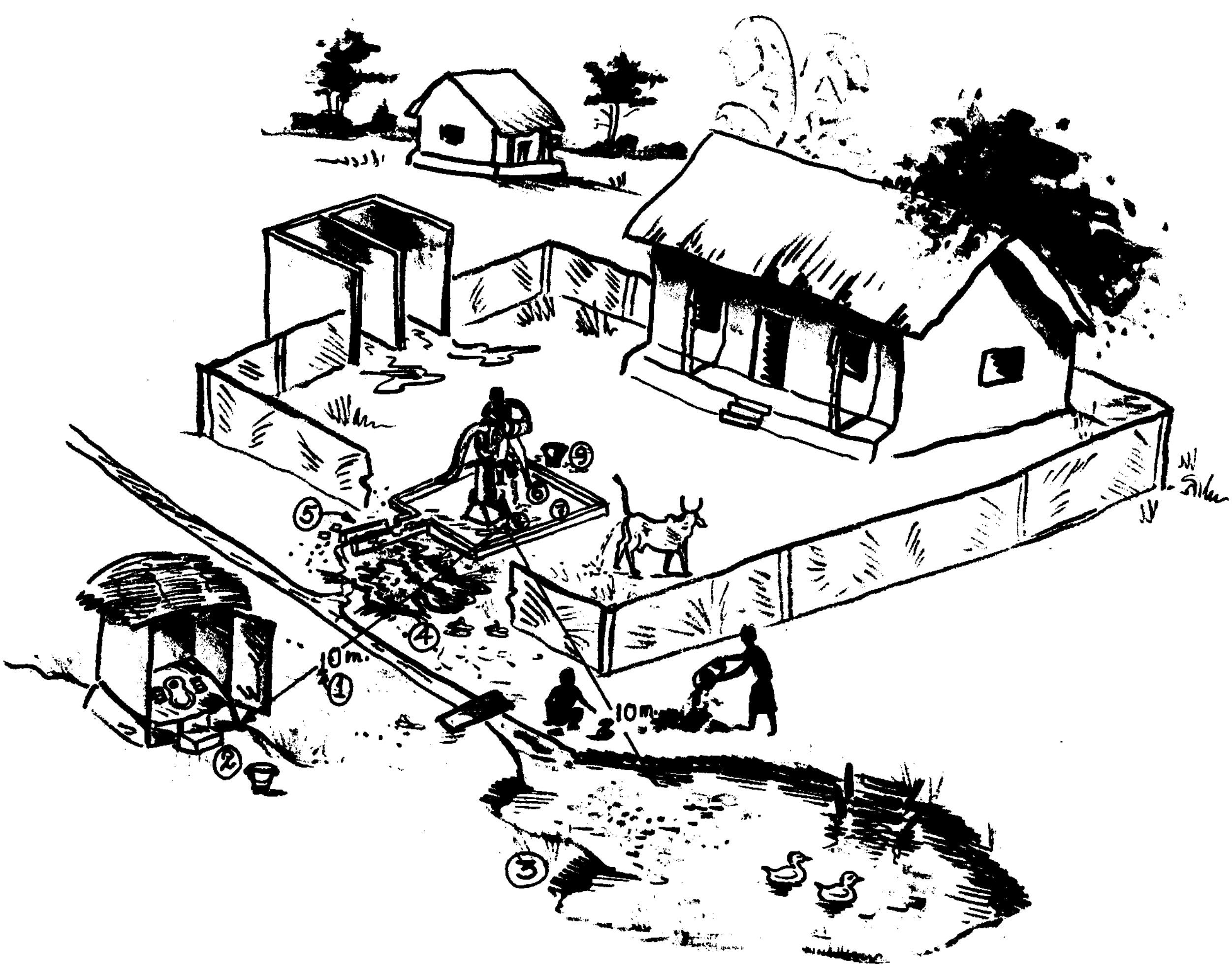


Figure - 6.3 Shallow and Deep Tubewell (Handpump Attached) - Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **DEEP BOREHOLE (Ref. Fig. 6.4)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../../.......................................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?..................................Sample No.................................... Water Quality Acceptable/Rejectable

II. Specific Diagnostic Information for Assessment (Numerical-Legends may read from Fig. 6.4)

	Risk Yes	Risk No
1. Is there a latrine or sewer within 30m of the pumphouse?	•	•
2. Is the nearest latrine unsewered? (a pit latrine that percolates to soil)	•	•
3. Is there any other source of pollution within 10m of the well? (e.g. animal excreta, rubbish, surface water)	•	•
4. Is there an uncapped well within 100m of the borehole?	•	•
5. Is the drainage area around the pumphouse faulty? (permitting ponding and/or leakage to ground)	•	•
6. Is the fencing around the installation damaged in any way which would allow animals access or any unauthorised entry?	•	•
7. Is the floor of the handpump permeable to water?	•	•
8. Is the well seal insanitary?	•	•
9. Does the chlorination record show any interruption in dosing? (if there is no record of chlorination, risk (yes) should be recorded)	•	•
10. Is the free chlorine residual at the sample tap less than 0.2mg/l?	•	•

Total Score of risks ..../10

Contamination risk score: 9-10=V, high; 6-8=high; 3-5= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

(list nos 1-10)

Signature of Investigator ....

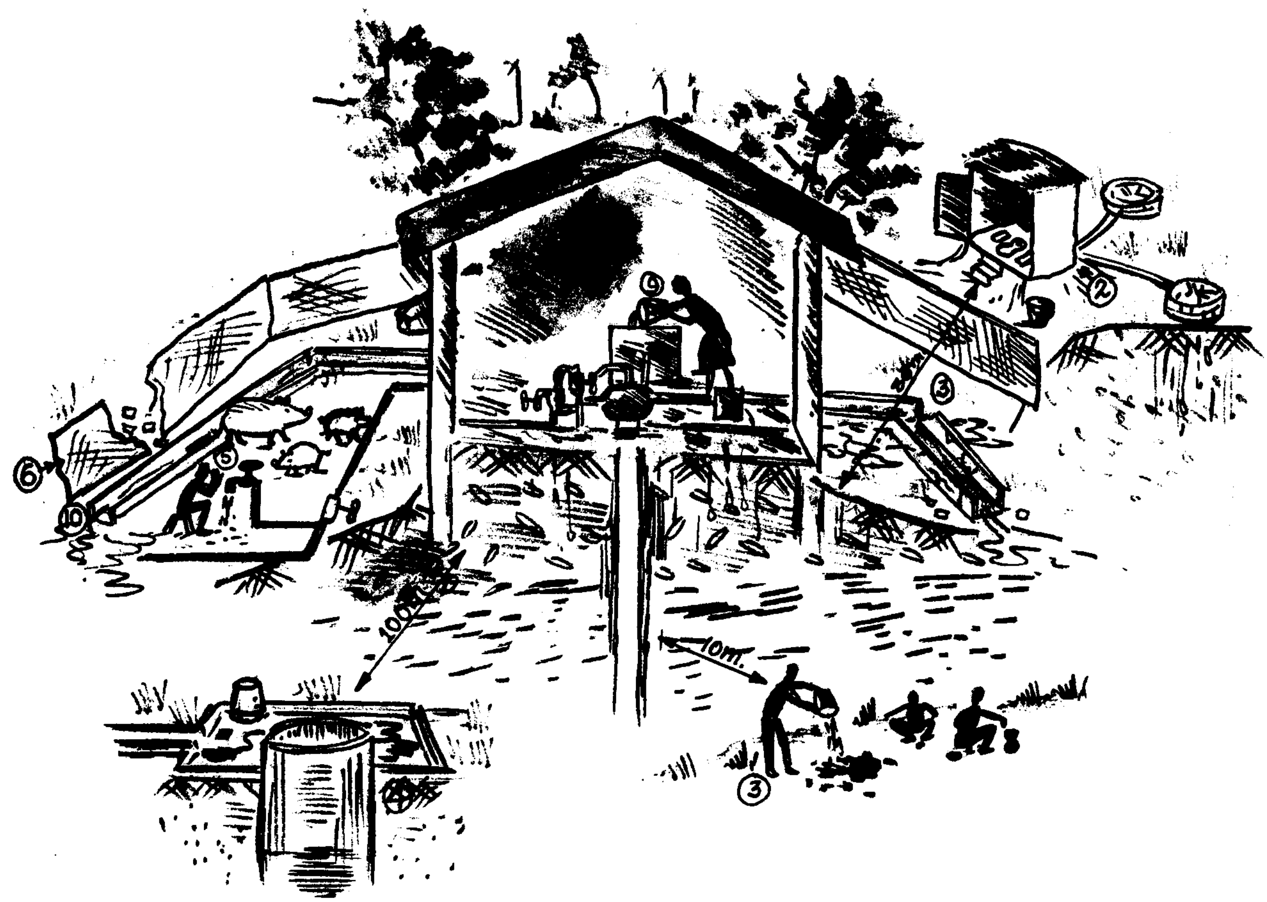


Figure - 6.4 Deep Borehole with Mechanical Pumping - Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **GRAVITY FEED PIPED SPRING WATER SYSTEM (Ref. Fig. 6.5)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../................................/................................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?..............................Sample No.............................. Water Quality Acceptable/Rejectable

II. Specific Diagnostic Information for Assessment (Numerical-Legends may read from Fig. 6.5)	**Risk** Yes	No
1. Is the source unprotected by masonry or concrete wall or spring box (open to surface contamination)?	•	•
2. Is the masonry protecting the source faulty?	•	•
3. Does the spring box contain contaminating silt or animals?	•	•
4. If there is an overflow pipe, is it insanitary?	•	•
5. Is the area around the spring unfenced?	•	•
6. Can animals have access within 10m of the spring source?	•	•
7. Is the spring lacking a surface water diversion ditch above it, or (if present) is it non functional?	•	•
8. Is there any latrine upstream of the spring?	•	•

Total Score of risks ..../8

Contamination risk score: 7-8=V, high; 5-6=high; 3-4= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

(list nos 1-8)

Signature of Investigator ....

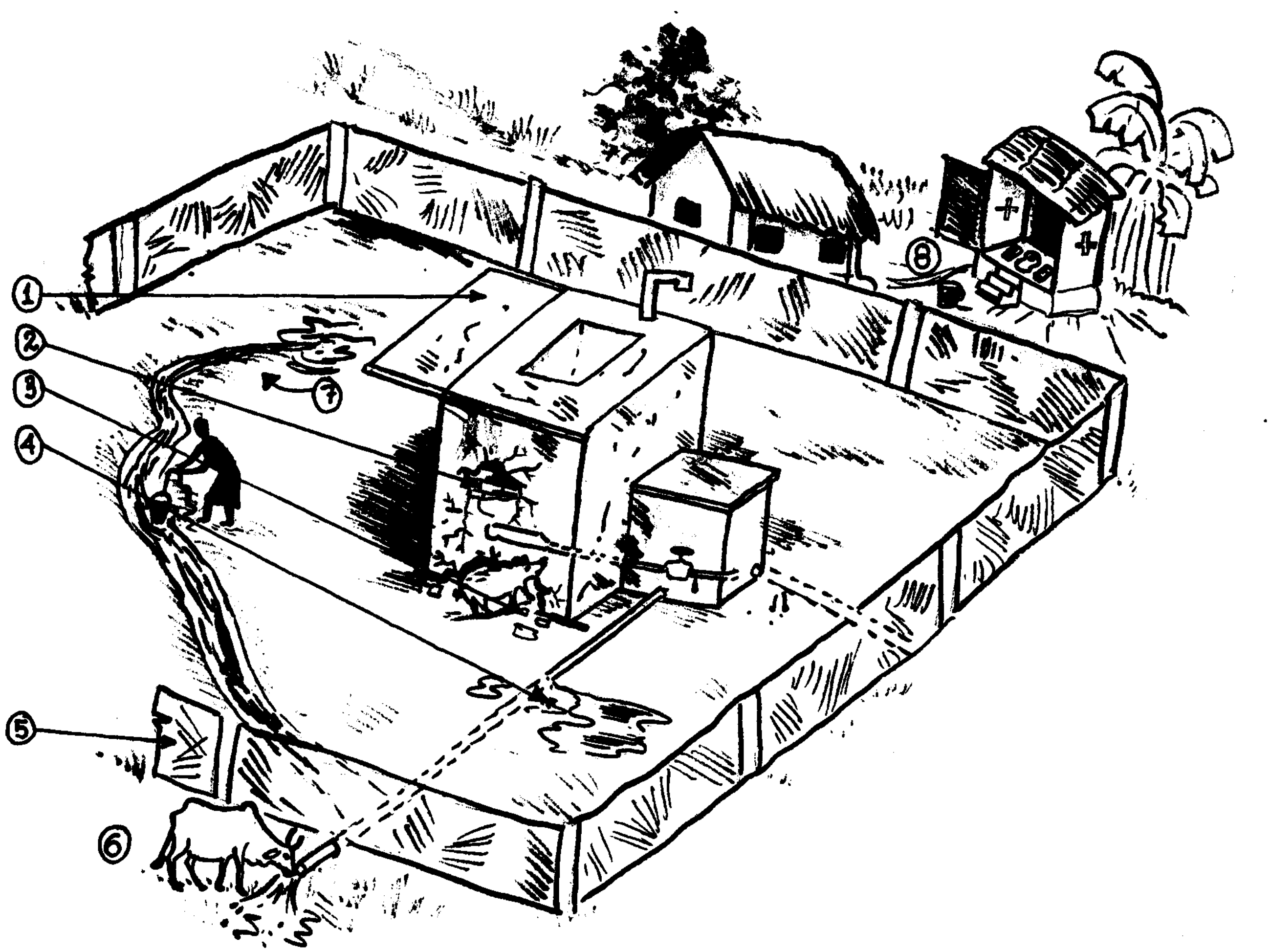


Figure - 6.5 Protected Spring - Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **GRAVITY FEED PIPED SUPPLIES (Ref. Fig. 6.6)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../........../..........

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?..........Sample No.......... Acceptable/Rejectable Water Quality

II. Specific Diagnostic Information for Assessment (Numerical-Legends may read from Fig. 6.6)

		Risk Yes	Risk No
	Conduction pipe to reservoir		
1.	Is there any point leakage between the source and the reservoir?	•	•
2.	If there are any pressure break boxes, are their covers insanitary?	•	•
3.	Is the inspection cover on the reservoir insanitary?	•	•
4.	Are any air vents insanitary?	•	•
5.	Do the roof and walls of the reservoir allow any water to enter (is the reservoir cracked?)	•	•
6.	Is the reservoir water unchlorinated?	•	•
	Distribution pipes		
7.	Does the water entering the distribution pipes have less than 0.4ppm free residual chlorine (<0.4mg/l)?	•	•
8.	Are there any leaks in any part of the distribution system?	•	•
9.	Is pressure low in any part of the distribution system?	•	•
10.	Does any sample of water in the principal distribution pipes have less than 0.2ppm free residual chlorine?	•	•

Total Score of risks ..../10

Contamination risk score: 9-10=V, high; 6-8=high; 3-5= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

(list nos 1-10)

The following important points of risk (serially from the top) were noted :
and the authority advised on remedial action

Signature of Investigator ....

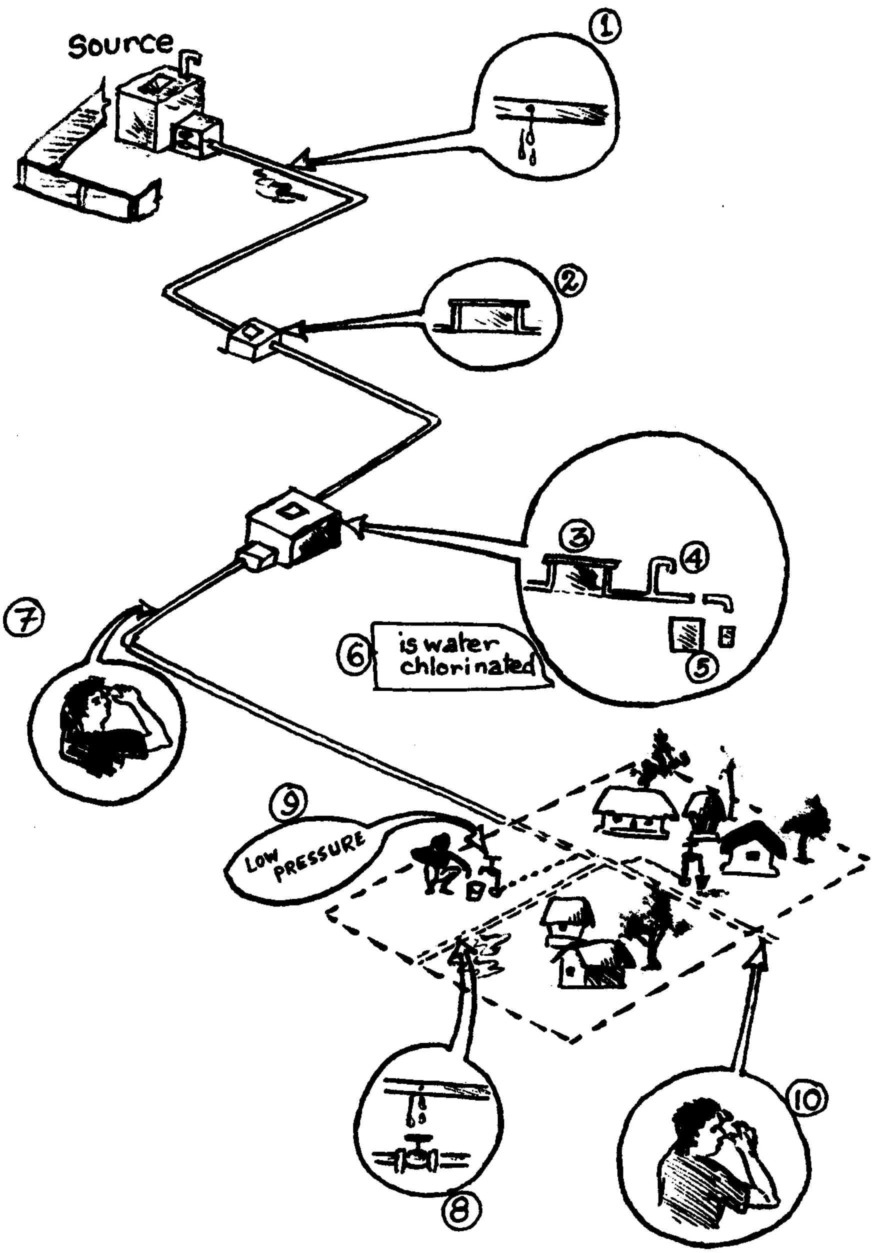


Figure - 6.6 Gravity Feed Piped Distribution System - Sanitary Survey

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **RAIN WATER TANK CATCHMENT (Ref. Fig. 6.7)**

General information :

i. Location : Village ....

: Gram Panchayat ....

: District ....

ii. Code No. ..../../..

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?................................Sample No.................................... Acceptable/Rejectable Water Quality

II. Specific Diagnostic Information (Numerical-Legends may read from Fig. 6.7)

		Risk Yes	Risk No
1.	Is there any contamination of the roof catchment area? (e.g. plants, dirt or excreta)	•	•
2.	Are the guttering channels which collect water dirty?	•	•
3.	Is there any deficiency in the filter box at the tank inlet? (e.gs. lacks fine gravel)	•	•
4.	Is there any other point of entry to the tank which is not properly covered?	•	•
5.	Is there any defect in the walls or top of the tank (e.g. cracks), which could let water in?	•	•
6.	Is the tap leaking or other wise defective?	•	•
7.	Is the floor under the tap defective or dirty?	•	•
8.	Is the water collection area inadequately drained?	•	•
9.	Is there any source of pollution around the tank or water collection area? e.g. excreta.	•	•
10.	Is the water bucket left in such a position that it may be contaminated?	•	•

Total Score of risks ..../10

Contamination risk score: 9-10=V, high; 6-8=high; 3-5= intermediate; 0-2= low

Number of 'YES' to be counted

III. Results and recommendations:

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

(list nos 1-10)

Signature of Investigator ....

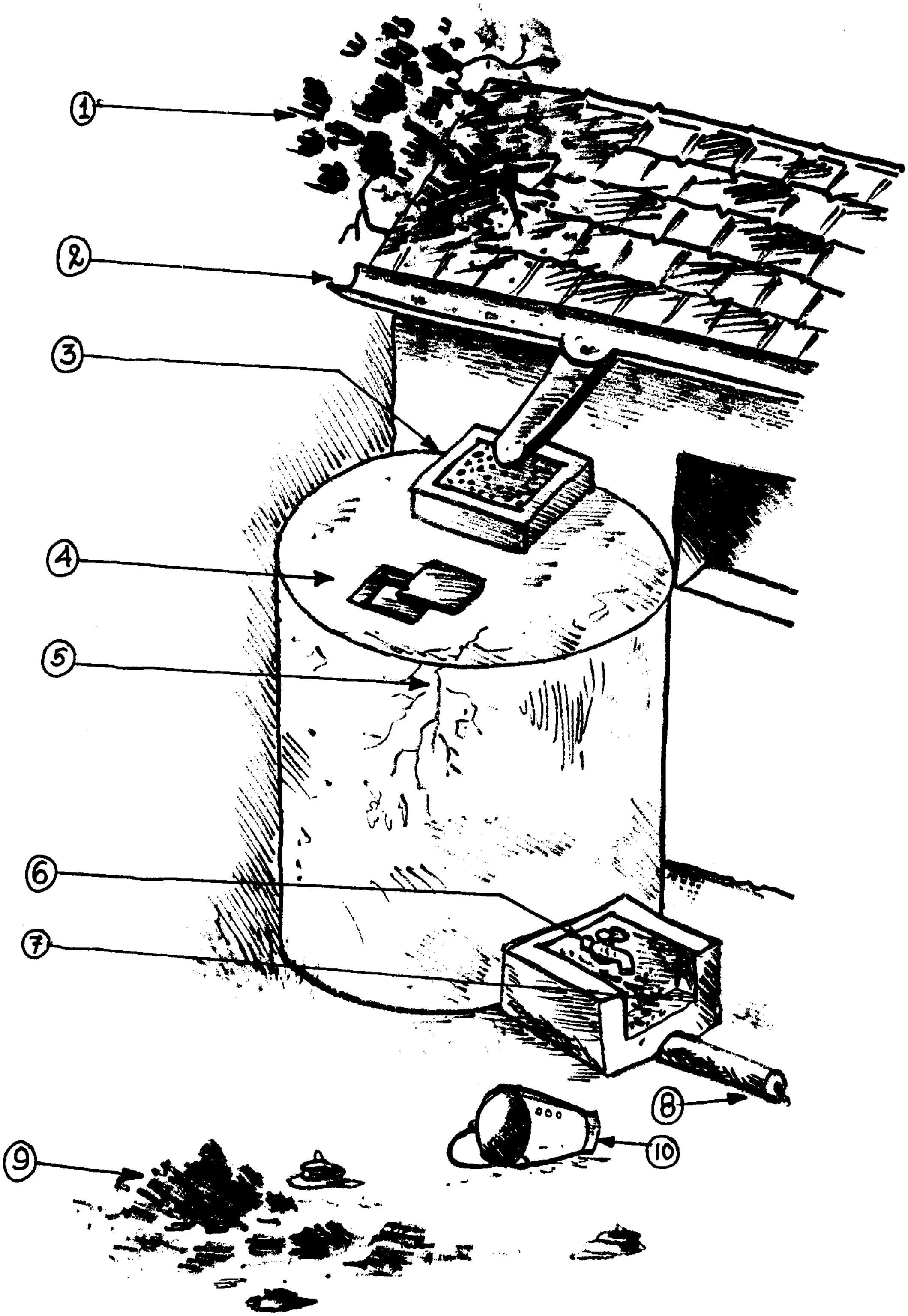


Figure - 6.7 Rain Water Catchment Tank - Sanitary Survey

SOURCE PROTECTION AND IMPROVEMENT OF WATER QUALITY

7.1 General Considerations

Surveillance is the process of keeping of watch and collecting informations relating to risks and hazards of water supplies for rendering services for taking appropriate preventive measures against any failure or quality degradation in water supply. Water quality monitoring and sanitary survey are considered to be integral parts of surveillance strategy. Infrastructure development and capacity building is needed to be developed for water quality surveillance, which in turn is a necessity for each and every water supply agency for preventing water supply failure and contamination.

Water supply services need to be of consumer satisfaction and in order to achieve this objective, preventive and remedial measures are to be taken in time and in appropriate manner. Such measures may be technical as well as social interventions designed to improve water supply services. Such interventions include operation & distribution ; preventive and remedial action. Nature of interventions may be technical as well as non-technical such as health education ; man-power training etc.

Quality of water at source determines the extent and magnitude of treatment necessary to upgrade the quality of water so as to conform to drinking water quality standard. One of the cost component of water supply system is the cost for treatment of water. Surface water needs treatment usually for removal of suspended and colloidal solids whereas, ground water from confined and semi-confined sources does not require any treatment except in certain condition when it is chemically or bacteriologically contaminated. Protection of both surface as well as ground water is of paramount importance and all administrative, legislative, technological and social measures are to be taken to achieve it.

Selection of appropriate technology for treatment of surface water is required for producing safe water at affordable cost. Monitoring and surveillance of water treatment units is essentially required for optimal operation of the units and production of estimated safe water. Ground water generally does not require any treatment. However, if ground water contains certain parameters to be beyond permissible limit, then specific treatment for removal of specific contaminants is necessary. Ground water supply through pipe network may require disinfection to get rid of contamination problem in pipe line.

7.2 Sources of water

7.2.1 Choice of source

The various sources of water available on the earth can be classified into following two categories : -

A) Surface sources, such as,

i) Ponds and lakes

ii) Streams and rivers

iii) Storage reservoirs

iv) Oceans, generally not used for water supplies, at present

B) Sub - surface sources or underground sources, such as,

i) Springs

ii) Infiltration galleries

iii) Infiltration wells

iv) Wells and tubewells

C) Rain water

Most of the earth's water sources get water from precipitation. Since, precipitation is the principal source of water, rainwater may be straightway collected and used for domestic purposes. Such direct use of rain water is usually considered in water scarcity and problem areas.

