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CHAPTER 7: WATER QUALITY TESTING AND LABORATORY FACILITIES

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CHAPTER 7: WATER QUALITY TESTING AND LABORATORY FACILITIES

7.1 Introduction

Water quality is typically categorized into physical, chemical, microbiological, and radiological parameters. As the water comes into contact with various substances in different phases of the hydraulic cycle, such as rainfall, runoff, infiltration, impoundment, use, and evaporation, many minerals get dissolved and suspended. Drinking water quality is influenced by the source water quality, the efficacy of water treatment plants, the integrity of the water distribution system, and, more importantly, the service line to households.

The water quality is very critical in all design aspects of various components of the water supply system. The input quality decides the detailed engineering design of the components e.g., intake arrangements, Treatment process, boosting/ correcting measures needed in the transmission as well as the long distribution system to deliver assured water quality to all the beneficiaries. The design should also take into consideration the parameter in raw water, which are at present within the permissible limits, but have increasing trend and might change during the course of design period and make the water unfit for drinking and specific treatment is required for its removal before it can be delivered to the consumers.

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The primary purpose of water quality monitoring in the water supply system is to ensure compliance with water quality criteria and standards stipulated by the concerned agencies, assess the state of water, and determine trends. Strategies need to be developed for undertaking monitoring and surveillance, collecting and analyzing data, and delineating preventive and remedial actions for the provision of safe water, which are explained in details in Chapter 8: Drinking Water Quality Monitoring and Surveillance.

7.2 "Drink from Tap" Initiative

The '*Drink from Tap*' Initiative of the Government of India, is undertaken to supply assured quality piped drinking water to citizens on a 24x7 basis. The '*Drink from Tap*' aims to ensure that the water received at the consumer tap can be directly used for drinking and cooking purposes, without any need for further filtration/

boiling/ treatment. With this initiative, GoI aims to match the service delivery standards of the developed countries.

The initiatives aim at availability of quality water round the clock (24x7) in each house, elimination of household level storage (sump), efficient pumping and treatment, water conservation through metering, reduction in NRW & cost of production, quick resolution of issues/complaints, and above all real-time data sharing on water quality levels to enhance public perception and trust in the service delivery.

The objectives are:

- **'*Drink from Tap*'**: Conversion of intermittent water supply systems to continuous (24x7) water supply systems to reduce the health risks for users, that are likely to be caused due to contamination of water pipelines through joints and damaged segments in intermittent supplies, when a system is not under pressure.
- Equitable, sustainable and people-centric service provision with focus on the urban poor.
- Water Supply Management through Community Partnership (Self Help Groups)
- 100% coverage of households with piped drinking water in adequate quantity and with quality as per recommended standards.
- 100% metering of house connections to reduce non-revenue water (NRW) due to leakages and wastage, for full cost recovery.
- Adoption of innovative, state-of-the-art technology & management techniques, both during construction and operation & maintenance.
- Quality Assurance through Third Party Quality Monitoring.

It is thus imperative to be absolutely sure that the water quality is maintained throughout the water supply system, i.e., from source to tap. The Treatment facilities must be designed to cater to all possible variations in the raw water quality, as well as developing an infrastructure for establishing a foolproof water quality testing laboratory, has to be provided while designing and implementing the water supply system. To make '***Drink from Tap***' a success, adequate provision for resources including manpower for providing the laboratory facilities, and operating the laboratory during day-to-day monitoring and surveillance, to supply assured quality has to be made in the project costing, as described in the chapter.

7.3 Health Effects of Unsafe Drinking Water

Water is necessary for survival, and everyone should have access to an adequate, safe, and reliable water supply. In terms of quantity and quality, water profoundly affects the health and well-being of individuals and the community. Pathogens in drinking water are likely to result in infectious diseases. In addition, chemical contaminants are increasing in the water, posing health risks when their presence is above stipulated standards and consumed without treatment. Many factors, such as the type of contaminant and concentration in water, the quantity of water consumed, duration of exposure and individual susceptibility, largely govern the severity of the impact of the disease. Inadequate management, monitoring, and surveillance of urban, industrial, and agricultural water and sanitation services contaminate or chemically pollute the drinking water, exposing individuals to preventable health risks.

Diseases like cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio have been linked to contaminated water and poor sanitation. Tables 7.1 and Table 7.2 give details of the diseases likely to be caused by contaminants and microorganisms in the water. **Impact of prolonged consumption of contaminated water is as shown in** Figure 7.1 below.

Table 7.1: Water Contaminants and Associated Diseases

S-No.	Contaminants	Diseases or Impacts
1	Alkalinity	Gastrointestinal irritation and irritation to the eyes, skin, and mucous membranes
2	Hardness	Eczema, in addition to this it causes scaling and inability to form lather.
3	Copper	Vomiting, diarrhoea, stomach cramps, nausea, liver damage, and kidney disease
4	Chloride	Chloride toxicity has only been observed rarely in impaired sodium chloride metabolism cases, such as congestive heart failure.
5	Fluoride	Weakness, shallow respiration, spasms and convulsions, jaundice and urine suppression, discoloration of teeth, mottling in infants, and fluorosis
6	Nitrates as NO_3	Methaemoglobinaemia and congenital malformations
7	Sodium	Nausea, vomiting, muscular twitching and rigidity, convulsions, and cerebral and pulmonary oedema
8	Arsenic	Fatigue, nausea, vomiting, stomach pain, bloody diarrhoea, thickening or discoloration of the skin leading to skin cancer, numbness in hands & feet
9	Cadmium	Bone disease, osteomalacia, choking, vomiting, diarrhoea, abdominal pain, anaemia, renal dysfunction
10	Cyanide	Unresponsive hypotension, slow respiration and gasping, cyanosis at high levels and finally, death

(Source: World Health Organization, 2017)

Table 7.2: Microorganisms and Associated Diseases

S. No.	Microorganism	Diseases or Impacts
Pathogenic protozoans		
1	*Cryptosporidium homonis, C. parvum*	Gastroenteritis
2	*Acanthamocba astellani*	Amoebic meningoencephalitis
3	*Entamoeba histolytica*	Amoebic dysentery
4	*Balantidium coli*	Dysentery
5	*Giardia lamblia*	Giardiasis (gastroenteritis)
Pathogenic bacteria		
6	*Shigella spp.*	Bacillary dysentery
7	*Salmonella typhi*	Typhoid fever
8	*Salmonella paratyphi*	Paratyphoid fever
9	*Vibrio cholera*	Cholera
10	*Leptospira spp.*	Leptospirosis
11	*E. coli*	Gastroenteritis, ear and eye infections, diarrhoea, urinary tract infections, skin diseases
Enteric Viruses		
12	Polio viruses	Poliomyelitis
13	Rotaviruses	Gastroenteritis
14	Hepatitis A virus	Infectious hepatitis, Jaundice
15	Hepatitis E virus	Infectious hepatitis, Jaundice, miscarriage, and death

(Source: World Health Organization, 2017)

