सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation

(Picture: Holy River Ganga at Varanasi)

REPORT ON WATER QUALITY HOT-SPOTS IN RIVERS OF INDIA

River Data Compilation-II Directorate,
Planning & Development Organisation
Central Water Commission, New Delhi

November, 2021

रंजन कुमार सिन्हा
अध्यक्ष
तथा पदेन सचिव, भारत सरकार

RANJAN KUMAR SINHA
CHAIRMAN
& *ex-officio* Secretary
to the Government of India

सत्यमेव जयते

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग,
केन्द्रीय जल आयोग
Government of India
Ministry of Jal Shakti
Deptt. of Water Resources,
River Development and Ganga Rejuvenation,
Central Water Commission

FOREWORD

Water in its purest form on the Earth, comes from rain, snow and glacier melting. This water is available first in the form of surface water through Rivers and Lakes. Thus we can say the journey of water on Earth starts in the shape of surface runoff. This surface water forms the lifeline of almost all the human activities as also most of nature's activities. It is the surface water which percolates down and recharges the aquifers and becomes part of Ground Water. Therefore, it can be easily said that contamination of surface water has a cascading effects and has far reaching implications throughout the reach of the river, Ground water aquifers, flora and fauna, and human activities.

Due to the fast pace of industrialisation and urbanization a lot of effluent and sewage is being generated, for a major portion of which there are no effluent treatments. This has resulted in discharge of this sewage in to the rivers untreated or only partially treated. Besides this rampant use of fertilizers and pesticides, open defecation, lack of solid waste management practices also contributes to surface water pollution.

Rivers are our lifeline and we all have the responsibility of preserving it, to make our development and consequently quality of like sustainable. Pollution of rivers does not mean that they are polluted from its source to mouth, but there are stretches in some rivers which are polluted and actions are being taken by the Government to bring these stretches to acceptable conditions.

At present Central Water Commission has been monitoring the water quality of river water at 764 stations on different rivers, all over the India. It all started with the aim of monitoring the water quality parameters for agricultural purposes, but later on many more parameters were added and at present it covers more or less the entire spectrum of water quality. This report attempts to provide the water quality scenario of our rivers based on BIS and CPCB standards. First and second edition of this report were published in August, 2011 & November, 2017. This is the third edition of Hot spots report and it is based on the average values observed during the last 10 years from 2010 to 2020 at 588 out of 764 water quality monitoring Stations of CWC. I hope in future report will be further updated to include more information by inclusion of more water quality stations data, various maps and graphs.

I would like to put on record my appreciation of the initiative taken by Chief Engineer (P&DO) and Director, RDC-II Directorate as well as the dedicated efforts put in by the each officers of directorate in compilation and preparation of this report.

(Ranjan Kumar Sinha)

द्वितीय तल (द), सेवा भवन
आर. के. पुरम, नई दिल्ली-110066
दूरभाष : 011-26715351, 26195415
फैक्स : 011-26108614

2nd Floor (S), Sewa Bhawan
R. K. Puram, New Delhi-110066
Tel. : 011-26715351, 26195415
Fax : 011-26108614
Email : chairman-cwc@nic.in

ACKNOWLEDGMENT

A. GUIDANCE:

1. Shri Reading Shimray, Chief Engineer (Planning & Development Organisation), CWC, New Delhi
2. Shri Pankaj Kumar Sharma, Director (River Data Compilation -2 Dte), CWC, New Delhi
3. Shri Rakesh Kumar Gupta, Deputy Director (River Data Compilation -2 Dte), CWC, New Delhi
4. Shri Devendra Patel, Assistant Director (River Data Compilation -2 Dte), CWC, New Delhi

B. DATA CHECKING AND ITS VALIDATION:

1. All scientific staffs of divisional laboratories of Central Water Commission. Draft Report presented on 29th OCT, 2021 during technical discussion.

C. DATA COMPILATION AND REPORT PREPARATION TEAM:

1. Shri Nitish Kumar Singh, Assistant Research Officer, (River Data Compilation -2 Dte), CWC, New Delhi
2. Dr. Sakshi Sharma, Senior Research Assistant, (River Data Compilation -2 Dte), CWC, New Delhi

CONTENTS

EXECUTIVE SUMMARY

Central Water Commission is a premier technical organization of India in the field of Water Resources and is presently functioning as an attached office of the Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti, Government of India. The Commission is entrusted with the general responsibilities of initiating, coordinating and furthering in consultation of the State Governments concerned, schemes for control, conservation and utilization of water resources throughout the country, for purpose of Flood Control, Irrigation, Navigation, Drinking Water Supply, Water Power Development and Water Quality. Central Water Commission (CWC) is also playing an important role in the water quality monitoring of river water since year 1963. As on January, 2021, CWC is monitoring river water quality at 764 sites located on important rivers across the India.

First edition of "REPORT ON WATER QUALITY HOTSPOTS IN RIVERS OF INDIA" was published in August, 2011. In this report, water quality data observed during ten years (2001-2010) at 371 water quality monitoring stations of CWC was included. This report was based on physical-chemical parameters like pH, Electrical Conductivity (EC), Chloride (Cl^-), Fluoride (F^-), Iron (Fe), Nitrate (NO_3^-), Sulphate (SO_4^{-2}), Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD).

In November 2017, a report on "WATER QUALITY HOTSPOTS IN RIVERS OF INDIA OTHER THAN GANGA, INDUS & BRAHMAPUTRA BASIN" was published. In this report, only Biochemical Oxygen Demand (BOD) parameter was considered for study, which is the most common parameter that measures of pollution level in terms of organic material present in river water and it defines the health of the river also. The study was done on BOD data from 2012-2017 periods of Indian river basins except for Ganga, Brahmaputra, and Indus basins at 429 water quality stations of CWC.This report was prepared for assessing the capacity of proposed STPs.

This third edition of report on "WATER QUALITY HOTSPOTS IN RIVERS OF INDIA" is based on the data of 10 nos. of water quality parameters observed during 2010-2020 at 588 water quality monitoring stations out of 764 stations of CWC. The eight parameters: pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Total Coliform (TC), Free Ammonia (NH_3-N), Electrical Conductivity (EC), Boron (B),Sodium Adsorption Ratio (SAR) are required for classification based on uses defined by CPCB. Fluoride (F^-) and Sulphate (SO_4^{-2}) are among the parameters of BIS specification for drinking water (BIS: 10500:2012).These parameters are important constituents defining the quality of river water in surface water. Therefore, presence of these parameters in river water beyond the permissible limit in the absence of alternate source has been considered as river water quality hot spots. After analysis of water quality data (2010-2020),summary of the report, for each parameter wise is given below:

1. pH

During the **monsoon season**, average value of pH greater than 8.5 was observed at single water quality station located in Tamil Nadu (Noyyal) and pH average value less than 6.5 observed at water quality station located in Kerala (Thodupuzha). In non-**monsoon season** average values of pH greater than 8.5 were observed at two (2) water quality stations located in Tamil Nadu (Noyyal) and Gujarat (Banas).

2. Electrical Conductivity (EC)

During the **monsoon season**, average values of EC greater than 2250 µS/cm was observed at one (1) water quality station located in Tamil Nadu (Noyyal) and in **non-monsoon season**, average values of EC greater than 2250 µS/cm were observed at three (3) water quality stations located in Tamil Nadu (Noyyal,) and Gujarat (Sabarmati, Shetrunji).

3. Ammonia as N (NH_3-N)

During the **monsoon season**, average values of Ammonia greater than 1.2 mg/l were observed at (6) six water quality stations located in Delhi (Yamuna), Gujarat (Sabarmati), Tamil Nadu (Ponnaiyar), and Uttar Pradesh (Yamuna) and in **non-monsoon season** the average values of Ammonia greater than 1.2 mg/l were observed at (8) eight water quality stations located in Delhi (Yamuna), Gujarat (Sabarmati, Dhadar), Tamil Nadu (Ponnaiyar), and Uttar Pradesh (Yamuna)

4. Boron (B)

During the **monsoon** and **non-monsoon seasons**, average values of Boron of all water quality stations were observed within the permissible limit of Class E of CPCB designated best uses of Water.

5. Fluoride (F^-)

During the **monsoon** and **non-monsoon seasons**, average values of Fluoride of all water quality stations were observed within the permissible limit of BIS drinking water standard (BIS:10500:2012).

6. Sulphate (SO_4^{-2})

During the **monsoon** and **non-monsoon seasons**, average values of Sulphate of all water quality stations were observed within the permissible limit of BIS drinking water standard (BIS:10500:2012).

7. Sodium Adsorption Ratio (SAR)

During the **monsoon** and **non-monsoon seasons**, average values of Sulphate of all water quality stations were observed within the permissible limit of Class E of CPCB designated best uses of Water.

8. Dissolved Oxygen (DO)

During the **monsoon season**, average value of Dissolved Oxygen (DO) below 5.0 mg/l were observed at fifty-four(54) water quality stations located in Tami Nadu, Bihar, Uttar Pradesh, Madhya Pradesh, Jharkhand, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Telangana, Himachal Pradesh, Karnataka, Sikkim, Assam, Delhi, Uttarakhand, Haryana, Kerala, Chhattisgarh and West Bengal and in **non-monsoon season**, average value Dissolved Oxygen (DO) below 5.0 mg/l were observed at twenty-six (26) water quality stations located in Tamil Nadu, Uttar Pradesh, Himachal Pradesh, Jharkhand, Odisha, Gujarat, Maharashtra, West Bengal, Karnataka, Sikkim, Assam, Delhi and Haryana.

9. Biochemical Oxygen Demand (BOD)

During the **monsoon season**, average value of Biochemical Oxygen Demand (BOD) more than 3.0 mg/l were observed at seventy-three(73) water quality stations located in Tamil Nadu, Rajasthan, Jharkhand, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, Telangana, West Bengal, Bihar, Odisha, Gujarat, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh and in **non-monsoon season**, average value of Biochemical Oxygen Demand (BOD) more than 3.0 mg/l were observed at sixty-seven (67) water quality stations located in Tamil Nadu, Rajasthan, Jharkhand, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar, Odisha, Gujarat, Karnataka, Delhi, Haryana and Chhattisgarh.

10. Total Coliforms (TC)

During the **monsoon season**, the average value of Total Coliforms (TC) more than 500 MPN/100 ml were observed at two hundred thirty-eight (238) water quality stations located in Rajasthan, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Telangana, Himachal Pradesh, Gujarat, Himachal Pradesh, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh and Tamil Nadu and in **non-monsoon season**, average value of Total Coliforms (TC) of more than 500 MPN /100 ml were observed at two hundred thirty-three (233) water quality stations located in Andhra Pradesh, Telangana, Himachal Pradesh, Gujarat, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh, Tamil Nadu, Rajasthan, Uttarakhand, Madhya Pradesh, Uttar Pradesh and Maharashtra.