The selection of the source determines the adequacy, reliability and quality of the water supply. The raw water quality dictates the treatment requirements. For example, most groundwaters that are free from objectionable substances are both safe and potable, and may be used without treatment, provided the wells or springs are properly located and protected. Surface waters, on the other hand, are exposed to direct pollution, and treatment is usually required for their upgradation as a drinking water supply. The location of the source also defines the energy requirements for raw water pumping, which can directly affect recurrent operational costs.

Whenever possible, the raw water source of highest quality economically available should be selected, provided its capacity is adequate to meet the water supply needs of the community.

Ground water is the preferred choice for community water supplies,particularly for rural and peri-urban areas, because it generally does not require extensive treatment and operation is limited to pumping and possibly chlorination in piped water supply schemes. If ground water is not available or not safe and potable, surface water from lakes or streams are preferred because these can be treated by conventional process. Table – 7.1. highlights the quality of raw water sources.

Table 7.1. : Quality of raw water sources

	Excellent source source	Good source	Poor source	Rejectable
pH	7.0 to 8.5	6.5 to 9.2	5.5 to 6.5	< 5.5
			9.2 to 10.0	
BOD, mg/l (5 days 20^{0}C)	0.75 to 1.5	1.5 to 2.5	2.5 to 4.0	> 4.0
Faecal coliform (MPN/100 ml)	50 to 100	100 to 5000	5000 to 20000	> 20000
Chloride, mg/l	< 50	50 to 200	200 to 1000	> 1000
Iron, mg/l	0.3	0.3 to 1.0	1.0 to 5.0	> 5.0
Fluoride, mg/l	0.5 to 1.0	1.0 to 1.5	-	> 1.5
Arsenic, mg/l	NIL	Nil	0.01 to 0.05	> 0.05

A sanitary survey for potential drinking water sources for a community is an essential step in source selection. The survey should be conducted in sufficient details to determine the following : -

i) The suitability of each source, based upon its adequacy, reliability and its actual and potential risks for contamination

ii) The treatment needs and feasibility before the water can be considered acceptable.

Physical, bacteriological and chemical analysis can in addition, be helpful in providing useful information about the source and the conditions under which it will be developed.

7.2.2 Need for protection of sources

If water supplies are to remain potable, both the source and catchment need protection. Deterioration of the quality of water at source may necessitate complex treatment system which may not be economically viable. Discharge of any polluted effluent at source or in the catchment area must be prohibited. Administrative as well as legislative measures must be appropriate and strong so that polluters adopt adequate measures for abatement of pollution.

7.2.3 Protection measures

Catchment protection

In order to identify potential sources of contamination, sanitary survey of the catchment area is necessary. Surface waters and ground waters are both vulnerable. Surface water reservoirs, tanks, etc. can be protected from pollution caused due to various human activities. Rivers are polluted due to receiving discharges from urban centres and industries. Ground water may be contaminated due to seepage from domestic and industrial discharges. Surface run-off from agricultural land may also pollute surface water and ground water sources.

Where possible, protection zones should be clearly demarcated and activities that may affect water quality should be restricted or prohibited within their boundaries. Such activities may include the dumping of toxic waste, the discharge of undesirable effluents, drilling, mining, quarrying and the use of agricultural fertilizers & pesticides . In order to establish protection zones, inter-sectoral coordination is necessary.

Safe-Distance between water source and on-site sanitation

In rural areas mostly on-site sanitation is practised. The ground water sources naturally must be protected from on-site sanitation leach pits. Bacterial contamination in leachate from leach pits travel though soil grain. But such movements of contaminants through soil strata are restricted since faecal micro organisms are arrested to a large extent and many chemical compound are broken down. The pollution travels from leach pits are dependent on characteristics of soil, ground water table, rate of ground water flow, hydraulic gradient, pit condition etc. It has been found that micro biological pollution could travel a short distance through sandy loam and clay whereas it could travel an indefinite distance through coarse gravel, fissured rocks, dried out cracked clay etc. The safe distance of ground water source, therefore, need to be assessed on the basis of underground pollution travel in different soil and other conditions. Nath, Majumder & Kahali of All India Institute of Hygiene & Public Health, Calcutta studied extensively on pollution travel from leach pits in ascertaining the safe distance of ground water source from underground spot sources of pollution.
The pollution travel under varying soil conditions are presented in the table 7.2.

7.3 Protection of wells

7.3.1.Dugwells

Uncovered or poorly covered dug wells are generally faecally contaminated. Dug wells also get contamination from inappropriate water lifting system. Often agro-chemicals may contaminate dug wells water.

Table 7.2: Maximum travel of Pathogens from leach pits (in 10 days) for different types of soil under different pit conditions

Soil Character %		Travel distance in meter	
Sand	Silt + Clay	Saturated condition of leach pit (Monsoon)	Un-saturated condition of leach pit (Non-Monsoon)
98.4	1.6	10.0	8.4
90	10	9.4	8.2
80	20	8.8	7.9
70	30	8.2	7.4
60	40	7.6	7.0
50	50	7.0	6.5
40	60	6.4	5.9
30	70	5.8	5.1
20	80	5.2	4.4
10	90	4.8	3.6
0	100	4.4	2.6

Sanitary survey as well as on-site inspection can effectively reveal the most obvious sources of contamination, and as such appropriate protective measures can be taken to upgrade the well.

Dug well with proper lining, apron, parapet wall, cover, lead drain and pumping system will protect the dug well from faecal contamination. Even then, if faecal coliform persists, pot or drip chlorination may be resorted to for reduction of bacteriological contamination.

7.3.2. Hand pumped and mechanically pumped well

Generally hand pumped and mechanically pumped well water will be free from bacterial contamination, provided a proper sanitary sealing is done.

To ensure adequate sanitary protection of a tubewell, a reinforced plinth should be built on to the well-head; its diameter should be greater that of the sides. The plinth should be sound and drained, and the hand pump should be located and sealed in a sanitary manner above the surrounding plinth and ground level. A concrete apron should be laid around the well-head and plinth, at least 2 metres in diameter and sloped towards the drainage channel, which should run to a soakaway located away from the tubewell. Additional sanitary protection should be provided by fencing the well site to keep animals out.

Latrines with on-site sanitation pit may be located at least 10 metres (in case of sandy soil) downhill from the well. Safe distance of latrines under different soil condition may be obtained from Table 7.2.

If tubewells show evidence of persistent contamination, either disinfect the water supply continuously or relocate the tubewell by selecting deeper aquifer. Certain structural precautions are essential when wells and the associated pumps are installed. The pump casing should extend approximately 30 cm above ground and downwards to the parent rock. Concrete apron and platforms should be constructed for shallow wells, and the concrete sanitary seal should extend down into the space between the casing and excavation.

7.4 Treatment of water

If ground water sources is protected, it generally does not require any treatment. Special treatment may be necessary for ground water in case if contains iron, fluoride, arsenic etc. beyond maximum permissible limit.

Surface water is exposed to faecal contamination and is usually of poor quality. However, extent of water treatment necessary is dependent on the surface water quality.

7.4.1. Treatment technology options

Qualitatively, any type of water contains solids and gases. Solids are present in water in dissolved, colloidal and suspended forms.

In ground water, generally, colloidal and suspended solids are absent; whereas, dissolved solids content are more than that in surface water. In surface water, where dissolved solids are lesser the colloidal and suspended solids are very high. As such, the turbidity of surface water is high and it may be even more than 2000 NTU in monsoon.

The method of treatment to be employed depends on the nature of raw water constituents and the desired standards of water quality. The unit operations in water treatment include aeration, flocculation, sedimentation, filtration, disinfection, softening, deferrization, defluoridation etc. Turbidity parameter can be examined to propose water treatment methods as presented here-under.

Turbidity NTU	Treatment options	Remarks
£30	Plain sedimentation, slow sand filtration and disinfection	If Turbidity £ 10 NTU, Plain sedimentation can be done away with
> 30	Coagulation, flocculation, sedimentation, rapid sand filtration and disinfection	Conventional treatment
>30	Horizontal Roughing Filtration, slow sand filtration, disinfection	If Turbidity > 600 NTU, Plain sedimentation may be considered before HRF
>30	Prolonged storage, sedimentation, slow sand filtration, disinfection	Very high detention time, say 15 days is required in prolonged storage tank

The primary factors influencing the selection of treatment processes are:

(i) Treated water specification

(ii) Raw water quality and its variations

(iii) Local constraints

(iv) Relative costs of different treatment processes.

Table 7.3. – which highlights minimum treatment possibility with regard to different raw water quality.

7.4.2. Pre-treatment

Surface water bodies exhibit wide variation of turbidities resulting from silt carriage in rainy seasons. The turbidity of many rivers may rise even more than 2000 NTU during monsoon. In order to operate either slow sand filters or rapid sand filters effectively selection of appropriate pre-treatment is of great importance. Table 7.4 – indicates the usual conventional methods of pre-treatment (Plain sedimentation, storage and roughing filtration) for given turbidities.

Table 7.3. : Classification of Raw waters with Regard to Treatment Process

Classes	Av. Coliform, Most Probable Number (MPN) per 100 ml	Turbidity (NTU)	Color (Platinum Cobalt Scale)	Iron (mg/l)	Total Solids (mg/l)	Chlorides (mg/l)	Hardness (mg/l)	Plankton & Algai Growth
I.	< 1	< 25	< 50	< 1.0	< 1500	< 600	< 250	Insignificant
II.	< 2	< 25	< 50	< 1.0	< 1500	< 600	< 250	Insignificant
	< 50							
III.	< 2	< 25	< 50	< 1.0	< 1500	< 600	< 250	excessive
	< 50							
IV.	< 50	< 25	< 50	< 1.0	< 1500	< 600	< 250	Insignificant
V.	< 50	< 25	< 50	< 1.0	< 1500	< 600	> 250	Insignificant
VI.	< 1,000	< 50	< 70	< 2.5	< 1500	< 600	< 250	Insignificant
VII.	< 5000	< 75	-	< 2.5	< 1500	< 600	< 250	Insignificant
VIII.	< 20000	< 250	-	< 2.5	< 1500	< 600	< 250	Insignificant
IX.	< 20000	< 250	-	> 2.5	< 1500	< 600	< 250	Insignificant
X.	< 20000	> 250	-	< 2.5	< 1500	< 600	< 250	Insignificant
XI.	< 20000	< 250	-	< 2.5	< 1500	< 600	> 250	Insignificant

Note : Classification will be governed by dissolved phosphate concentration in water

Classes	Minimum Treatment Possible	Example of Source
I.	None	Protected spring
II.	Chlorination	Spring
III.	Chemical pretreatment and chlorination	Impounded reservoir
IV.	Iron removal and chlorination	Groundwater
V.	Hardness reduction and chlorination	Groundwater
VI.	Slow sand filtration and chlorination	Mountain stream
VII.	Pretreatment slow sand filtration – chlorination ; upflow-downflow filtration and chlorination	Clear water from lakes or reservoirs
VIII.	Coagulation-Sedimentation-Filtration-Chlorination ; Upflow-downflow filtration and chlorination	River
IX.	Aeration-Coagulation-Sedimentation-Filtration-Chlorination ; Upflow-downflow filtration and chlorination	River or lake low in oxygen
X.	Pretreatment - Coagulation-Sedimentation-Filtration-Chlorination	Very turbid river
XI.	Coagulation-Sedimentation-Filtration-Hardness reduction -Chlorination	River

Source : Adapted from Azevdo-Netto

Table 7.4: Coventional methods of Pre-treatment

Pre-treatment	Turbidity range (NTU)
Plain sedimentation	15 to 50
Storage(prolonged)	> 600
Roughing Filtration	30 to 600

For rapid sand filtration plants, pre-treatment can improve the performance of the unit processes for the following reasons:

(i) better operation of the unit processes in likely because raw water quality is less variable;

(ii) less voluminous sludge is produced, and therefore less cleaning is needed for the main sedimentation basins,

(iii) because a large portion of the suspended solids is removed in the pre-treatment step, fewer chemicals are used in subsequent treatment.

For slow sand filtration, pre-treatment is essential if the raw water has a turbidity not more than 30 NTU. The best purification occurs when the average turbidity of the water on top of the slow sand filters is 10 NTU or less.

7.4.2.1. Plain Sedimentation

The process of plain sedimentation allows for the removal of suspended solids in the raw water by gravity and the natural aggregation of the particles in a basin, without the use of coagulants.

The suspended solids removal (by settling) efficiency is depended on the surface are of the sedimentation tank and on the depth of the tank. Thus surface loading rate is the basic guiding parameter for determining on size of the sedimentation tank.
Table 7.5. – presents the design criteria for plain sedimentation basins

Table 7.5 : Design criteria for Plain sedimentation basin

Parameter	Range of value
Detention time (hrs.)	1 to 4
Surface loading rate (lt/hr/m^2)	500 – 750
Depth of the tank (m)	1.5 to 2.5
Length : width ratio	4: 1 to 6:1 (8 : 3)
Length : depth ratio	5: 1 to 20 : 1
Weir loading rate (litre / sec. Metre)	£ 2 –3

Settling column analysis can be carried to assess the clarification efficiency and the analysis data can be used to calculate the size of the sedimentation tank.

The use of tube settlers for upgrading the pre-treatment of water in existing plain sedimentation basins or for reducing the size of basin has been established. Tube settlers are effective in removing turbidity from water containing silt clay particles. Hexagonal tubes are more effective than square and rectangular tubes.

7.4.2.2. Storage

Storage basins or reservoirs can be used for pre-sedimentation. The detention time is generally much greater than that for conventional sedimentation basins, ranging from about one week to a few months. For extremely turbid rivers or streams (average annual turbidity over 1000 NTU), storage provide the best pre-treatment. Storage serves several purposes in water treatment:

(i) it reduces the turbidity by natural sedimentation,

(ii) it attenuates sudden fluctuations in raw water quality,

(iii) it improves the quality of water by reducing the number of pathogenic bacteria,

(iv) it improves the reliability of the water supply because it can be drawn upon during periods of short supply of raw water, and,

(v) it can be drawn upon during short periods of exceedingly high turbidity, during which river water is not fed into the storage basin.

Usually, storage basin size of between 15 and 20 days detention time may be considered appropriate for most of the rivers in India.

7.4.2.3. Roughing Filter

Particles removed in filters are much smaller than the pore spaces in the media, so the process of filtration is not straining. The principal processes are sedimentation in the pore spaces, adhesion to the media particles and , in slow sand filters, bio-chemical degradation of particles that are captured. Roughing filters allow deep penetration of suspended materials into a filter bed, and they have a large silt storage capacity.

Roughing filters are three types, according to the direction of flow. They are: Up-flow, down-flow and horizontal flow roughing filter. Roughing filters are constructed mostly with three inter-connected separate compartments packed with the different specific sizes of gravels: The salient features of roughing filters are furnished below :

(a) *Up-flow roughing filter*

Number of compartment	:	3
Gravel size : 1st Compartment	:	12 – 18 mm
2nd Compartment	:	8 – 12 mm
3rd Compartment	:	4 – 8 mm
Rate of filtration	:	0.3 to 1.0 m^3/m^2 hr
Flow through media	:	Up-flow
Depth of media	:	60 – 100 cm
Cleaning mechanism	:	Flushing
Rate of flow during flushing	:	40 – 60 m/hr.

(b) *Down-flow roughing filter*

Number of compartment	:	3
Gravel size : 1st Compartment	:	12 – 18 mm
2nd Compartment	:	8 – 12 mm
3rd Compartment	:	4 – 8 mm
Rate of filtration	:	0.3 to 1.0 m^3/m^2 hr
Flow through media	:	Down-flow
Depth of media	:	60 – 100 cm
Cleaning mechanism	:	Flushing
Rate of flow during flushing	:	40 – 60 m/hr.

(c) Horizontal-flow roughing filter

Number of compartment	:	3 to 4
Gravel size : 1^{st} Compartment* : 20 mm		
2^{nd} Compartment : 15 mm		
3^{rd} Compartment : 10 mm		
4^{th} Compartment : 5 mm		

* May be required if raw water turbidity is high (> 300 NTU)

Rate of filtration	:	0.5 to 1.5 m^3/m^2 .hr.
Depth of media	:	100 – 150 cm
Cleaning mechanism	:	Flushing
Rate of flow during flushing	:	40 – 60 m/hr.

Horizontal Roughing Filter (HRF) (figures 7.1 & 7.2) has been found to be more effective than up-flow and down-flow roughing filter. HRF can be used as effective pre-treatment unit before slow sand filter. HRF can bring down suspended solids to such an extent that filter run of SSF may be as high as 90 days on an average. Depending upon the suspended solids concentration of raw water, the cleaning interval of HRF is on an average 90 days. No mechanical cleaning like back-washing is necessary for HRF.

The length of HRF is the guiding factor for removal of solid from water. The total length of HRF varies between 5 m and 12 meter. Tentative design guidelines are presented in Table 7.6:

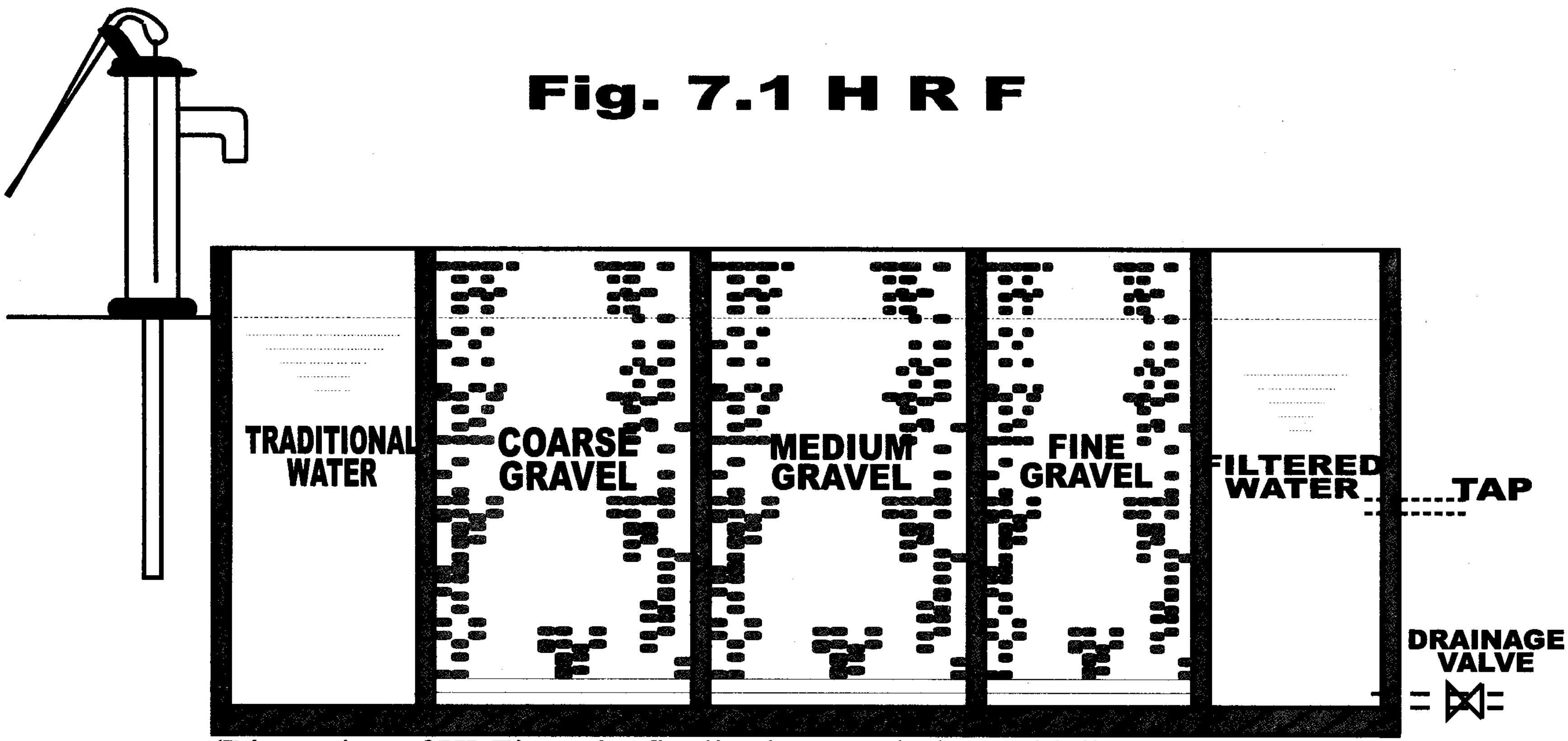
Table 7.6 Design Guidelines of HRF

The following tentative design guidelines may be used

Maximum suspended solids concentration in pre-settled water	CO (mg/l)	> 300 high	300 –100 medium medium	< 100 low
Filtration rate	V_f m/h	0.5	0.75 – 1	1 –1.5
Filter length for dg = 20 mm	Li (m)	3 – 5	3 *	3 *
15 mm		2- 5	2 – 4	2 –3
10 mm		2- 4	2 – 3	2
		1 – 2	1- 2	1
Maximum suspended solids concentration in HRF effluent	Co (mg/l)	5	2 – 3	2

*This gravel fraction can possibly be omitted.

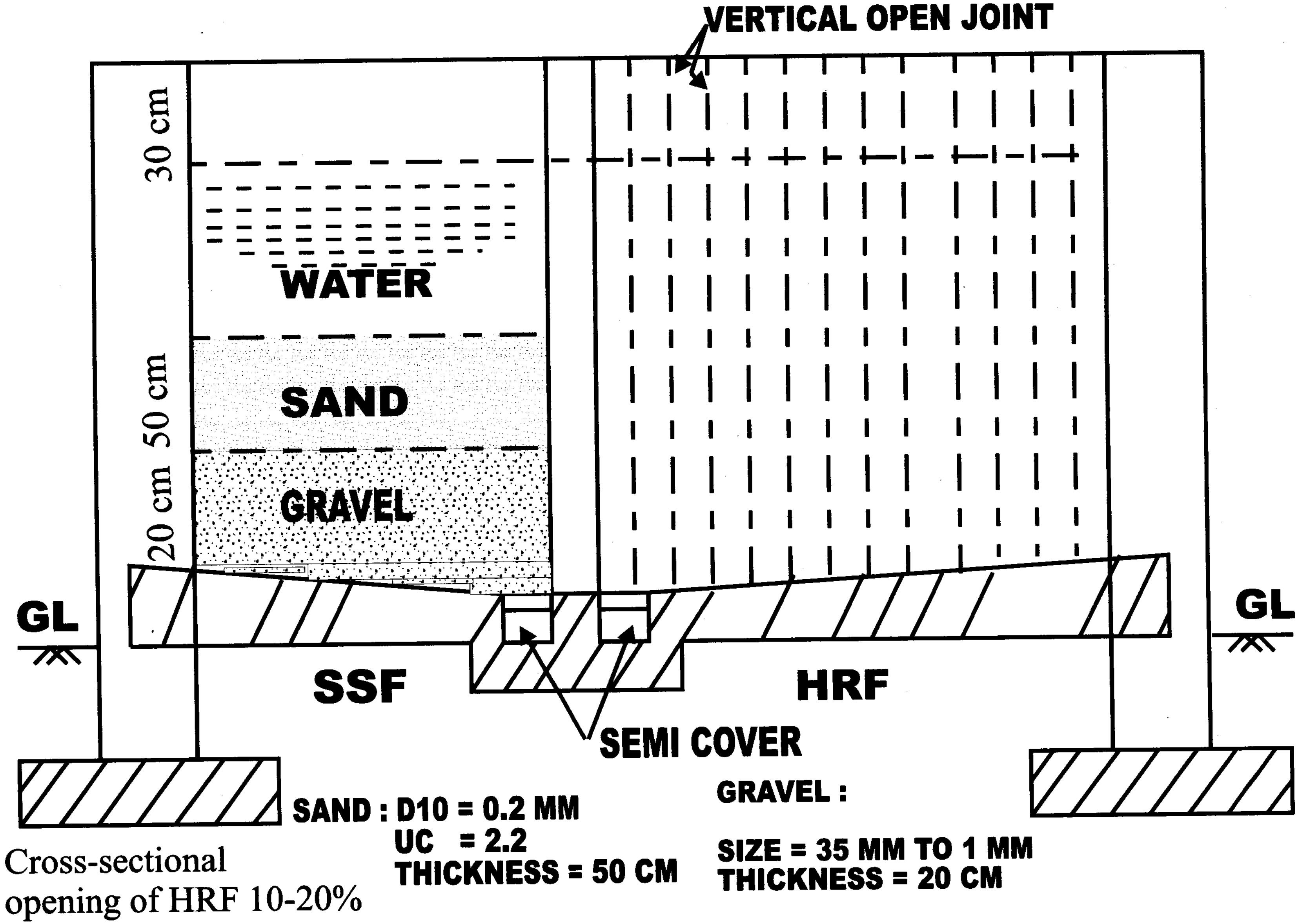
Fig. 7.1 H R F



(Dimension of HRFis to be finalised as per design guidelines given in Table - 7.6)

Depth of HRF 1.0m to 1.5m.
Width of HRF 1.0m to 5.0.
Max. Head Loss 30cm

Fig. 7.2 : CROSS SECTIONAL VIEW OF HRF - SSF



7.4.3. Slow Sand Filtration

Slow sand filtration improves the physical, chemical and microbiological quality of water; it is reliable and inexpensive, and is particularly useful in small-community water supplies. The most significant feature of slow sand filtration is that the purification of the influent is effected by microbiological means. On the surface of the sand a gelataneous layer develops which is rich in micro-organisms (for example, bacteria, protozoa, algae) called the Schmutzdecke. It is this layer that is largely responsible for the treatment of pollutents and by the biological treatment of dissolved organic matter and nutrients. While water percolating downwards, the fine particles are trapped on the sand grains, where micro-organisms consume organic material. The overall effect is a substantial reduction in the number of coliform organisms and pathogenic microorganisms in the water. In a well operated SSF, the efficiency of pathogen removal may exceed 99.5%.

Salient guidelines of slow sand filters are suggested below :

Rate of filtration	:	0.1 to 0.2 $m^3/hr.m^2$
Depth of filter box	:	Free board – 20 cm Depth of supernatant Water above sand : 90 – 100 cm Filter sand : 90 –100 cm Supporting gravel : 30 cm Under drainage system : 20 cm
Effective size of sand (D_{10})	:	0.20 mm and 0.40 mm
Uniformity co-efficient	:	1.8 to 3.0
Interval of cleaning	:	75 to 90 days
Method of cleaning	:	Scrapping and removing top 1.5 cm to 3 cm thick layer; washing sand and placing again. Renewal of 10 cm
new		sand every year.