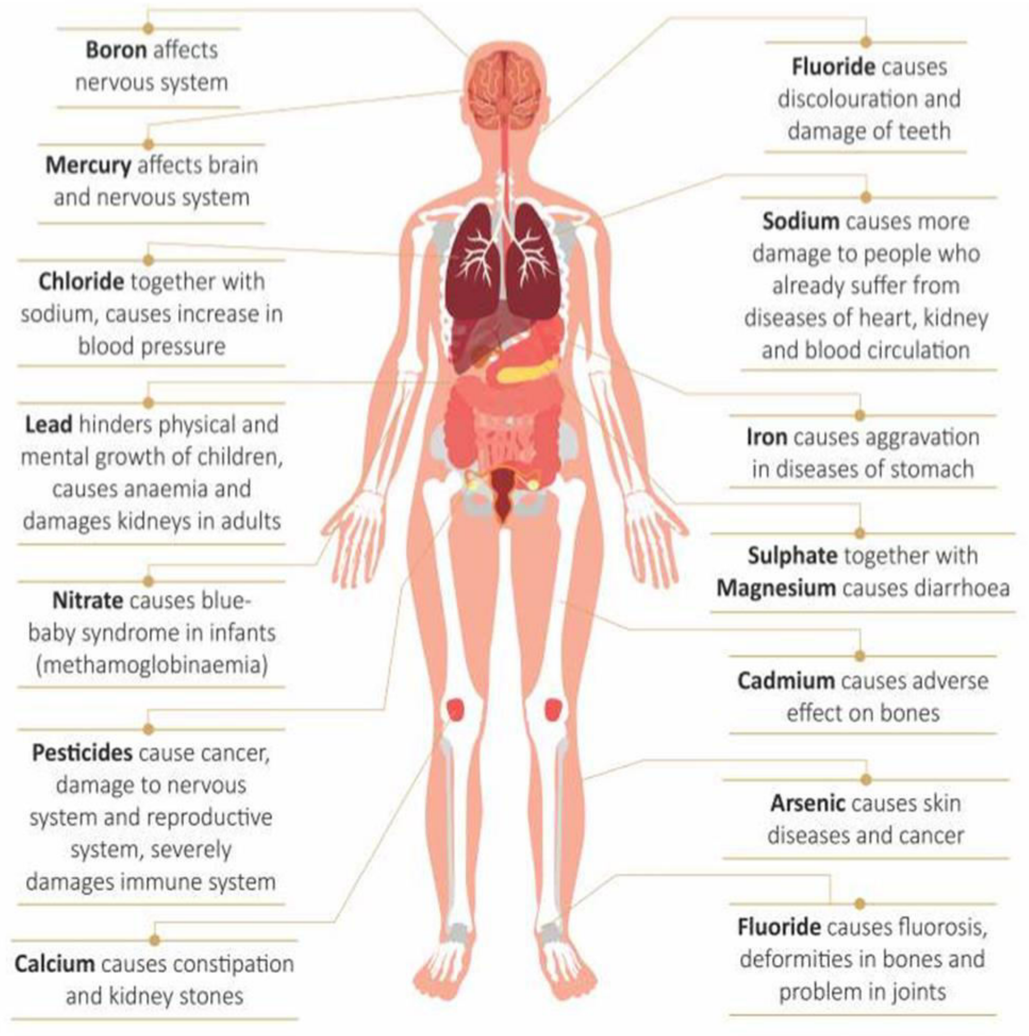

Figure 7.1: Impact of prolonged consumption of contaminated water

Source: JJM Quality framework

7.4 Standards and guidelines

Legislative Provision: The Article 21 in 'The Constitution of India', 1949 states "Protection of life and personal liberty: No person shall be deprived of his life or personal liberty except according to procedure established by law". Thus, the right to access to drinking water is fundamental to life and there is a duty on the State under Article 21 to provide clean drinking water to its citizens.

India is a party to the Resolution of the UNO passed during the United Nations Water Conference in 1977 as under: "All people, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantum and of a quality equal to their basic needs."

Standards and Guidelines: There are various standards and guidelines published by BIS, WHO, EPA, EU and Ministry of Jal Shakti from time to time, which forms the basis of planning the Water Quality Testing requirements and laboratory facilities to be provided, so as to provide safe drinking water to all residents, at all times.

The Standards and Guidelines applicable are:

1. IS 10500: 2012 Drinking Water - Specifications (second revision)
2. IS 3025: 2019 Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater
3. CPCB Water Quality Standards - Designated Best Use Water Quality Criteria
4. WHO Guidelines for Drinking Water Quality. 3rd Edition Vol. 1 Recommendations, 2008
5. Uniform Drinking Water Quality Monitoring Protocol, Ministry of Drinking Water and Sanitation, 2013
6. Drinking Water Quality Monitoring & Surveillance Framework, Jal Jeevan Mission, Ministry of Jal Shakti, October 2021
7. EU Directives relating to the quality of water intended for human consumption (80/778/EEC) and Council Directive 98/83/EC.
8. USEPA standard — National Primary Drinking Water Standard. EPA 816-F-02-013 dated July, 2002.

7.5 Water Quality Regulations

Water that is fit for human consumption (drinking water) must meet specific criteria/guideline values/standards to avoid adverse health effects as mentioned in above paras. For design purposes, contaminants with similar qualities that can be treated with the same technique are usually grouped. In most cases, it is impossible to address each contaminant in terms of treatment. However, specific contaminants (e.g., fluoride, arsenic, iron) must be removed and require specific treatment.

7.5.1 Raw Water Quality Criteria

The standards applicable for the surface water source, are prescribed by Central Pollution Control Board (CPCB) as 'Water Quality Criteria' which are based on the designated use. The water quality criteria are stipulated to define the goals and aspirations for the usage of each water body. Typical examples of designated uses include; fish, and wildlife conservation and propagation, recreation, water supply (as source) to the general public, agricultural, industrial, navigational, and other applications.

Water quality criteria of CPCB based on designated use are given in Table 7.3 which indicates that criteria provided against Class A and Class C apply to water supply schemes with surface source. Hence, surface water sources should be chosen to meet the water quality criteria.

Table 7.3: Surface water quality criteria for designated best use

Designated-Best-Use	Class of water	Criteria

Drinking Water Source without conventional treatment but after disinfection	A	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6 mg/L or more • Biochemical Oxygen Demand 5 days 20°C, 2 mg/L or less
Outdoor bathing (Organized)	B	• Total Coliforms Organism MPN/100ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 5 mg/L or more • Biochemical Oxygen Demand 5 days 20°C, 3 mg/L or less
Drinking water source after conventional treatment and disinfection	C	• Total Coliforms Organism MPN/100 ml shall be 5000 or less • pH between 6 to 9 Dissolved Oxygen 4 mg/L or more • Biochemical Oxygen Demand 5 days 20°C, 3 mg/L or less
Propagation of Wild life and Fisheries	D	• pH between 6.5 to 8.5 • Dissolved Oxygen 4 mg/L or more • Free Ammonia (as N) 1.2 mg/L or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	• pH between 6.0 to 8.5 • Electrical Conductivity at 25°C micro mhos/cm Max.2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2 mg/L

(Source: Central Pollution Control Board guidelines, 2019)

7.5.2 Drinking Water Specification (IS 10500:2012)

Water, an excellent solvent, ensures the solubility of chemicals from natural and anthropogenic sources. There can be several constituents in water which may adversely affect water quality. In providing safe drinking water, determining the water quality parameters is essential to avoid adverse health effects on consumption. All the water quality constituents (parameters) do not have adverse health effects, and their determination has implications ranging from water treatment to aesthetic value.

