Water Resources Conservation and Preventive and Remedial Measures in Drinking Water Supply

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1.0 Introduction:

Rural India has more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals and water availability add to the complexity of the task.

Around 37 million Indians are affected by water –borne diseases annually and around 73 million working days are lost due to water borne diseases each year. The resulting economic burden is estimated at 600 million dollars a year.

The provision of clean drinking water has been given priority in the constitution of India, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State.

In India, 85% rural habitations are dependent on groundwater. Normally groundwater is safe for drinking but chemical contaminations of ground water have been reported from many areas in the country. Presence of excess fluoride , arsenic, salinity, iron, nitrate etc. are area specific and causes of contamination are mostly natural and geogenic but not anthropogenic. In India, 85% fresh water is used in agriculture; 10% water is used in Industries and Power generation sectors. The rest quantum of fresh water is used in public water supply. As fresh water is a limited resource, with the increasing demand in agriculture ,industry etc, the per capita availability of the water is sharply declining in the

country. Water-stress as well as water –acute conditions have been reached in many places in the country.

2.0 W**ater Resources and Utilisation**

- India has 16 per cent of the world population and 4 percent of its fresh water resources.
- Estimates indicate that surface and ground water availability is around 1869 billion cubic meters (BCM). Of this, 40 percent is not available for use due to geological and topographical reasons.
- Around 4000 BCM of fresh water is available due to precipitation in the form of rain and snow, most of which return to the seas via rivers.
- 92 percent groundwater extracted is used in the agricultural sector, 5 and 3 percent respectively for industrial and domestic sector.
- 89 percent of surface water use is for agriculture sector and 2 percent and 9 percent respectively are used by the industrial and domestic sector.

3.0. Behavioural Practices:

Interventions for providing safe drinking water can become ineffective in the absence of improved sanitation. In order to provide access to sufficient quantities of safe water, the provision of facilities for sanitary disposal of excreta and introducing sound hygiene behaviour are of utmost importance. The ways and means by which water is collected also has an impact on its quality. It is essential to have a clean surrounding around the source to prevent contamination. Open drains and disposal of solid wastes near sources of water may lead to presence of ammonia and coliform bacteria in the drinking water source. Thus prevention of water contamination at source is necessary to ensure the potability of supplied water.

4.0. **Preventive and remedial measures in drinking water supply**.

4.1 **Approach:**

The purpose of the surveillance of drinking water supplies is to control the quality of the water and thereby protect the consumers. The sanitary deficiencies identified by such surveillance are not remedied, then the situation may become dangerous, because the faith of community in the system will be lost. As a result effective preventive and remedial measures with reliable advance warning system must be adopted.

4.2 Preventive Measures:

The preventive measures are follow up activities of water analysis and sanitary survey. The preventive activities can substantially reduce expensive and complicated subsequent remedial measures. The remedial measures can be taken based on priority of problems. The method and technique of remedial measure will depend upon level and type of contamination. This will decide degree and stages of water purification system.

4.3 Water Purification:

4.3.1. Introduction:

Water is usually withdrawn for drinking and household purposes from the following sources.

a)Groundwater (springs, infiltration galleries, wells , etc).

b)Surface water (streams, lakes, ponds, rivers, impounded reservoirs, stored rain water, etc).

If groundwater is found in adequate quantity and if it is conveniently located for the water supply, the ground water should be used, as it is less polluted compared to surface water.

Groundwater may be aerobic or anaerobic, depending on the environmental conditions where it is found. The anaerobic ground water often contains CO_2 , which makes it corrosive. Chlorination also removes CO_2. Some groundwater contains

excessive amounts of Fe, Mn, hardness, fluoride or arsenic etc. and these should be removed.

The surface waters are generally more polluted than ground water due to their exposure to the environment, hence they may require more treatment steps than ground water. The typical impurities may include turbidity, colour, algae, floating debris, bacteria and other microorganisms, etc.

Surface water in general contains physical, chemical and biological impurities (such as clay, sand, colloids, minerals, color , odor, taste, microorganisms). Rivers and streams, because of the flowing nature of the water and exposure to sunlight, have self purification properties. However, they carry sand, silt, and clay. The intake point for the water supply should be far from the sewage effluent discharge point. Lakes and ponds are generally contaminated with bacterial impurities because the water is stagnant. Water quality in impounded reservoirs is highly variable, depending on the season. Table –1.0 presents the common pollutants in different water sources and the essential and optional treatment methods available for their removal.

4.3.2 Water Supply From Surface water Source

Usually surface water requires treatment for up-gradation of water quality to conform to the drinking water quality standards. The extent of water treatment depends on raw water quality . The unit operations in water treatment include aeration , coagulation, flocculation, sedimentation , filtration , disinfection , softening etc. Turbidity parameter could be examined before proposing water treatment method as presented in Table 1.

Table 1: Turbidity Parameters and Treatment

Turbidity	Treatment options	Remarks
<30	Plain sedimentation, slow sand filtration and disinfection	If turbidity is 10 NTU, plain sedimentation can be the only treatment followed by disinfection
>30	Coagulation, flocculation, sedimentation, rapid sand filtration	In some cases, this treatment option is applicable if turbidity is >50 NTU
>30	Horizontal roughing filtration, slow	If turbidity is >600 NTU, plain

	sand filtration, disinfection	sedimentation may be considered before Horizontal Roughing Filtration (HRF)
>30	Prolonged storage, sedimentation, slow sand filtration, disinfection	Very high detention time, say 15 days is required in prolonged storage tank

If turbidity of as surface water body is less than 30 NTU, Plain Sedimentation can be adopted as Pre-treatment Process. Thereafter, Slow Sand Filtration can be adopted for removal of remaining suspended solids.