Sanitary inspection of slow sand filters should check the following principal points:

- Is the turbidity of the filtered water less than 2.5 NTU ?
- Is the flow rate of the water through the sand filter in the range 0.1 – 0.2 $m^3/hr.m^2$ and is it constant ?
- Is the turbidity of the water entering the slow sand filter consistently less than 20 NTU ?
- Is the slow sand filter skimmed when necessary ?
- Is the depth of the sand in the filter bed greater than 0.5 m ?
- Is the interval of cleaning of filter is less than 60 days ?

Rapid Sand Filtration

The Rapid Sand Filter comprises a bed of sand serving as a single medium granular matrix supported on gravel overlying an under drainage system. The distinctive features of rapid sand filtration as compared to slow sand filtration include careful pre-treatment of water to effectively flocculate the colloidal particles, use of higher filtration rates and coarser but more uniform filter media to utilise greater depths of filter media to trap influent solids without excessive headloss. Backwashing of filter bed by reversing the flow direction is carried out to clean the entire depth of filter.

Salient feature of rapid sand filters are :

Rate of filtration	:	3 – 6 $m^3/hr.m^2$		
Depth of bed	:	Sand : 60 – 75 cm		
		Gravel : 30 – 45 cm		
Sand size	:	Effective size	:	0.45 to 0.70 mm
		Uniformity Coefficient (U.C.)	:	1.2 to 1.8
Cleaning mechanism	:	Back-washing.		

7.4.4 Disinfection

The filtered water which is obtained either from slow sand filters, or rapid sand filters may contain some pathogenic organisms in it. These micro - organisms must be killed in order to make the water safe for drinking. The chemicals used for killing these micro-organisms are known as disinfectants and the process is known as disinfection.

The disinfection not only removes the existing micro-organisms from water but also ensures their immediate killing even afterwards in the distribution system. The chemicals used for disinfection must be capable for providing residual disinfecting effect for a long period so as to take care of post contamination, if any. A few disinfection methods are mentioned below : -

a) Treatment with chlorine (chlorination)

b) Treatment with ozone

c) Treatment with U-V rays

d) Treatment with Sodium hypochlorite

e) Treatment with potassium permanganate

f) Boiling of water

Of the above boiling for at least 10 minutes is essentially a domestic treatment is very effective. The others viz. (b) to (d) are not only expensive but none of these have residual effects. Therefore, chlorination which is much less expensive and has a residual effect is generally resorted to.

Chlorination

Chlorine in its various forms is widely used for disinfection of water. When chlorine is added to water, it forms hypochlorous acid or hypochlorite ions ; both of which have immediate disastrous effect on most form of microscopic organisms. The reactions that take place are : -

$Cl_2 + H_2O \rightarrow HOCl + HCl$

The hypochlorous acid is unstable and may break into hypochlorite ions.

$HOCl \rightarrow OCl^- + H^+$

The above reaction is reversible and depends on pH of water.

Chlorine is an oxidizing agent that reacts rapidly with organic and inorganic matter present in water. The chlorine demand therefore is not only dependent on the quantity required for killing of micro - organisms but also reacting with ammonia, organic compounds, etc. Therefore, chlorine dose must be sufficient to meet the chlorine demand and also to keep free residual chlorine to take care of any post contamination. The minimum contact time for chlorine is 30 minutes and maximum free residual chlorine after disinfection may be 0.5 mg/l.

Chlorination may be done by using any of the following substances : -

a) Chlorine gas, liquified under pressure. It requires careful handling, safety measure and risk control system.
b) Sodium hypochlorite solution (available chlorine 1 to 14%). This hypochlorite solution should be kept at dark cool place ; stored in dark glass or plastic container. It is unstable at warm temperature. With time, it may lose strength.
c) Calcium hypochlorite with available chlorine between 60 to 65%.
d) Bleaching powder. It contains 30 - 33% available chlorine. It requires safe handling and it must be stored properly in closed containers. Warm temperature and storing in open container must be avoided.

7.4.4.1. Disinfection process by chlorination in rural and peri-urban areas

Disinfection of water supply system by chlorination requires determination of dosage of chlorine. In rural water supply, bleaching powder is generally used for disinfection.

Determination of dosage of disinfecting powder

Description of content

Following materials are required as field outfit for disinfection of water.

a) Four white enamelled tumblers, of capacity 500 ml each.

b) One spoon holding 1 gm. of disinfecting powder or 1 ml of water, filled to brim.

c) One glass stirrer rod.

d) One 6 " rule.

e) One chlorine comparator.

Instruction

a) Place in one of the tumblers one spoonful (level with the brim) of the disinfecting powder and make it into a paste with little water, stirring with a glass rod and carefully breaking up the lumps. Add more water to fill the tumbler and stir vigorously with the glass rod.

b) Arrange the other three tumblers in a row. Add 1, 2, & 4 spoonful of the solution of disinfecting powder to the three tumblers in turn and fill them with the sample of water to be disinfected. Stir the liquid of the tumblers thoroughly with the clean glass rod, allow them to stand for 30 minutes. After this period, test the residual chlorine in the water supply taken from each of the three tumblers. The reisdual chlorine is carried out with chlorine comparator (orthotoludine test). The first tumbler which show 0.2 to 0.5 mg/l of residual free chlorine indicates the dosage of disinfecting power. (e.g. bleaching powder)

c) If the desirable residual chlorine is not found in any of the three tumblers, throw away the contents and repeat the procedure mentioned in b) above, using more than 4 spoonful (such as 6, 8 and 10 spoonfuls) of disinfecting solution to the three tumblers. Fill them with fresh samples of water to be disinfected and take residual chlorine readings after 30 minutes.

d) Each spoonful of solution added correspond to 4 mg/l of the disinfecting powder or 1 spoonful of powder for every 250 litres of water. Actual quantity of disinfecting powder required for the given volume of water can thus be computed.

Disinfection of dugwell

Direction (addition of bleaching powder solution)

Dugwell water, if used for drinking need to be disinfected, as mostly such waters are bacteriologically contaminated. The process of disinfection of dugwell is as follows : -

a) Find out the volume of water in the dugwell. In order to do so, measure the diameter (D) of the dugwell and also depth (H) of water in dugwell in metre.

Volume of water in litre = $0.785\ D^2H\ (M^3) \times 1000 = 785\ D^2\ H$ litres

b) Find out the bleaching powder / chlorine demand of the dugwell water (already mentioned). Take the requisite quantity of bleaching powder in a plastic mug. Make paste by adding small amount of water. After this, put the paste liquid in a bucket full of water. Allow settlement of suspended solids at the bottom of the bucket. The supernatant is now to be screened through cloth or nylon strainer. Lower the bleaching powder solution filled bucket in the dugwell. Mix the solution well in the dugwell. After a period of 30 minutes, the residual chlorine of the dugwell is assessed and then used for drinking purposes.

c) If facility for determining chlorine demand is not available in field, then disinfection can be done for dugwell by trial and error method. Initially, disinfection is to be tried with 1 mg/l of chlorine (i.e. 4 mg/l of bleaching powder ; considering available chlorine in BP as 25%). Bleaching powder quantity as calculated need to be added as mentioned in b) above. If residual chlorine is not available after 30 minutes, the process is to be repeated unless residual chlorine between 0.2 and 0.5 mg/l is available in the dugwell water.

Pot chlorination

Single pot system (figure 7.3)

An earthen pot or a plastic container of 2 to 2.5 litres capacity with 3 - 5 mm dia holes at the bottom is half filled with gravels of 8 to 20 mm size. Bleaching powder and sand (1 : 2 proportion) is placed on top of the gravels and is further filled with gravels upto the neck. The pot is then lowered into the well with its mouth open.

For a well from which water is taken at a rate of 1,000 - 1,200 litres / day, a pot containing about 50 - 55 gm of bleaching powder could provide adequate chlorination for about 1 week. Often over chlorination may result from single pot chlorination system.

Double pot system (figure 7.4)

A unit consisting of two cylindrical pots one inside the other with openings (top side opening of inner pot and bottom side opening of outer pot) may be used as double pot chlorinator. The inner pot is filled with bleaching powdr and coarse sand (1 : 2) to the level just below the opening. It is then placed inside the outer pot. The top of the chlorinator is covered by polythene sheet. The unit is lowered into the well with the help of a rope.

The single pot or double pot chlorination will be effective, once the dugwell has been disinfected properly.

Drip chlorination

A plastic container (3 - 5 litres capacity) with brass tap is used for drip chlorination. Bleaching powder solution is prepared and kept in the container. The brass tap is adjusted in such a way that drops of solution at regular interval is mixed with the dugwell water. The tap is kept in operative during the drawal of well water.

Disinfection of tubewells

Disinfection of tubewells is done for disinfecting different part of the tubewell by a high dose of 60 mg/l chlorine. Volume of water in the tube is calculated initially. Bleaching powder solution is prepared a bucket of water and then it is added in the tube. However, before that pump is removed and different parts of pump are immersed in a bucket full of bleaching powder solution of strength 60 mg/l of chlorine. After at least 30 minutes, the pump is refitted and chlorine solution is pumped out from the pipe. When the residual chlorine become absent, the tubewell is then allowed to be used by the beneficiaries.

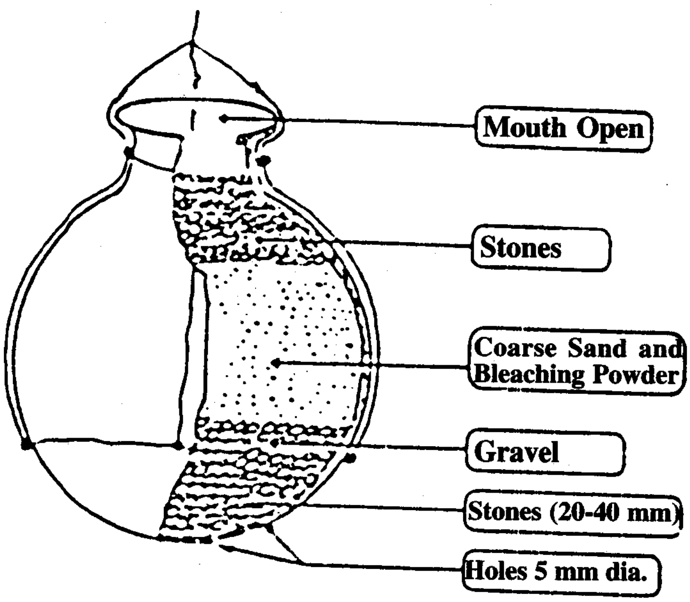


Figure - 7.3 Single Pot System

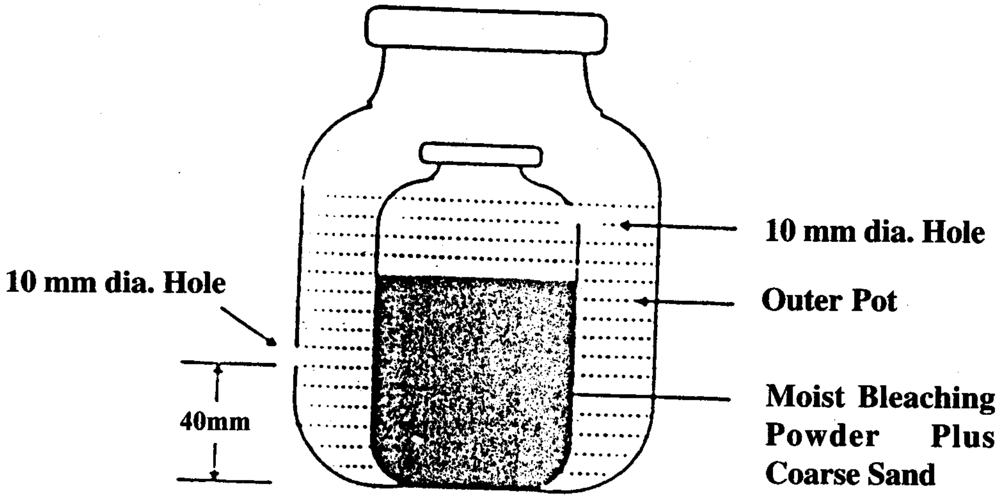


Figure - 7.4 Double Pot System

Disinfection of water for piped water supply schemes

In a rural piped water supply scheme usually either bleaching powder solution or sodium hypochlorite solution is used. Initially chlorine demand is determined. Disinfectant solution is then added to maintain free residual chlorine at the farthest point as 0.2 mg/l. However, residual chlorine at the consumer end should not be more than 0.5 mg/l.

If residual chlorine cannot be maintained throughout the pipe network due to post contamination entering in the disinfection system, sanitary survey must be carried out to take up mitigation measures for minimizing post contamination in the distribution system.

7.4.5 Aeration

Aeration is required for transfer of gas in water or from water. Aeration may be necessary in water treatment due to following reasons : -

i) To impart freshness to water.

ii) To reduce corrosiveness of water (specially ground water) by driving off carbon dioxide and raising the pH.

iii) To oxidize iron and manganese.

iv) To strip out carbon dioxide, hydrogen sulphide, ammonia and other organic matters including volatile substances causing taste and odour.

Usually following four types of aeration systems are used : -

a) Gravity aeration.

b) Spray aeration.

c) Diffused aeration.

d) Mechanical surface aeration

In water treatment, gravity aeration and spray aeration are mostly used. Waterfall, single or multiple tray aerators, cascade aerators are basically gravity aeration. In tray aerators, gravel, stone, coke, etc. of size ranging from 25 mm to 100 mm are placed. Cascade aerators comprise 4 to 6 steps. Space requirement for aeration varies from 0.015 to 0.05 m^2 / m^3 / hr.

7.4.6 Adsorption

Adsorption is a physical process where soluble molecules (adsorbate) are removed by attachment to the surface of a solid substrate (absorbent) primarily by Van der Waals forces, although chemical or electrical attraction may also be important. Adsorbents must have a very high specific surface area and include activated alumina, clay colloids, hydroxides and adsorbent resins, with the most widely used being activated carbon. In water treatment it is used to remove taste and odour - causing trace organic compounds as well as colour and other organic residual especially chlorination disinfection by - products such as Tri halo methanes THMs.

The most widely used adsorbent is activated carbon. It has a highly porous structure resulting in specific surface areas of between 600 and 1,500 m^2 / gm. The overall rate of adsorption is dependent on particle size which varies reciprocally with the square of he particle diameter. The adsorption rate also increases with increasing molecular weight of solute and decreases with increasing pH with adsorption very poor at pH > 9.0. The rate of adsorption is also proportional to the square root of the time of contact.

7.4.7 Iron and Manganese Removal

Both iron and manganese are extremely common metals and found in large amount in soil and rocks, although normally in an insoluble form. However, dur to a number of complex reactions which occur naturally in the ground, soluble forms of the metals can be formed which can then contaminate any water passing through. Therefore, excess iron and manganese are a common phenomenon of ground waterrs, specially those found in soft ground water areas.

When iron and manganese concentration in water become more than the permissible limit, the following problems may take place : -

i) They cause discoloration of clothes washed in such waters.

ii) They cause incrustation of water mains due to deposition of ferric hydroxide and manganese dioxide.

iii) They make the water unpleasant in taste.

iv) They impart red or brown colour to the water. The reddish tinge is due to the iron and the brownish is due to mangenese.

The iron and manganese may be present in water either in combination with organic matter or without such combination. When present without combination with organic matter, they can be easily removed by aeration followed by sedimentation and filtration. During aeration, the soluble ferrous and manganese compounds present in water get oxidised into insoluble ferric and manganese compounds. Such insoluble particles are then removed by sedimentation followed by filtration.

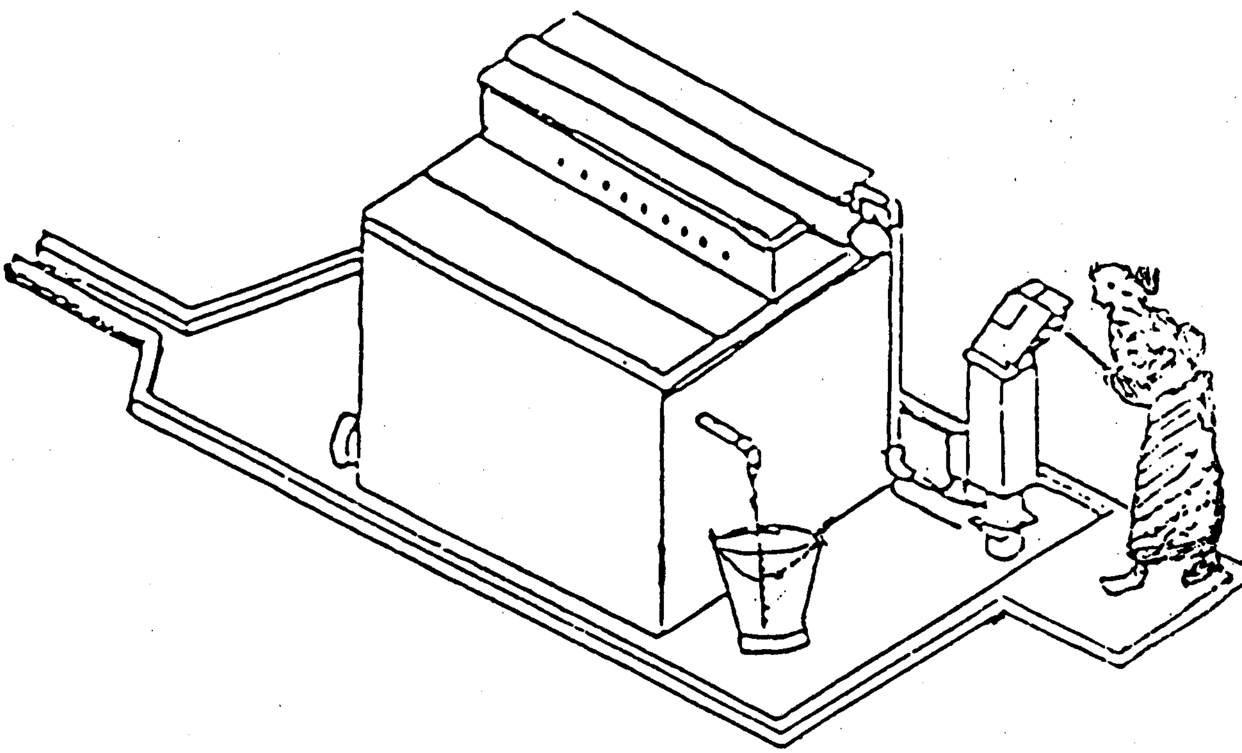


Figure 7.5 Iron Removal Plant
(Suitable for Rural Community

If iron and manganese are present in combination with organic matter then strong oxidizing agent, such as chlorine or potassium permanganate can be added for oxidation of iron and manganese. In soluble iron and manganese are then removed by sedimentation and filtration. Figure 7.5 shows an iron removal plant suitable for rural community.

7.4.8 Fluoride Removal

Presence of fluoride more than the permissible limit in drinking water may cause mottling of teeth or dental fluorosis. Excessive fluoride may cause skeletal fluorosis. Contamination of ground water with fluoride is severe in Rajasthan, Andhra Pradesh, Gujarat, Haryana, Karnataka and Punjab. In addition, ground water of certain areas of Madhya Pradesh, Chattisgarh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, Kerala, Bihar, Jharkhand, Delhi and Jammu & Kashmir have been reported to be contaminated with fluoride. Recently fluoride concentration beyond permissible limit have also been reported from some parts of Assam and West Bengal.

There are various methodologies by which fluoride can be removed. These methodologies are presented below : -

a) Co - precipitation

Filter alum (ferric alum) can be added in water for removal of fluoride. During the process, lime or sodium carbonate, bleaching powder solution and alum (aluminium sulphate) are added in water. Initially, lime or sodium carbonate solution is added and mixed. Thereafter, alum is added and mixed rapidly for at least 60 sec. Slow mixing for at least 5 to 7 minutes will help in forming floc. Fluoride will be adsorbed out on sludge. Settlement is allowed for 2 hrs. The supernatant is then filtered to obtain fluoride safe water. The method is known as Nalgonda Technique. The quantity of chemical required is dependent on alkalinity and fluoride content in the water.

b) Adsorption by activated carbon and activated alumina

Activated carbon and activated alumina can be used as an adsorbing media for removal of fluoride. Different grannuled activated carbon/alumina materials have been developed commercially for different uses including removal of fluoride.

c) Exchange method

Anion exchange resins can be used for removal of fluoride from ground water.

d) Reverse Osmosis (Membrane Technology)

Fluoride from water can be removed by the action of reverse osmosis by using semi-permeable membrane. Figure 7.6 demonstrates household method for fluoride removal.

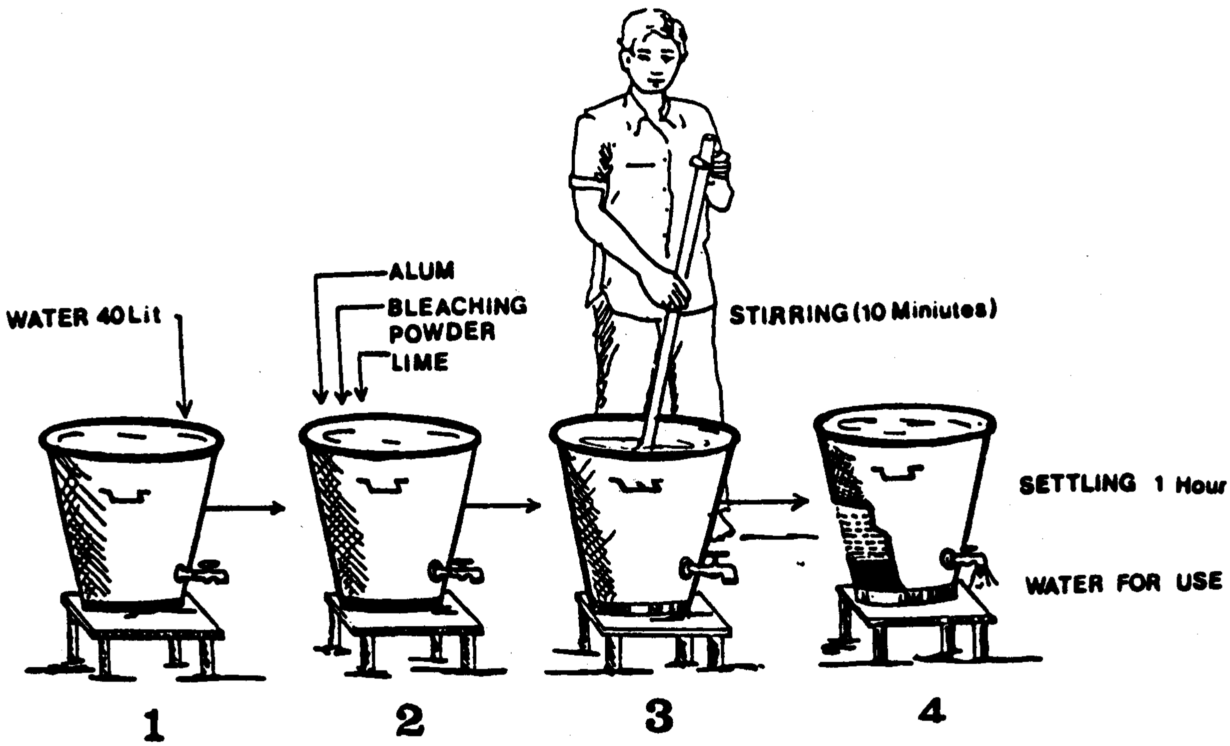


Figure 7.6 Household Method for Fluoride Removal

7.4.9 Arsenic Removal

In nature, arsenic is widely distributed. Although, arsenic has served mankind well in different ways, it is often viewed as being synonymous with toxic. The sources of arsenic in soil are mainly the parent (or rock) materials from which it is derived.

The symptoms of chronic arsenic poisoning include various types of dermatological lesions, muscular weakness, liver disorder, etc. Arsenic is a potential carcinogen and skin cancer can occur after prolonged exposure.

The following methods may be used for removal of arsenic from drinking water : -

i) Oxidation of arsenic (III).
ii) Coagulation - flocculation - sedimentation - filtration.
iii) Ion exchange.
iv) Adsorption.
v) Osmosis / electrodialysis

Oxidation

The effective removal of arsenic from water requires complete oxidation of arsenic (+3). There are several oxidants available for such oxidation. However, considering it to be used for drinking water treatment, selection of oxidant is very important. Chlorine, bleaching powder, sodium hypochlorite, calcium hypochlorite, potassium permanganate can be used for oxidation.

Coagulation - Floccupation - Sedimentation - Filtration

After converting arsenic +3 to arsenic +5 by adding oxidizing agent (say bleaching powder solution, chlorine dose 0.5 mg/l approx.), a coagulant is added. Alum, ferric sulphate, ferric chloride etc. can be used as coagulant. Alum is cheaper and readily available in remote villages.

Alum is to be added in water at 40 - 65 mg/l dose (depending on arsenic concentration in raw water) by rapid mixing for 60 sec. Thereafter, slow mixing may be carried out for approximately 10 minutes. The whole quantity of water is to be kept for 2 hrs. The supernatant is filtered to obtain arsenic - safe water. Any type of filter (candle filter, sand - gravel filter) can be used for filtering the supernatant.

Ferric suplhate or ferric chloride can also be used as coagulant. Sodium hypochlorite or calcium hypochlorite can also be used as oxidizing agent for conversion of arsenite to arsenate.