The Bureau of Indian Standards (BIS) prescribes the tests for assessing water quality and standards that must be met for making the water potable in IS 10500:2012 and subsequent amendments and IS 3025: 2019 - Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater.

In the absence of an alternate source, the standard specifies acceptable and permissible limits. It is recommended that the acceptable limit be implemented, as values above those listed under 'Acceptable' render the water unfit for consumption. Such a value may be tolerated in the absence of an alternative source. However, if the value exceeds the 'permissible limit in the absence of an alternate source' limits, the water must be rejected for drinking.

IS 10500:2012 - Drinking Water - Specification has the following categories of water quality parameters for which limits (standards) are provided:

i) Organoleptic and physical parameters
ii) General parameters concerning substances undesirable in excessive amounts (chemical parameters)
iii) Parameters concerning toxic substances (chemical parameters)
iv) Pesticide residues (chemical parameters)
v) Parameters concerning radiological substances
vi) Microbiological parameters namely indicator bacteria, viruses, protozoa and helminths
vii) Biological parameters namely algae, zooplankton, flagellates

Physical water quality parameters can be detected by the senses. Chemical tests are used to determine the quantity of mineral and organic substances that impact water quality. Microbiological tests reveal the presence of pathogens and indicator bacteria that are associated mainly with faecal matter pollution.

Due to its inherent benefits, biological monitoring is an integral part of the water quality monitoring program. Moreover, increasing incidences of algal bloom proliferation due to the presence of nutrients in surface water sources are reported. Hence, biological parameters should be monitored during the peak of summer (April-May) every year. Microbiological quality (indicator bacteria), turbidity, free chlorine residual and pH are the most critical parameters in water quality surveillance in small towns. Whether additional physical or chemical variables are to be assessed, these tests should be performed whenever a water sample is taken.

In addition, radiological parameters, namely Alpha emitters and Beta emitter, and bacteriological parameters, namely *E.coli* or *Thermotolerant coliforms,* are included in IS 10500:2012. In addition, Dissolved Oxygen (DO) and Bio-chemical Oxygen Demand should be monitored in surface water sources, as presented in Table 7.3.

Virological Requirement

Ideally, all samples taken from the distribution system including consumers' premises, should be free from virus. Virus can be isolated from raw water and from springs, enterovirus, reovirus, and adenovirus have been found in water, the first named being the most resistant to chlorination. If enterovirus are absent from chlorinated water, it can be assumed that the water is safe to drink. Some uncertainty still remains about the virus of infectious hepatitis, since it has not so far been isolated but in view of the morphology and resistance of enterovirus it is likely that, if they have been inactivated hepatitis virus will have been inactivated also.

Viruses are generally resistant to disinfectants as well as get protected on account of presence of particulate and organic matter in water. Because the difference between the resistance of coliform organisms and of virus to disinfection by oxidants increases with increasing concentration of reducing components, for example, organic matter, it cannot be assumed that the absence of available coliform organisms implies freedom from active virus under circumstances where a free chlorine residual cannot be maintained. Sedimentation and slow sand filtration in themselves may contribute to the removal of virus from water.

In practice, >0.5 mg/L of free chlorine for 1 h is sufficient to inactivate virus, even in water that was originally polluted provided the water is free from particulates and organic matter. MS2 phage are indicator of viral contamination in drinking water. MS2 phage shall be absent in 1 litre of water when tested in accordance with USEPA method 1602. If MS2 phage are detected in the drinking water, virological examination shall be done by the Polymerase Chain Reaction (PCR) method for virological examination as given in Annex B of IS 10500. USEPA method in Manual of Method for Virology Chapter 16, June 2001 shall be the alternate method. If viruses are detected, the cause shall be determined by immediate further investigation.

Drinking water shall comply with the requirements given in Tables 7.4 to Table 7.9. The methods of sampling and testing have been explained in relevant parts of IS 3025.

Table 7.4: Organic and Physical Parameters

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit In the Absence of Alternate	Method of Test, Ref to Part of IS 3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	**Color, Hazen units, Max**	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources

ii)	**Odour**	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
iii)	**pH value**	6.5-8.5	No relaxation	Part 11	-
iv)	**Taste**	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
v)	**Turbidity, NTU, Max**	1	5	Part 10	-
vi)	**Total dissolved solids, mg/L, Max**	500	2000	Part 16	-

NOTE - It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under “acceptable" render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under permissible limit in the absence of alternate source in col 4, above which the sources will have to be rejected.

Table 7.5: General Parameters Concerning Substances Undesirable in Excessive Amounts

S.No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit In the Absence of Alternate	Method of Test, Ref to	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Aluminium (as Al), mg/L, Max	0.03	0.2	IS 3025 (Part 55)	-
ii)	Ammonia (as total ammonia-N), mg/L Max	0.5	No relaxation	IS 3025 (Part 34)	-
iii)	Anionic detergents (as MBAS) mg/L, Max	0.2	1.0	Annex K of IS 13428	-
iv)	Barium (as Ba), mg/L, Max	0.7	No relaxation	Annex F of IS 13428* or IS 15302	-
v)	Boron (as B0, mg/L, Max	0.5	1.0	IS 3025 (Part 57)	-
vi)	Calcium (as Ca), mg/L, Max	75	200	IS 3025 (Part 40)	-
vii)	Chloramines (as Cl_2), mg/L, Max	4.0	No relaxation	IS 3025 (Part 26)* or APHA 4500-Cl G	-
viii)	Chloride (as Cl), mg/L, Max	250	1000	IS 3025 (Part 32)	-
ix)	Copper (as Cu), mg/L, Max	0.05	1.5	IS 3025 (Part 42)	-
x)	Fluoride (as F), mg/L, Max	1.0	1.5	IS 3025 (Part 60)	-
xi)	Free residual chlorine, mg/L, Min	0.2	1	IS 3025 (Part 26)	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be minimum 0.5 mg/L
xii)	Iron (as Fe), mg/L, Max	0.3	No relaxation	IS 3025 (Part 53)	Total concentration of manganese (as Mn) and iron (Fe) shall not exceed 0.3 mg/L
xiii)	Magnesium (as Mg), mg/L, Max	30	100	IS 3025 (Part 46)	-

S.No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit In the Absence of Alternate	Method of Test, Ref to	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
xiv)	Manganese (as Mn), mg/L, Max	0.1	0.3	IS 3025 (Part 59)	Total concentration of manganese (as Mn) and iron (Fe) shall not exceed 0.3 mg/L
xv)	Mineral oil, mg/L, Max	0.5	No relaxation	Clause 6 of IS 3025 (Part 39) Infrared	-
xvi)	Nitrate (as No_3), mg/L, Max	45	No relaxation	IS 3025 (Part 34)	-
xvii)	Phenolic compounds (as C_6H_5OH), mg/L, Max	0.001	0.002	IS 3025 (Part 43)	-
xviii)	Selenium (as Se), mg/L, Max	0.01	No relaxation	IS 3025 (Part 56) or IS 15303*	-
xix)	Silver (as Ag), mg/L, Max	0.1	No relaxation	Annex J of IS 13428	-
xx)	Sulphate (as SO_4), mg/L, Max	200	400	IS 3025 (Part 24)	May be extended to 400 provided that Magnesium do not exceed 30
xxi)	Sulphide (as H_2S), mg/L, Max	0.05	No relaxation	IS 3025 (Part 29)	-
xxii)	Total alkalinity as calcium carbonate, mg/L, Max	200	600	IS 3025 (Part 23)	-
xxiii)	Total hardness (as $CaCO_3$), mg/L, Max	200	600	IS 3025 (Part 21)	-
xxiv)	Zinc (as Zn), mg/L, Max	5	15	IS 3025 (Part 49)	-

NOTES:

1. In case of dispute, the method indicated by '*'shall be the referee method.
2. It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence or an alternative source but up to the limits indicated under 'permissible' limit in the absence or alternate source' in col 4, above which the sources will have to be rejected.