CHAPTER - 1

1. Introduction

1.1 Water Quality & its Importance

"**Water quality**" term in general can be defined as suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water. It is most frequently used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be assessed. The most common standards used to monitor and assess water quality convey the health of ecosystems, safety of human contact; extend of water pollution and condition of drinking water. Water quality has a significant impact on water supply and oftentimes determines supply options. The parameters for water quality are determined by the intended use. Work in the area of water quality tends to be focused on water that is treated for potability, industrial/domestic use, or restoration (of an environment/ecosystem, generally for health of human/aquatic life).

The composition of surface and underground waters is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels. Large natural variations in water quality may, therefore, be observed even where only a single watercourse is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities, such as the discharge of domestic, industrial, urban and other wastewaters into the watercourse (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin. Water quality is affected by a wide range of natural influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available.

The water quality of the Indian rivers has a considerable importance as these waters are used for various purposes such as: drinking domestic and residential water supplies, agriculture (irrigation), hydroelectric power plants, tourism, recreation, and other human or economic ways to use water.

The river water quality monitoring is most essential aspect of restoring the water quality. One of the main objectives of the river water quality monitoring is to assess the suitability of river water for drinking purposes, irrigation, out- door bathing and Propagation of wildlife, fisheries. The physical and chemical quality of river water is important in deciding its suitability for drinking purposes. As such the suitability of river water for potable uses with regard to its chemical quality has to be deciphered and defined on the basis of some vital characteristics of the water. Bureau of Indian Standards (BIS) formally known as Indian Standard Institute (ISI) vide its document IS 10500: 2012 has recommended the quality standards for drinking water and these have been used for finding the suitability of river water. On this basis of classification, the natural river water of India has been categorized as desirable, permissible and unfit for human consumption.

Monitoring and assessment of water quality are essential for understanding the intensity and scope of water quality challenge. Unlike water quantity, monitoring water quality is not a straightforward and simple process. Managing water quality of river is a rather complex task. Further various manmade and natural reasons may likely to increase complexity of managing the water quality of river in upcoming future. One of the main reasons is that the number of new chemicals that are being introduced and used each year in agriculture, chemical industries, pharmaceutical industries etc. The quantity of these new chemicals is very large amount and most of them are not easy to quantify due to certain limitations. It is very difficult or sometimes not possible to reliably assess the health and environmental consequences of the newly chemicals that have been introduced in recent decades and the new ones that are likely to be introduced in the coming years.

1.2 Water Quality Hot Spots

As per Guidelines Water Quality Monitoring, 2017 "**Hotspot**" define as location/site where concentration of a particular parameter is beyond the permissible limits as prescribed water quality standard in the BIS code IS 10500:2012. In this report "Hotspot" is defined based on the location/site where concentration of a particular parameter is beyond the permissible limits as prescribed drinking water quality standard in the BIS code IS 10500:2012 & "Designated Best Use Water Quality Criteria" by CPCB. This report includes data of 588 water quality stations of CWC covering important rivers of India. The report is based on the average values of monsoon and non-monsoon seasons observed during the last 10 years at CWC water quality monitoring stations from year 2010 to 2020. The river water quality has been assessed on 10nos of parameters: pH, Electrical Conductivity (EC), Fluoride (F^-), Ammonia as N (NH_3-N), Sulphate (SO_4^{-2}), Boron (B), Sodium Adsorption Ratio (SAR), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Total Coliform (TC). They are the main constituents defining the quality of river water in surface water. Therefore, presence of these parameters in river water beyond the permissible limit in the absence of alternate source has been considered as river water quality hotspots.

CHAPTER -2

2. Indian Water Resources Scenario

2.1 River Basin of India

CWC's under its publication No. 30/88 "Water Resources of India", April 1988 has standardized the river basins of India. The country was divided into 20 river basins comprising of 12 major basins and 8composite river basins.

The 12 major basins are: (1) Indus; (2) Ganga-Brahmaputra-Meghna; (3) Godavari; (4) Krishna; (5) Cauvery; (6) Mahanadi; (7) Pennar; (8) Brahmani-Baitarani; (9) Sabarmati; (10) Mahi; (11) Narmada and (12) Tapi. Each of these basins is having a drainage area exceeding 20000 sq.km.

The 8 composite river basins are:

(1) Subarnarekha – combining Subarnarekha and other small rivers between Subarnarekha and Baitarni.

(2) East flowing rivers between Mahanadi and Pennar.

(3) East flowing rivers between Pennar and Kanyakumari.

(4) Area of Inland Drainage in Rajasthan Desert.

(5) West flowing rivers of Kutch and Saurashtra including Luni;

(6) West flowing rivers from Tapi to Tadri.

(7) West flowing rivers from Tadri to Kanyakumari.

(8) Minor rivers draining into Myanmar (Burma) and Bangladesh.

2.2 Indian River System

The Indian River Systems can be divided into four categories:- the Himalayan, the Rivers traversing the Deccan Plateau, the Coastal and those in the inland drainage basin (Figure 1).

Figure 1: Indian River Basins (Source:River Basin Atlas of India, October,2012)

The Himalayan Rivers are perennial as they are fed by melting glaciers every summer. During the monsoon, these Rivers assume alarming proportions. Swollen with rainwater, they often inundate villages and towns in their path. The Gangetic basin is the largest River system in India, draining almost a quarter of the country.

The Rivers of the Indian peninsular plateau are mainly fed by rain. During summer, their flow is greatly reduced, and some of the tributaries even dry up, only to be revived in the monsoon. The Godavari basin in the peninsula is the largest in the country, spanning an area of almost one-tenth of the country. The Rivers Narmada and Tapi flow almost parallel to each other but empty themselves in opposite directions. The two Rivers make the valley rich in alluvial soil and teak forests cover much of the land. While coastal River's gush down the peaks of the Western Ghats into the Arabian Sea in torrents during the rains, their flow slow down after the monsoon. Streams like the Sambhar in western Rajasthan are mainly seasonal in character, draining into the inland basins and salt lakes. In the Rann of Kutch, the only River that flows through the salt desert is the Luni.

2.2.1 Indus system

This comprises the river Indus and its tributaries like the Jhelum, Chenab, Ravi, Beas and Sutlej. These originate in the North and generally flow in a West or South-West direction to eventually flow into Arabian Sea through Pakistan.

2.2.2 Ganga-Brahmaputra-Meghna system

The main river Ganga and its tributaries like the Yamuna, Sone, Gandak, Kosi and many others; similarly, main rivers Brahmaputra, Meghna and their tributaries. All these eventually flow into Bay of Bengal, through Bangladesh. Some of the tributaries of these rivers are larger than other independent rivers. e.g. Yamuna, a tributary of Ganga, has a larger catchment area than the Tapi, a small peninsula river.

2.2.3 Rivers of Rajasthan and Gujarat

Mahi, Sabarmati, Luni etc. These are rivers of arid regions, they carry relatively little flow, some of them flow to Arabian Sea through Gujarat while some are land-locked and their flow is lost through percolation and evaporation in the vast arid regions.

2.2.4 East Flowing Peninsular Rivers

The important members of this group are: Damodar, Mahanadi, Brahmani, Baitarani, Subarnarekha, Krishna, Godavari and Cauvery. They all flow into Bay of Bengal at various places along the Eastern Coast of India.

2.2.5 West Flowing Peninsular Rivers

Narmada and Tapi rivers originate in Central India and flow in a western direction to meet Arabian Sea south of Gujarat.

2.2.6 Western Coast Rivers

There are large number of rivers in the Western Coast - i.e. coastal Maharashtra and Karnataka, and entire Kerala. These rivers are small in length but carry a significant amount of water due to very high rainfall in Western Ghats. They drain only 3% of the India’s land area but carry 11% of India’s water resources