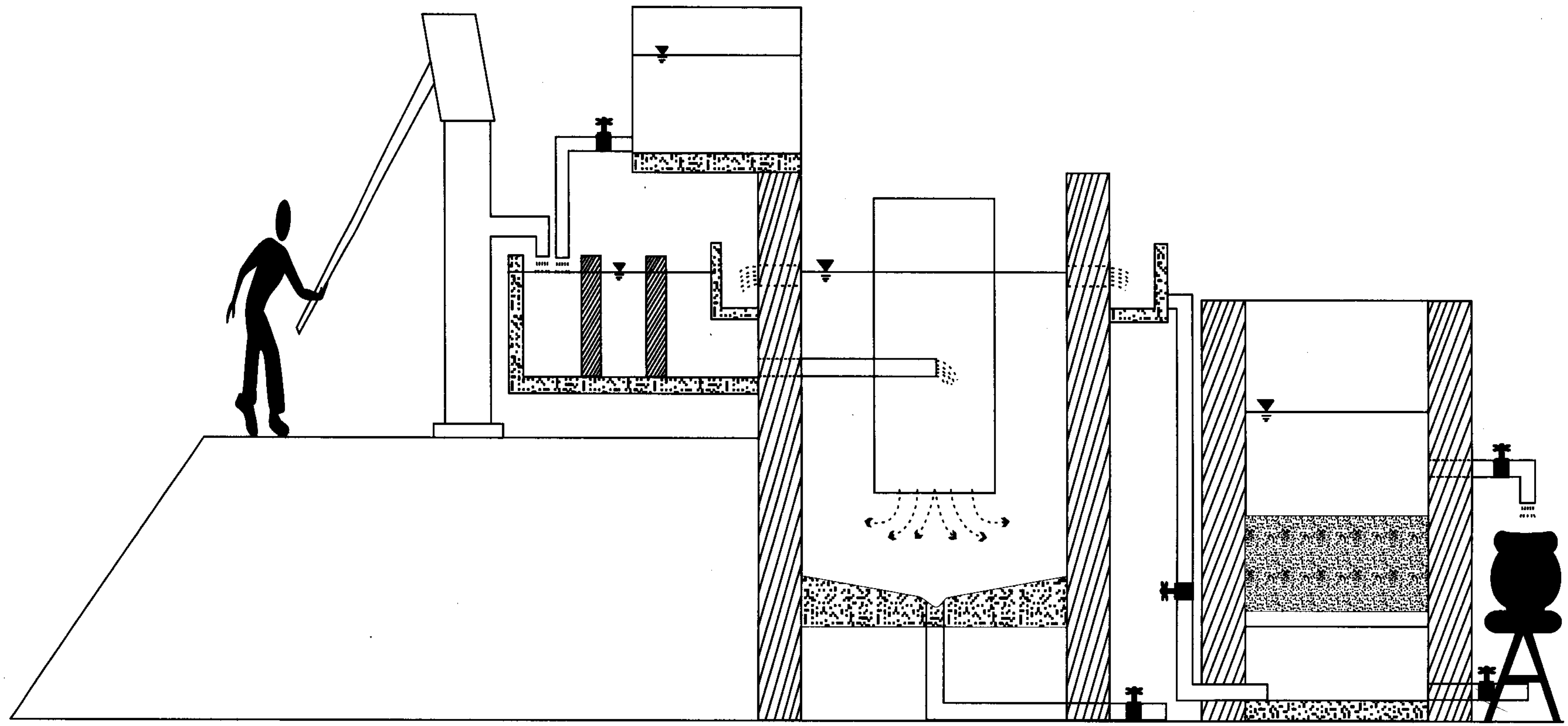
The sludge should not be thrown in open drain or in any water body. The sludge can be stored separately and at a specific interval of time it can be disposed by burning wirth clay (0.01% sludge in clay) or mixing with cement concrete (0.01% sludge in concrete). Figure 7.7 shows handpump attached arsenic removal plant based on above principle of treatment.

Ion exchange

Resin can be used for removal of arsenic. Iodized resin has been found to be excellent in removing not only arsenic but also iron and pathogenic organisms.

Adsorption

Activated alumina can be used for removal of arsenic. At lower pH, however, activated alumina functions much better in adsorbing arsenic. A model of domestic arsenic removal unit is shown in figure 7.8.

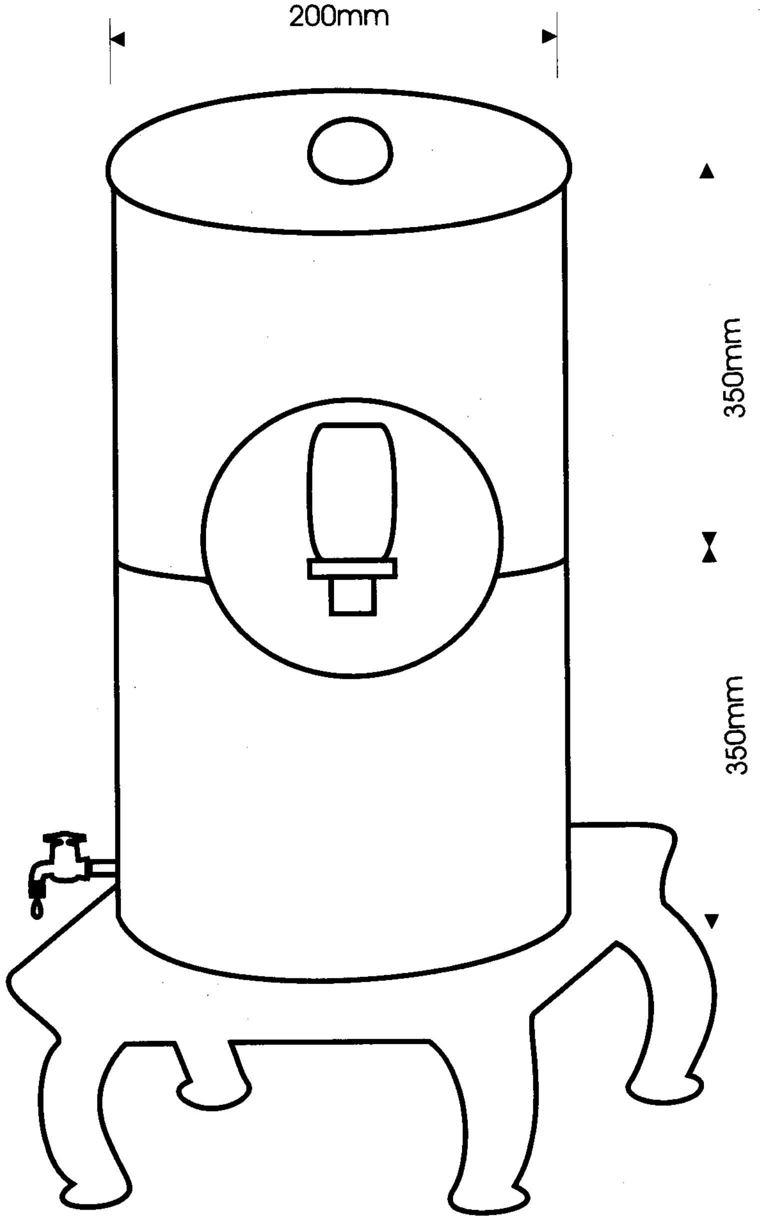


Department of Sanitary Engineering
All India Institute of Hygiene and
Public Health

Fig. 7.7

ARSENIC & FLUORIDE REMOVAL PLANT
(Handpump Attached Model)

Developed by :
Department of Sanitary Engineering
All India Institute of Hygiene and Public Health, Kolkata.



Treatment Capacity 25-30 Litres per Day
Cost of Filter Rs. 100/- - 150/-

Fig - 7.8 :

Domestic Arsenic & Fluoride Removal Unit
Made of Earthen Pots & One Candle Filters

CHAPTER – 8

MANAGEMENT INFORMATION SYSTEM (MIS)

8.1. General Consideration

MIS does not only envisage the networking and data base, the data while being communicated, are utilized for helping the management take decision about improvement of a work system. At every stage of movement of the data, the management is oriented and upgraded as and where needed. The toying with data and information base has revolutionized the day to day technological system. This has been the backbone of a sound and efficient management system, whether it is oriented towards production or utility services such as water supply, sanitation and other environmental needs. Its use in utility sectors such as water supply sanitation, and other environmental services is extremely important and hence needs urgent attention of government and consumer community as well.

8.2. Information Network

As stated earlier, the generation of data or information does not ensure a well organised management system unless they are interpreted properly and timely communicated in a right direction. This linkage of generation – interpretation -communication in a modern management system is very important.

In the era of computerization global networking has become a powerful means of communication, storage and utilization of data. Today, quite a good numbers of softwares are available world wide on the information technology which are tailored according to the demand of the problem.

In the matter of water quality surveillance (WQS) issue which is the context of the present discussion the networking of data is extremely significant. The issue of WQS essentially warrants the application of geographic information system (GIS) which is a part of MIS. Hence, before getting into MIS, a brief introduction of GIS is necessary which is provided in the following text.

8.3 Geographic Information System (GIS) for Water Quality Surveillance

8.3.1 Introduction about GIS

Maps and image data in both vector & raster formats can be merged with statistical information to facilitate mapping, modelling, and decision making for applications such as forest management, ecological impact, hazardous waste management, urban planning and map revision, and water quality mapping. Emphasis is placed on developing digital technologies for the integration of photogrammetric and remote sensing data with land and geographic information systems (GIS).

Remotely sensed imagery is an invaluable source of information, essential in making decisions concerning the use and care of land-based resources, eg water availability and its quality. The use of such information involves the following four stages:

- Data Collection
- Image Correction
- Information Extraction
- Information Analysis and Interpretation

Each of the stages requires specialized tools and procedures. The four stages are briefly described below, and the available tools are characterized.

8.3.2 Data Collection

In this stage the imagery of the Earth surface is acquired remotely. The most useful types of remotely sensed imagery are:

- high resolution satellite images, both black & white and multispectral (coloured).
- aerial photographs, available at a variety of scales (from larger than 1:1000 to smaller than 1:60,000), and either in black & white or in true colour.
- radar imagery, both space-borne and air-borne.

In addition to collection of imagery data this stage includes the acquisition of auxiliary data, such as:

- ground positioning data, either by traditional ground surveys or, increasingly by the use of Global Positioning System (GPS);
- ground truth information, ie detailed observation and documentation of localized land cover types.

8.3.3 Image Correction and Enhancement

Raw image obtained from data suppliers always have geometric distortions, and often may be radiometrically unsuitable for viewing. Such problems are corrected or minimized at the stage of image correction and enhancement. The geometric corrections require resampling of the raw images. The process of interpolation invariably leads to some loss or distortion of information in the image. Therefore, it is essential to minimize the number of resampling steps.

8.3.4 Information Extraction

Depending on the image type and user requirements, the following operations may be performed at this stage:

- image classification
- vector digitization
- feature extraction
- information compression
- geo-morphological analysis

The capabilities described at this stage are provided by most image analysis and processing systems. The processing of this stage results in various types of information, stored digitally as images (for example, image of terrain slope), digitized vectors, classification polygons, location of various features, and their attributes. The role of image processing software ends here, as the data are exported to dedicated systems, usually Geographic Information System (GIS), performing the final analysis and interpretation.

8.3.5 Information Analysis and Interpretation

Image analysis systems extract information from images. In most practical applications, the extracted information has to be combined with other data to arrive at the required decisions. A spatial analysis systems or GIS is often used to bring image and other spatial and non-spatial information together for the purpose of analysis and interpretation.

GIS facilitates the analysis and permits the operator to produce spatially formatted responses to the spatial problems. In a very broad sense, the results of such analyses are a representation of the "cost" of the solution. This cost could be monetary (expected profit from residential development of a given parcel), environmental (locaton of a hydro-electric dam), or to a human health(location of a hazardous waste storage facility).

Consider a hypothetical application where the cost of drilling a well is a function of the location of the potential site relative to existing transportation infrastructure (rail and roads), surface and subsurface hydrogeology, proximity to the proposed user base, and location of existing wells (current demand on the aquifer).To satisfy the requirement of transportation , a line layer with transportation routes will be required. Surficial and substrate hydrogeology require a layer for each of elevation (contours or digital elevation model), substrate geology (digital geological survey polygons), surface cover and drainage (remotely sensed classified imagery).

The digital representation is rarely the last step in the process. Most users require graphically formatted output for presentation and final decision making. As well as facilitating the analysis and interpretation of image data, spatial analysis and GIS tools generally provide powerful output options. This permits the user to represent the results of the analysis spatially, in the form of maps, statistical graphs or charts, or in tabular reports and summaries. Legends, scale bars, labels, north arrows, and cartographic symbols, all enhance the interpretability of the digital product.

8.3.6 Water Quality Mapping - a current need

While the quantity of water is emphasized to a good degree in our urban and rural water supply schemes, the aspect of water quality is always given a step motherly attention in our community water supply system. Considerable deaths are reported in each and every year which are caused by water borne diseases, such as diarrhoeal, infective hepatitis, etc. Quite a good amount of money is spent from the individuals for remedying these diseases and our Govt. also is providing a handsome fund for combating these ailments. If a part of this fund is diverted to practise a routine WQS in an organised manner, perhaps the nation can save a lot, both in terms of money and human lives.

Water quality mapping is a very important tool to secure a successful WQS programme. This will identify the problem areas in respect of water quality, both as a part of short and long term mitigatory measures.

With the help of such water quality mapping the identification of each water sources, status, water quality (e.g. Turbidity, TDS, Chloride, Fluoride, Iron, Arsenic, Nitrate, etc. and Total and Faecal Coliform) etc. could be plotted for an area under WQS programme.

Water quality mapping of all the water sources along with the quality could be done at village level, district level and state level. The village level maps may be well displayed in the village at all important points such as gram panchayat office, school, Primary Health Centre (PHC) etc. The potable water sources could be painted blue while unpotable sources may be painted red.

All the data related to WQS such as problem parameters, surveillance personnel involved in an area, mitigatory measures taken, emergency measures required, long term strategy, etc. shall be known through water quality mapping.

To ensure a successful WQS programme, computerised networking of the concerned surveillance agencies is important.

8.4. Formats and Instructions for Collection and Coordination of Data

The surveillance team should try to collect as much information as possible of all the water sources in the area and keep them recorded in a systematic fashion. This will serve as an inventory of water related data of the area.[ref 6.2]

During the survey all possible sources of contamination should be identified and recorded.

The observable faults in the drinking water system, which may give rise to problems of quality or continuity of supply and hence to disease, can most readily be identified by careful on-site inspection. Every fault should be systematically listed during the sanitary survey and each point may therefore be considered as a sanitary risk factor.

Risk factors (such as construction of a latrine near a community well, or the absence of an impervious concrete plinth around the well) are causes or signals which can be identified prior to the event that they predict, e.g. pollution of the well causing an outbreak of disease. It is logical that the greater the number of risk factors the greater the possibility that the community will be subjected to poor water quality and continuity, and as a consequence suffer from increased water-related diseases. Every extra mechanical fault, or point of exposure to risk, may serve to increase the intensity of contamination and thus the risk to health. Similarly, every remedial action which eliminates a point of risk will reduce the probability of water-borne disease.

Separate proforma (log sheets) should be prepared for different water sources. [Figure 6.1 to 6.7] Scoring systems may be introduced, which can help the surveillance team in assessing the risk. In chapter 6, log sheets are provided for different types of water sources, which incorporate a risk assessment scoring system. The sources for which sanitary survey could be done are :

1. Dugwells.
2. Converted covered dugwells (sanitary Ring Well) with handpumps.
3. Deep and shallow tubewells with handpumps.
4. Boreholes with mechanised pumping.
5. Gravity fed protected spring sources.
6. Simple distribution systems.
7. Rainwater catchment.

It should be kept in mind that these survey forms are models developed for assessing risk and may be modified or extended as the need arises depending on the local situations.

A complete WQS programme shall consist the following components :

1. Land cover / land use information on vegetation, land cover
2. Demographics
3. Hydrology
4. Infrastructure
5. Climatology
6. Topography
7. Economy
8. Water quality

While in some countries, the surveillance staff are qualified to carry out the surveillance jobs, in others the staff are either not available or available only at the Central level. Every effort should be made to ensure that the transmission and dissamination of information and data are as direct and simple as possible. While coordinating the activities of the various bodies in a water quality surveillance agency. The transmitted data ought to be clear and correct.

As regards the collection of data, relating to water quality surveillance, the extensive sampling and analysis of water samples on routine basis, say weekly monitoring for common water quality parameters, while monthly testing of relatively less important parameters, is suggested. The common water quality parameters may include pH, turbidity, hardness, iron, coliform organism, etc. and relatively less common parameters may consider monitoring of heavy metals, fluoride, salinity, etc. A communication network schedule for water quality surveillance data transfer at different levels is shown in Figure 8.2.

These parameters may be set depending on the local water quality and the community need. A suggestive format for such monitoring is provided below :

Name of water supply scheme : Location of the scheme:

Nature of the water supply scheme : Private / Public

Year of installation : Owned by :

Maintained by : Monitoring agency :

Name and Address of the Sample Collector :

Name and Address of the Laboratory where tested :

Date of Sampling	Place of Sampling	Date of Testing	Place of Testing	Analyzed Results	Mitigatory Measures Taken	Remarks

While the collection of data is an important component of a successful WQS programme, the coordination and communication of available data is equally important for an effective programme.

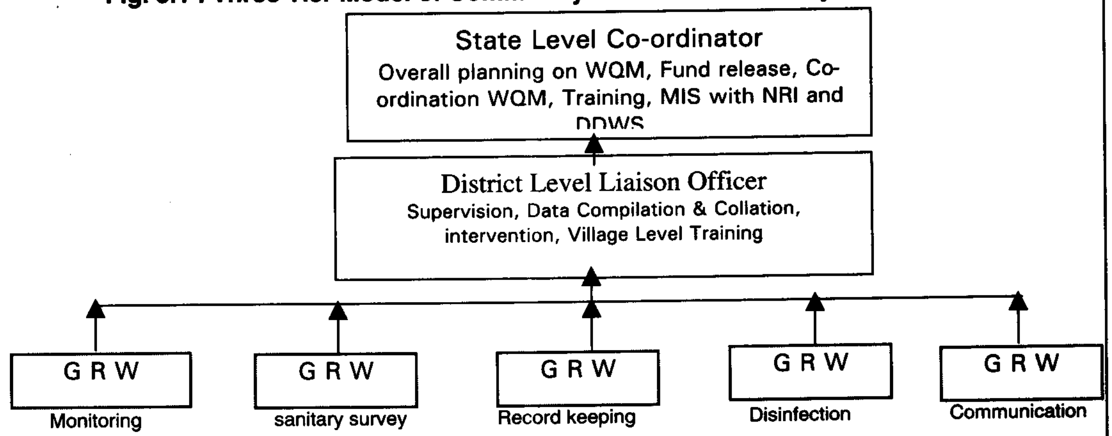
A sound collection schedule and a precise testing programme may prove to be a flop if the results of the water quality monitoring are not properly and timely conveyed to the competent authority for subsequent measures.

The strategy for a successful WQS programme ought to be formulated keeping an eye to an organised coordination of data. In the process of water quality surveillance programme, the user community should also be taken into confidence.

8.5. Organogram of Three-tier MIS

Based on different pilot projects carried out in different districts of West Bengal, All India Institute of Hygiene and Public Health and UNICEF, Calcutta have jointly proposed a three tier model of community based Water Quality Surveillance (WQS).

Fig. 8.1 : Three Tier Model of Community Based Water Quality Surveillance



In this model (Ref. Figure 8.1), some key persons at the district level would be identified and trained to oversee, monitor and evaluate the district wise programme. They in turn would identify and train some key persons at the village level. The village level trainer would take up the task of training and supervising the programme at the village level.

Grass-root workers (GRW) would analyse the water sources 4 times in a year, and as and when required. In situations of water quality problems particularly in cases of deterioration of bacteriological water quality they would approach health authorities for rectification. In cases of chemical contamination GRWs would immediately inform the Village Level Key Trainer. If the problem be a major one, information would now be transmitted to District level Co-ordinator (eg., CMOH or Executive Engineer, PHED). A Surveillance Co-ordinator would be placed in each district who may be the ADM (Dev.) or the District Programme Officer of ICDS or person of similar rank. College professors could also be chosen for the post. This person would co-ordinate the total programme within the district and make liaison with the State Administration. Co-ordinators would get a monthly honorarium for supervising the whole programme in the district.

It is envisaged that a **National Information & Communication Network** could be established to facilitate Water Quality Monitoring throughout the country and to create an **Information Database System.** The district headquarter based NICNET (National Informatics Centre Network) may extend their help for this purpose through their satellite based information sharing network all over the country.

Fig. – 8.2 : COMMUNICATION NETWORK

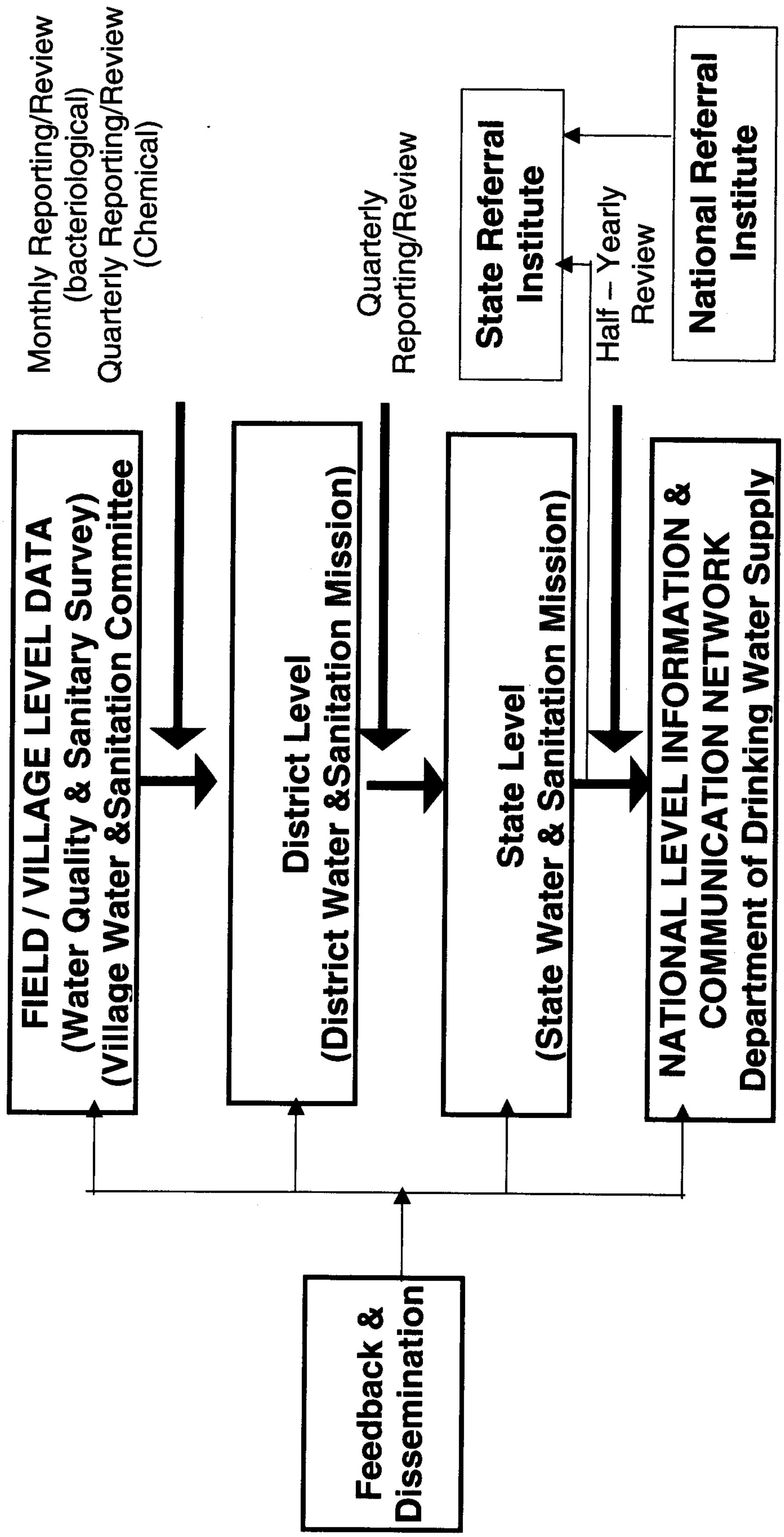
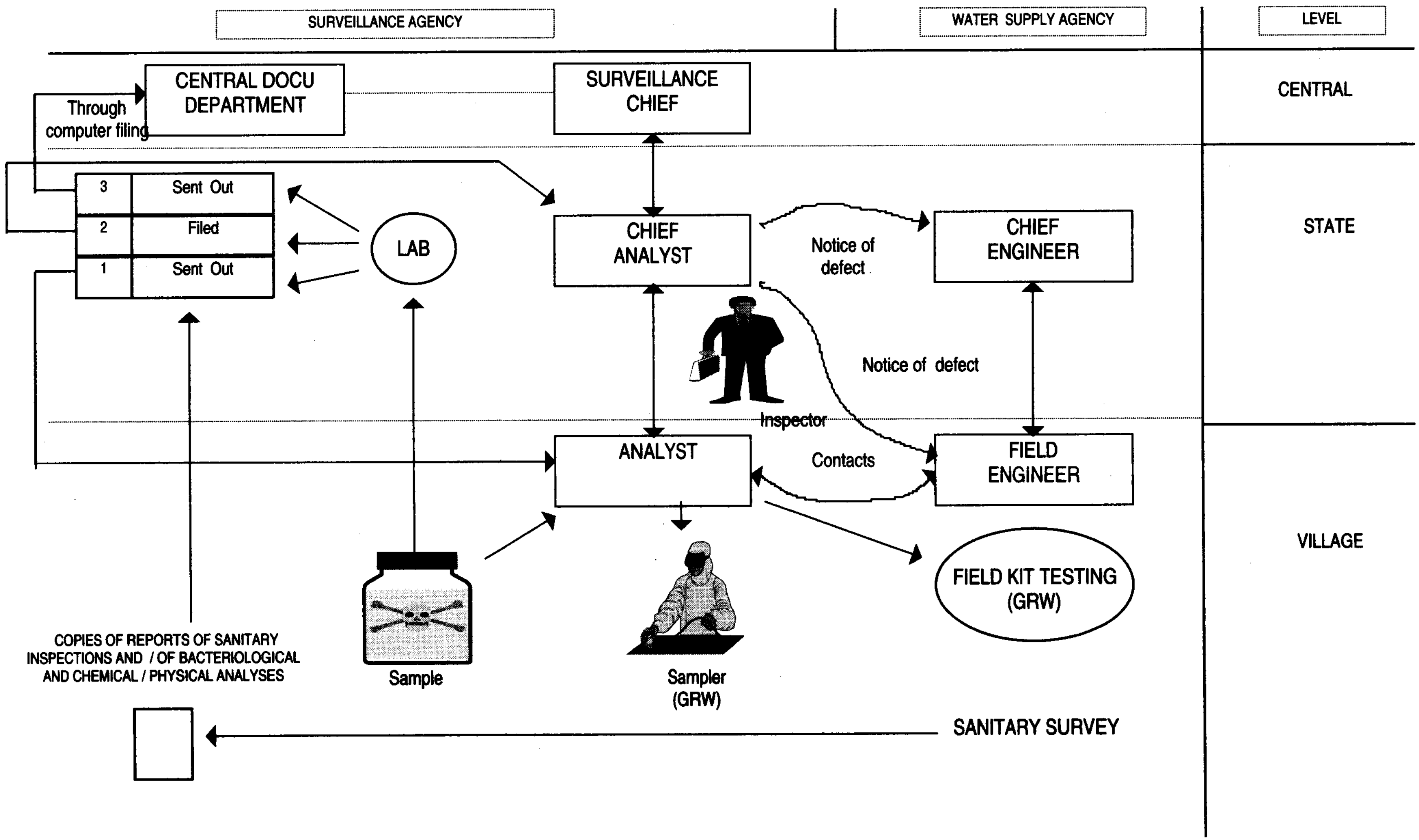


Fig 8.3 FLOW SHEET FOR COMMUNICATIONS AND ACTION RELATED TO WATER QUALITY SURVEILLANCE



8.6. Data Linkage

Subsequent to the generation of a reliable set of data their linkage remains to be done as early and as effectively as possible. The job of linking the data would rest on the available computer networking in the departmental level. In the stage of data propagation, the appropriate mitigatory measures at various departmental levels as shown earlier need to be taken as early as possible. The action, both remedial and preventive, shall be aptly taken by GRW and conveyed to the next designated higher authority as depicted in the given organogram. If the action is not possible to be taken up by the GRW, it should be immediately informed to the appropriate level for necessary guidance on the next course of action. In the event of action to be directed by further higher level, the flow of data/ information takes place both in upward, if any and downward levels.