Table 7.6: Parameters Concerning Toxic Substances

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit In the Absence of Alternate	Method of Test, Ref to	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Cadmium (as Cd), mg/L, Max	0.003	No relaxation	IS 3025 (Part 41)	-
ii)	Cyanide (as CN), mg/L, Max	0.05	No relaxation	IS 3025 (Part 27)	-
iii)	Lead (as Pb), mg/L, Max	0.01	No relaxation	IS 3025 (Part 47)	-
iv)	Mercury (as Hg), mg/L, Max	0.001	No relaxation	IS 3025 (Part 48)/Mercury analyser	-
v)	Molybdenum (as Mo), mg/L, Max	0.07	No relaxation	IS 3025 (Part 2)	-
vi)	Nickel (as Ni), mg/L, Max	0.02	No relaxation	IS 3025 (Part 54)	-
vii)	Pesticides, µg/L, Max	See Table 7.7	No relaxation	See Table 5	-
viii)	Polychlorinated biphenyls, mg/L, Max	0.0005	No relaxation	ASTM 5175*	- Or APHA 6630
ix)	Polynuclear aromatic hydrocarbons (as PAH), mg/L, Max	0.0001	No relaxation	APHA 6440	-
x)	Total arsenic (as As), mg/L, Max	0.01	0.05	IS 3025 (Part 37)	-
xi)	Total chromium (as Cr), mg/L, Max	0.05	No relaxation	IS 3025 (Part 52)	-
xii)	Trihalomethanes: a) Bromoform, mg/L, Max b) Dibromochloromethane, mg/L,	 0.1 0.1	 No relaxation No relaxation	 ASTM D 3973-85* Or APHA 6232 ASTM D 3973-85* Or APHA 6232	 - -

	Max			ASTM D 3973-85* Or APHA 6232	
	c) Bromodichloromethane, mg/L, Max	0.06	No relaxation	ASTM D 3973-85* Or APHA 6232	-
	d) Chloroform, mg/L, Max	0.2	No relaxation		-

NOTES:

1. In case of dispute, the method indicated by '*' shall be the referee method.
2. It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence or alternate source’ in col 4, above which the sources will have to be rejected.

Table 7.7: Parameters Concerning Radioactive Substances

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit In the Absence of Alternate	Method of Test, Ref to	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Radioactive materials:				
	a) Alpha emitters Bq/L, Max	0.1	No relaxation	Part 2	-
	b) Beta emitters Bq/L, Max	1.0	No relaxation	Part 1	-

NOTE - It is recommended that the acceptable limit is to be implemented. Values in excess or those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under permissible limit in the absence or alternate source' in col 4. above which the sources will have to be rejected.

Table 7.8: Pesticide Residues Limits and Test Method

S. No.	Pesticide	Limit µg/L	Method of test, Ref to	
			USEPA	AOAC/ ISO
(1)	(2)	(3)	(4)	(5)
i)	Alachlor	20	525.2, 507	-
ii)	Atrazine	2	525.2. 8141 A	-
iii)	Aldrin/ Dieldrin	0.03	508	-
iv)	Alpha HCH	0.01	508	-
v)	Beta HCH	0.04	508	-
vi)	Butachlor	125	525.2, 8141 A	-
vii)	Chlorpyriphos	30	525.2. 814 1 A	-
viii)	Delta HCH	0.04	508	-
ix)	2.4-Dichlorophenoxyacetic acid	30	515.1	-
x)	DDT (*o, p* and *p, p* - Isomers of DDT, DDE and DDD)	1	508	AOAC 990.06
xi)	Endosulfan (alpha, beta and sulphate)	0.4	508	AOAC 990.06
xii)	Ethion	3	1657 A	-
xiii)	Gamma -HCH (Lindane)	2	508	AOAC 990.06
xiv)	Isoproturon	9	532	-
xv)	Malathion	190	8141 A	ISO 10695
xvi)	Methyl parathion	0.3	8141 A	-
xvii)	Monochrotophos	1	8141 A	-
xviii)	Phorate	2	8141 A	-

NOTE - Test methods are for guidance and reference for testing laboratory. In case of two methods. USEPA method shall be the reference method.

Table 7.9: Bacteriological Quality of Drinking Water[1)]

S. No.	Organisms	Requirements
(1)	(2)	(3)
i)	All water intended for drinking:	
	a) E coli or thermotolerant coliform bacteria[2), 3)]	Shall not be detectable in any 100 ml sample
ii)	Treated water entering the distribution system:	
	a) E coli or thermotolerant coliform bacteria[2)]	Shall not be detectable in any 100 ml sample
	b) Total coliform bacteria	Shall not be detectable in any 100 ml sample
iii)	Treated water in the distribution system:	
	a) E coli or thermotolerant bacteria	Shall not be detectable in any 100 ml sample
	b) Total coliform bacteria	Shall not be detectable in any 100 ml sample

1) Immediate investigative action shall 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 shall be determined by immediate further investigation.
2) 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 tests shall 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 or no sanitary significance occur in almost all untreated supplies.
3) It is recognized that, 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.

7.6 Water Quality Data

The water quality data of surface raw water source and ground water source is very crucial for designing and implementing the water supply systems. Thus the quality data has to be collected from authentic sources so as to design the treatment system which will cater to all quality fluctuations and shocks during the design period.

7.6.1 Surface Water Quality Data

In 1978, the Central Pollution Control Board began monitoring national water quality as part of the Global Environmental Monitoring System (GEMS) Water Program. With 24 surface water and 11 groundwater stations, the monitoring program was off to a start. In addition to GEMS, in 1984, a system for **Surface Water, viz., a**

National Programme of Monitoring of Indian National Aquatic Resources (MINARS) was launched, with 113 stations spread across ten river basins.

The monitoring activities carried out as part of the national network serves various assessment objectives as given below in determining:

- natural freshwater characteristics without direct human influence,
- long-term trends in critical water quality indicators in freshwater resources,
- organic matter, suspended solids, nutrients, toxic chemicals, and other pollutants that flow from river systems to the sea/coastal interfaces

A selective network of strategically vital monitoring stations has been established to achieve the earlier objectives. It is being operated in the country's major, medium, and minor watersheds of rivers, lakes, ponds, and storage tanks, bodies of water, drains, water channels, and subsoil aquifers. Three types of stations are set up for monitoring: baseline, trend, and flux stations.