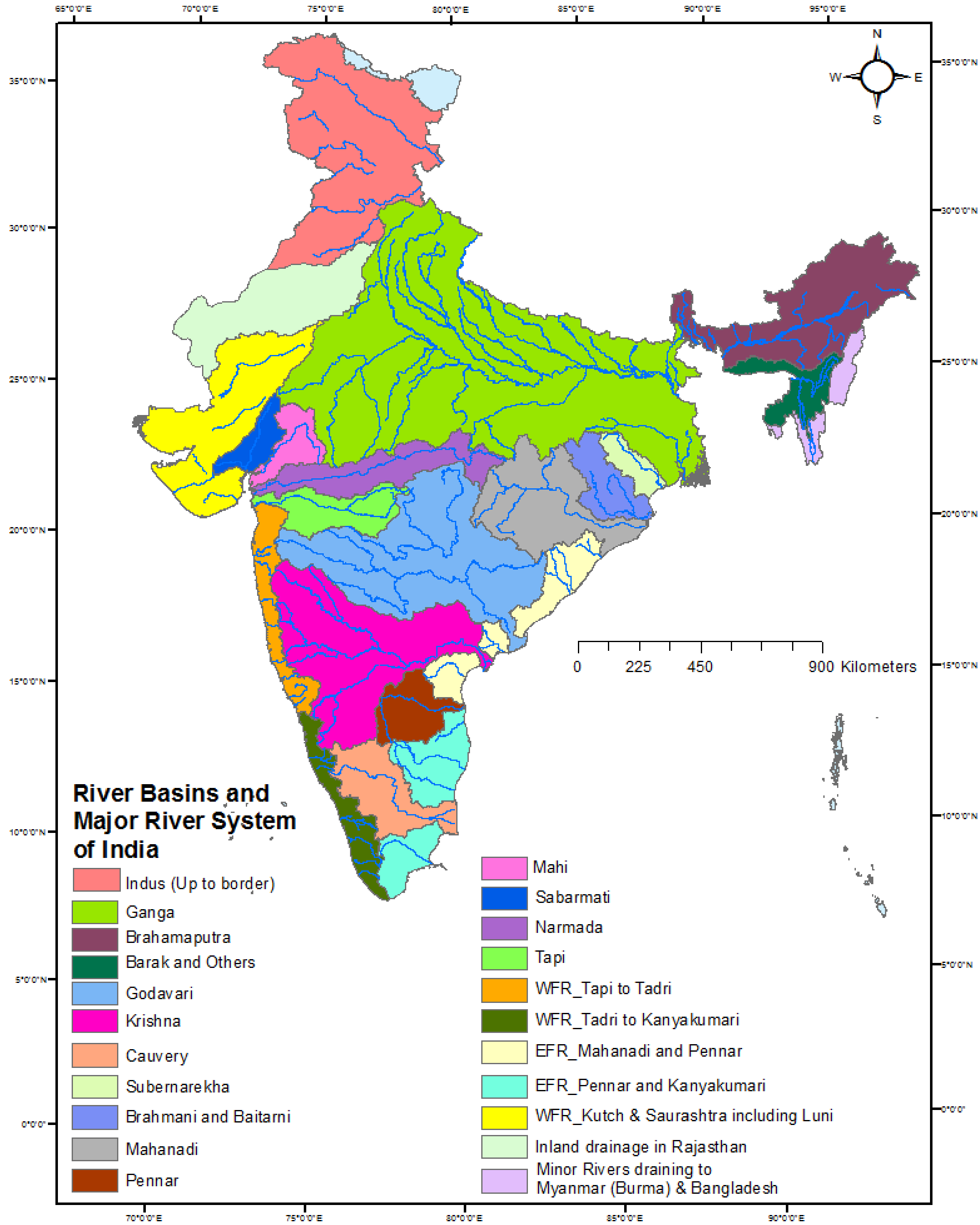


Figure.2 River Basins and Major River Systems of India

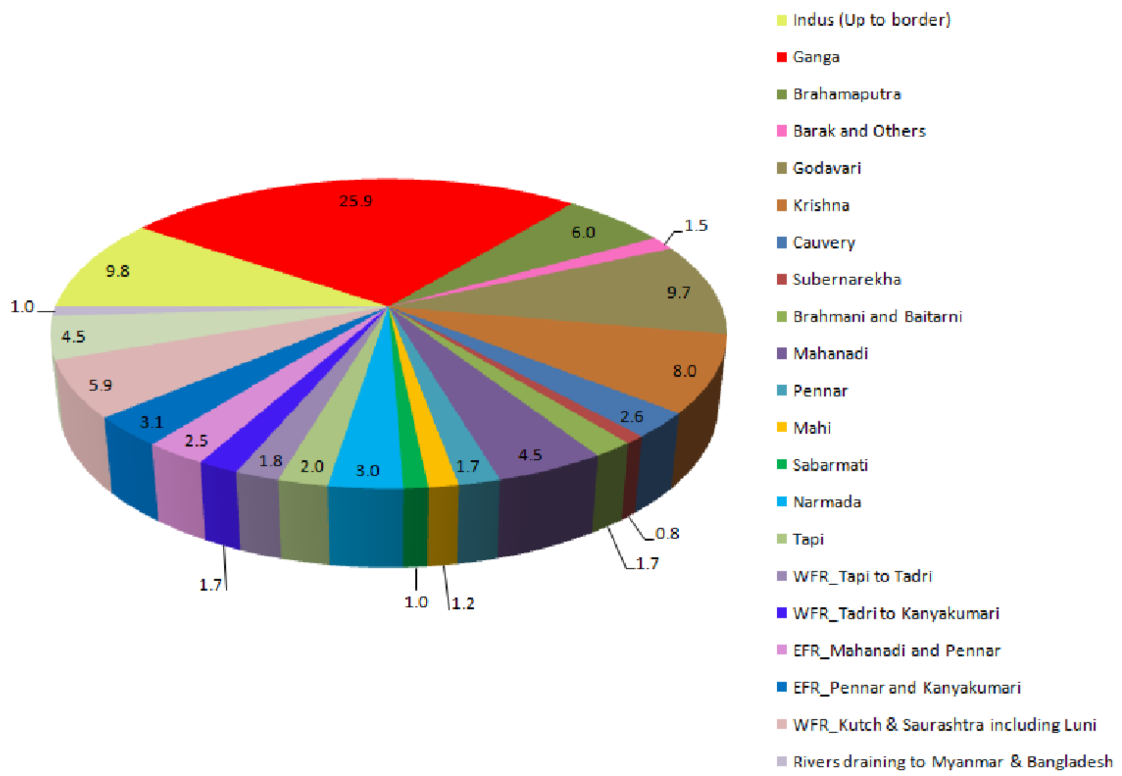


Figure.3 Percentage of geographical area in each basin

Sources:

1. *CWC publication "Reassessment of Water Availability in India using Space inputs" June 2019 from Basin Planning & Management Organization, CWC, New Delhi. India WRIS:*
2. *India Water Resources Information System*

The more details may be assessed by clicking the links given below: (http://old.cwc.gov.in/main/downloads/ReassessmentMainReport.pdf)&(https://indiawris.gov.in/wris)

CHAPTER – 3

3. Hydrochemistry

Hydrochemistry is an interdisciplinary science that deals with the chemistry of water in the natural environment. Professional fields such as chemical hydrology, aqueous chemistry, hydrochemistry, water chemistry and hydro-geochemistry are all more or less synonyms. The classical use of chemical characteristics in chemical hydrology is to provide information about the regional distribution of water qualities.

Main areas of work are the chemical characterization of the water (which is highly dependent on the regional and geochemical event units), the determination of water-chemical parameters and the assessment of anthropogenic and other influences on the water quality.

At the same time, hydrochemistry can also be of immense help in yielding information about the environment through which water has circulated. It is essential to study the entire system like atmospheric water (rainwater), surface water and ground water simultaneously in evaluating their hydrochemistry and pollution effect.

3.1 Chemistry of Rainwater

The atmosphere is composed of water vapors, dust particles and various gaseous components such as N_2, O_2, CO_2, CH_4, CO, SO_2, NO_2 etc. Pollutants in the atmosphere can be transported through long distances by the wind. These pollutants are mostly washed down by precipitation and partly as dry fall out. Composition of rainwater is determined by the source of water vapors and by the ion, which are taken up during transport through the atmosphere. In general, chemical composition of rainwater shows that rainwater is slightly mineralized with specific electrical conductance (EC) generally below 50 µS/cm, chloride (Cl^-) below 5 mg/l and HCO_3 below 10 mg/l. Among the cations, concentration of Ca, Mg, Na & K vary considerably but the total cations content is generally below 15 mg/l except in samples contaminated with dust. The concentration of sulphates and nitrates in rainwater may be high in areas near industrial hubs.

3.2 Chemistry of Surface Water

Surface water chemistry is a direct indicator of the effects of acid rain on water bodies. Networks that monitor surface water chemistry over long time periods provide valuable information on aquatic ecosystem health and how water bodies respond to changes in acid-causing emissions.

Surface water is found extremely variable in its chemical composition due to variations in relative contributions of ground water and surface water sources. The possible causes and consequences of changes in climate, land use and industrial, urban and agricultural pollution can be expected to be indicated by changes in the physical and chemical composition of water in rivers and streams. The mineral content in river water usually bears an inverse relationship to discharge. The mineral content of river water tends to increase from source to mouth, although the increase may not be continuous or uniform. Other factors like discharge of city wastewater, industrial waste and mixing of waters can also affect the nature and concentration of minerals in surface water. Among anions, bicarbonates are the most important and constitute over 50% of the total anions in terms of milli equivalent per litre (meq/l). In case of cations, alkaline earths or normally calcium predominates but with increasing salinity the hydro chemical facies tends to change to mixed cations or even to Na-HCO_3 type.

3.3 Chemistry of Ground Water

The downward percolating water is not inactive, and it is enriched in CO_2. It can also act as a strong weathering agent apart from general solution effect. Consequently, the chemical composition of ground water will vary depending upon several factors like frequency of rain, which will leach out the salts, time of stay of rain water in the root-zone and intermediate zone, presence of organic matter etc. It may also be pointed out that the water front does not move in a uniform manner as the soil strata are generally quite heterogeneous. The movement of percolating water through larger pores is much more rapid than through the finer pores. The overall effect of all these factors is that the composition of ground water varies from time to time and from place to place.

Before reaching the saturated zone, percolating water is charged with oxygen and carbon dioxide and is most aggressive in the initial stages. This water gradually loses its aggressiveness, as free CO_2 associated with the percolating water gets gradually exhausted through interaction of water with minerals.

Before reaching the saturated zone, percolating water is charged with oxygen and carbon dioxide and is most aggressive in the initial stages. This water gradually loses its aggressiveness, as free CO_2 associated with the percolating water gets gradually exhausted through interaction of water with minerals.

$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

$$H^+ + \text{Feldspar} + H_2O \longrightarrow \text{Clay} + H_4SiO_4 + \text{Cation}$$

The oxygen present in this water is used for the oxidation of organic matter that subsequently generates CO_2 to form H_2CO_3. This process goes on until oxygen is fully consumed.

$$\underset{\text{(Organic matter)}}{CH_2O} + O_2 = CO_2 + H_2O$$

Apart from these reactions, there are several other reactions including microbiological mediated reactions, which tend to alter the chemical composition of the percolating water. For example, the bicarbonate present in most waters is derived mostly from CO_2 that has been extracted from the air and liberated in the soil through biochemical activity.

Some rocks serve as sources of chloride and sulphate through direct solution. The circulation of sulphur, however, may be greatly influenced by biologically mediated oxidation and reduction reactions. Chloride circulation may be a significant factor influencing the anion content in natural water.

4. River Water Pollution

River Water pollution occurs when pollutants are discharged directly or indirectly into rivers without adequate treatment of harmful compounds. River Water pollution affects humans, plants and organisms living in these rivers. Water pollutants are damaging not only the individual species and populations, but also the natural biological communities. Moving water dilutes and decomposes pollutants more rapidly than standing water.

The primary reasons for river water pollution are because of three major sources of pollution i.e. industry, agriculture and domestic situated along the rivers. Industries and cities have been located along rivers historically, because rivers provide transportation and have traditionally been a convenient place to discharge waste. Agricultural activities have tended to be concentrated near rivers, because river floodplains are exceptionally fertile due to the many nutrients that are deposited in the soil when the river overflows.

4.1 Sources of Pollution

(A) Point source pollution

Point source pollution refers to the pollution entering the water way through a discrete conveyance like pipes, channels etc., from source such as industry.

(B) Non- point source pollution

Non-point source pollution refers to the pollution that does not enter the water way through a discrete source but accumulative in nature. The pollutants are collected in small amounts from over a large area. These pollutants are:

1. Natural contaminants such as dry leaves, dead insects and animals, bird droppings etc.
2. Agricultural contaminants such as agricultural runoff containing fertilizers, pesticides etc. The fertilizers and pesticides can be washed through the soil by rain, to end up in rivers.
3. Industrial contaminants such as industrial runoff containing industrial wastes.
4. Microbial contaminants such as fecal & Total Coliform.
5. Human added contaminants such as organic matter through domestic discharges.

If large amounts of fertilizers or farm waste drain into a river the concentration of nitrate and phosphate in the water increases considerably. Algae use these substances to grow and multiply rapidly turning the water green. This massive growth of algae, called eutrophication, leads to pollution. When the algae die they are broken down by the action of the bacteria which quickly multiply, using up all the oxygen in the water which leads to the death of many animals.