In case of higher turbidity (>30 NTU) coagulation, flocculation, sedimentation, rapid sand filtration are adopted as unit operations for conventional water treatment.

In case of higher turbidity (>30 NTU) prolonged storage followed by slow sand filtration could be an alternative option of surface water treatment. This treatment system may be applicable for rural areas with community participation for operation and maintenance.

The other alternative option for treatment of surface water having higher turbidity (>30 to 600 NTU) is the application of Horizontal Roughing Filtration followed by Slow Sand Filtration. Rainwater harvesting through surface reservoirs could be linked with HRF-SSF technology for up-gradation of water quality.

Table 2:. Selection of raw water treatment process depending on the common impurities in raw water

Pollutant	Suggested Treatment Steps
Floating matter	Screening
Algae	Coagulation, flocculation and sedimentation, followed by rapid sand filtration.
Turbidity (NTU) < 15	Slow sand filtration and post-chlorination
Turbidity <15-30	Sedimentation, SSF , Post chlorination
Turbidity <30-1000	Coagulation, sedimentation, rapid filtration, and post-chlorination
Turbidity >1000	Preliminary settlement, coagulation, sedimentation, rapid filtration and post-chlorination.
Colour (if greater than 30 Hazen units)	Coagulation, flocculation, sedimentation, and RSF
Tastes and odors	Aeration, SSF, adsorption, chlorination
Hardness	Lime and Soda ash softening
Iron and manganese	Aeration, sedimentation and filtration
Fluorides (>1.5 mg/1)	Alum+ lime+ bleaching powder addition by rapid mixing followed by slow mixing

	and sedimentation and filtration (co-precipitation method / Nalgonda Technique).
Do	Adsorption by using activated alumina
Do	Ion exchange
Chlorides (>1000mg/1)	Desalination
Arsenic (>0.05mg/1)	Co-precipitation (using alum or ferric sulphate and bleaching powder)
Do	Adsorption by using activated alumina or ferric hydroxide
Do	Ion exchange
Pathogenic organisms (Bacteriological contamination in water)	Pre -chlorination (where applicable) Post- chlorination

Table –3.0 : Selected Unit Operations in Water Supply.

Unit Operations	Conventional	Modified process	Comments
Rapid mixing	Hydraulic mixers Mechanical backmix reactor	Flash mixing facility (injection type)	Suitable for water treatment plants of all sizes. Higher percentage of coagulant utilization (much better effluent quality).
Flocculation	Hydraulic and mechanical type flocculation	Tapered flocculation	Less energy imput, better floc formation.
		Gravel bed flocculator	Simplicity, effective flocculation, suitable to be used in low cost package plants.
		Alabama flocculator	Economical to construct, operate and maintain , minimum supervision needed
Sedimentation	Rectangular horizontal flow filtration	Solids contact clarifier.	Smaller size, better efficiency.

		Tube Settler	Modular design, surface loading rate is 2 to 10 times or greater, thus very compact, upgrading of existing treatment plants possible by placing modules in existing sedimentation tank.
Filtration	Slow sand filtration	HRF	3 or 4 gravel pack compart are used. Retains suspended and colloidal particles including organic matter. Excellent in removing microorganism.
	Rapid sand filtration	Dual media filter Coarse media filter Declining rate filter Direct filtration	Better filtration efficiency, longer filter run. No sedimentation, smaller flocculation facility, lower chemical use, low energy requirement.
Disinfection	Chlorine	ClO_2 O_3	No THM formation, lower chemical requirement, better disinfection.

Selection of water treatment processes depend on the characteristics of raw water. Table 2.0 highlights suggested treatment steps for removal of specific pollutants from raw water. Table 3.0 refers to various unit operations used as conventional as well as modified process for treatment of water. Salient characteristics of such unit processes have been highlighted in the table.

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4.4 Disinfection

No water treatment process is complete without disinfection. In fact, the most important of all the water treatment process is disinfection because it prevents waterborne diseases in humans. Chlorine has been used extensively for decades as a disinfectant. But problems and after effects due to chlorine use, such as tri-halomethane (THM) formation, have encouraged the use of alternative disinfectants as well as alternative techniques of disinfection.

4.4.1. Disinfection Methods:

Following removal of chemical contaminations, there will be need for disinfection of water for removal of micro-organisms. Discussed here are a few methods of disinfection for rendering drinking water safe.

The filtered water obtained from slow or rapid sand filters normally contains some pathogenic micro-organisms in it. Dug-well waters often may contain bacteriological contaminants. These micro-organisms must be destroyed in order to make the water safe for drinking. The chemicals used for destroying these micro-organisms are called as disinfectants and the process is known as disinfection.

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

a) Treatment with chlorine (chlorination)
b) Treatment with ozone
c) Treatment with Ultraviolet rays
d) Treatment with potassium permanganate
e) Boiling of water
g) Solar disinfection
h) Use of silver

5.0. Conclusion

Health risks from unsafe drinking water can be reduced to a negligible level by the following approaches.

- -Protecting water sources from Pollution.
- Preventing contaminants from reaching consumers. This can be achieved through preventive and curative measures at different stages.
- Prioritizing safety of drinking water.
- Ensuring rational water quality management and sound operating system through water supply agencies.
- Adopting water quality monitoring and surveillance programme.
- Providing effective legislation / regulation.

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