7.6.2 Ground Water Quality Monitoring (GWQM)

GWQM is a coordinated effort to collect and analyze data on groundwater's physical, chemical, and biological characteristics, aquifer conditions, and designated ground use. Groundwater is characterized by contrasting aquifer and geologic features, limited accessibility (i.e., groundwater must be sampled through an existing or newly drilled well or spring), and 3-D distribution movement within a geologic framework. Central Ground Water Board (CGWB) coordinates GWQM through a network of observation wells spread across the country.

7.7 Water Quality Assessment

Assessment is the systematic documentation and study of the quality phenomenon to take decisions in designing the water supply system components, mainly intake and treatment processes. The assessment should take into account the following parameters:

(a) Where to sample: Locating the sampling point
(b) What to measure: Define the parameters to be monitored
(c) When to observe (how often): Frequency of observation

After the installation of the water supply system, it is vital to monitor the water quality parameters to ensure the proper functioning of the system. Water quality data collected during the water supply system operation should help take any corrective changes if required to deliver ‘Drink from Tap’ with 24x7 continuous water supply. Refer Chapter 8 in part B of this Manual for detailed deliberation on monitoring aspects.

7.7.1 Critical Water Quality Assessment/Assurance Points

The quality of water being supplied through the water supply system has to be monitored to ensure conformance with the desired drinking water standard. The facility has to be in place to carry out these water quality tests at the critical points and transmit the data to the central unit to make positive changes in the design of various components to optimize the system.

These critical points must be carefully selected to capture variations in water quality in the water supply system. It is recommended to provide the following critical points to assess the water quality:

i) At the intake/ Tubewell (water source)
ii) At the inlet and outlet of the treatment plant
iii) At the inlet and outlet of ESRs/DMAs
iv) The farthest point of the water supply in each District Metered Area (DMA)
v) At discrete locations in the network/DMA

The emerging technologies, e.g., IoT and related instrumentation, can be used for efficient water quality monitoring at these critical points. The Quality data has to be mapped on GIS and connected to SCADA and analysed with Digital Twin Technology for taking decisions and implementing corrective measures needed.

7.8 Establishing Testing Mechanism

Several institutions are catering to water testing requirements. An institutional mechanism of laboratories is proposed below that can be made functional at different levels, e.g., at National, State and ULB levels. Water quality laboratories are also the main backbone of water quality monitoring and surveillance program. Well-located and well-equipped analytical laboratories with competent staff are essential to evaluate water utility services' efficiency in terms of water quality. Therefore, the provision of safe drinking water warrants a strong laboratory network within the state and ULB for water quality assessment.

7.8.1 Proposed institutional mechanism of laboratories

As explained earlier, an institutional mechanism exists for water quality monitoring and surveillance at various levels. To synchronize water quality monitoring and surveillance and have a similar template for the data collection, compilation and analysis, existing mechanisms need strengthening.

Strengthening the network of water quality assessment laboratories is based on a state laboratory and a series of laboratories at the ULB, including mobile and basic laboratories at the Water Treatment Plant level (Figure 7.2). The laboratory at the water treatment plant can also serve the entire water supply system, including the function of the basic laboratory. ULB can have any of the following laboratory systems:

i) two laboratories separately catering to (a) the source and distribution system and (b) the basic laboratory preferably at water treatment plant
ii) single laboratory catering to the entire water supply system

In addition to ULB laboratories, a state laboratory is also proposed which may coordinate activities of all the ULB supported laboratories in the state. The state laboratory should be accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) and International Standard Organization (ISO). The laboratory should be well-equipped to deal with the parameters identified in the Bureau of Indian Standards on quality standards for drinking water (IS 10500:2012). It is required to perform external control on the quality of the analysis performed by the smaller laboratories.

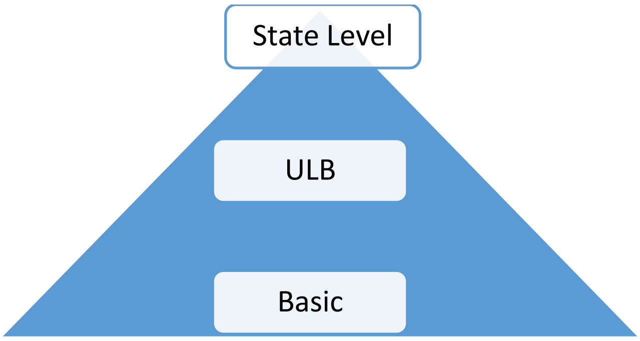

Figure 7.2: Laboratory Network for Water Quality Assessment

The ULB-level laboratories should be capable of carrying out a moderate series of physical, chemical and microbiological analyses, which must be subject to quality assurance programs to guarantee their quality. In addition, they should be able to offer support services to the field staff carrying out tests using portable equipment. The number of laboratories and their locations shall depend on various aspects as listed below:

- Number of water supply schemes in the ULB;
- Population served;
- Water Quality Hotspots
- Concentration of industries;
- Logistics (distance); and
- Financial implications.

A minimum of one water testing laboratory should be established in each ULB. The State Laboratory of the concerned State Government Department (e.g., Urban Development Department) can coordinate with any of the laboratories being operated by other State and Central Government agencies (PHED, CGWB, CWC etc.) to optimize available resources.

7.8.2 Functions of Water Quality Testing Laboratories

Within the proposed hierarchy, the basic laboratory at WTP controls and optimizes the treatment process. In case of a plant of greater capacity (>50 MLD), all the additional parameters shall be monitored in the ULB laboratory.

In general, the critical function of a water-testing laboratory is to determine the water quality for drinking and domestic use. To undertake these function, following activities are involved, viz.:

a. Collection of water samples from the field with suitable preservation,
b. Sanitary surveillance,
c. Water sample storage with suitable preservation, and
d. Requisite data analysis.
e. The other functions would include:
    - Delineating the potential areas of water contamination (hotspots);
    - Determining the risk of pollution from various sources like agricultural practices (pesticides and fertilizers), industrial discharges, municipal sewage disposal and disposal of solid wastes;
    - Communicating the results to concerned officials for corrective actions;
    - Follow-up water quality monitoring after implementation of corrective actions, mainly if the source is bacteriologically contaminated;
    - Identifying sampling stations and frequency; and
    - Providing reference/critical points to monitor improvement or deterioration in water quality.

Water quality testing laboratories will carry out the following activities:

i.) Set up/ strengthening of State and ULB level NABL accreditation laboratories
ii.) Upgrade existing water quality testing laboratories, including procurement of equipment, instruments; chemicals/ reagents; glassware; consumables, etc.
iii.) Procure special vehicles for transportation of water samples from the field to the laboratory;
iv.) Carry out additional activities, viz., testing of water quality using Field Test Kits (FTKs) and corroborating with the water testing laboratory;
v.) Performing Information, Education and Communication (IEC) activities on the importance of consuming safe drinking water, capacity building, and training various stakeholders.

The envisaged functions of different laboratories within the proposed hierarchy and requisite staffing shall be as given below in Table 7.10.