Chemical waste products from industries are discharged in to rivers. Such pollutants include cyanide, zinc, lead, copper, cadmium and mercury. These substances may enter the water in such high concentrations that fish and other animals are killed immediately. Sometimes the pollutants enter a food chain and accumulate until they reach toxic levels, eventually killing birds, fish and mammals.

Factories use water from rivers to power machinery or to cool down machinery. Dirty water containing chemicals is put back in to the rivers. Water used for cooling is warmer than the river itself. Raising the temperature of the water, lowers the level of dissolved oxygen and upsets the balance of life in the water. People sometimes carelessly throw rubbish directly into rivers.

4.2 Effects of Environmental factors on River water quality

River water quality is highly variable by nature due to environmental conditions such as basin lithology, vegetation and climate. In small watersheds spatial variations extend over orders of magnitude for most major elements and nutrients, while this variability is an order of magnitude lower for major basins. Standard river water for use as reference is therefore not applicable. As a consequence, natural waters can possibly be unfit for various human uses, even including drinking.

There are three major natural sources of dissolved and soluble matter carried by rivers: the atmospheric inputs of material, the degradation of terrestrial organic matter and the weathering of surface rocks. These substances generally transit through soil and porous rocks and finally reach the rivers. On their way, they are affected by numerous processes such as recycling in terrestrial biota, recycling and storage in soils, exchange between dissolved and particulate matter, loss of volatile substances to the atmosphere, production and degradation of aquatic plants within rivers and lakes etc. As a result of these multiple sources and pathways, the concentrations of elements and compounds found in rivers depend on physical factors (climate, relief), chemical factors (solubility of minerals) and biological factors (uptake by vegetation, degradation by bacteria). The most important environmental factors controlling river chemistry are:

- Occurrence of highly soluble (halite, gypsum) or easily weathered (calcite, dolomite, pyrite, olivine) minerals.

- Distance to the marine environment which controls the exponential decrease of ocean aerosols input to land (Na+, CI-, SO- , and Mg2+).
- Aridity (precipitation/runoff ratio) which determines the concentration of dissolved substances resulting from the two previous processes.
- Terrestrial primary productivity which governs the release of nutrients (C, N, Si, K).
- Ambient temperature which controls, together with biological soil activity, the weathering reaction kinetics.

Uplift rates (tectonism relief) Stream quality of unpolluted waters (basins without any direct pollution sources such as dwellings, roads, farming, mining etc.

CHAPTER-5

5.1 CWC Water Quality Network

CWC has been playing a important role in the water quality monitoring of river water since year 1963 and at present, CWC is monitoring river water quality at 764 sites, which includes 652 key hydrological observation stations covering all the important river basins of India and water quality samples are being collected from 112 water quality sampling stations. Details may be seen at Figure 4 and Table 1.

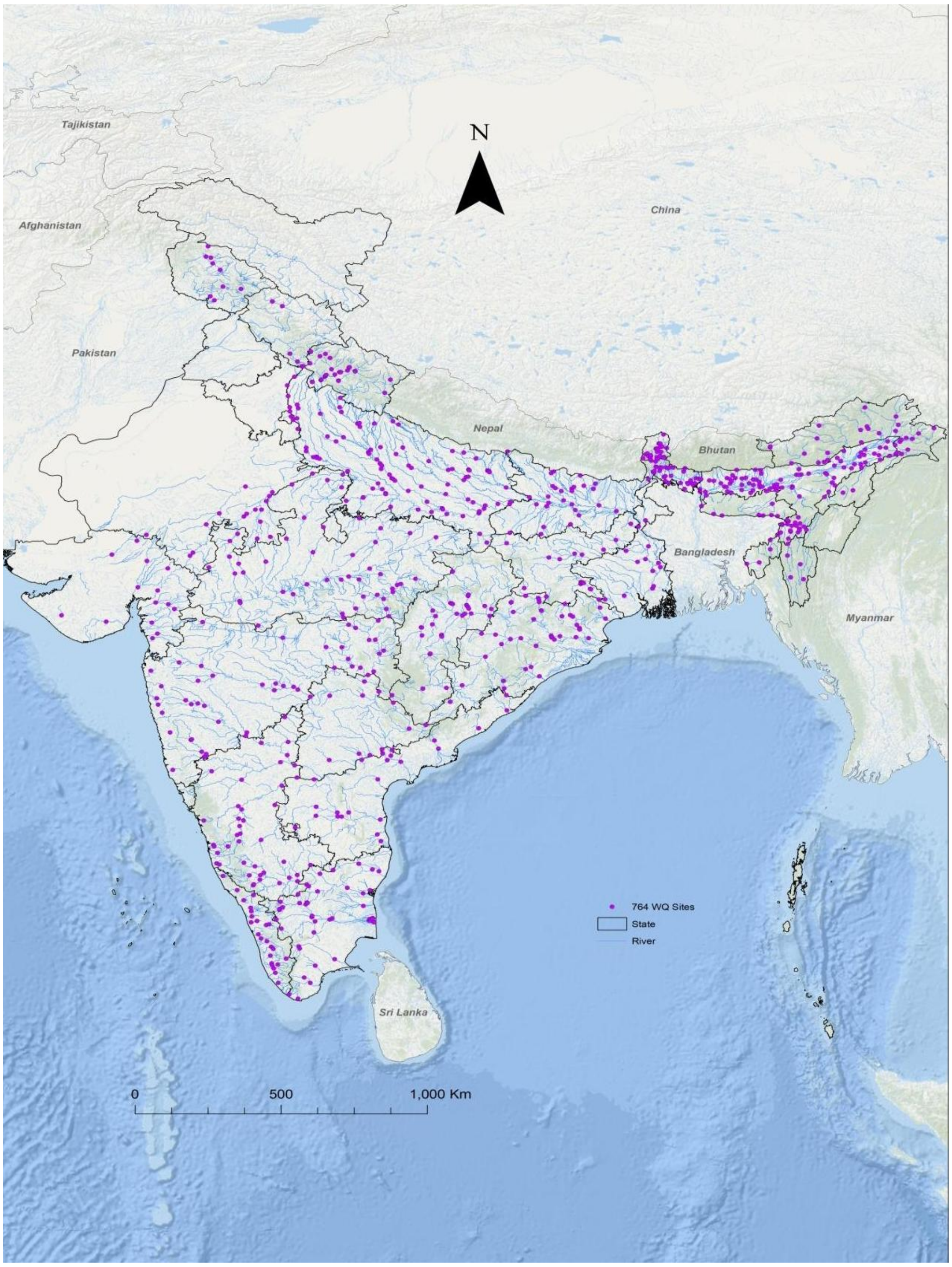


Figure 4: Water quality network of CWC

Table 1: Organisation–wise distribution of Water Quality Sites of CWC

Organisation	GDQ	GDSQ	GQ	WQSS	Grand Total
B&OBO, Shillong	7	21	8		36
BBO,Guwahati	28	24	59		111
C&SRO, Coimbatore	35	53			88
IBO, Chandigarh	3	8			11
KGBO, Hyderabad	21	34	6		61
LGBO, Patna	8	33	2	6	49
MTBO, Gandhinagar	6	15		1	22
MCO, Nagpur	4	20	1		25
MERO, Bhubneshwar	2	43	1	43	89
MSO, , Bengaluru	9	19			28
NBO, Bhopal	7	8	1		16
T&BDBO,Kolkata	12	32	18	22	84
UGBO, Lucknow	6	31	1	33	71
YBO , New Delhi	24	37	5	7	73
Grand Total	**172**	**378**	**102**	**112**	**764**

Note: GQ = Gauge & Water Quality; GDQ= Gauge, discharge & Water Quality; GDSQ= Gauge, Discharge, Sediment & Water Quality, WQSS = Water Quality Sampling Station

5.2 Classification of Water Quality Monitoring Stations

In accordance with the definition given in the "Uniform Protocol on Water Quality Monitoring Notification" 2005, subsequently updated during 2017, available at CPCB website (http://cpcb.nic.in/wqm/Guidelines_Water_Quality_Monitoring_2017.pdf) water quality monitoring stations are classified as follows:

•Baseline stations

Baseline stations mean the monitoring location where there is no influence of human activities on water quality.

•Trend stations

"Trend station" means the monitoring location designed to show how a particular point on a watercourse varies over time due, normally, to the influence of man's activities.

•Flux stations or Impact stations

"Flux stations or Impact stations" means the location for measuring the mass of particular pollutant on Main River stem for measuring the extent of pollution due to human interference or geological feature at any point of time and is necessary for measuring impact of pollution control measures adopted.

The details of basin-wise and state-wise water quality stations monitored by Central Water Commission as on January, 2021 may be seen at below Table 2 & 3 respectively. The depiction of sites on map basin-wise and state wise are also shown and may been in Figure 5 & 6 respectively.