It is important to ensure that while linking the water quality data, generated either in lower and higher levels, the appropriate mitigatory action both in terms of emergency and follow up basis, are taken and conveyed to the appropriate levels. In order to do this linking job, tailor made softwares are required to be developed or for readymade computational backup the professional agency needs to be resorted to.

The development of softwares should commensurate with the requirement of the linkage taking into consideration all the related aspects of WQS in that area. Apart from water quality related data, other relevant features such as GIS, organisational structure, intersectoral coordination, financing, socio-economical impacts, peoples participations are to be incorporated into the softwares developed for this purpose so as to make it informative and beneficial for the future uses by the department.

8.7. Data Access

Regarding the accessibility of data, the use of internet and other data storage and propagation systems should be exploited. Water quality data in the yesteryears should be stored wherever its significance is felt in the present context of WQS plan. The data relating to the common water quality parameters are require to be stored with adequate backup for, say last 10 years or so, while for uncommon but significant parameters such as arsenic, fluoride, mercury, etc. the storage of data may be practised for a few decades according to the significance of the parameters.

The data ought to be made accessible to all concerned in monitoring cum surveillance team to update them regarding the current WQS status including the mitigatory actions or strategies undertaken at different levels of the surveillance agency. This will ensure a consistent and successful WQS programme.

8.8. Development of Software for Water Quality Surveillance

In the above backdrop of the nationwide water quality surveillance, need, the data generation, data compilation and interpretation, communication of results and mitigation of water quality related problems are important components in a successful community based water quality surveillance programme. The linkage of the above components warrants the use of a suitable and powerful software.

As regards the generation of database relating to water quality surveillance, a reporting format is presented below which includes socio-economic information water quality status, water related diseases/ailment data, awareness related to water quality and health.

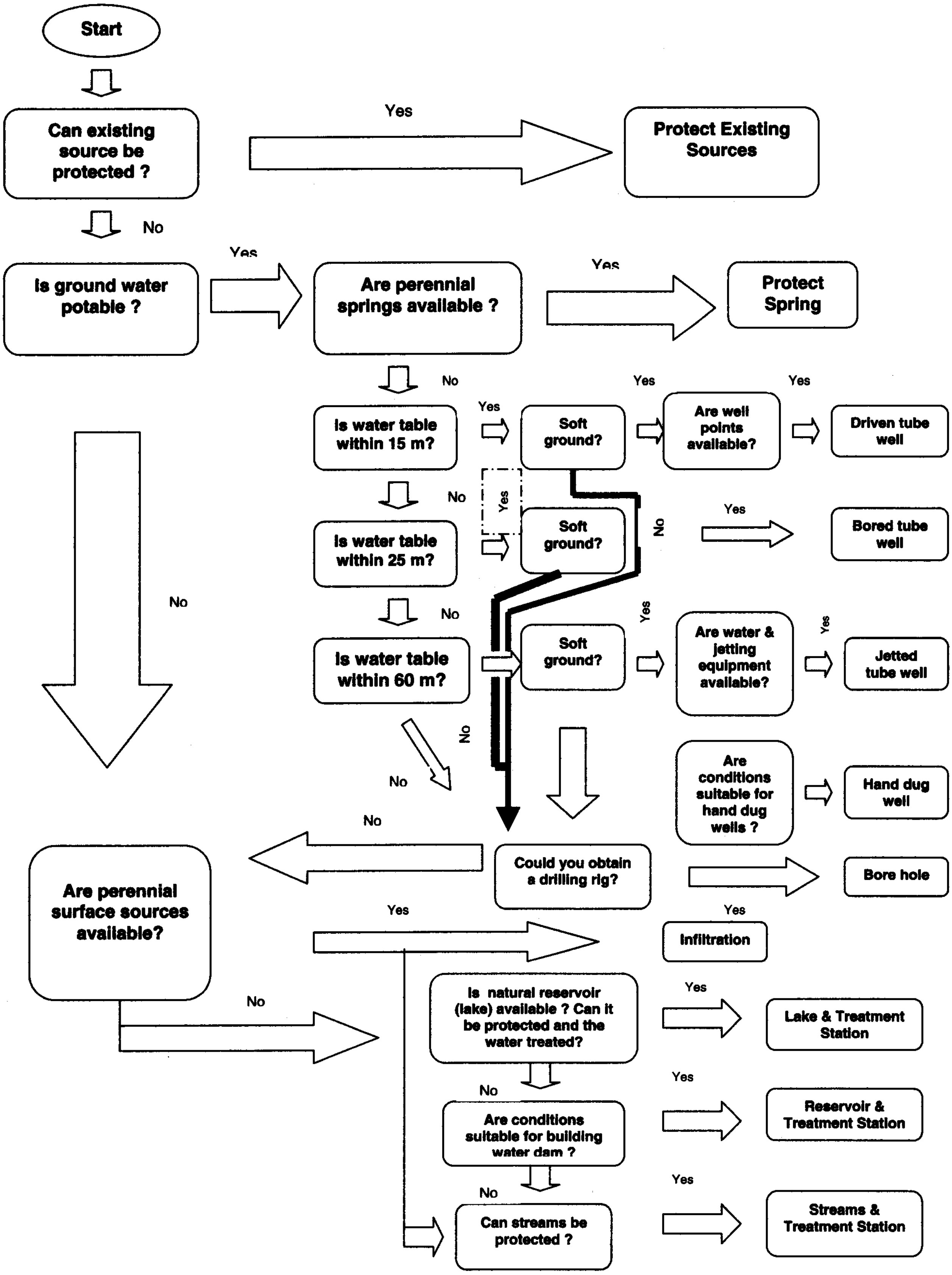
Figure 8.4 provides an approach to the water source selection while figure 8.5 depicts the selection criteria for water treatment.

The above formats relating to water quality surveillance will essentially form the basis for developing a suitable user-friendly software which will help the nation build up a sustainable and effective water quality surveillance programme for urban and rural communities as well.

For developing the above stated softwares using GIS or such other powerful tools, the agencies like PCI software, etc. may be resorted to.

A sample software tailored for creating a database including strategy is presented below and the similar approach may be followed for community based national water quality surveillance strategy.

Figure 8.4 : **The Source Selection Approach**



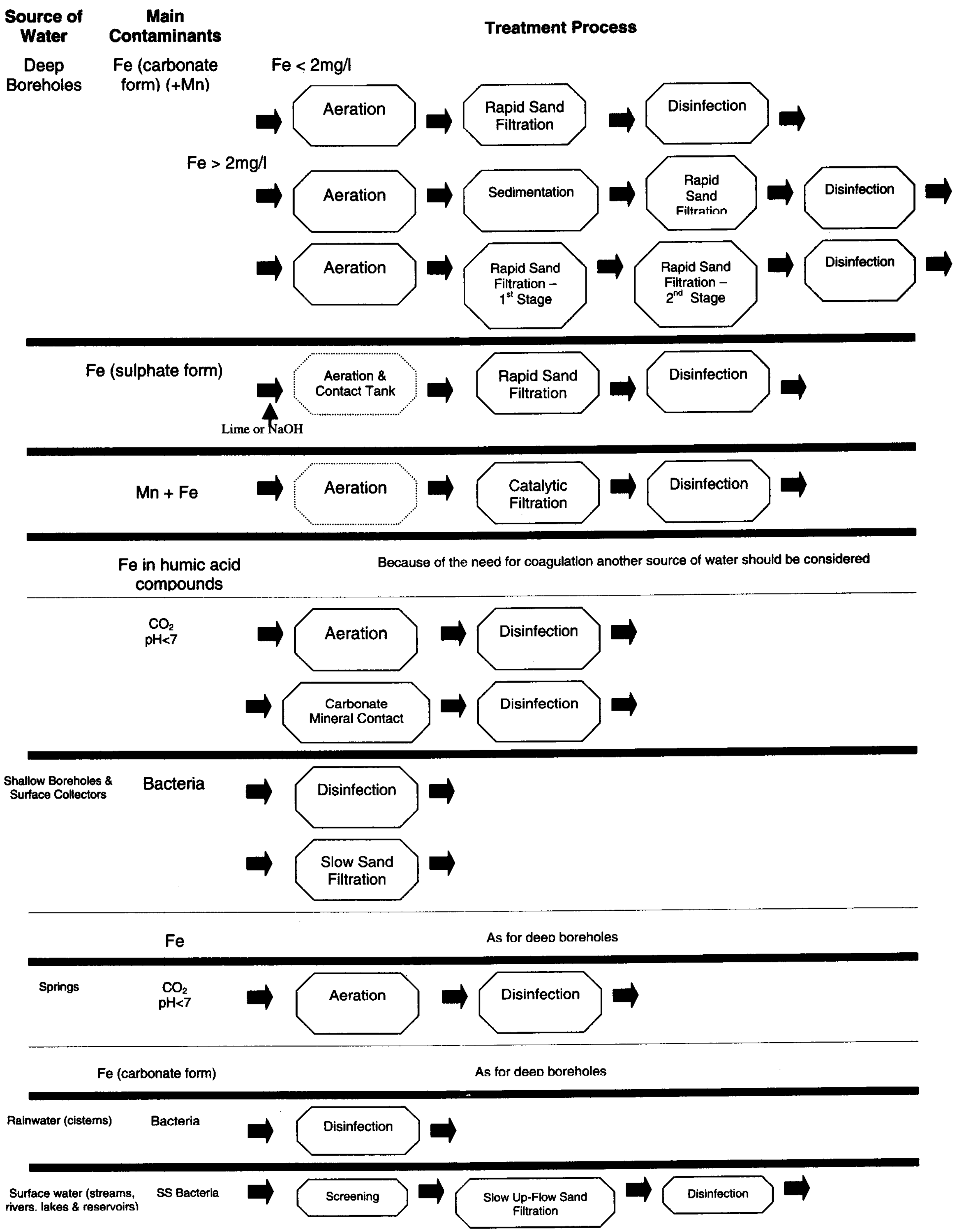
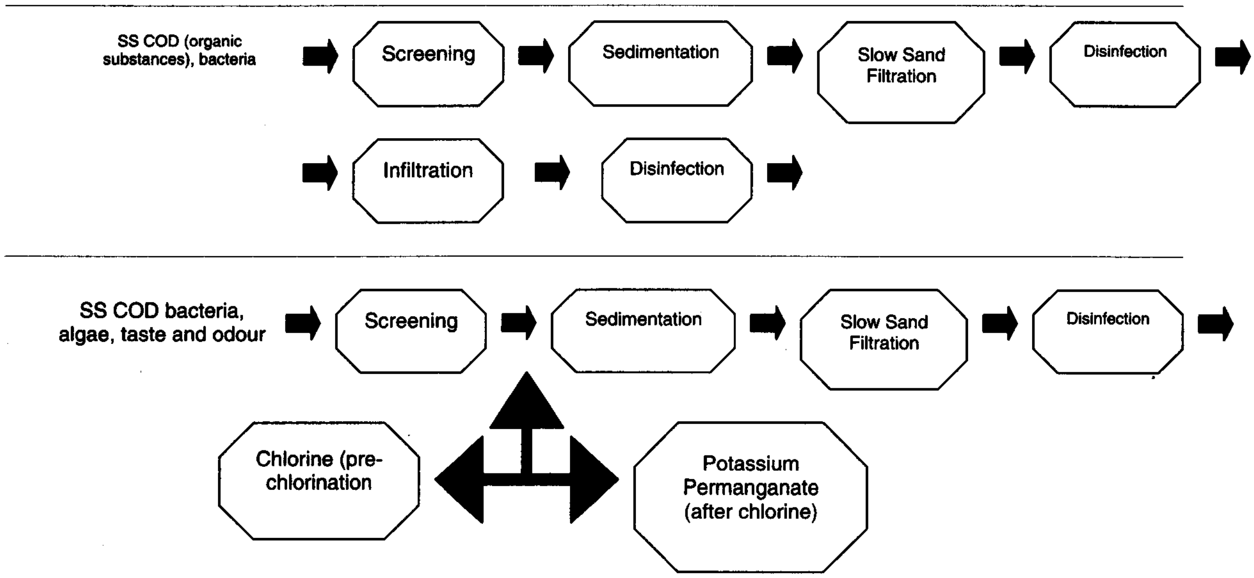


Figure 8.5: **The Treatment Choice Approach**

Contd..........



Note : The octagons drawn with broken lines indicate that the process is applicable under some circumstances but may be omitted under others.

COMMUNITY BASED WATER QUALITY SURVEILLANCE PROJECT REPORTING FORMAT

REPORTING ORGANISATION :
ADDRESS :

A. VILLAGE PROFILE

A.1. SOCIO-ECONOMIC INFORMATION

DISTRICT : **BLOCK/PS :**
G.P. : **MOUZA :**
VILLAGE NAME : **J.L.NO. :**

Distance from Major Towns/City/Rail/Road : Km

I. POPULATION DATA:

Male Child	Male Adult	Male Old	Male Total	Female Child	Female Adult	Female Old	Female Total	Population Total

II: COMMUNITIES

Hindu	Muslim	Christian	Sikh	Buddhist	Others	Total

III: FAMILIES

BPL	SC	ST	Farmers	Artisans	Other Employed	Total

IV. WATER RESOURCES:

TUBE-WELL	Total =	PONDS	Total =	DUG-WELL	Total=
Community	Private	Big> 1 acre	Small< 1 acre	Big dia>6 ft	Small dia<6 ft

Canal Length	Canal Av. Depth	Canal Av. Width	River Length	River Av. Depth	River Av. Width

V. WATER QUALITY RELATED DATA:

Water quality parameter concerened	Affected Family No.	Affected Persons No.	Male	Female	Child	Total	Persons Died	Tube well Tested No.	Contaminated. Tube well No.	House hold treat	Community treatment Plant/ Facilities	Remarks

VI. TYPE OF MEDICARE : TRADITIONAL/MODERN

Allopath	Ayurved	Homeopath	RMP	Ojha	Hospital (Km)	PHC (Km)	SHC (Km)

VII. INCOME STRUCTURE:

Income Total	Income per capita	Families above per capita Income	Families below per Capita Income

A.2. QUALITY OF WATER

DISTRICT :

G.P. :

VILLAGE NAME :

BLOCK/PS :

MOUZA :

J.L.NO. :

Sl. No	T. wl. No.	Deepth (m)	Deep ft	Plot No.	Plot Owner's name who is closest to (Govt/community TW)	Tested date	Value+ Ppb /ppm	Status *	Collection Time**	Data tested by	Remarks

*Pre-monsoon (PM)/Post-monsoon (POM)/Monsoon (M) **Pre-drawl (PD)/Post-Drawl (POD)/ During Day (DD)

+ for major ground water quality parameters

A.3. WATER RELATED DISEASE /AILMENT DETAILS

b) Surface water same s A.2

DISTRICT :

G.P. :

VILLAGE NAME :

BLOCK/PS :

MOUZA :

J.L.NO. :

Sl. No.	Name	Sex	Age	Year of detection	Current Condition*	Any other person in family Y/N	Water quality parameter affecting the person	Remarks

*Primary (P)/Mid-stage(M)/Advanced (A)

COMMUNITY BASED WATER QUALITY SURVEILLANCE PROJECT
PROJECT REPORTING FORMAT

Reporting Period (From_______________to_______________)

REPORTING ORGANISATION :
ADDRESS :

B. WATER AWARENESS RELATED ACTIVITIES

I. Number of Group formation Meeting/s held :

Place : Date : Participants : Place : Date : Participants :

Place : Date : Participants : Place : Date : Participants :

II. Number of Village Interaction Meeting/s held :

Place : Date : Participants : Place : Date : Participants :
Panchayat Person : Panchayat Person :

Place : Date : Participants : Place : Date : Participants :
Panchayat Person : Panchayat Person :

III. Number of Village Awareness Meetings/Camp held :

Place : Date : Participants : Male : Female :

Name of Resource Persons :
1.
2.
3.
Name of Panchayat Person present :

Place : Date : Participants : Male : Female :

Name of Resource Persons :
1.
2.
3.
Name of Panchayat Person present :

IV. Number of Health Camp held

Place : Date : Participants : Doctors : Paramedics: Patients:

V. No. of Tube-wells Tested : a) Fit for drinking b) Unsafe for drinking
VI. Intervention Activities : a) No. of Removal facilities: Model :
VII. Other Activities (Training Workshop/Exposure Visit, etc., Please write, if any) :

CHAPTER – 9

PLANNING MANAGEMENT & INSTITUTIONAL ASPECTS

9.1. Organisational Framework

Water quality surveillance requires strong and effective organisational framework for carrying out duties and responsibilities for assessing the safety and accessibility of water supplied to the people. The Surveillance agency may be separate from the water supply agency; alternatively there may be two separate wings of the rural water supply department. Water supply agency or wing is responsible for safe water supply to the consumers, while Surveillance agency or wing ensures water supply free from health hazards. However, their activities are essentially complementary.

In rural water supply the water quality monitoring and surveillance programme need institutional development and capacity building. There could be at least five options for setting up of institutional framework as mentioned hereunder.

Some important aspects of surveillance programme are as follows :

(a) To ensure services to protect the consumers from water-borne diseases and water supply related other hazards.

(b) It may be integrated with environmental sanitation programme.

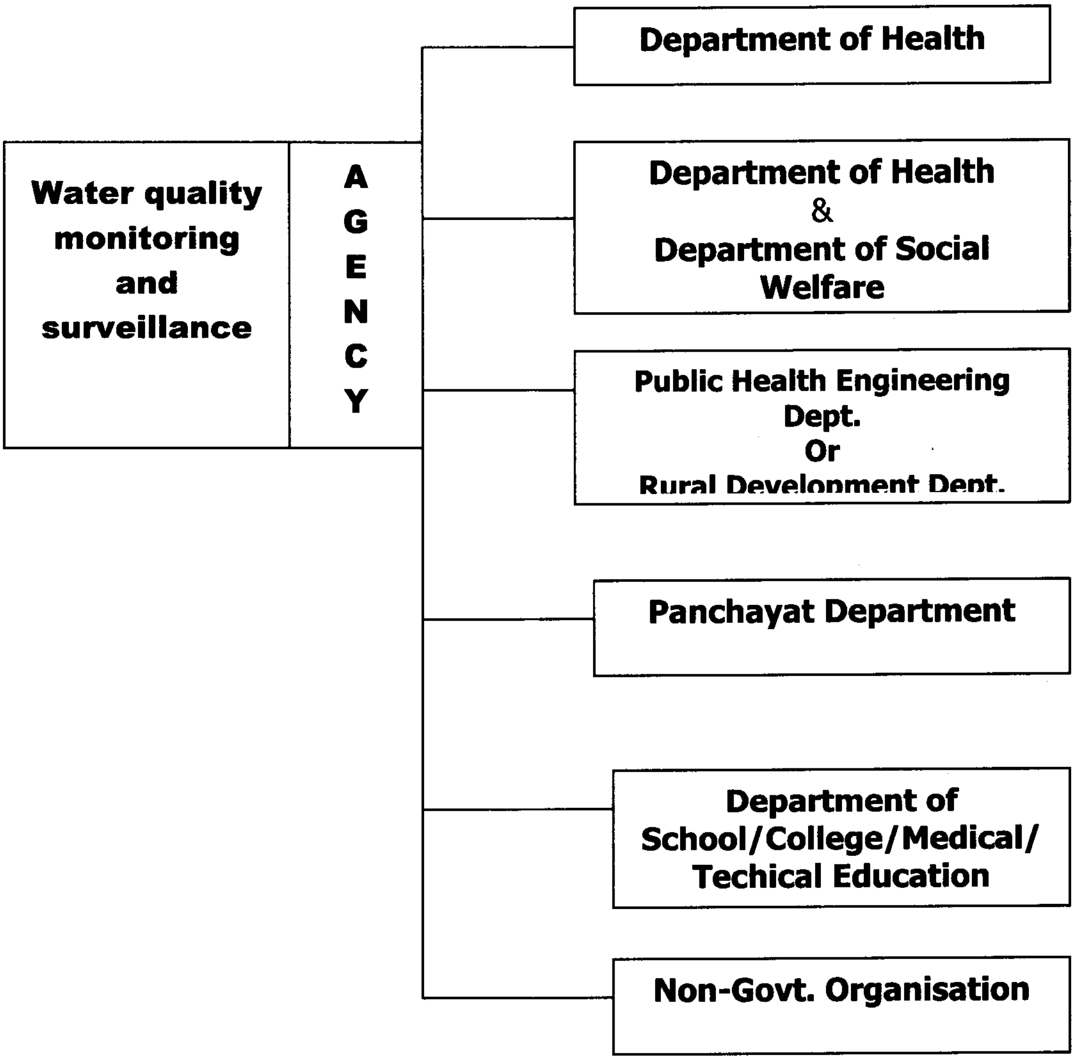
(c) Personnel involved in surveillance programme should be trained so as to impart knowledge on various issues of environmental sanitation and community health.

(d) Adequate infrastructure must be available for cross checking of water quality and extending support to quality monitoring at grass root level.

(e) Sustainability of the programme through community participation.

(f) Establishing cascading communication system and information management and recording.

Water quality monitoring and surveillance are to be carried out by the trained grass root level workers. User-friendly water quality testing field kits can be used for both bacteriological and chemical analysis of drinking water samples. Sanitary surveying for prevailing water supply system is to be done for assessing risk of contamination. Continuous


Water quality monitoring and surveillance
AGENCY
Department of Health
Department of Health & Department of Social Welfare
Public Health Engineering Dept. Or Rural Development Dept.
Panchayat Department
Department of School/College/Medical/ Techical Education
Non-Govt. Organisation

watch on safety of water supplies should be kept so as to maintain supply of safe water. Routine re-checking of water quality need to be done at District-level laboratory. Such laboratory must be equipped with analysis of all relevant parameters of drinking water.

At the initial stage, it is advisable to start with a fairly basic surveillance programme and then to improve programme in steps. The level of surveillance, therefore, may be basic and advanced with activities mentioned below (Table 9.1).

Table – 9.1. : Activities for basic and advanced levels of surveillance

Item	Activities for Surveillance	
	Basic	Advanced
Drinking water standards	Routine physical and chemical parameters and bacteriological parameters	Numerous parameters as per BIS
Technical Assistance	Limited	Broad based
Sanitary Survey	Spot sources and some pipe water supply	All water supplies
Source selection	Some spot sources	All spot sources and piped water supplies
Sampling and monitoring	Spot and piped water supplies with less frequency	All spot and piped water supplies with more frequency
Water analysis	Bacterial, residual chlorine and routine chemical analysis	Majority of parameters analysis as per BIS
Laboratories	Field kit and a few district level laboratories	Field kit, Block level and District level laboratorieswith support from state level reference laboratory
Laboratory support survices	Field kit and refill (reagents) must be available. Selected district level laboratories to be adequately equipped	Fully equipped laboratory available at District level and State level
Training of Personnel	Three tier training for water quality monitoring using field kit, sanitary survey, remedial measures,	Orientation training for senior-mid and junior level personnel operation and maintenance
Remedial measures	As required, field specific	As required
Awareness, motivation and and consumer training	Habitation wise imparting knowledge attitude and practice	Using media, involving school, panchayat, NGO, Mahila Mondal
Regulations and policies enforcement	Basic	Complete

9.2. Assessment of existing situation

Rural water supply system vary greatly in size as well as in modalities of supply. Where safe underground aquifers are available, community water supply through spot sources (hand-pump) are maintained. If settlements in habitations are dense, ground water supply through piped network system are adhered to. In rural water supply through community water supply systems are major, yet house connections are also provided if economically feasible. Surface water supplies using different treatment options are also maintained in many places where mostly stand posts are available for the consumers. There are even instances where surface water supply systems provide house-connections. Control, operation and maintenance of water systems varies from place to place. The rural water supply systems, in general, need to be safeguarded which can only be achieved through proper surveillance.

An inventory for all types of water supply system should be prepared for each habitation / village where details regarding status, condition, risk, sustainability etc. must be incorporated. Such inventory must also indicate the source, treatment system if any, past history regarding epidemic, people's perception in water supply and quality. All such information will help in framing surveillance programme in each of the habitation / village.