Table 7.10: Envisaged Functions of Various Laboratories

Laboratory	Envisaged Functions
State level Laboratory/ Large ULB (10 lakhs or greater)	It will be a well-equipped laboratory capable of • Analysis of physico-chemical & microbiological parameters of water & wastewater • Supervise and guide all small laboratories in its jurisdiction on sampling, water quality analysis, data analysis, and crosschecking of standard • Undertake routine monitoring & surveillance of the

Laboratory	Envisaged Functions
	distribution system and suggest corrective actions based on water quality analysis data • Routine monitoring of identified control measures within the water supply system • Identify contamination points within water supply systems and control; • Validate & enter data in a standard database • Undertake analysis of all routine water quality parameters, viz., heavy metals, pesticides, bacteriological, and biological analysis with sophisticated instruments • Establish area-specific health-based targets for microbial and chemical quality of water • Take up independent public health surveillance for water safety. • Offer handholding support to ULB labs • Collaborate with similar water testing laboratories in the State, e.g. State Laboratory of Rural Water Supply Agency (PHED)
Medium (1-10 lakhs) **and small ULB (<1 lakh) Laboratory, and Basic Laboratory at WTP**	It will be a well-equipped laboratory capable to: • Analyze minimum required parameters, as mentioned earlier, for source, WTP and distribution system • Undertake routine monitoring & surveillance of the distribution system. • Enter data in a standard database • Collaborate with similar water testing laboratories in the State, e.g. District Laboratory of Rural Water Supply Agency (PHED)

7.8.3 Mobile Drinking Water Quality Testing Laboratory

ULBs can procure mobile water quality testing laboratories to test specified endemic parameters, local communities' congregation areas, and inaccessible parts of the city. This type of mobile laboratory may be needed in areas where water samples cannot be transported to designated laboratories on time. The mobile laboratories should be fully equipped to conduct on-the-spot water analysis concerning drinking water sources' safety. The results of the tests will help determine what treatments are needed to make the contaminated water safe to drink. They play a significant role during calamities/ disasters as they can reach these areas quickly, i.e., cyclone and flood-prone areas, landslides and earthquake-prone areas, etc. The primary functions of a mobile laboratory include:

i.) water quality testing, monitoring and surveillance in remote areas/ hot spots/ disaster-prone areas;
ii.) cross-verification of results with other laboratories;
iii.) water quality testing and management during disasters and natural calamities;
iv.) awareness generation amongst the community;

7.8.4 Staffing

Staff requirements for water quality testing varies widely according to the population of ULB, number of water samples to be collected and analysed, number of water sources, treatment plant size, and financial resources. A suggestive staff requirement for various levels of laboratories is given below in Table 7.11 and Table 7.12. The requisite qualification of each staff can be based on the concerned State Government guidelines. The position of Chief Water Analyst can be held by chemist/microbiologist/environmental scientist having experience in water quality analysis and surveillance.

Table 7.11: State/ULB Level Water Quality Testing Laboratory

S. No.	Position	Numbers			
		State Laboratory	ULB		
			Large ULB (population > 10 lakhs)	Medium ULB (1-10 lakhs)	Small ULB (< 1 lakh)
1.	Chief Chemist/ Water Analyst	01	01	01	-
2.	Senior Chemist/ Water Analyst	02	01	01	-
3.	Environmental Engineer	02	02	01	-
4.	Chemist/ Water Analyst	03	02	01	01
5.	Microbiologist/ Bacteriologist	02	01	01	01
6.	Laboratory Assistant	04	03	02	01
7.	Lab Attendant	06	04	03	02
8.	Data Entry Operator	02	02	01	01
9.	Field Assistant (task/ need-based field staff)	06	04	03	02

Table 7.12: Mobile Water Testing Laboratory

S. No.	Position	Numbers
1.	Chemist/Water Analyst/ Microbiologist	01
2.	Field Assistant (task/ need-based field staff)	01
3.	Driver	01
4.	Helper	01

7.9 Laboratory Facilities and Equipment

7.9.1 Facilities

At the time of construction of water works assets, it is critical to provide testing laboratories and procure applicable standard instruments and equipment. The laboratory's layout will be determined by the various analytical work that must be completed. When choosing the required space, consideration should be given to the space needed for permanently installed equipment and the efficient completion of analytical work by laboratory workers. Future growth should be considered while building the new laboratory or retrofitting the old laboratory. Urban areas for developing separate structures of laboratory facilities are categorized as follows

i) Large ULB (Metropolitan areas having a population > 10 lakhs)
ii) Medium ULB (Municipal Corporations having a population 1-10 lakhs),
iii) Small ULB (Municipalities having a population <1 lakh).

Although these laboratories will be operated and maintained by individual ULBs, cross-linkages among laboratories should be encouraged in a State for optimizing resource availability. This is similar to the institutional mechanism developed for water quality analysis in the rural area. Table 7.13 lists the necessary laboratory equipment.

Table 7.13: Facilities Required in a Laboratory

Sl. No.	Infrastructure	**State or Large ULB Laboratory** (population > 10 lakhs)	**Medium ULB Laboratory** (population 1-10 lakhs)	**Small ULB Laboratory (population <1 lakh)**
1.	Space for Analysis (minimum area)	80 m^2 (including 20 m^2 biological)	60 m^2 (including 20 m^2 for biological testing)	50 m^2 (including 10 m^2 for biological testing)
	Space for storage (in m^2)	45	25	20
	Space for office & library (in m^2)	45	15	10
	Total space req. (in m^2)	200	100	80

Sl. No.	Infrastructure	State or Large ULB Laboratory (population > 10 lakhs)	Medium ULB Laboratory (population 1-10 lakhs)	Small ULB Laboratory (population <1 lakh)
2.	No. of Computers	03 (include 1 system for library)	01	01
3.	Internet facility	Yes	Yes	Yes
4.	No. of UPS	02	01	01
5.	Inverters (back up time-3 hrs.)	02	02	01
6.	Printer	02	01	01
7.	Telephone Facility	Yes	Yes	Yes
8.	Fax	Yes	Yes	Yes
9.	AC.	Yes	Yes	Yes
10.	Provision for Fume hood	Yes	Yes	May not be needed at this level
11.	Provision for gas connection	Yes	Yes	Yes (Only LPG)

(Source: Drinking Water Quality Monitoring & Surveillance Framework, 2021 of GOI)

7.9.2 Equipment

Water quality testing equipment is a staple in environmental laboratories. Various types of water quality testing equipment are used to test water for physical, chemical and microbiological contaminants. These equipment can be used to test a variety of parameters in water. Equipment to be procured by municipal corporations and other ULBs should be decided by the concerned ULB based on water quality parameters to be analyzed. It is recommended that Metropolitan areas should have facilities to analyze all the water quality parameters, as mentioned in Table 7.14. This laboratory should cater to other ULBs in case episodic monitoring needs to be carried out and other laboratories don't have facilities to analyze the concerned water quality parameters.

Table 7.14: List of Equipment/Instrument (Indicative)

S. No.	Equipment/Instrument
1	pH Meter
2	Conductivity meter
3	Turbidimeter
4	Hot air oven
5	UV Laminar Air Flow
6	UV-Visible Spectrophotometer

7	Bacteriological Incubators
8	Autoclave
9	Refrigerator
10	Digital Balance
11	Atomic Absorption Spectrophotometer
12	Jar test apparatus
13	Water distillation plant
14	Water bath
15	Dissolve oxygen analyzer
16	Chlorine comparator
17	Heating metal
18	Magnetic stirrer
19	GC-MS/ HPLC/ GC
20	Ion Meter
21	EC meter
22	Nephalometer
23	MF Assembly
24	PC-Colony Counter

Required Laboratory apparatus (Glassware & Accessories) and Chemicals in required quantity should also be maintained in stores.