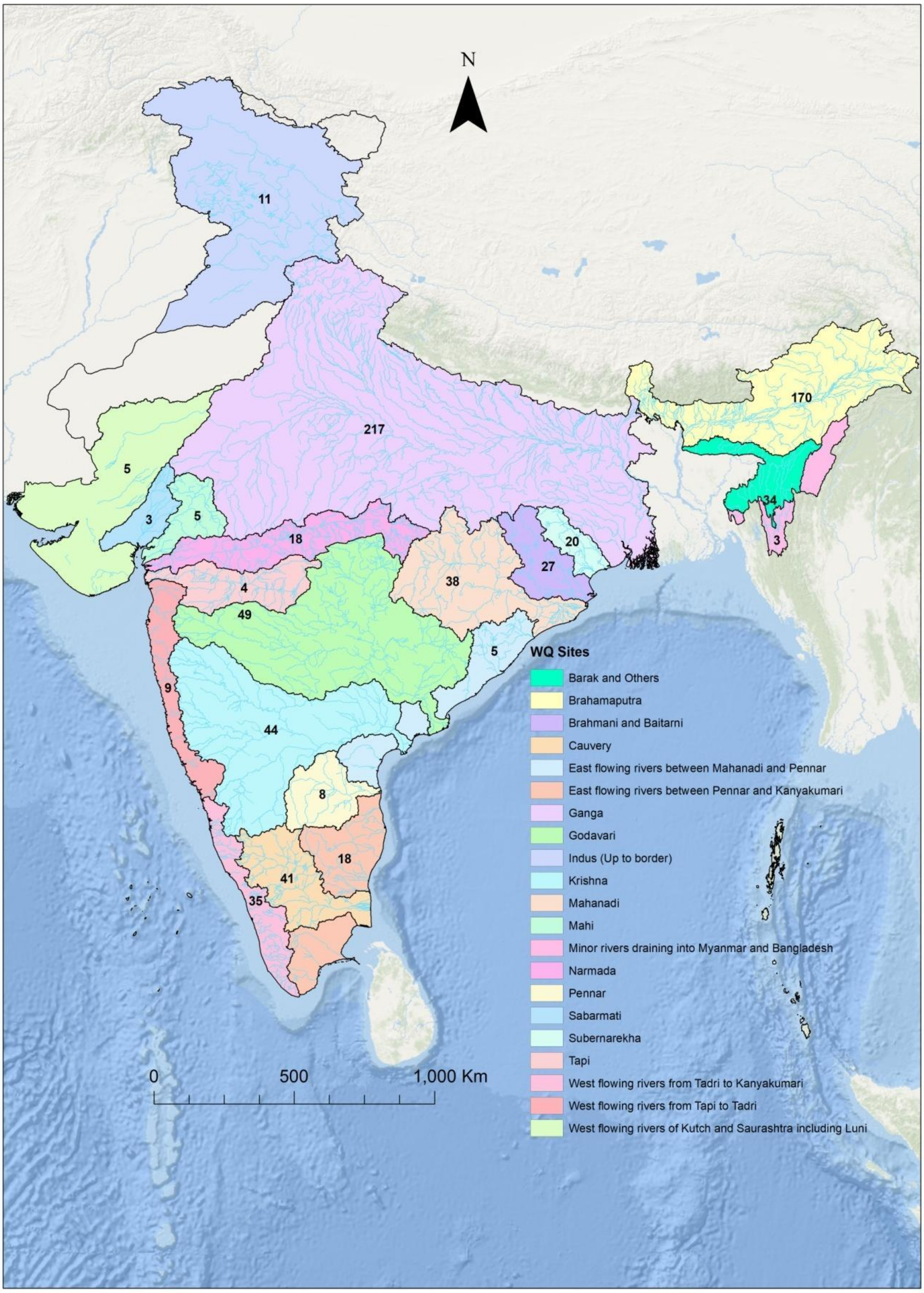


Figure 5: Map showing the basin-wise no. of water quality sites monitored by CWC.

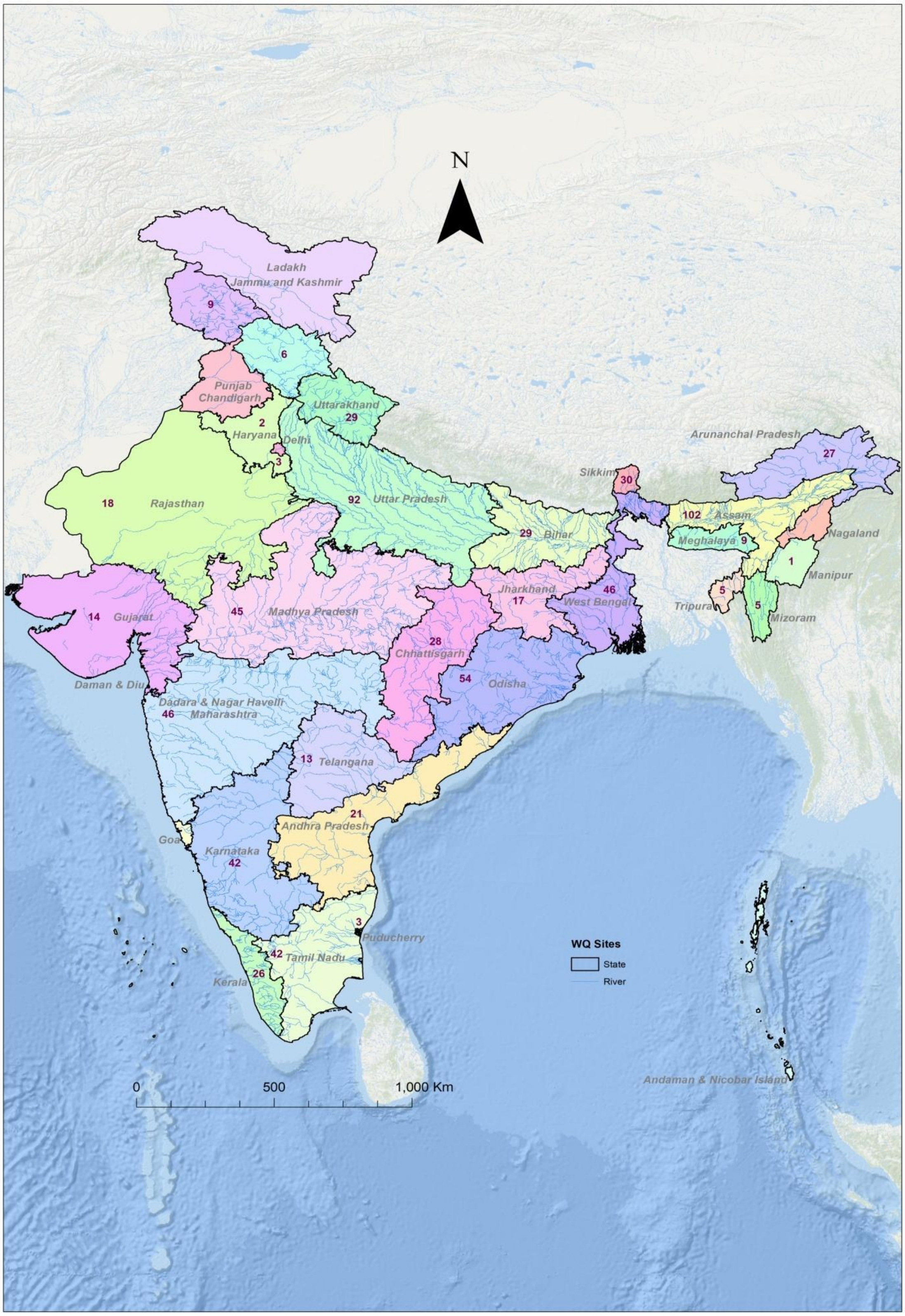


Figure 6: Map showing the state-wise no. of water quality sites monitored by CWC.

Table 2: Basin–wise distribution of Water Quality Sites of CWC

S.No.	Basin	WQ Sites
1	Brahamputra, Barak & Meghana Basin	204
2	Brahmani-baitarni Basin	27
3	Cauvery Basin	41
4	EFR b/w Mahanadi-Pennar	10
5	EFR b/w Pennar-Kanyakumari	18
6	Ganga Basin	217
7	Godavari Basin	49
8	Indus Basin	11
9	Krishna Basin	44
10	Mahanadi Basin	38
11	Mahi Basin	5
12	Minor rivers draining into Myanmar and Bangladesh	3
13	Narmada basin	18
14	Pennar Basin	8
15	Sabarmati basin	3
16	Subernarekha	15
17	Tapi Basin	4
18	WFR from Tadri to Kanyakumari	35
19	WFR from Tapi to Tadri	9
20	WFR of Kutchh, Saurashtra including Luni	5
Grand Total		**764**

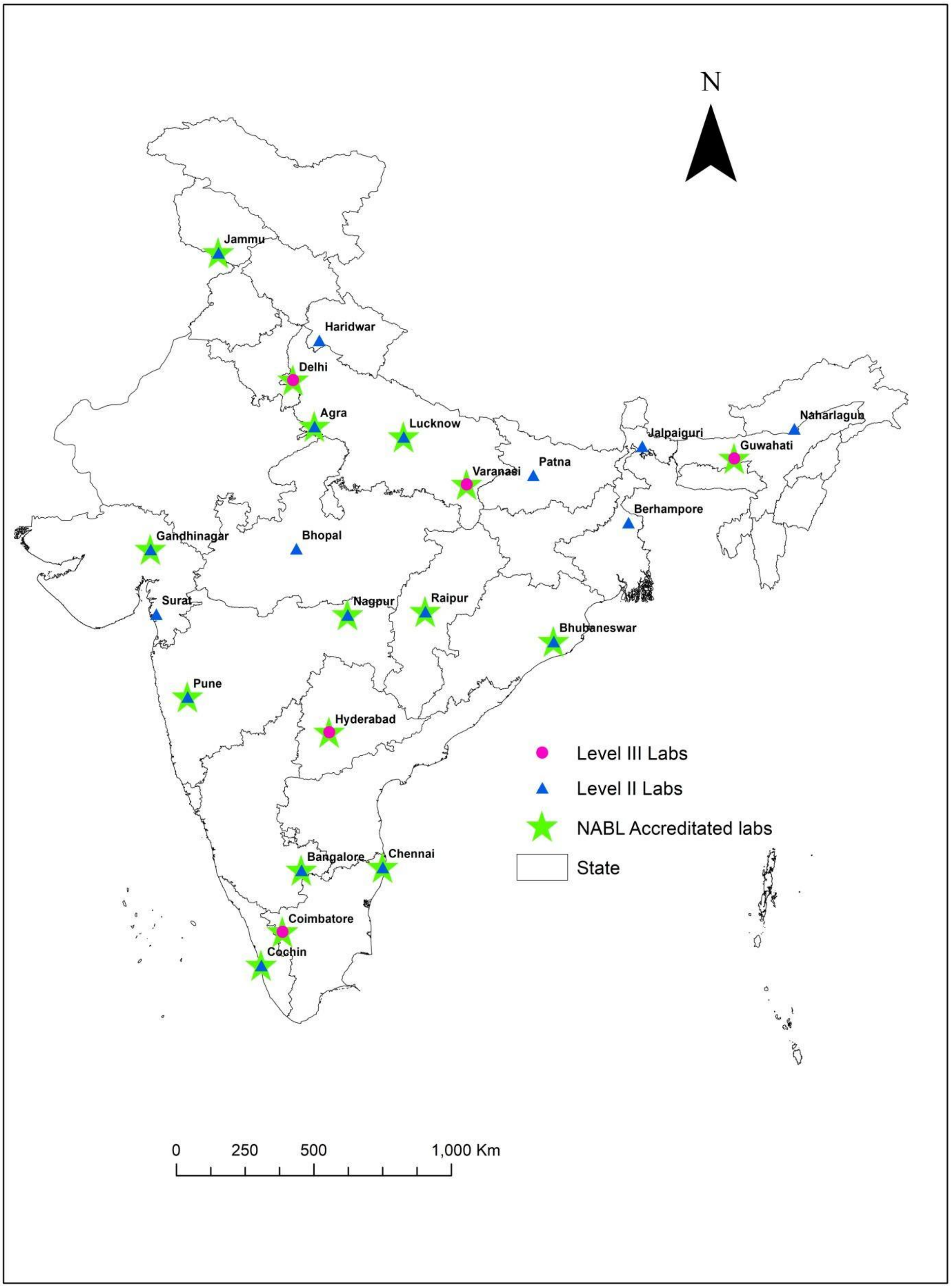
Table 3: State–wise distribution of Water Quality Sites of CWC