A suggested form for such inventory of water supply system is furnished below:

Suggested form for inventory of water supply system

Date of Inspection :

Habitation Village :

Code No. Block: District:

Name of Water Supply:

Maintained by :

Source of water :	Ground water	☐
	Surface water	☐
	Rain water	☐
Type of supply :	Non-piped water supply	☐
	Piped water supply	☐
	Stand post or public hydrants	☐
	House connection	☐
	Hand pump	☐
	Dug well	☐

Number of persons served :

- By Stand post or public hydrants
- By House connection
- By Hand pump
- By Dug well

Quality of water supply (per capita per day) ____________

Water collection (C) and treatment (T)

Dug well	☐
Spring	☐
Drilled well	☐
Infiltration Gallery	☐
Surface water intake	☐
Rain water collection system	☐
Slow sand filtration	☐
Coagulation and rapid sand filtration	☐
Aeration	☐
Iron removal	☐
Fluoride removal	☐
Arsenic removal	☐

Piped water supply:

Gravity feed ☐ Pumped supply ☐

Period of supply ______________________

Disinfections

- ◆ Disinfective practised for piped supply Yes No

If yes, is the system functioning continuously ?

- ◆ Disinfection of handpumps done regularly ? Yes No

If yes, Pre-monsoon Post-monsoon

- ◆ Disinfection of dugwells done regularly ?
- ◆ Frequency of dugwells disinfection ? __________________
- ◆ Number of house connections __________________
- ◆ Number of stand post or public hydrant __________________
- ◆ Number of hand pump __________________
- ◆ Number of dug well __________________
- ◆ Number of house supplied with rainwater __________________

Whether water sanitation committee is existing Yes No

No. of epidemic relating to water borne diseases during last 5 years.

Water supply problem, if any ——————————

Water quality problem, if any ——————————

General morbidity pattern relating to water borne diseases ——————————

Name of Enumerator ——————————

Signature of Enumerator ——————————

9.3. Water Supply Management vis-a-vis Surveillance Programme

The Department of Public Health, Public Health Engineering / Water Supply Boards and Environment Pollution Control / Protection will all be involved in water supply management, but their functions and responsibilities need to be delineated clearly according to its administrative structure. A broad outline is indicated below : -

Table – 9.2

Agency	**Function**	**Responsibility**
Surveillance		
Ministry of Health / State Health Department	Surveillance of drinking water quality	Ensure that all drinking water quality in the country is free from health hazards and to find out what is wrong and assist in setting matters right for both urban and rural systems
State PHE Department/ Jal Boards	Monitoring of quality of drinking water supplied	
Water Supply Agency		
State PHED / Water Boards	Supply of potable water	Provide water of sufficient quantity and quality to the rural population
Pollution Control Board	Controlling of pollution at source	Protect the raw water sources from being unduly polluted for the entire state / country.

9.4. Water Quality Control Responsibilities

Major activities to be carried out by different agencies associated with water supply and management and health protection and promotion vary, but broadly they are : -

Department of Drinking Water Supply

a) Administer and coordinate the drinking water quality control programme. This includes providing consultancy and technical assistance to the states in formulating and implementing their monitoring programmes and sanitary survey programmes.

b) Recommend and review guidelines, standards, manuals, etc. for programme implementation.

c) Process, analyse and evaluate all data pertaining to drinking water quality and to make these available for decision makers.

d) Identify technical and methodological gaps, training needs and other problems associated with the implementation of the programme and provide or recommend solution.

e) Promote health education and self inspection (especially for process quality surveillance and analytical quality control).

f) Promote and coordinate research activities,

g) 'Approve' new sources for potable supply and water treatment methods, and

h) Develop/ maintain MIS on WQM

State Public Health Engineering Departments / Rural Development Departments

a) Administer and coordinate the drinking water quality control activities.

b) Supervise and assist the district in the formulation and implementation of the district drinking water quality control programmes and sanitary survey programmes.

c) Compile all data pertaining to drinking water quality from the districts and forward them to the state / national surveillance agency for processing

d) Coordinate in investigation and research activities.

Department of Health

- Surveillance of privately owned public water supply systems, if prevalent and

Role of Panchayati Raj Organisations

In India, Panchayati Raj system plays an important role in rural development. In the process of decentralization of activities, Panchayat's responsibility have increased enormously. Water quality surveillance programme could be undertaken by Panchayats and the Panchayat personnel are already involved in health promotion activities and with additional support by way of trained personnel, equipment, glassware and media, the task of surveillance could be undertaken more effectively.

Zilla (District) Parishad

a) Formulate and implement the district water quality monitoring programmes and sanitary survey programmes together with the divisional / district Public Health Engineering Department

b) Collect water samples and make sanitary survey as scheduled in the programmes and submit monthly summary reports of such activities to the State Public Health Department for processing

c) Liaise with the DPHE to investigate water quality problems and, where appropriate, assist in remedial actions and report the incidence to the State Health Department

d) Coordinate water quality monitoring activities of Panchayats, Primary Health Centre to collect and collate data from rural water supply systems.

e) Assist in carrying out investigation such as public complaints or on the basis of reports from Panchayats.

Panchayat

a) Collect and analyse water samples periodically, from all the water supply systems, wells, public stand posts, etc. periodically.

b) Send reports on water quality to Zilla Parishad / district laboratories periodically.

c) Check residual chlorine levels and alert water supply agency, if deficiency is noticed (in case of piped water supply).

In case water analysis facilities are not available, a section along with a trained Laboratory Analyst / Technician and a field kit for chemical and bacteriological; analysis need to be provided.

a) Liaise with community volunteers to sensitise community on water quality monitoring and surveillance through health education programmes.

b) Use mass / visual media in villages to promote the concept of safety of drinking water systems.

State Water Supply Board / Public Health Engineering Department

a) Examine and analyse the results of laboratory tests on water samples for process control purposes.

b) Identify and appraise new projects

c) Implement new projects, and

d) Assist in organization and management of the water supply systems in the state.

e) Examine whether water supply facilities are adequate in service, supply safe water and are financially sound.

Role of PHCs / RHCs in Organization of Water Supply Surveillance

In view of the fact that most of the states in the country a network of Rural / Primary Health Centre, established (or proposed) to cover a group of villages, to which various health promotion activities are entrusted, it is logical that water quality surveillance programme is also added to its activity. PHC / RHC already plays a pivotal role in immunization, family planning, nutrition and other activities through health education and community participation. When epidemics, floods or other calamities take place, it is the personnel working in PHC /

RHC who get the first information and are entrusted with field action, to remedy the situation. Water-borne epidemics take place through contaminated water sources whether traditional or protected piped systems. In such cases, PHC / RHC personnel could monitor water sources and take primary remedial measures in collaboration with PHED / Zilla Parishad / Panchayat.

9.5. Inter – Sectoral Coordination

The fact that a number of government agencies are involved in carrying out the drinking water quality surveillance programme ; regular cooperation and liaison among theses agencies is a must. To avoid overlapping or duplication of activities and programmes, each agency must confine its activities within the specific function and responsibilities assigned to it. It is most desirable that there should be purposeful intra agency surveillance (vertically) and appropriate inter agency interaction (horizontally) at the respective levels to guarantee unhindered implementation of the programme.

Table 9.3 Inter and Intra-Agency Orgnisation Chart (Drinking Water Quality Surveillance Programme)

	Ministry of Health / Ministry of Rural Development	PHED	Agency	Department of Drinking Water Supply
National	Ministry of Health & Family Welfare / Ministry of Rural Development, Department of DWS	-	National Referral Institute (NICD)	National Policy making & provide technical assistance at national level
State	DPH	PHED	State level Referral Institute (SRI)	State level committee (SWSM) coordination supervisory assistance in implementation at State level
District	DHD	PHED	District Laboratory	Implementation at District level (DWSM)

9.6. Community Based Approach

Various institutions mentioned in the preceding discussions would help the water quality surveillance activities at the National, State and District level. However, at the grass root level, the monitoring of the public / private water sources at the village level and catering to the immediate and localised remedial needs, could be effectively undertaken only by empowering the community and building capacity at the grass root level through training and awareness campaign. An appropriate and effective MIS and Intervention Network, involving Panchayati Raj Organisations at the Block / District level and Govt. organisations (Health / PHED / Rural Development) at the District / State level would ensure a vigrilant WQS, throughout the country. This community based approach has been described in details in the next chapter.

9.7. Support Structure

Surveillance programme requires laboratory network, offices, transport, financial support, manpower etc.

At grass root level (village / habitation level) water quality testing field kits can be used. District level laboratories should be equipped with all instruments to carry out analysis as prescribed in BIS. There should be state level laboratory with sophisticated instruments for analysing specific parameters causing concern to different water supplies. Any doubtful analysis at grass root level need to be checked by the district laboratories.

Samples are to be analysed at the field, as far as practicable. However, some water samples need to be brought regularly to the district laboratories. Transport must be available to bring samples at the earliest to the laboratories.

Substantial financial support is necessary for initiating the surveillance programme. Contribution from the community for the water quality monitoring and surveillance will ensure sustainability of the programme.

Manpower is necessary for carrying out surveillance programme. A group of existing staff members may be inducted for water quality monitoring and surveillance. The grass root level workers will be the working partners of the programme. Laboratory staff needs to be recruited for district level and state level laboratories. Greater community involvement will lead to more efficient and effective surveillance (Please see Chapter – 10).

CHAPTER - 10

COMMUNITY BASED WATER QUALITY SURVEILLANCE — PARTNERSHIP BUILDING AND NETWORKING

10.1. Introduction

As stated earlier the problems of undertaking WQS in rural India can be summarised as follows :

- Resource constraint, both in terms of manpower and infrastructure, is a major obstacle.
- There has traditionally been an urban emphasis in the developments in the WSS sector.
- The district level water testing laboratories are in no position to take the task of routinely monitoring the rural water sources. They can at the most play useful roles in crisis situations like water borne epidemics.
- No system of WQS exists at the village level.
- Water supply is a political issue and people even in remotest rural areas perceive it as a demand. Water quality monitoring, however, as yet is not the felt need of the people.

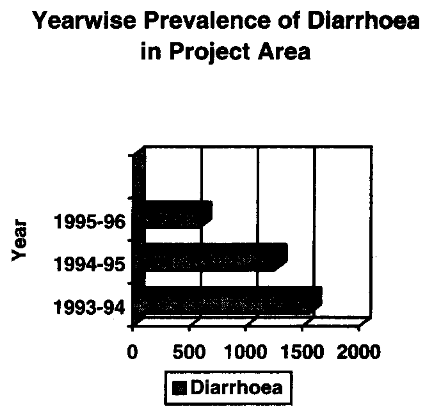
In the present socio-economic status of the country, such obstacles seem unsurmountable, unless we take a radically different approach to solve the problem. In a country like ours, the only viable option today is developing a process of community based water quality surveillance, through which people can develop the necessary knowledge and skill to monitor the potability of water they use, undertake corrective measures and sustain the same on their own.

10.2. A Sustainable and Community Based Approach for Water Quality Surveillance Programme

During the year 1993-97, All India Institute of Hygiene and Public Health, Calcutta in collaboration with UNICEF launched a R&D Project to develop a participatory model of community based water quality surveillance system in the district of Medinipur, West Bengal.

Major findings and achievements of the pilot study are —

- *Grass-root workers even in remote rural areas can be trained to use the field kit proficiently.*
- *Under proper guidance they could also undertake remedial actions, particularly disinfection of water sources.*
- *Simultaneously with the training and awareness programme, an effective communication cum intervention network could be built up.*
- *The programme has a positive impact on the community creating the much desired awareness about safe water and the importance of water quality testing.*



- *The programme, though implemented in only 20 ICDS Blocks has amply demonstrated its replicability and emerged as one of the viable alternatives for providing safe water to the community and improving public health.*
- *In a participatory programme if community could comprehend the necessity and goal, the programme would be sustainable both socially and economically.*

The pilot study helped make the following observations :

(i) With proper user-friendly water testing field kits community grass root members could easily assess the water quality with respect to potability of water.

(ii) If community could comprehend the relation between water quality and health, the programme would be sustainable both socially and economically.

Following are the key components of community based water quality surveillance programme in our country.

- Formation and composition of community based organization.
- Development of water testing field kits
- Participatory planning process and Institutional linkage.
- Legislative frame work
- Financial sustainability through community participation
- Transparency of planning, management & financial activities
- Water and sanitation linkages
- Training and awareness generation.

10.2.1. Formation and Composition of Community Based Organisation (Village Water and Sanitation Committee)

The organization must be representative of the various segment of the community. Each significant group should be represented but more importantly women should be adequately represented.

Apart from the above, other users' community can also be included in formation of the committee. The members if required can be coopted in the VWSC.

10.2.2. Water Testing Field Kit

To carry out a successful community based water quality surveillance programme a user-friendly water testing field kit is a necessity. The water testing kit : -

- should be cheap
- should be user-friendly
- should be dependable
- could be manufactured locally.

Before finalising the water testing field kit the evaluation of the same would also have to be done through the community workers.

The following parameters are essentially to be tested in the field kits —

i. Turbidity

ii. pH

iii. Hardness

iv. Chloride

v. Iron

vi. Nitrate

vii. Fluoride

viii. Residual Chlorine

ix. Arsenic

x. Bacteriological quality

The field kit will be basically meant for qualitative assessment of the water. For bacteriological analysis in many parts of India an incubator is required. Most of the incubators are operated electrically. As many of the villages are not having electricity, a kerosene operated incubator could also be used as an alternative to the electrically operated ones. It must be kept in mind that water testing field kit is not an alternative to the laboratory facilities. It can only help to identify unsafe water supply system immediately and consumer can have a general idea about the water which they are using. Water quality monitoring at the grass-root level with field kits, should be followed up by sanitary inspection or the other way round, so as to have adequate knowledge about the contamination of water sources. This may help to generate awareness among the user community on water quality aspects and need for protection of the water source. The field kit will also help to screening water samples to be sent to laboratories. A number of designs of field kits are presently available.

10.2.3. Participatory Planning Process

Participation should mean that communities have a role in choosing the methodology, appropriate to them, in developing that technology and controlling its management. In the past, when communities have been indifferent to official programmes, the assumption has often been that programme benefits need to be more intensely directed at the 'target' population in order to convince them that this is what they should want. The last decade has revealed that in most cases the programme design and methodologies were absolutely inappropriate to community needs and aspiration. Community participation can therefore no longer be interpreted as a community acceptance of a given technology or service, pre-conceived and pre-designed at a higher level of decision making.

It has been found in pilot study on water quality surveillance conducted by AIIH&PH that when Anganwadi Workers (AWW's) were asked to select an appropriate water testing kit, from amongst the then available kits, none of the kits was fully accepted by them. They had identified their deficiencies as well as probable corrective measures in an absolutely participatory manner. They were helped in their exercise by the Resource Personnel. On the other hand, if the AWWs were asked to perform the water quality monitoring by any pre-selected water testing kit that could have been a major cause of the failure of the project. AIIH&PH kit was actually developed with the help of their participatory evaluation and the kit has been accepted as very much user-friendly in various parts of rural India.

10.2.3.1. Institutional Linkage : Establishing Partnership and Networking

The importance of such community participation does not reduce the critical role of implementers in water supply programmes because placement of alternatives before the community is still very much in the hands of the professionals. While community and voluntary effort can help extend the range of the motivators influence, the role of professional is crucial. The emphasis must therefore be on establishing network which bring professionals and communities into closer dialogue and partnership, helping government to move from being providers of services to becoming promoters, facilitators and partners of a programme for the communities who should act as clients not merely beneficiaries or users.

If one carefully analyses the institutional role of water quality surveillance activities in rural areas it could be observed that Panchayat Raj Institutions (PRIs) or Public Health Engineering Departments (or equivalent) do not have the necessary infrastructure or personnel to develop even a rudimentary system of water quality monitoring at the village level. As such the most viable alternative would be to establish community based organisation at the grass-root level and then establish Institutional Linkage and Networking bottom to up by building partnership between community and government viz. Catchment Area Approach (CAA).

In Indian situation there may be many networks who can perform the community based water quality surveillance effectively. It is desirable to have three tier arrangement for managing the system adopting CAA different options for network have been shown. From the Table – 10.1 it can be obtained that all the networks are based on three tier arrangement.The intervention network of any quality problem would be developed as shown in **Figure 10.1.**

The data generated from the field kit analysis and sanitary survey would be communicated upto the national level at least once in a year through a network system as shown in **Figure 8.2.**

Table – 10.1 : Water Quality Surveillance Network

Strata	Network I	Network II	Network III	Network IV
Grass Root Level	Mechanic / Panchayat Members	Health Workers / Auxiliary Nurse / Mid- Wife	Anganwadi Workers	Members of Local Youth Clubs / Mahila Mandal
District Level	Exe. / Asstt Engg. (PHED / RDD) / Zila Parishad	DMO	DPO / ICDS	NGO Personnel
State Level	Chief. Engineer / Chief Chemist / PHED	CMO	Director ICDS	NGO personnel

10.2.4. Legislative Frame Work

A community based organisation of any kind, set up to manage infrastructure facilities, should be recognised by the various level of governments as legitimately representing the consensus of the community. This may sometime encourage powerful person or community to rule over the weaker section but it can be checked effectively by the combined force of the community. But without the ability to enforce the rule community organisation may prove paper-tigers. It should act as an extension of district / village administrations. The administrations would act as a supportive agency in ensuring that organisation perform adequately. In the case of non-performance by an organisation, the activities has an obligation to intervene in the management of the scheme.

10.2.5. Financial Sustainability through Community Participation

Community based organisation assuming managerial responsibility for a water quality surveillance programme must approach the O&M of the facilities on a full cost recovery basis. The determination of revenue requirements must take into account both the direct and indirect operating cost, and the capital cost of asset (e.g. field kits) replacement over time. In India, most cases, full cost recovery will not be practical through direct service charge (tariff) and a certain amount subsidy will be required. However, it is important that the community based organisation identify all of the cost categories and develop a plan for ensuring that they are catered for adequately. For example the following is the budgetary estimate of the proposed model project (village level water quality surveillance of 25 sources/ 5000 population/year), taking into consideration the annuity of field kit, honorarium to grass-root workers (GRW) and minor remedial expenses.

Number of water samples that can be tested in each refilling	-	100
Test frequency	-	4 times a year (i.e. quarterly)

Therefore, 25 Nos. of sources can be monitored in a year with a single field kit or with a single refill of reagents.

Considering one source each for 200 population, approximately 5000 population (25 x 200) could be served by one field kit.

Again considering 1 GRW for 1000 population 5 number of GRWs need to be allotted for 5000 population.

An additional honorarium of Rs. 500/- would be given to each GRW per annum.

Capital Expenditure :		
Cost of one Field kit	-	Rs.7000/-

Annual Recurring Expenditure :

a. Addl. Honorarium to Grass-root Workers (GRW) (5 x Rs.500/-)	-	Rs.2500/-
b. Refilling Cost for Field Kit (Chemical & Bacteriological reagents)	-	Rs.1400/-
c. Cost of disinfectants, minor remedial expenses, mobility, etc.	-	Rs.1500/-
d. Annuity (10% of the capital)	-	Rs. 700/-
Total	-	Rs.6100/-

Estimated annual per capita contribution (Rs.6100 / 5000)	-	Rs.1.22
Estimated annual per family contribution (6 x Rs.1.22)	-	Rs.7.32
Estimated monthly per family contribution (Rs.7.32/12)	-	61 paise

10.2.6. Transparency of Planning, Management & Financial Activities

When a portion of the community hold responsibilities of finance handling other part of the community may complain of not getting any information on the finance management. The community organisation would be set up in such a way that the finance matter like purchase of refill, disinfectant, etc. should be transparent to every section of the community. A bank account or post office account should be opened and it must be audited periodically. In pilot study conducted by AIIH&PH monetary contributions from the community were encouraged and the people were motivated to contribute Re.1/- per family per month to create a revolving fund to be utilised towards the refilling cost of the reagents of the kit, bleaching powder for disinfection, etc. There were enthusiastic responses and most of the village level water committees opened savings accounts in the local post offices or rural banks.

10.2.7. Water and Sanitation Linkages

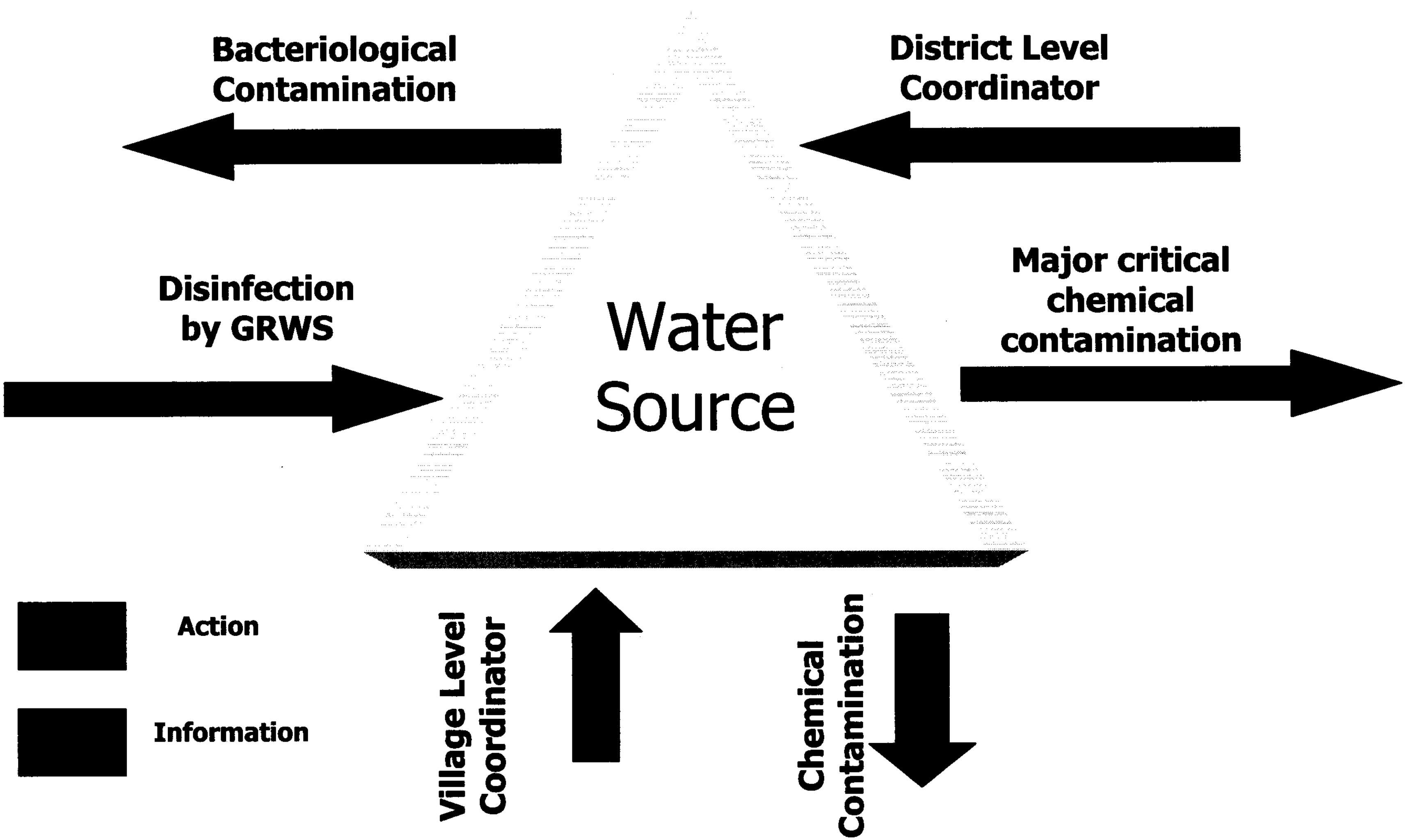
'Safe Water for All' cannot be achievable without providing sufficient attention towards sanitation coverage. Community, especially rural one, must be continuously motivated to use sanitary latrines for defecation. Presently for towns it is not a problem but for the rural areas in almost all the states of India it is still a major but under-recognised problem. An appropriate and situation specific community based hygiene education programme should be developed, as part of a community based water quality surveillance programme.

10.2.8. Training & Awareness Generation

Training is an integral part of the process of implementing a community managed water quality surveillance strategy. Training should be considered to be the final stage of planning and first stage of implementation. It must be a bad planning if implementation cannot quickly follow training because without rapid implementation the community surveillance worker soon require retraining. (Further discussed in details in Chapters – 11).

The principal elements of a community based water quality surveillance programme are summarized is the form of a flow chart as shown in Figure 10.2.