7.10 Water Quality Index (WQI)

A Water Quality Index provides a single number (like a grade) that expresses the overall water quality of a particular water sample (location and time specific) for several water quality parameters. Developing an index aims to simplify the complex water quality parametric data into comprehensive information for easy understanding. A water quality index based on important parameters provides a simple indicator of water quality which gives a general idea of the possible problems with the water in the region and across the stretch of the river/ stream, helping in deciding the best alternative location of intake.

The WQI has been determined based on the formula developed by NSF (National Sanitation Foundation) and modified by CPCB (Central Pollution Control Board), which depicts the water quality simply and easily for utilities and the general public at large. To maintain uniformity while comparing the WQI across the nation, the NSF-developed WQI has been modified, and CPCB has assigned relative weights. The modified weights are given in Table 7.15, and the equations used to determine CPCB also provide the sub-index values. The formula and classification of Water quality indices for surface and groundwater is given in Table 7.15. The water quality is described upon determining the Water Quality Index for easy understanding and interpretation.

Table 7.15: Modified Weights for Computation of WQI based on DO, FC, pH and BOD

Parameters	Original Weights from	Modified Weights by

	NSF WQI	CPCB
Dissolved oxygen (DO.)	0.17	0.31
Faecal Coliform (FC)	0.15	0.28
pH	0.12	0.22
BOD	0.1	0.19
Total	0.54	1

Table 7.16: Formula and Classification of Water quality indices for Surface and Groundwater

Surface Water Quality	Ground Water Quality
$WQI = \sum_{i=1}^{P} W_i I_i$	$WQI = \sum_{i=1}^{n=9} q_i . W_i$
Where; I_i = sub index for water quality parameter W_i = weight (in terms of importance) associated with water quality parameter P = number of water quality parameters	Where; q_i = quality rating, $= \frac{C_i}{S_i} \times 100$ W_i = the relative weight $= \frac{w_i}{\sum_{i=1}^{n} w_i}$ w_i = the weight of each parameter or relative of each weight C_i = the concentration of each chemical parameter in each water sample in mg/L S_i = the Indian drinking water standard for each chemical parameter in mg/L according to the guidelines of the BIS 10500, (2004-2005)

WQI	Quality classification	Remarks	Color code
Surface Water Quality			
63 - 100	Good to Excellent	Non Polluted	
50 - 63	Medium to Good	Non Polluted	
38 - 50	Bad	Polluted	
38 and less	Bad to Very Bad	Heavily Polluted	
Ground Water Quality			
<50	Excellent	Non Polluted	
50-100	Good Water	Non Polluted	
100-200	Poor Water	Polluted	
200-300	Very Very Poor	Polluted	
>300	Water Unsuitable for drinking	Heavily Polluted	

7.10.1 Advantages of WQI

The following are the advantages of WQI:

- Reduce the number of parameters needed to compare water quality for a specific application
- A single number that represents overall water quality to a particular location and time
- Identification of water quality in terms of time and space dynamics
- The assurance of a water body's safety to users, such as aquatic life habitat and drinking water supplies.
- It is indeed a great way to monitor water quality.
- Allows comparisons between various rivers and sampling sites
- The indices are one of the most straightforward ways to communicate water quality categorization to the general public and decision-makers.
- It breaks down a complex dataset into information that is simple to comprehend and use.
- The index gives a single-value output derived from several parameters and provides important information about water quality that the general public and non-technical population can understand.
- An index is a valuable tool for disseminating information about water quality to the general public and legislative decision-makers.

7.10.2 Limitations of WQI

Despite the many benefits of the WQI, it is beset by specific challenges.

- The Water Quality Index (WQI) is not an absolute standard of pollution or water quality.
- There is a lack of precision and accuracy in the classification method of the significance of parameter evaluation.
- Ineffectiveness in mitigating risk and subjective experience in a complex environmental problem, such as observation incompatibility, uncertainty, and criteria imprecision
- There is a lack of a standardized method for measuring biological parameters in water pollution.
- The transfer of critical environmental data into meaningful information is insufficient.

7.11 Sanitary Survey

The sanitary survey should include the location of all potential and existing health hazards.

The information obtained from a sanitary survey is essential for evaluating the microbiological and chemical water quality data. It is desirable to

i) Identify potential hazards
ii) Determine factors that affect water quality

The sanitary survey is elaborately discussed in Part B, Chapter 8, Drinking water quality monitoring and surveillance in section 8.9.

The following are some factors that should be investigated in a sanitary survey.

7.11.1 Surface Water

i) Proximity to watershed and character of sources of contamination, including industrial wastes, oil field brines, acid waters from mines, sanitary landfills, and agricultural drain waters.

ii) Population and wastewater collection, treatment, and disposal in the watershed

iii) The closeness of sources of faecal pollution to intake of water supply.

iv) Wind direction and velocity data; the drift of pollution; algae/ aquatic growth potential in case of lake or reservoir supplies.

v) Character and quality of raw water.

vi) Protective measures in the watershed to control fishing, boating, car washing, swimming, wading, ice cutting, and permitting animals on shoreline areas

vii) Efficiency and constancy of surveillance on the watershed and around the surface water source

7.11.2 Ground Water

i) Nature, distance, and direction of local sources of pollution including pit latrines, twin pits etc.
ii) Possibility of surface-drainage water entering the supply and of wells becoming flooded.
iii) Drawdown when pumps are in operation, recovery rate when pumps are off.
iv) Methods for protecting the water supply against contamination from wastewater collection, treatment facilities, and waste disposal sites
v) The presence of an unsafe supply nearby and the possibility of cross-connections cause a danger to public health.
vi) Occurrence of geogenic contaminants such as arsenic, fluoride etc.
vii) Disinfection: equipment, supervision, test kits, or other types of laboratory control.

7.11.3 Water Safety Plan (WSP)

"The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management

approach that encompasses all steps in water supply from catchment to consumer." In the Guidelines for Drinking Water Quality, Fourth Edition, published by the World Health Organization (WHO) in 2011, such an approach is termed a 'Water Safety Plan' (WSP).

The purpose of a WSP is to consistently ensure the safety and acceptability of a drinking water supply by adopting principles of preventive management. This is done by eliminating/minimizing potential sources of contamination in the catchment, raw water sources, water treatment plants, distribution network, storage, collection and handling. The concept was drawn from traditional multiple-barrier risk management techniques and the Hazard Analysis at Critical Control Point (HACCP) approach, which has been applied in the food manufacturing industry for several decades. This forms the basis of the development of the WSP approach. WSP can be developed for and applied to a large piped drinking water supplies, small community supplies and household systems.