S.No.	State/UT	WQ Sites
1	Andhra Pradesh	21
2	Arunachal Pradesh	27
3	Assam	102
4	Bihar	29
5	Chhattisgarh	28
6	Delhi	3
7	Gujarat	14
8	Haryana	2
9	Himachal Pradesh	6
10	Jammu & Kashmir	9
11	Jharkhand	17
12	Karnataka	42
13	Kerala	26
14	Madhya Pradesh	45
15	Maharashtra	46
16	Manipur	1
17	Meghalaya	9
18	Mizoram	5
19	Odisha	54
20	Pondicherry	3
21	Rajasthan	18
22	Sikkim	30
23	Tamil Nadu	42
24	Telangana	13
25	Tripura	5
26	Uttar Pradesh	92
27	Uttarakhand	29
28	West Bengal	46
Total		**764**

5.3 Water quality laboratories system

CWC is maintaining a three-tier laboratory system for analysis of the physicochemical parameters of the water. The Level-I laboratories are located at 378 field water quality monitoring stations on major rivers of India where 6 physical parameters such as temperature, colour, odour, specific conductivity or total dissolved solids, pH and dissolved oxygen of river water are observed. There are 18 Level–II laboratories located at selected division offices throughout India to analyses 25 nos. of physio-chemical and bacteriological parameters of water. 5 Level-III laboratories are functioning at Varanasi, Delhi, Hyderabad, Coimbatore, and Guwahati, where 41 parameters including heavy metals / toxic parameters and pesticides are analysed. The list of 23 Level-II and Level-III laboratories and parameters analysed in the laboratories are given in Annexure-I and Annexure-II respectively. Out of above 23 (level II & III both) laboratories, 16 laboratories are accredited from National Accreditation Board for Testing and Calibration Laboratories (NABL) in accordance with Standard ISO/IEC 17025:2017. The details of 23 water quality laboratories and its NABL accreditation are given in Figure 7.

Figure 7: Water quality laboratories of CWC



CHAPTER – 6

6. River Water Quality Hot Spots in India

The river water quality monitoring is most essential aspect of restoring the water quality. One of the main objectives of the river water quality monitoring is to assess the suitability of river water for drinking purposes, irrigation, outdoor bathing and Propagation of wildlife, fisheries. The physical and chemical quality of river water is important in deciding its suitability for drinking purposes. As such the suitability of river water for potable uses with regard to its chemical quality has to be deciphered and defined on the basis of the some vital characteristics of the water. River water quality is very important for aspect in India. The physico-chemical parameters like pH, Electrical Conductivity (EC), Fluoride (F^{-}), Ammonia as N (NH_3-N), Sulphate (SO_4^{-2}), Boron (B), Sodium Adsorption Ratio (SAR), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Total Coliform (TC) are important constituents defining the quality of river water in surface water. Therefore, presence of these parameters in river water beyond the permissible limit in the absence of alternate source has been considered as river water quality hot spots. The best use classification is essential, for maintaining the quality of river water of the particular stretch. The study is based on the average monsoon and non-monsoon values of 10 nos. of water quality parameters which were observed during 2010-2020 at 588 water quality monitoring stations out of 764 stations of CWC. The remaining 176 water quality stations are opened in recent years, no historical data are available.

In this study identification of hot spot in Indian river wrt pH, Electrical Conductivity (EC), Ammonia as N (NH_3-N), Boron (B), Sodium Adsorption Ratio (SAR), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Total Coliform (TC) parameters are done based on Class B, D & E of Designated best uses of water by Central Pollution Control Board (CPCB) (Table.4). In addition to above parameters, hotspots identification in Indian River wrt Fluoride (F^{-}), Sulphate (SO_4^{-2}) parameters are done based on BIS (Bureau of Indian Standards) IS 10500: 2012(Table.5).

Study Area

A total number of 588 water quality stations covering all the important rivers of country were studied for water quality hotspots in rivers of India. The details of these 588 stations are shown in map in Figure 8. The metadata(information about the site) of 588 sites may be seen in book of water quality monitoring network, November, 2021 which is available in other publication section of CWC website (cwc.gov.in).

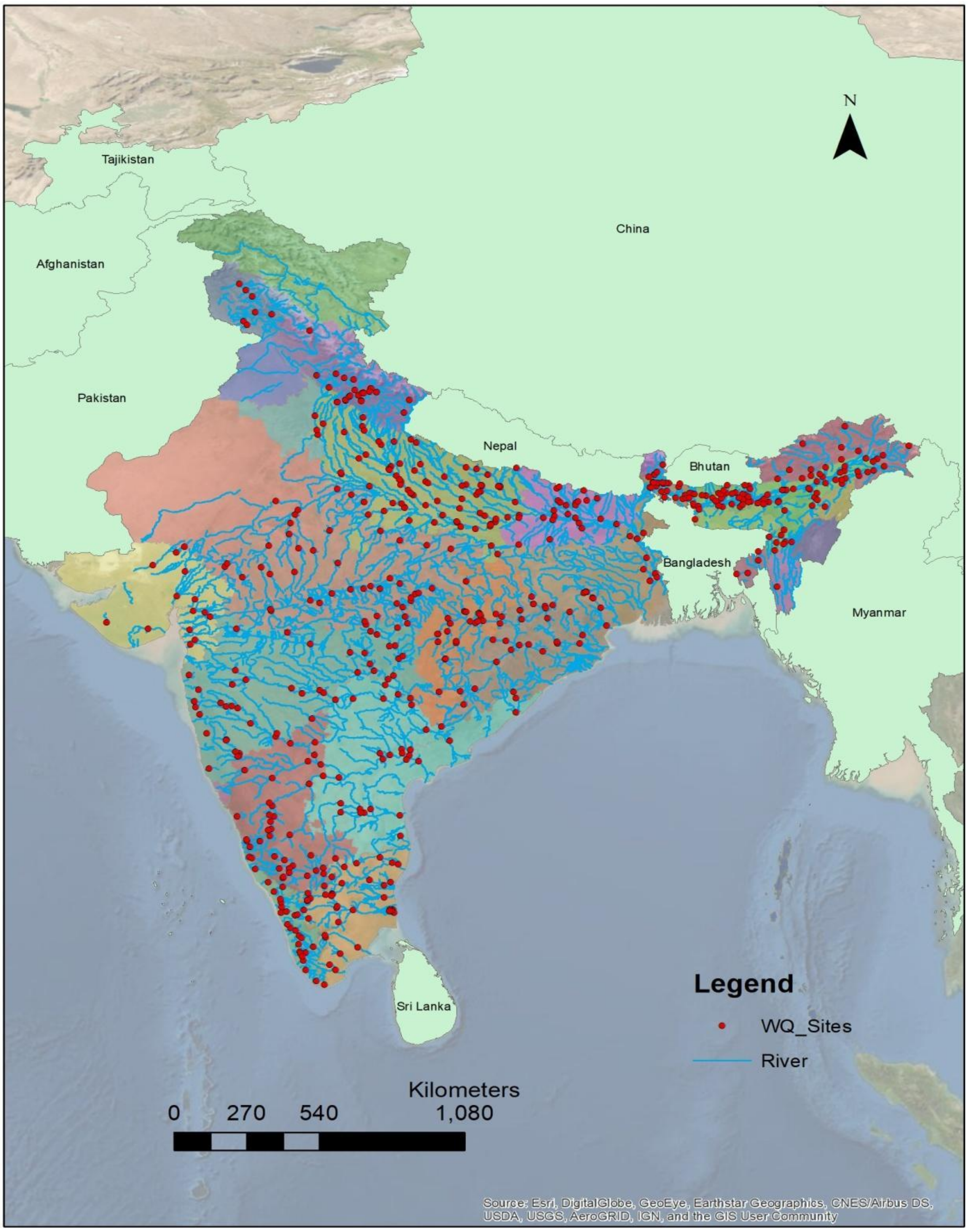


Fig 8: Study area of 588 Water Quality (WQ) Stations on important rivers of India.

6.1 Water Quality Standard in India

Central Pollution Control Board (CPCB) has identified water quality requirements in terms of certain chemical characteristics, known as primary water quality criteria (Table 4). Based on this classification, the natural water has been categorized as Class-A Drinking Water Source without conventional treatment but after disinfection; Class-B Outdoor bathing (Organized); Class-C Drinking water source after conventional treatment and disinfection; Class-D Propagation of Wild life and Fisheries; Class-E Irrigation, Industrial Cooling, Controlled Waste disposal.

Further BIS vide its document BIS 10500:2012 has recommended water quality standards for drinking water (Table 5).

Table 4: Designated Best Uses of Water by CPCB

Designated Best Use	Class	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1.Total Coliforms Organism MPN/100 ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6 mg/L or more 4. Biochemical Oxygen Demand 5 days 20 °C, 2 mg/L or less
Outdoor bathing (Organised)	B	1.Total Coliforms Organism MPN/100 ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5 mg/l or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3 mg/L or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 and 9 3. Dissolved Oxygen 4 mg/L or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/L or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved Oxygen 4 mg/l or more 3. Free Ammonia (as N) 1.2 mg/L or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 and 8.5 2. Electrical Conductivity at 25 °C micro mhos/cm, maximum 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2 mg/L
	Below -E	Not meeting any of the A, B, C, D & E criteria