Fig. 10.1 : Intervention Network



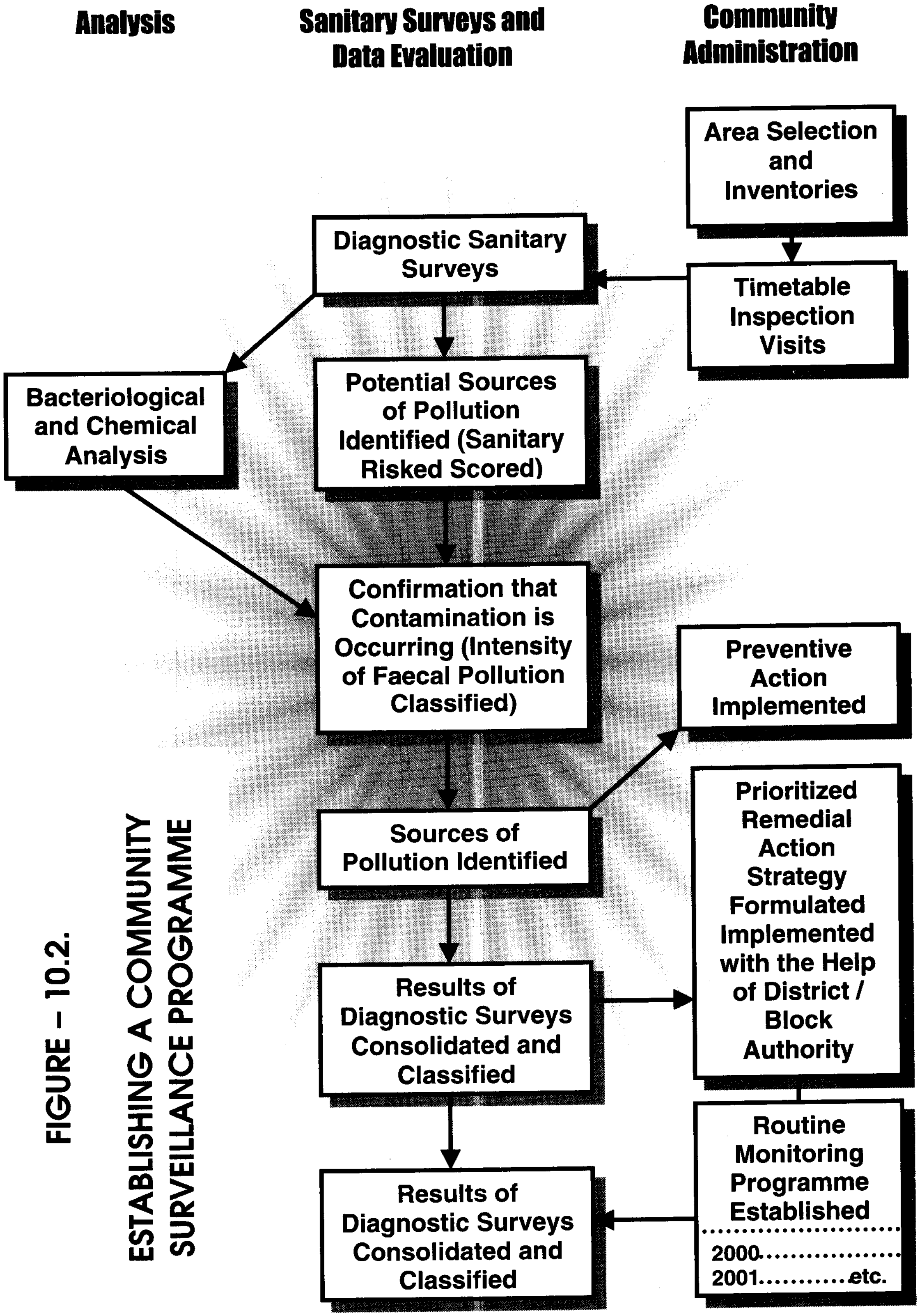


FIGURE – 10.2.

ESTABLISHING A COMMUNITY SURVEILLANCE PROGRAMME

COMMUNITY EDUCATION AND TRAINING

11.1. Introduction

Majority of the people's perception of good quality water is limited to aesthetic and organoleptic characteristics such as colour, odour, turbidity and taste as revealed in a number of studies conducted by different investigating agencies in different regions. Bacteriological and chemical criteria of water quality are yet to be determined and appreciated by all sections of the community. The policy makers, planners, and engineering professionals conceive and create protected water supply systems to ensure supply of safe water in adequate quantity on a continuing basis without taking cognizance of the conceptual gap between the people and the planners in their perception of wholesome water. This often results in under utilization or even non-utilization of the safe drinking water supply systems in some rural areas. Moreover, this apathy of the community towards safe water supply systems deprives the planners and executors of an effective back-up support from the community after the installation of a safe water source which is so essential for the success of the programme.

It is thus evident that in addition to installation of hardware, there is an urgent need for consumer information and education to generate awareness and consciousness in the community about the importance of water quality and its impact on public health. This would naturally ensure the cooperation and active participation of the community in maintaining the safe water supply system and take lead in demanding supply of safe drinking water. It would also develop positive attitude towards prevention of contamination and even eliminate vandalism or damage to vulnerable parts of the system. Community education and participation is thus a sine quq non for successful implementation of Water Quality Surveillance (WQS) programme.

Several options are available for organizing mass awareness campaign to create general awareness in the community about the importance of safe water, personal hygiene and sanitation in man's life and involve them in all activities of national water supply and sanitation programme. A broad guidelines for organizing such campaigns in rural areas is offered below.

11.2. Guideline For Organizing Mass Awareness Campaign

a) Components of the campaign

The campaign shall have two components : -

a) Camps (popular talks, demonstration, etc.)
b) Visits to villages

Camps

The general guideline for organizing a camp sa given below should be followed as far as practicable. The voluntary organizations and other organizers of camp may modify the guidelines to suit local conditions and other compulsions without deviating from the objective.

a) The camp shall be of 5 day duration.

b) The number of participants should be 30 to 40.

c) The participants should be from various walks of life, such as Mahila Samities, local youth clubs, social workers, panchayats, college and school teachers, primary health centres, ICDS workers, gramsevaks and gramsevikas, local PHED personnel, etc. In addition, there should be adequate representative from all sections of the society in a particular community or village, with particular emphasis on participation by women.

Methodology

The methodology to be adopted for propagating the message shall be through popular talks by resource personnel on different topics during the first 3 days and also include maximum use of posters, leaflets, models, charts, visual and audio-visual aids, such as slide and sound show, video films, etc.

On the 4th day the participants shall be divided into 4 or 5 groups and each group shall visit 4 to 5 villages to spread the message of the campaign and identification of local problems and needs in achieving the objective of the mission.

On the 5th day, the participants shall reassemble at the camp for evaluation and formulation of action plan.

b) Contents of the popular talks

Day 1

Popular talks in local language for 1 hours on following topics followed by discussions for half an hour.

a) "Aims and objectives of the National Drinking Water Mission".

b) "Water and Man's Life" - beneficial uses of water.

c) "Water and Man's Health".

Day 2

a) Drinking water quality standards.

b) Effect of different parameters of water on human health and domestic use.

c) Safe water and child's health.

Day 3

a) "Importance of personal hygiene and sanitation".

b) "Importance of operation and maintenance of water treatment plants, hand pumps, and dug wells by the community" - Dos and Don'ts.

c) "Ways in which the community can play an active role in monitoring and surveillance of water quality" - followed by demonstration of the working of field kit for water quality testing.

Day 4

Visit to villages by the participants in groups.

After attending the camp for 3 days, the participants would be asked to visit selected villages to carry out the following programmes : -

a) Person to person contact with community members to appreciate and identify specific problems.

b) Communication with small group of people in the village by using low cost flip charts, black boards and models, well prepared slide and sound shows to suit the specific audience.

c) Individual discussion with respected and influential community leaders as useful introduction to the community.

d) Distribute hand bills through educational institutions to generate awareness among younger generation.

Day 5

The participants reassemble at the camp and : -

a) Evaluation of the entire programme is done by the participants and organizers.

b) Identification of specific problems and the needs of the villages by the participants.

c) Draw up action plan.

11.3. Organizational Facilities

a) The camps shall be organized by the respective state governments or other autonomous or voluntary organization with government support.

b) All infrastructural facilities for conducting the camp shall be provided by the state governments.

c) All charts, models, video strips, posters, films shall be prepared and made available by the state government.

11.4. Training

The result of the surveillance programme is dependent on how efficiently sanitary inspections are carried out and documented properly, water samples analyzed and results interpreted, appropriate remedial and preventive measures undertaken promptly. The personnel involved for survey, data collection, sample analysis, etc. need to be trained. As number of villages and habitation are huge, therefore, cascading training strategy can be adopted whereby district level trainers, block level trainers would ultimately train the grass-root level workers. Besides, technical personnel of water supply agencies must be trained. The training strategy for surveillance is presented in **Figure 11.1**.

Fig. 11.1 **TRAINING STRATEGY FOR SURVEILLANCE**

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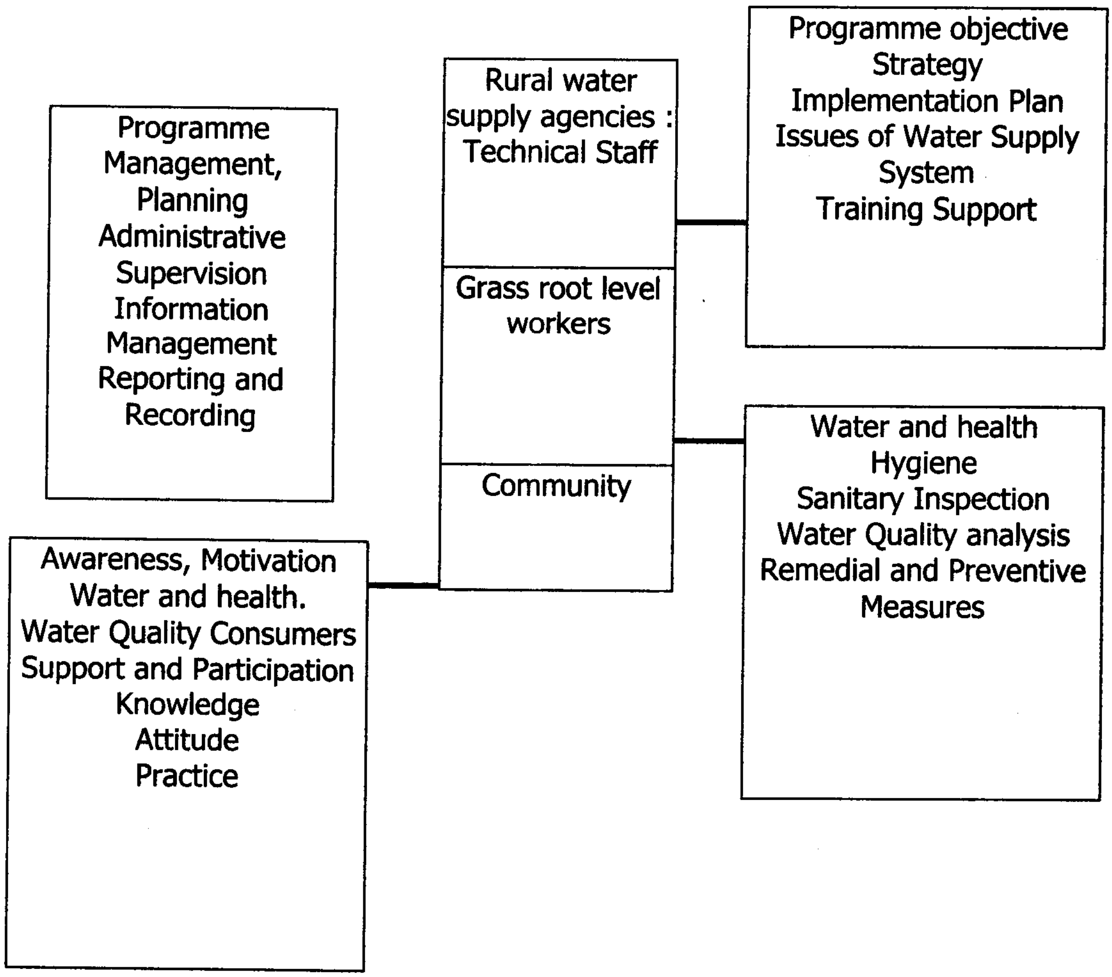


11.5 Framework of a National Human Resources Development Programme for Water Quality Surveillance

There are 516 districts in India. For this programme 3 to 4 key persons from each district would be identified and trained to become 'District Level Key Trainers (DLKT)' of the districts. The state and district administration would select the DLKTS, who may be college teachers, NGO personnel, Executive Engineers of Zilla Parishad, Medical Officers, District Planning Officers, etc. At least 5 persons from each blocks of the country would be trained. Block Level Key Trainers (BLKTs) would preferably be NGO personnel. District authorities in consultation with BDO or other responsible block level officers would select the BLKTs. BLKT in turn would train the village based grass-root workers. One person would be trained from each village. These persons may be Anganwadi workers, Auxiliary nurse midwife, health worker, Panchayat member, local club member, etc.

On a National level, a three-tier pyramidal level has been envisaged. At the top, there would be the district level key trainers. From each of 516 districts in India, 3 to 4 key persons would be identified and appropriately trained to conduct and supervise the training and surveillance activities in his/her district. They would in turn train block level trainers – at least 5 in each block. The block level trainers, in turn would disseminate the knowledge to the grass-root workers at the village level. The idea is to develop a grass-root worker in each village in India, who would, armed with a field kit, not only be in charge of water quality surveillance in rural areas, but would also act as a nucleus of change.

About 2000 DLKTs identified from all the districts of India would be trained by AIIH&PH. 2 days training course would be organized, each having 40-50 participants and the trainings would be organized in the respective states. Approximately, 50 training course would be required for the training of key trainers requiring duration of 5 months. BLKTs would be trained by DLKTs in the respective districts. About 55,000 BLKTs would be required to be trained for covering all the blocks of India. Considering 50 participants per course, there would be 11 hundred courses, which may be held simultaneously. All the identified BLKTs would be trained approximately within a period of 4 months.

The BLKTs in turn would simultaneously start training the grass-root workers, the total number of which would be 5,76,000 for all the Indian villages. Each training would be of 2 days duration. At least 40 training course would be conducted simultaneously, each course having 50 trainees. Thus a total of 11520 (5,76,000/50) training courses would be required to be conducted by the 55,000 BLKTs. Schematic representations of flowchart & the Training Schedule is given in the figures 11.2 & 11.3 respectively.

11.6 Total National Budget required for the Programme

The unit rates adopted for arriving the total financial requirement is based on the draft Implementation Manual, which was approved by the Expert Committee constituted by Govt. of India. It is now proposed to provide one field test kits to each revenue village in all the Gram Panchayats of the country.

The budget proposal comprises of :-

I. Non-recurring cost :

Sl. NO.	Item	Nos	Unit cost	Total amount (Rs. in lakhs)
1.	Procurement of water testing kits @ one kit per village.	5,76,000	Rs.7000/-	40320.00
2.	Training for key district level trainers including TA/DA for AIIH &PH personnel	50 courses	Rs.50,000/-	25.00
3.	District level laboratories	516 Nos.	Rs.3.00 lakhs	1548.00
4.	Block level key trainers.	1100 training courses	Rs.20.000/-	220.00
5.	Training of grass root level trainees for 5,76,000 villages.	11520 Grass root level trainees.	Rs.12,000/-	1382.40
			Sub-Total I	43495.40

Note :

1. The estimates are tentative and subject to actual requirement by States/UT's
2. 100 % Central Assistance is provided for procurement of field test kits, strengthenining of labs, IEC & HRD activities.
3. Item-3 above include provision for new district level laboratories also at a unit rate of Rs.4 lakh per lab (Rs.3 lakh for chemicals&equipment &Rs.1 lakh for lab building). However, proposals of funds required for strengthening of existing labs could be considered, only on the basis of guidelines to be issued by the National Referral Institute i.e., NICD, New Delhi.

II. Recurring cost (for 5 years)

Sl No.	Items	Amount(Rs. in lakhs)
1.	Travel and Transportation	150.00
2.	Data base reporting	100.00
3.	Stationery	50.00
4.	Honorarium to Distt. level surveillance coordinators 516 Nos.x 5 years x 12 months @ Rs.1500/- each	464.40
	Sub-Total II	Rs.764.40 lakhs

III. Grand Total

Sl No.	Items	Amount(Rs. in lakhs)
1.	Sub-Total I	Rs. 43495.40 lakhs
2.	Sub-Total II	Rs. 764.40 lakhs
3.	Grand Total I + II	**Rs. 44259.80 lakhs**
		Say Rs.44260 lakhs
		Or Rs.442.60 crore *

* In addition to the above budget requirements, an additional fund of Rs.120 Crore (which constitutes to about 25% of the total requirement of funds of NRWQMSP for catchment area approach assessed at Rs.442.60 crore) has been exclusively earmarked for necessary IEC activities.

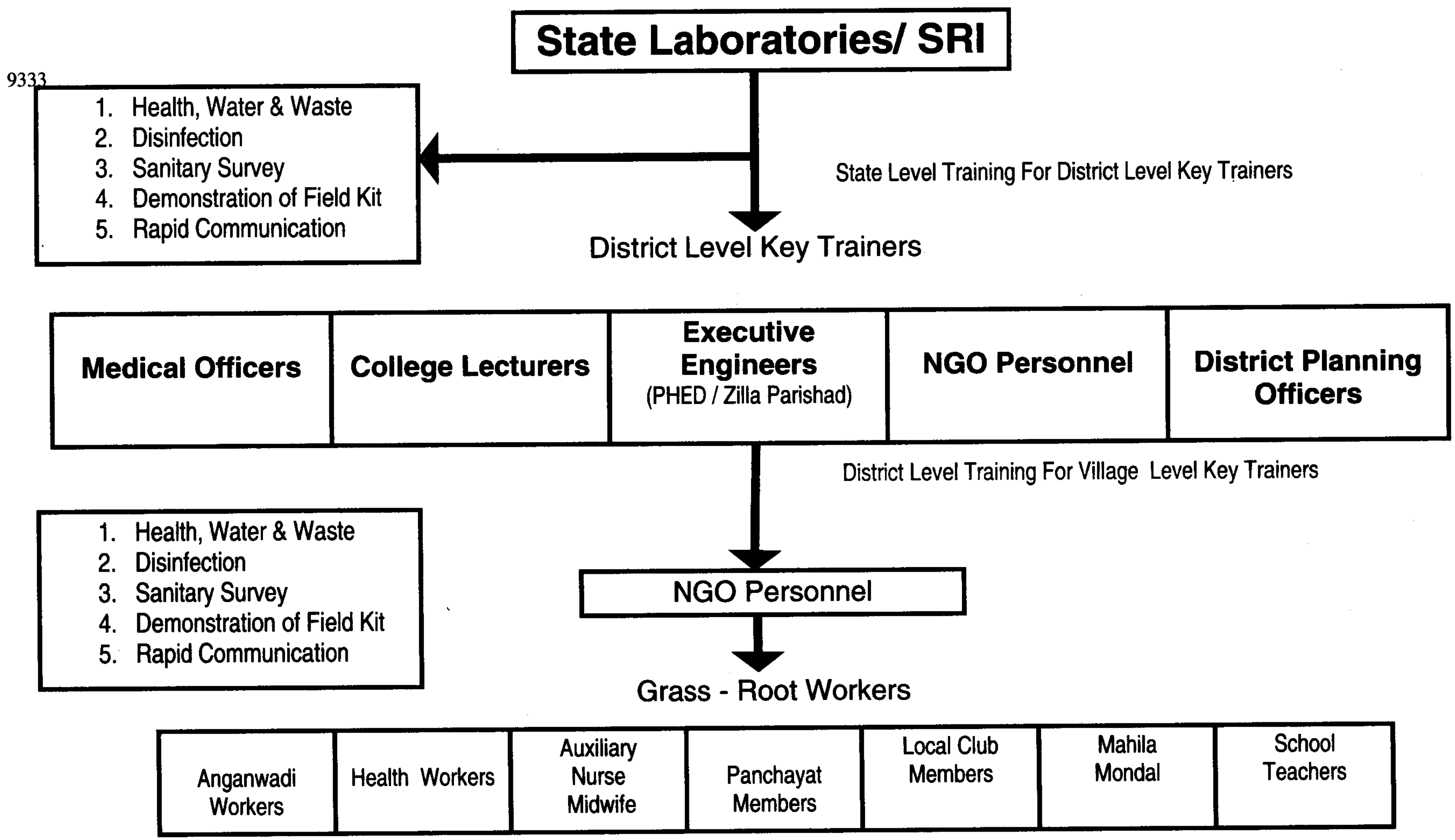


Fig. 11.2 TRAINING FLOW CHART

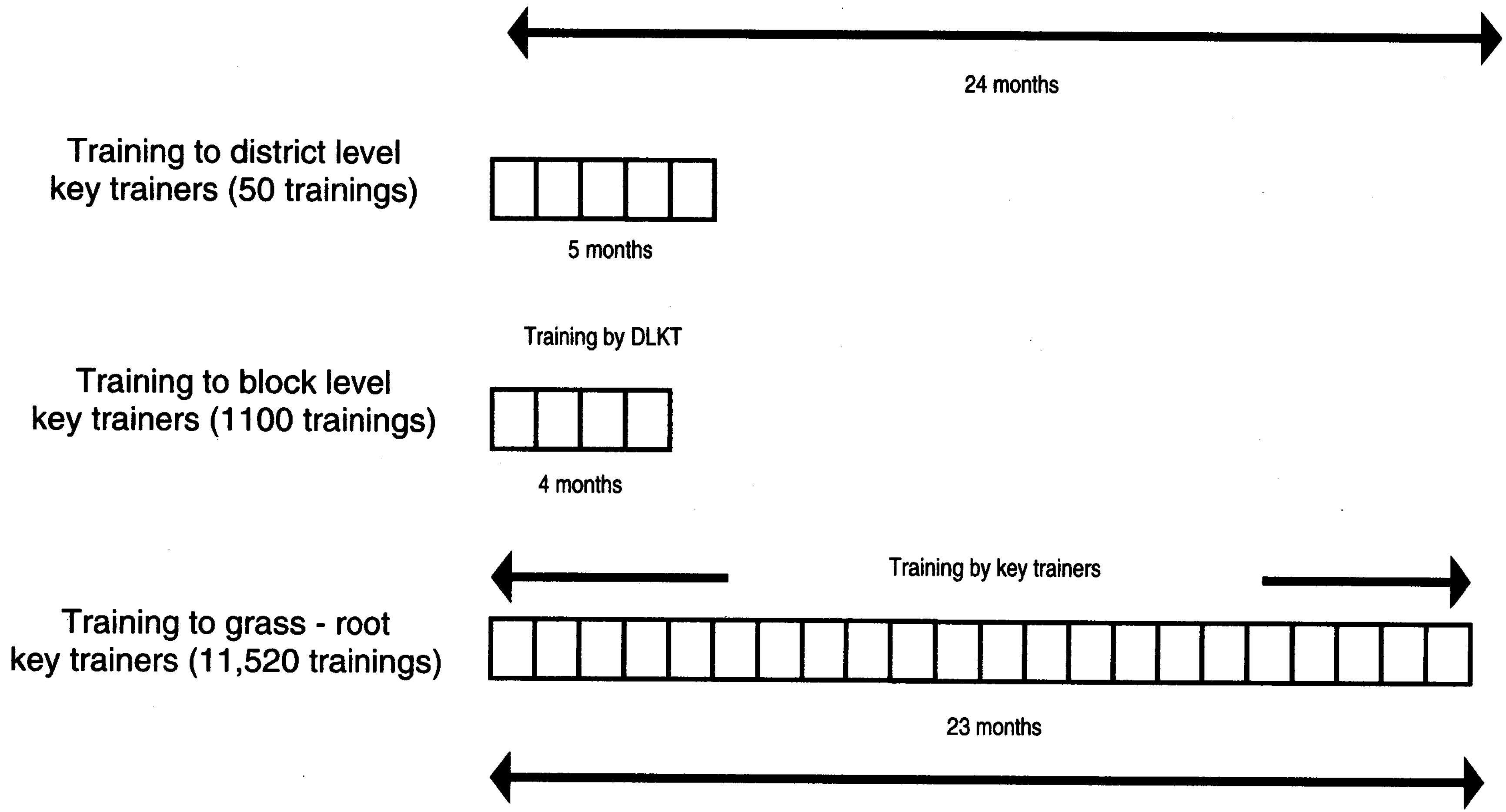


Fig. 11.3. TRAINING SCHEDULE

CHAPTER - 12

NATIONAL STRATEGY & ACTION PLAN

12.1 Background

12.1.1 Before the launch of the RGNDWM, scattered information on water quality was available through Geological Survey of India, Central Ground Water Board, State PHEDs and many research institutes engaged in environment and water management research. The Mission took initiative in building up an authoritative and exhaustive database on water quality throughout the country, particularly in areas already known to have water quality problems reporting prevalence of water borne diseases.

12.1.2 The analytical facilities required for assessment of water quality were available with research laboratories then but these were few and far between. In 1990s, the Mission laid emphasis on setting up District level Laboratories in all the States affected by water quality problems. Five Regional Centres, viz. All India Institute of Hygiene & Public Health (AIIH&PH), Calcutta; Defence Laboratory, Jodhpur; Bhabha Atomic Research Centre, Mumbai; Indian Toxicology Research Centre (ITRC), Lucknow and SJR College of Engineering, Mysore provided technical support to the Public Health Engineering Departments (PHED) and State Governments to set up District laboratories and train the personnel to carry out routine water quality analysis. The total number of laboratories approved under the programme is 586. However, this system was not found effective as it lacked a co-ordinating mechanism at the national level.

12.2 Need of a Community Based System

12.2.1 The data on existing water quality monitoring systems in various States reveal that at present the Departments concerned, be it Public Health Engineering or Rural Development or Panchayat Raj Engineering Organizations, have far inadequate infrastructure for carrying out the task. A very huge outlay would be required to provide the requisite infrastructure, physical facilities, etc. which would be next to impossible. An instance of a small State of Haryana would clarify. Population of rural Haryana is 1,22,72,000. Number of samples required to be analysed per year on the basis of 1 sample per 250 persons being tested 4 times a year i.e. 4 samples per 250 persons would work out 1,96,352. But at present only 15,000 samples can be analysed per year. Thus, if current set up is multiplied, it would take ages to reach this target, which again, would increase a few times. Therefore, simple expansion/multiplication of men, material, etc. under the control of a single department would probably land us nowhere. Also some of the texts need not be Institution based.

12.2.2 To effectively tackle the enormous task of water quality testing, monitoring & surveillance in rural areas, it is, therefore, imperative that a community based programme is adopted by fully utilizing the manpower and infrastructure already available in different Departments and educational institutions, e.g., polytechnics, high secondary schools, etc. and achieving networking of institutions and coordination amongst different Departments. Water quality testing/monitoring and water quality surveillance are two distinct but closely inter-related terms. While the former is the concern of Public Health Engineering Department (PHED)/ Nigams at the State level, the latter is looked after by State Health Departments. The Union Ministry of Health & Family Welfare is implementing the National Disease Surveillance Programme, including surveillance of water borne diseases. Both the Health Department and the PHED in the States have to team up in such a way as to ensure constant information exchange and convergence of functions at different levels. This will also economize costs, if done, jointly.