7.11.4 Need for WSP in India

Urban water supply in India is characterized by intermittent supply, high rates of non-revenue water (NRW) and poor operation and maintenance. Available data infer that water supply coverage in 28 cities ranged from 9.3% to 99.5%; NRW from 6% to 72.9% and continuity of supply varied from 0.5 to 18 hours a day (MoUD 2009). Water samples from only 39 out of 423 cities qualified all three tests conducted to check water quality in the household: turbidity, residual chlorine and thermo-tolerant coliforms (MoSPI 2010). A practical risk management approach is required to resolve these issues of urban water, particularly with respect to inferior water quality. WSP will help in implementing 'Drink from Tap' initiative.

Over the last decade, WSPs have gained acceptance as an essential framework for achieving water quality and health-based targets. Public water utilities in Australia, the United Kingdom, Latin America and the Caribbean, Bangladesh and Uganda have successfully developed and implemented WSPs for their water supply systems. Case studies document increased compliance with drinking water quality regulations, improved watershed management practices, reduced cost of operation and significant cost savings as a result of implementing WSPs. Case studies from India are presented below:

Case Study
Hazard in the catchment and implementation of control measures

Figure 1: Ash Pond in the Catchment of Kanhan River
(Intake well of Kanhan WTP encircled, and change in colour of water due to overflow of breached ash pond in February 2017)

Kanhan river is a major source of water supply to Nagpur, India. A water safety plan was prepared in 2011 and updated in 2014. The ash pond of Koradi/Khaparkheda thermal power plants upstream of the intake point in the catchment was identified as a major hazard. Supernatant/overflow from the ash pond to the intake point in Kanhan River was identified as a major hazardous event in WSP-2011. In contrast, the breach is identified as another hazardous event in WSP-2014 (this was missed in earlier WSP). Although existing control measures, such as a bund around the ash pond, were in place, the residual risk was identified as high. Control measures like coordination among thermal power plant authorities, water suppliers and statutory authorities were also recommended. Another measure was a stoppage of the intake well pumping if there was the slightest evidence of ash in the river water. Water suppliers implemented these measures. There was an accidental breach in the ash pond in February 2017 (Figure 1), and because of the control measures in place, the water supply from Kanhan river could be normalized in a couple of days which otherwise could have taken weeks.

Case Study
Hazard Identification and implementation of control measures in Master Balancing Reservoir

The Master Balancing Reservoir (MBR) of about 2.5-million-litre capacity at

Seminary Hills was in a state of disrepair, and leakage was observed at its inlet valve (Figure 2), which is identified as a major hazard during WSP preparation in 2011. The slabs of the inlet chamber are in need of repair, and the iron reinforcement rods were corroded. Control measures included the replacement of the valve as the risk was very high. The water supplier implemented and replaced the valve (Figure 3).

Figure 2: Leaking valve identified as a very high risk during WSP preparation

Figure 3: Replacement of leaking valve (an example of control measure implementation)

Case Study

Digital Monitoring of 24X7 water supply (drink from tap mission) in Puri City, India

In the Indian context, intermittent water supply systems have several issues, including inefficient and poor design, concerns with maintenance and operation, financial instability, etc. Throughout the decades, urban Odisha was under great difficulty in terms of water supply infrastructure such as Inadequate service coverage, poor drinking water quality, discontinuous supply and high-water losses, and could not keep up with the rate of expanding urbanization. To tackle this problem, Government of Odisha initiated ‘Drink from Tap’ Mission, during October 2020 to provide good quality piped drinking water to approximately 2.5 lakh consumers of Puri city on a 24x7 basis. The objective of the mission was to make available sufficient quantity and good quality water directly from the Tap. Water supply management was achieved through a community partnership known as "Jalsaathi," which provided equitable, sustainable, and people-centered service provisions. It also focused on 100% coverage of both household connections and metering to avoid non-revenue water (NRW) and quality assurance through third-party quality monitoring and laboratories. Jalsathis contributed to a change in the situation on the ground and increased public trust in the water supply system. The "Smart Water Management System under "Drink from Tap Mission" was created and has initially been implemented in 4 pilot zones of Puri City to enable real-time data collecting, analysis, decision making, and public reporting (Figure 4).

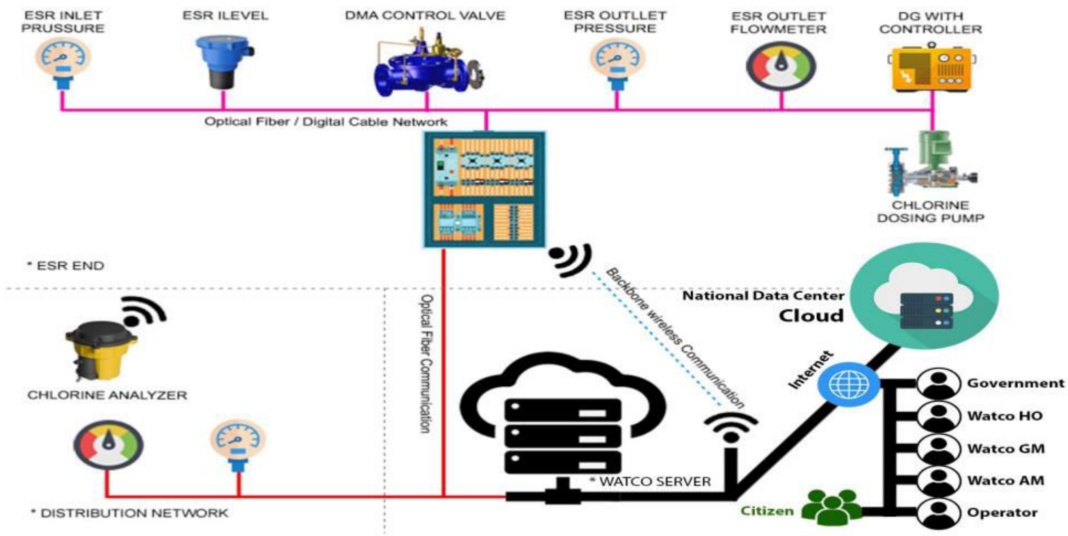

Figure 4: System Architecture of Smart Water Management System in Puri

It aims to build public trust in the public water supply system so that individuals can drink from the tap instead of relying on the current delivery systems. In order to increase customer confidence, real-time online water quality data is broadcast on LCD panels in public areas (Figure 5). For better water quality monitoring of essential parameters and effective incident management, mobile van laboratories have been deployed. The main difficulty has been reducing non-revenue water usage. To reduce leakage, a special cell with a committed crew has been developed. with implementation targeted at NRW reduction. The NRW is now less than 15%, down from a high of 54%. Special Mobile Team have been established for speedy reaction to water supply-related incidents and immediate maintenance of leaks.

Figure 5: Digital display board mounted at public places

The public and communities now have more faith in government because each home has access to high-quality water around-the-clock (24/7), there is no need for household storage, pumping, or treatment, house connections are simple, water is conserved through metering, production costs are reduced, issues and complaints are resolved quickly, and above all, end-to-end services are provided right at the doorsteps.

7.11.5 Preparation and Implementation of Water Safety Plan

It is recommended that ULBs should prepare and implement water safety plans. Preparing and implementing a water safety plan will help us ensure water safety in the water supply system and match International best practices. Several guidance documents are available for the preparation of a water safety plan, which can be referred for preparing a water safety plan for the entire water supply system:

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