Table 5: Drinking Water Quality Standards, BIS: 10500, 2012

S. No.	Characteristic	Requirement (Acceptable Limit)	Permissible limit in the absence of Alternate source
Essential Characteristics			
1	Colour, Hazen units, Max	5	15
2	Odour	Agreeable	Agreeable
3	Taste	Agreeable	Agreeable
4	Turbidity NTU, Max	1	5
5	pH Value	6.5 -8.5	No relaxation
6	Total Hardness (as $CaCO_3$) mg/L, Max.	200	600
7	Iron (as Fe), mg/L, Max	0.3	No relaxation
8	Chlorides (as Cl), mg/L, Max	250	1000
9	Residual free chlorine, mg/L, Minimum	0.2	1.0
Desirable Characteristics			
10	Total Dissolved solids, mg/L, Max	500	2000
11	Calcium (as Ca) mg/L, Max.	75	200
12	Magnesium (as Mg) mg/L, Max	30	100
13	Copper (as Cu), mg/L, Max	0.05	1.5
14	Manganese (as Mn) mg/L, Max	0.1	0.3
15	Sulphates (as SO_4), mg/L, Max	200	400
16	Nitrate (as NO_3) mg/L, Max.	45	No relaxation
17	Fluorides (as F), mg/L, Max	1	1.5
18	Ammonia (as total ammonia-N) mg/L	0.5	No relaxation
19	Mercury (as Hg), mg/L, Max	0.001	No relaxation
20	Cadmium (as Cd), mg/L, Max	0.003	No relaxation
21	Selenium (as Se), mg/L, Max	0.01	No relaxation
22	Total Arsenic (as As), mg/L, Max	0.01	No relaxation
23	Cyanides (as CN), mg/L, Max	0.05	No relaxation
24	Lead (as Pb), mg/L, Max	0.01	No relaxation
25	Zinc (as Zn), mg/L, Max	5	15
26	Anionic detergents (as MBAS), mg/L, Max	0.2	1
27	Total Chromium (as Cr), mg/L, Max	0.05	No relaxation
28	Polynuclear aromatic hydrocarbons (as PAH), mg/L, Max	-	-
29	Mineral oil, mg/L, Max	0.5	No relaxation
30	Pesticides mg/L, Max	Absent	0.001
33	Alkalinity mg/L, Max	200	600
34	Aluminum (as Al) mg/L, Max	0.03	0.2
35	Boron mg/L, Max	0.5	1.0

6.2 Water Quality Parameters

6.2.1 pH

The pH of a solution measures the degree of acidity or alkalinity relative to the ionization of water. The Danish scientist Sørensen defined the concept of pH according to which “pH equals the inverse of the logarithm to the base 10 of the hydrogen ion concentration”, as shown by the formula:

$$\mathbf{pH = -10log\ [H^+]}$$

Also, pH measures the acidity or alkalinity of the solution. The acidity or alkalinity of a water solution is determined by the relative number of hydrogen ions (H^+) or hydroxyl ions (OH^-) present. In water solutions, the product of the molar concentrations1 of hydrogen and hydroxyl ions is equal to dissociation constant (Kw). Knowing the value of the constant and the concentration of hydrogen ions makes it possible to calculate the concentration of hydroxyl ions, and vice versa. At 25°C, the value of Kw is 10^{-14}.

Acids:	HA	$\rightarrow$	H^+	+	A^-
	Acid		hydrogen ion		anion
Bases:	MOH	$\rightarrow$	OH^-	+	M^+
	Base		hydrogen ion		cation

$$(H^+)\ x\ (OH^-) = Kw = 10^{-14}\ (25°C)$$

pH is the measurement of the hydrogen ion concentration, $[H^+]$. Water and water based solutions, consist of charged particles called ions and uncharged particles called molecules. Some ions have a positive electrical charge and others have a negative charge. In every case, the number and magnitude of the charges balance so that there is no excess charge. In pure water, some of the water molecules, which consist of two hydrogen atoms and one oxygen atom (H_2O), dissociate into ions:

$$H_2O \rightleftarrows H^+ + OH^-$$

The pH value is express the ratio of $[H^+]$ to $[OH^-]$ (hydroxide ion concentration). Hence, if the $[H^+]$ is greater than $[OH^-]$, the solution is acidic. Conversely, if the $[OH^-]$ is greater than the $[H^+]$, the solution is basic. At 7 pH, the ratio of $[H^+]$ to $[OH^-]$ is equal and, therefore, the solution is neutral. As shown in the equation below, pH is a logarithmic function. A change of one pH unit represents a 10-fold change in concentration of hydrogen ion. In a neutral solution, the $[H^+] = 1 \times 10\text{-}7$ mol/L. This represents a pH of 7.

BIS (Bureau of Indian Standard) have recommended a desirable limit of 6.5 – 8.5 of pH in drinking water.

The limit prescribed by CPCB for class-A; Drinking water source without conventional treatment but after disinfections, class B: Outdoor bathing Organized, class D: Propagation of wild life and class E: Fisheries and Irrigation; all are defined from 6.5 to 8.5.

During the monsoon season, average value of pH greater than 8.5 was observed at single water quality station located in Tamil Nadu (Noyyal) and pH average value less than 6.5 observed at water quality station located in Kerala (Thodupuzha). In non-monsoon season average values of pH greater than 8.5 were observed at two (2) water quality stations located in Tamil Nadu (Noyyal), and Gujarat (Banas). The hot spot study and GIS map for ph parameter are given below in Table 6 and figure 9.

Health Concerns

According to the World Health Organization, health effects are most pronounced in pH extremes. Drinking water with an elevated pH above 11 can cause skin, eye and mucous membrane irritation. On the opposite end of the scale, pH values below 4 also cause irritation due to the corrosive effects of low pH levels. WHO warns that extreme pH levels can worsen existing skin conditions. Because pH is related to a variety of other parameters, it is not possible to determine whether pH has a direct relationship with human health. Insofar as pH affects the unit processes in water treatment that contribute to the removal of viruses, bacteria and other harmful organisms, it could be argued that pH has an indirect effect on health. The destruction of viruses by the high pH levels encountered in water softening by the lime/soda ash process could also be considered beneficial. On the other hand, the increased yield of trihalomethanes at high pH values may be detrimental.

Stations having pH value above 8.5& below 6.5 in River Water

(During Period: 2010-2020)

S.No.	Site	River	CWC Division Office	State	District	M	NM
1	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamil Nadu	Erode	8.56	8.6
2	Manakkad	Thodupuzha	SWRD, Kochi	Kerala	Idukki	6.49	-
3	Kamalpur	Banas	MD, Gandhinagar	Gujarat	Banaskantha	-	8.53

(-) means: No Hotspot

Table 7: Stations having pH beyond range 6.5-8.5 in River water

Water Quality Stations having pH value <6.5 &>8.5 in River Water during period 2010-2020

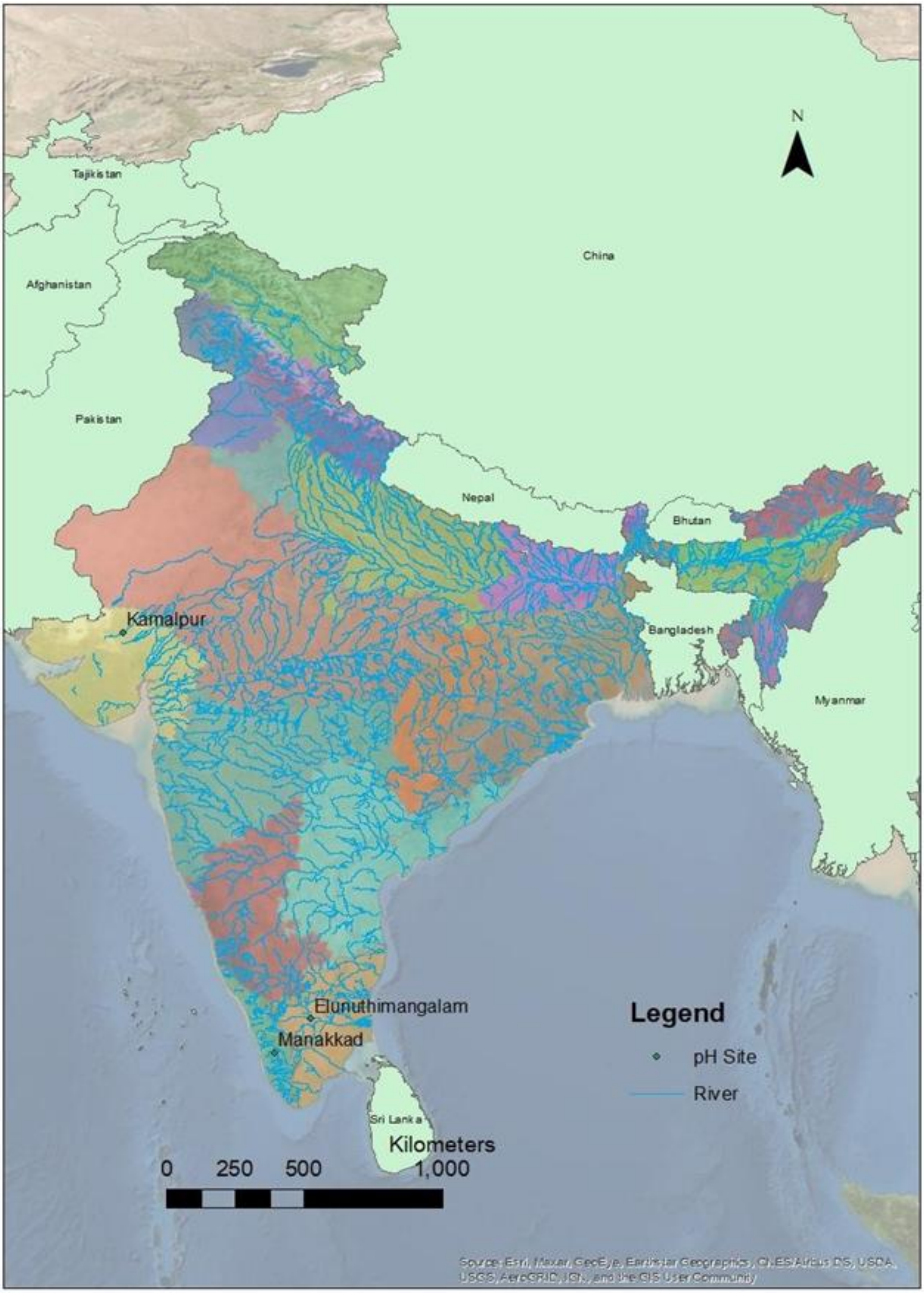


Figure 9: Stations having pH beyond range 6.5-8.5 in River water

6.2.2 Electrical Conductivity (EC)

Conductivity (specific conductance) of an electrolytic solution is a measure of its ability to conduct electricity. The SI unit of conductivity is siemens per meter (S/m). In many cases, conductivity is linked directly to the total dissolved solids (T.D.S.). High quality deionized water has a conductivity of about 5.5 µS/m, typical drinking water in the range of 5-50 mS/m, while sea water about 5 S/m (i.e., sea water's conductivity is one million times higher than that of deionized water). Resistance, R, is proportional to the distance, l, between the electrodes and is inversely proportional to the cross-sectional area. Writing ρ (rho) for the specific resistance (or resistivity) and the specific conductance, κ (kappa) is the reciprocal of the specific resistance.

$$R = \frac{l}{A}\rho \qquad \text{and} \qquad K = \frac{1}{\rho}$$

The conductivity or conductance of a solution is the reciprocal of its resistance and is given of units of µmhos, mhos, or Siemens (all a reciprocal ohms). Resistivity as the inverse of conductivity is defined as the measure of the ability of a solution to resist an electric current flow. The conductivity measurement is directly affected by the number of dissolved ions in the solution and will increase as the quantity and mobility of ions increases. The higher the conductivity reading, the better ability the solution has to conduct electricity. Conversely, the lower the conductivity reading, the poorer ability the solution has to conduct electricity.