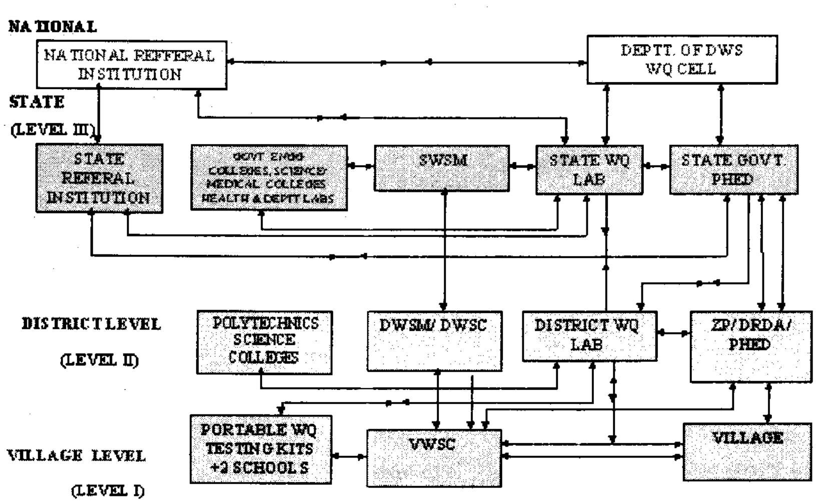
At the sub-District levels, services of existing 10+ educational institutions, polytechnics could be utilized for routine water testing instead of setting up new sub-District laboratories for water quality monitoring. Members of the Village Water and Sanitation Committee and PRI functionaries can be trained to carry out routine water quality testing with the help of field-testing kits. Thus, an effective system of water quality testing, monitoring and surveillance could be established by institutionalizing coordination amongst existing personnel – both technical and non-technical in several Departments of the Government such as PHEDs, Health Departments, Rural Development Departments, Panchayats and by integrating in the programme existing facilities potentially capable of carrying routine water testing such as 10+ institutions, polytechnics, etc. It is thus seen that even without recruiting a single staff and with coordination among various departments and appropriate training of the concerned staff, we could generate a much-expanded team capable of meeting this enormous challenge. This model of community based water health monitoring and surveillance, often referred to as a *Catchment Area Approach*, is essentially based on communities participating along with the government agencies in the water quality testing and surveillance programme to ensure safe potable water in rural areas.

12.3 Institutional Framework

An effective water quality monitoring and surveillance programme envisages not only systematic monitoring of water quality but also plausible causes of quality deterioration so as to enable the appropriate authorities to take timely appropriate remedial measures. This would call for a well structured network of horizontal linkages between the supplier and users of water, and public health authorities at different levels. Panchayat Raj Institutions at the village & Block levels, District Water & Sanitation Mission at the district level, State Rural Water Supply and Sanitation departments at the State level and Department of Drinking Water Supply, Ministry of Rural Development at the GOI level are concerned with supply and distribution of drinking water in rural areas. Health sub-centres and Primary Health Centres at Village & Block levels, District Public Health Officers at district level, State Health & Family Welfare departments at State level deal with disease surveillance. It is imperative for success of a rural quality monitoring and surveillance programme that horizontal linkages between those monitoring quality of water as suppliers and those exercising surveillance over diseases, including those resulting from quality of water, are institutionalized at different levels, and vertically integrated from the grass-root to the national level. The rural communities who are the major stakeholders of the rural water supply programme are to be suitably factored in the matrix of rural water quality monitoring and surveillance programme. The health agencies benefit from their access to catchment area of the water quality testing, while rural water supply agencies stand to gain from technical advice of health authorities relating to manner of data collection and monitoring so as to be of outmost use in improvement of public health, the summum bonum of Rural Water Quality Testing Monitoring & Surveillance Programme (WQTM&SP).

A flow diagram giving details of Catchment Area Approach is given below:

WATER QUALITY MONITORING ADOPTING CATCHMENT AREA APPROACH



12.4 Level – I (Village Level)

The base line water quality monitoring at the grass-root level would be carried out by community groups **(Village Water and Sanitation Committee- VWSC or Standing Committee of Panchayat on Water & Sanitation).** Initial support in terms of supplying the field kits, chemicals and training would be provided by the Department of Drinking Water Supply. The programme would be financially sustainable with cost recovery from the community. However, some amount of subsidy in terms of honorariums to community volunteers and periodic training, monitoring and evaluation may be provided from the budget of Zilla Parishad / District Water Supply Mission. Village level committee for water quality may consist of panchayat members; block level workers, teachers, Anganwadi, Primary Health Centre staff and Block Development Officer. The existing Village Water and Sanitation Committee (VWSC) would look after the activities relating to WQM and if required additional members would be co-opted from the above. There would be free exchange of information between VWSCs and Primary Health Centres for the purpose of disease surveillance.

12.5 Level – II (District Level)

Keeping in view the area, population and local resources, district level laboratories of PHEDs will be utilized to serve as District level Centres for WQTM&S Programme. Such a laboratory will have full water quality testing facilities. In the first phase, laboratories will be set up in the districts where these are yet to be set up. The district labs which have already been set up will be inspected to asses their requirement, facilities already available and balance equipment required. The District Water & Sanitation Mission shall monitor and guide the activities of the district level laboratories. The existing **District Water and Sanitation Mission (DWSM)** would be responsible for all the activities relating to WQM in a district. Additional members may be co-opted in DWSM, as required, district level departments and stakeholders.

The functions of the district level committee (DWSM) will be as under :

- Provide facilities for routine analysis of physico-chemical and bacteriological parameters relating to drinking water.
- Implement the action plan decided by state government/ zonal laboratory to which it is attached.
- Help analyze samples from each village under their jurisdiction at least four a year for public water supply and other sources.
- Supervise the operation of potable kits supplied to villages under their jurisdiction and provide them with necessary chemicals/glassware's, etc.

- Arrange periodical monitoring of bacteriological quality of water from the sources in villages and report to State PHED for remedial measures.
- To refer complex water quality problems beyond their control to State level Referral Institutions/ State Water & Sanitation Mission.

12.6 Level – III (State Level)

12.6.1 The **State Water and Sanitation Mission (SWSM),** will be the focal point for linkages with the Department of Drinking Water Supply, National Referral Institute, State level Referral Institution and District Water and Sanitation Committee. They would look after the activities relating to WQM in the State and if required additional members would be co-opted from any department/stakeholders in the sector.

The main functions of SWSM in respect of WQM & S will be as follows :

- Guide district level laboratories in successful implementation of programme
- Provide feed back data on water quality along with information related to quality consciousness and awareness.
- Plan, execute and monitor the collection, testing and reporting of water samples by state and district level laboratories.
- Promote people's participation by involving target groups, educational institutions, voluntary organizations, women etc.
- To consider the technical policy inputs referred by State level Referral Institute.
- To refer complex and nationally important water quality problems to Department of Drinking Water Supply.

12.6.2 State level Referral Institute

The State level Referral Institute (SRI) would advise PHEDs / Water Boards in setting up District level Water Quality Testing (WQT) laboratories covering the following :

- Identification and assessment of present facilities and needs including financial requirements in the state as per the guidelines developed for the purpose by the National level Referral Institution.
- Scope of strengthening the existing laboratories at district level.
- Arrangement for hardware and other requirements.
- Water quality monitoring and surveillance activities.
- Programme for training and development of human resources.
- Guide the District Water & Sanitation Committee in the planning and implementation of water quality monitoring and surveillance programme in the districts.

- To refer the complex and nationally important water quality problems to National level Referral Institute.

12.7 Level – IV (National level Referral Institute)

In order to formalise linkages and to facilitate monitoring/surveillance activities at various levels, Department of Drinking Water Supply, Government of India would identify/notify National Referral Institutes (NRI) and State Referral Institutes (SRI) (either State level Laboratories with PHED/Water Boards/ Health Departments or any other/ National Laboratories could be notified as SRIs).

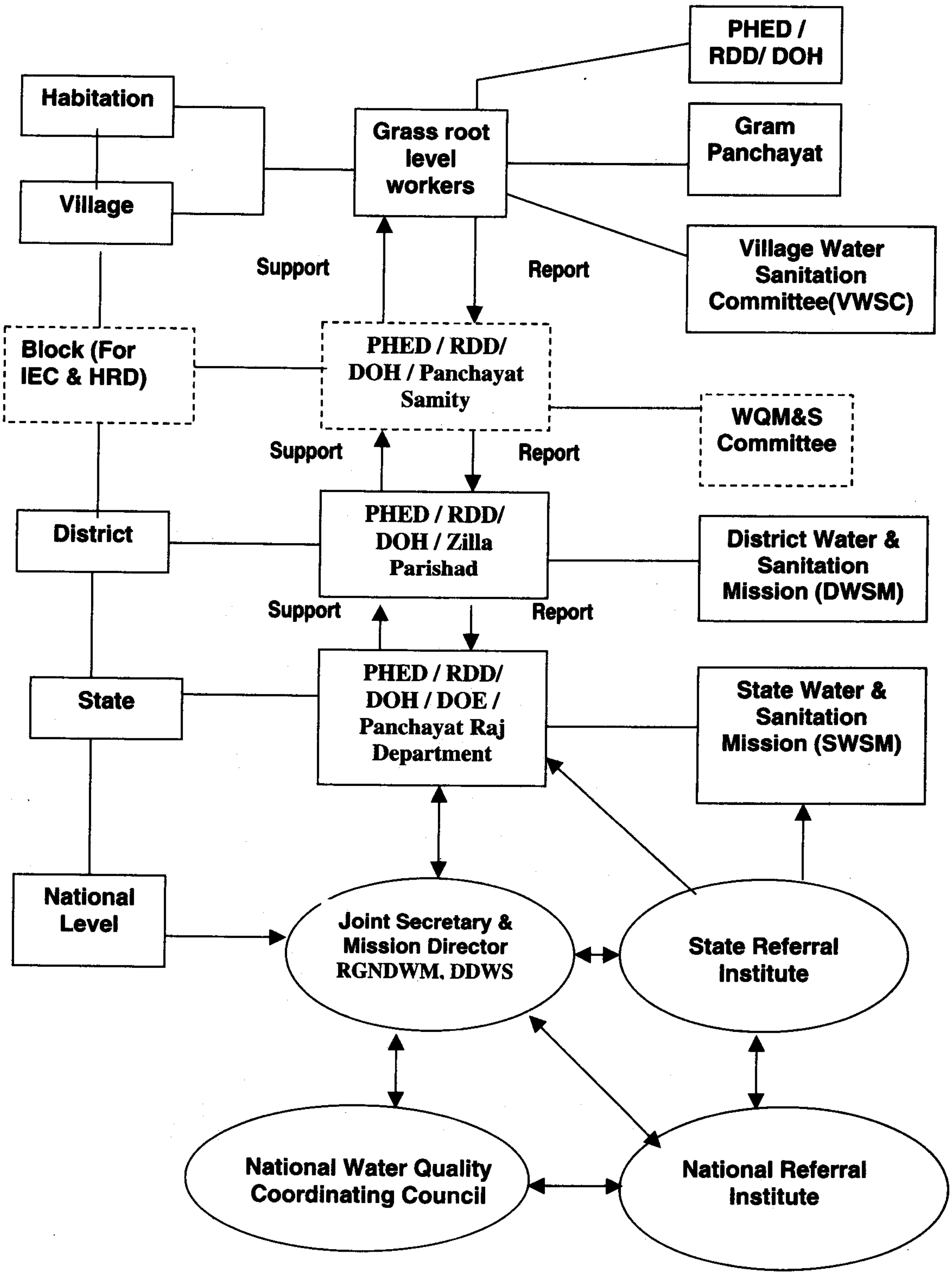
The National Referral Institute would advise the DDWS for setting up of new laboratories, upgradation, of existing laboratories and their functioning etc., covering the following activities:

- Review of guidelines, standards, manuals, water testing protocols at all levels.
- Formulation of guidelines for identification by the State level Referral Institution of technical and methodological gaps, training and IEC needs and other problems in implementation of the programme at all levels and recommend solutions
- Establishing linkages between water quality monitoring and surveillance.
- Processing, interpreting and evaluating all data pertaining to drinking water quality referred to NICD by Department of Drinking Water Supply or State level Referral Institutions.
- Promoting and coordinating research activities
- Validating new water testing methods
- Specification of laboratory equipment and reagents

12.8 Overall Monitoring

The entire programme of water quality 'assurance' will be monitored by Department of Drinking Water Supply. To this effect, the Management Information System (MIS) will be provided by DDWS. The Department of Drinking Water Supply shall be advised by a "National Water Quality Coordination Council" to be constituted by DDWS in consultation with the National Referral Institute having experts from various disciplines and UN agencies. The management of rural water quality testing and monitoring functions will be done by the Department of Drinking Water Supply as per the above details.

Fig 12.2 : Suggested Organizational Framework for National Rural Water Quality Monitoring & Surveillance Programme



ANNEXURE - I

BIS Standard : IS-10500 : 1991 (Rev-2.2)
Test Characteristics For Drinking Water

Sl. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the Absence of Alternate Source	Remarks
(1)	(2)	(3)	(4)	(5)
Essential Characteristics				
1.	Colour, Hazen units, Max	5	25	Extended to 25 only if toxic substances are not suspected, in absence of alternate source
2.	Odour	Unobjectionable	-	a. Test cold and when heated b. Test at several dilutions
3.	Taste	Agreeable	-	Test to be conducted only after safety has been established
4.	Turbidity NTU, Max	5	10	-
5.	pH value	6.5 to 8.5	No relaxation	-
6.	Total hardness (as $CaCO_3$) mg/l, Max	300	600	-
7.	Iron (as Fe) mg/l Max	0.3	1.0	-
8.	Chloride (as Cl) mg/l, Max	250	1000	-
9.	Residual, free chlorine, mg/l, Min.	0.2	-	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be Min. 0.5 mg/l
Desirable Characteristics				
10.	Dissolved solids mg/l, Max	500	2000	-
11.	Calcium (as Ca) mg/l, Max	75	200	-
12.	Copper (as Cu) mg/l, Max	0.05	1.5	-
13.	Manganese (as Mn), Max	0.1	0.3	-
14.	Sulphate (as SO_4), Max	200	400	May be extended up to 400 provided (as Mg) does not exceed 30
15.	Nitrate (as NO_3) mg/l, Max	45	100	-
16.	Fluoride (as F) mg/l, Max	1.0	1.5	-
17.	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	0.002	-

Sl. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit in the Absence of Alternate Source	Remarks
(1)	(2)	(3)	(4)	(5)
18.	Mercury (as Hg) mg/l, Max	0.001	No relaxation	To be tested when pollution is suspected
19.	Cadmium (as Cd) mg/l, Max	0.01	No relaxation	To be tested when pollution is suspected
20.	Selenium (as Se) mg/l, Max	0.01	No relaxation	To be tested when pollution is suspected
21.	Arsenic (as As) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
22.	Cyanide (as CN) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
23.	Lead (as Pb) mg/l, Max	0.05	No relaxation	To be tested when pollution/ plumbosolvency is suspected
24.	Zinc (as Zn) mg/l, Max	5	15	To be tested when pollution is suspected
25.	Anionic detergents (as MBAS) mg/l, Max	0.2	1.0	To be tested when pollution is suspected
26.	Chromium (as Cr^{6+}) mg/l, Max	0.05	No relaxation	To be tested when pollution is suspected
27.	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	-	-	-
28.	Mineral oil mg/l, Max	0.01	0.03	To be tested when pollution is suspected
29.	Pesticides mg/l, Max	Absent	0.001	-
30.	Radioactive materials :			
	a. Alpha emitters Bq/l, Max	-	0.1	-
	b. Beta emitters pci/l, Max	-	1	-
31.	Alkalinity mg/l, Max	200	600	-
32.	Aluminlum (as Al) mg/l, Max	0.03	0.2	-
33.	Boron, mg/l, Max	1	5	-

Note : Atomic absorption spectrophotometric method may be used.

Bacteriological Examination :

Water in Distribution System :

Ideally, all samples taken from the distribution system including consumers' premises, should be free from coliform organisms. In practice, this is not always attainable, and the following standard for water collected in the distribution system is therefore recommended when tested in accordance with IS 1622 : 1981.

a) Throughout any year, 95 percent of samples should not contain any coliform organisms in 100 ml;

b) No sample should contain E. Coli in 100 ml;

c) No sample should contain more than 10 coliform organisms per 100 ml; and

d) Coliform organisms should not be detectable in 100 ml of any two consecutive samples.

WATER QUALITY STANDARDS

(World Health Organisation (WHO) Standards) :

Guidelines for Drinking Water Quality

Parameter	Guideline Value	Remarks
Arsenic	0.01 mg/l (P)	
Cadmium	0.003 mg/l	
Chromium	0.05 mg/l (P)	
Copper	2.00 mg/l (P)	HBG[1]
Cyanide	0.07 mg/l	
Fluoride	1.5 mg/l	Climatic conditions, volume of water consumed and intake from other sources should be considered when setting national standards
Lead	0.01 mg/l	
Manganese	0.5 mg/l (P)	HBG
Mercury (Total)	0.001 mg/l	
Nickel	0.02 mg/l	
Selenium	0.01 mg/l	
Uranium		NAD[2]
Nitrate (NO_3)	50.00 mg/l	The sum of the ratio of the concentration of each to their respective guideline value should not exceed 1
Nitrite (NO_2)	3.00 mg/l	,,
Total Hardness	500 mg/l	(as $CaCO_3$)
E. coli bacteria	Not detectable in any 100 ml sample	
F. coli bacteria	Not detectable in any 100 ml sample	
Chlorine	5.00 mg/l	HBG. For effective disinfection free chlorine residual 0.5 mg/l after at least 30 minutes contact time as pH 8.0
Aesthetic Quality Values		
Aluminum	0.2 mg/l	
Ammonia	1.5 mg/l	
Chloride	250 mg/l	
Colour	15 TCU	
Copper	1.00 mg/l	
Hydrogen Sulphide	0.05 mg/l	
Iron	0.3 mg/l	
Manganese	0.10 mg/l	

Parameter	Guideline Value	Remarks
Dissolved Oxygen	-	No Guideline Value
pH	6.5 – 8.5	
Sulphate	250 mg/l	
Taste and Odour	-	Should be acceptable
Temperature	-	Should be acceptable
Suspended Solids	1000 mg/l	
Turbidity	5 NTU	For effective disinfection
Zinc	3 mg/l	1 NTU
Pesticides		
Alachlor	20 mg/l	For 10^5 excess risk
Aldicarbl	10 mg/l	
Aldrin / Dieldrin	0.03 mg/l	
Atrazine	2 mg/l	
Bentazon	30 mg/l	
Carbofuran	5 mg/l	
Chlordane	0.2 mg/l	
Chlortoluron	30 mg/l	
DDT	2 mg/l	
1,2-dibromo-3-chloropropane	1 mg/l	For 10^5 excess risk
2,4-D	30 mg/l	
1,2-dichloropropane	20 mg/l (P)	
1,3-dichloropropane		NAD
1,3-dichloropropane ethylene dibromide	20 mg/l	For 10^5 excess risk
Heptachlor & Heptachlor epoxide	0.03	
Hexachlorobenzene	1 mg/l	For 10^5 excess risk
Isoproturon	9 mg/l	
Lindane	2 mg/l	
MCPA	2 mg/l	
Methoxychlor	20 mg/l	
Metolachlor	10 mg/l	
Molinate	6 mg/l	
Pendimethalin	20 mg/l	
Pentachlorophenol	9 mg/l (P)	
Permethrin	20 mg/l	
Propanil	20 mg/l	
Pyridate	100 mg/l	
Simazine	2 mg/l	
Trifluralin	20 mg/l	
Dichlorprop	100 mg/l	
2,4-DB	90 mg/l	

Parameter	Guideline Value	Remarks
2,4,5-T	9 mg/l	
Silvex	9 mg/l	
Mecoprop	10	
MCPB		NAD

Source : "Revision of the WHO guidelines for drinking water quality", World Health Organisation, Geneva, 1992. Report of the final task group meeting, Geneva, Switzerland, 21-25 September, 1992.

BHG Health Based Guideline
NAD No Adequate Data to recommend a health-based guideline value
P Provisional Guideline Value

This term is used for constituents for which there is some evidence of a potential hazard but the available health effects information is limited.

Drinking Water Standards Set Up by Environmental Protection Agency (EPA), USA

1- Primary Standards – Microbiological Constitutents

Test Method Used	Monthly Basis	Individual Sample Basis (less than 20 samples / month)	Individual Sample 20 samples / Basis (more than month)
Membrane filter technique	1/100 ml average density	Coliform count shall not exceed 4/100 ml in more than one sample	Coliform count shall not exceed 4/100 ml in more than 5% sample
MPN method			
1. Ten ml standard portions	Not more than 10% of the portions	Coliform shall not be present in more than 3 portions from one sample	Coliform shall not be present in more than 3 portions in 5% of the sample analysed
2. The 100 ml standard portions	Not more than 60% of the portions	Coliform shall not be present in more than 5 portions from one sample	Coliform shall not be present in more than 5 portions in 20% of the sample analysed

2- Primary Standards – Turbidity Levels

Average	Maximum Contaminate Level (MCL) Turbidity Units (TU)
Monthly reading	1 TU up to 5 TU (5 TU may be allowed provided it does not interfere with disinfection process, maintenance of chlorine residual or bacteriological testing)
For two consecutive day's reading	5 TU

3- Primary Standards – Inorganic Chemicals

Contaminants	Level (mg/l)	Contaminants	Level (mg/l)
Arsenic (As)	0.05	Mercury (Hg)	0.002
Barium (Ba)	1.0	Nitrate (as N)	10.0
Cadmium (Cd)	0.010	Selenium (Se)	0.01
Chromium (Cr)	0.05	Silver (Ag)	0.05
Lead (Pb)	0.05		

4- Primary Standards – Maximum Contaminant Level for Fluoride

Annual Average of Max. Daily Air Temperature (°C)	Maximum Contaminant Level (MCL) (mg/l)
12.0 and below	2.4
12.1-14.6	2.2
14.7-17.6	2.0
17.7-21.4	1.8
21.5-26.2	1.6
26.3-32.5	1.4

5- Primary Standards – Organic Chemicals

Contaminants	Maximum Contaminant Level (MCL) mg/l
1. Chlorinated bydrocarbon	
Endrin	0.0002
Lindane	0.004
Methoxy Chlor	0.1
Toxaphene	0.005
2. Chlorophonoxys	
2,4 – D (2,4 – dichloro phenoxy acetic acid)	0.1
2,4,5 – TP Solvex (2,4,5 – trichloro phnoxy	0.01
propionic acid)	
3. Trihalomethanes	

6- Secondary Standards – Limits for Aesthetics

Contaminants	Maximum Contaminant Level (MCL)	Contaminants	Maximum Contaminant Level (MCL)
Color	Hazen Unit	Sulfate	250 mg/l
Odor	<3 TON	Chloride	250 mg/l
Corrosivity	Noncorrosive	Copper	1.0 mg/l
Foaming agent	0.5 mg/l	Manganese	0.05 mg/l
pH	6.5-8.5	Iron	0.3 mg/l
Total Dissolved Solids	500 mg/l	Zinc	5.0 mg/l
Hydrogen sulfide	0.05 mg/l		

Adapted from EPA, National Interim Primary Drinking Water Regulations, U.S. Environmental Protection Agency, Office of Water Supply, EPA 570/9-76-003, 1976.

CPHEEO Standard :

Recommended Guidelines for Physical and Chemical Parameters

Sl. No.	Characteristics	* Acceptable	** Cause for Rejection
1.	Turbidity (NTU)	1	10
2.	Colour (Units on Platinum Cobalt Scale)	5	25
3.	Taste and Odour	Unobjectionable	Objectionable
4.	pH	7.0 to 8.5	<6.5 or >9.2
5.	Total Dissolved Solids (mg/l)	500	2000
6.	Total Hardness (as $CaCO_3$) (mg/l)	200	600
7.	Chlorides (as Cl) (mg/l)	200	1000
8.	Sulphates (as SO_4) (mg/l)	200	400
9.	Fluorides (as F) (mg/l)	1.0	1.5
10.	Nitrates (as NO_3) (mg/l)	45	45
11.	Calcium (as Ca) (mg/l)	75	200
12.	Magnesium (as Mg) (mg/l)	≤ 30	150
If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates			
13.	Iron (as Fe) (mg/l)	0.1	1.0
14.	Manganese (as Mn) (mg/l)	0.05	0.5
15.	Copper (as Cu) (mg/l)	0.05	1.5
16.	Aluminium (as Al) (mg/l)	0.03	0.2
17.	Alkalinity (mg/l)	200	600
18.	Residual Chlorine (mg/l)	0.2	>1.0
19.	Zinc (as Zn) (mg/l)	5.0	15.0
20.	Phenolic Compounds (as Phenol) (mg/l)	0.001	0.002
21.	Anionic Detergents (mg/l) (as MBAS)	0.2	1.0
22.	Mineral Oil (mg/l)	0.01	0.03
	Toxic Materials		
23.	Arsenic (as As) (mg/l)	0.01	0.05
24.	Cadmium (as Cd) (mg/l)	0.01	0.01
25.	Chromium (as hexavalent Cr) (mg/l)	0.05	0.05
26.	Cyanides (as CN) (mg/l)	0.05	0.05
27.	Lead (as Pb) (mg/l)	0.05	0.05
28.	Selenium (as Se) (mg/l)	0.01	0.01
29.	Mercury (total as Hg) (mg/l)	0.001	0.001
30.	Polynuclear aromatic hydrocarbons (PAH) (μg/l)	0.2	0.2
31.	Pesticides (total, mg/l)	Absent	Refer to WHO guidelines for drinking water quality Vol I.–1993
	Radio Activity+		
32.	Gross Alpha activity (Bq/l)	0.1	0.1
33.	Gross Beta activity (Bq/l)	1.0	1.0

Note : * The figures indicated under the column 'Acceptable' are the limits upto which water is generally acceptable to the consumers.

** Figures in excess of those mentioned under 'Acceptable' render the water not acceptable, but still may be tolerated in the absence of an alternative and better source but upto the limits indicated under column "Cause for Rejection" above which the source will have to be rejected.

\+ It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyze the individual radio-nuclides in order to assess the acceptability or otherwise for public consumption.

Bacteriological Quality of Drinking Water[a]

Organisms	**Guideline Value**
All water intended for drinking purposes shall conform the following quality requirements:	
E. coli or thermotolerant coliform bacteria[b,c]	Must not be detectable in any 100 ml sample
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria[c]	Must not be detectable in any 100 ml sample
Total coliform bacteria	Must not be detectable in any 100 ml sample. In case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12 month period.

Source : WHO guidelines for Drinking Water Quality Vol. 1-1993

a Immediate investigative action must be taken if either E. coli or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling; if these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

b Although E. coli is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory test must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

c It is recognized, in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium term targets for progressive improvement of water supplies, as recommended in volume 3 of WHO guidelines for drinking water quality, 1993.