BIS has recommended a drinking water standard for total dissolved solids a limit of 500mg/l (corresponding to about EC of 750 µS/cm at 25^0C) that can be extended to a TDS of 2000mg/l (corresponding to about 3000 µS/cm at 25^0C) in case of no alternate source. Water having TDS more than 2000 mg/litter are not suitable for drinking uses.

The limit prescribed by CPCB for class-E Irrigation, Industrial Cooling, Controlled Waste disposal is less than 2250 µS/cm at 25^0C.

During the monsoon season, average values of EC greater than 2250 µS/cm was observed at (1) one water quality station located at Elunuthimangalam. During the non-monsoon season, average values of EC greater than 2250 µS/cm were observed at (3) three water quality stations located at Elunuthimangalam, Vautha and Luwara. The hot spot study and GIS map for EC parameter are given below in Table 7 and figure 10.

Health concerns:

The following health problems can occur where the EC exceeds 370 µS/cm:-

- Disturbance of the salt and water balance in children.
- In the blood pressure of heart patients and renal patients.
- Aesthetic problems of water with an EC as high as 150 mS/m, are that it tastes salty and water with an EC higher than 300 mS/m, fail to quench your thirst.
- Sensitive groups are, children under the age of 1 year, patients on salt-restricted diets, such as heart and kidney patients and individuals with chronic diarrhea

Stations having Electrical Conductivity (EC) >2250 µS/cm in River Water

(During Period: 2010-2020)

S.No.	Site	River	CWC Division Office	State	District	M	NM
1	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamil Nadu	Erode	3265.04	2840.9
2	Vautha	Sabarmati	MD, Gandhinagar	Gujarat	Kheda	-	2375.64
3	Luwara	Shetrunji	MD, Gandhinagar	Gujarat	Bhavnagar	-	7764.88

(-) means: No Hotspot

Table 7: Stations having Electrical Conductance (EC) >2250 µS/cm in River water

WQ Stations having EC > 2250 µS/cm in River Water during period 2010-2020

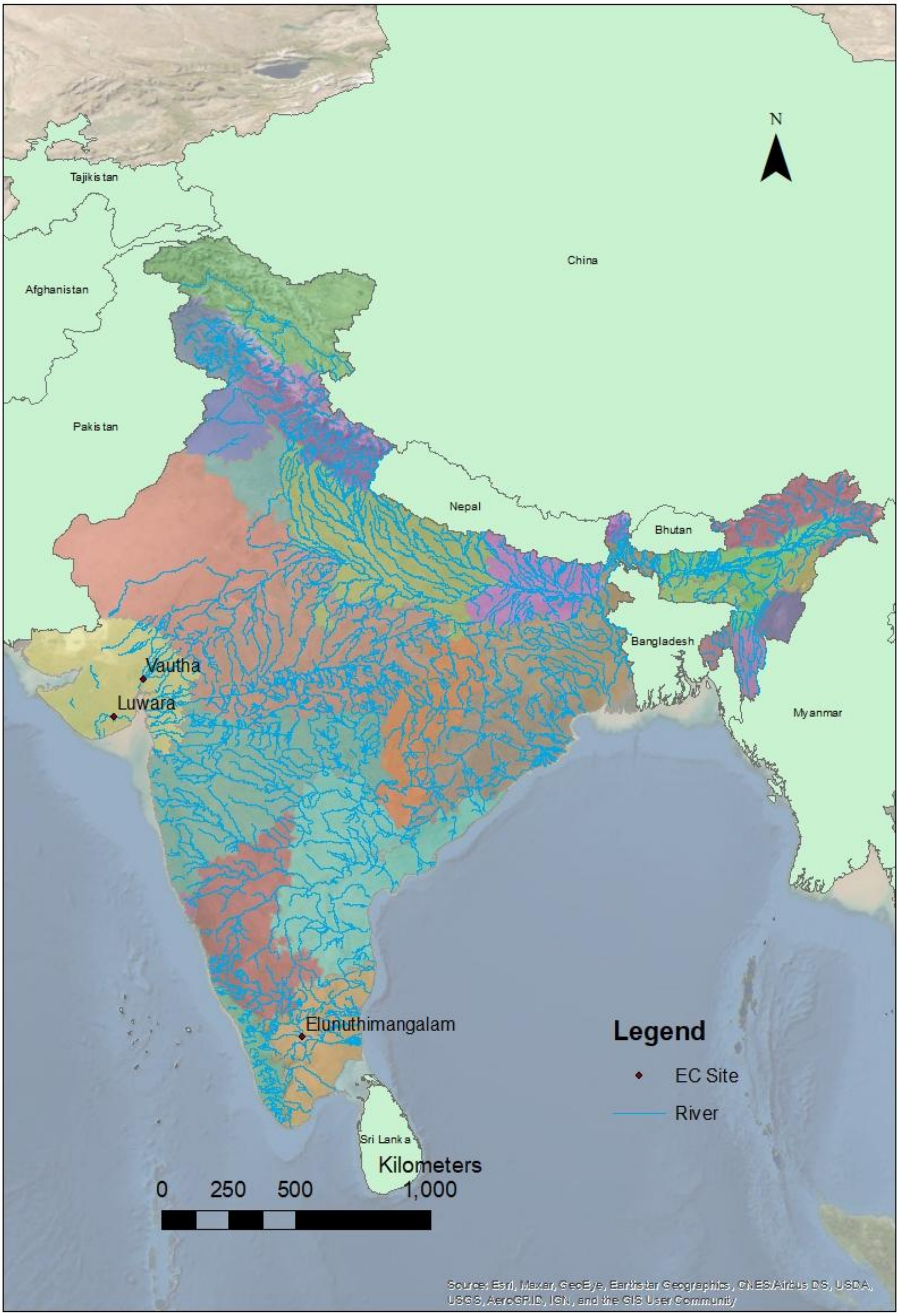


Figure 10: Stations having Electrical Conductance (EC) >2250 µS/cm in River water

6.2.3 Ammonia as N (NH_3-N)

Ammonia is a colour-less gas with a strong pungent odour. It is easily liquefied and solidified and is very soluble in water. One volume of water will dissolve 1,300 volumes of NH_3. Ammonia will react with water to form a weak base. Ammonia pungent gaseous compound of hydrogen and nitrogen that is highly soluble in water. It is a biologically active compound found in most waters as a normal biological degradation product of nitrogenous organic matter (protein). It also may find its way to ground and surface waters through discharge of industrial process wastes containing ammonia and fertilizers.

Ammonia is used in fertilizers either as the compound itself or as ammonium salts such as sulphate and nitrate. Large quantities of ammonia are used in the production of nitric acid, urea and nitrogen compounds. It is used in the production of ice and in refrigerating plants. "Household ammonia" is an aqueous solution of ammonia. It is used to remove carbonate from hard water. Since ammonia is a decomposition product from urea and protein, it is found in domestic wastewater. Aquatic life and fish also contribute to ammonia levels in a stream. Ammonia is the preferred nitrogen-containing nutrient for plant growth. Ammonia can be converted to nitrite (NO_2) and nitrate (NO_3) by bacteria, and then used by plants. Nitrate and ammonia are the most common forms of nitrogen in aquatic systems. Nitrate predominates in unpolluted waters. Nitrogen can be an important factor controlling algal growth when other nutrients, such as phosphate, are abundant. If phosphate is not abundant it may limit algal growth rather than nitrogen. Ammonia is excreted by animals and produced during decomposition of plants and animals, thus returning nitrogen to the aquatic system. Ammonia is also one of the most important pollutants because it is relatively common but can be toxic, causing lower reproduction and growth, or death. The neutral, unionized form (NH_3) is highly toxic to fish and other aquatic life.

The primary agricultural sources include accidental releases of ammonia-rich fertilizer during transport (because of vehicle accident, faulty hose connections, and human error); and livestock waste.

The limit prescribed by CPCB for Ammonia (as N) in class-D: Propagation of Wild life and Fisheries is 1.2 mg/l or less.

During the monsoon season, the average values of ammonia equal to or greater than 1.2 mg/l were observed at (6) six water quality stations located at Agra(P.G), JawaharBridge, Vautha, Singasadanapalli, Galeta and Delhi Railway Bridge. During the non-monsoon season, the average values of Ammonia equal to or greater than 1.2 mg/l were observed at (8) eight water quality stations located at Agra(P.G), Jawahar Bridge, Vautha, Singasadanapalli, Galeta, Delhi Railway

Bridge, Etawah and Pingalwada. The hot spot study and GIS map for ammonia parameter are given below in Table 8 and figure 11.

Health Concern:

- Ammonia exists in two forms in the water: NH_3 (this is called unionized ammonia) and NH_4^+ (this is called ionized ammonia). Together, these two forms of ammonia are called TAN which means total ammonia nitrogen.
- NH_3 is the principal form of toxic ammonia. It has been reported toxic to freshwater organisms at concentrations ranging from 0.53 to 22.8 mg/L. Toxic levels are both pH and temperature dependent. Toxicity increases as pH increases and as temperature increases. Plants are more tolerant of ammonia than animals, and invertebrates are more tolerant than fish. Hatching and growth rates of fishes may be affected. In the structural development, changes in tissues of gills, liver, and kidneys may also occur. Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death.

Stations having Ammonia (NH_3)> 1.2 mg/l in River Water

(During Period: 2010-2020)

S.No	Site	River	CWC Division Office	State	District	M	NM
1	Agra(P.G)	Yamuna	LYD, Agra	Uttar Pradesh	Agra	2.57	7.56
2	Delhi Rly Bridge	Yamuna	UYD, New Delhi	Delhi	North Delhi	10.6	15.56
3	Etawah	Yamuna	LYD, Agra	Uttar Pradesh	Etawah	-	4.28
4	Galeta	Yamuna	UYD, New Delhi	Uttar Pradesh	Meerut	9.67	10.74
5	Jawahar Bridge	Yamuna	LYD, Agra	Uttar Pradesh	Agra	2.45	10.2
6	Pingalwada	Dhadhar	TD, Surat	Gujarat	Vadodara	-	1.45
7	Singasadanapalli	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	15.89	17.47
8	Vautha	Sabarmati	MD, Gandhinagar	Gujarat	Kheda	15.27	23.92

(-) means: No Hotspot

Table 8: Stations having Ammonia (NH_3) ≥ 1.2 mg/l in River

Stations having Ammonia (NH_3)> 1.2 mg/l in River Water during period 2010-2020

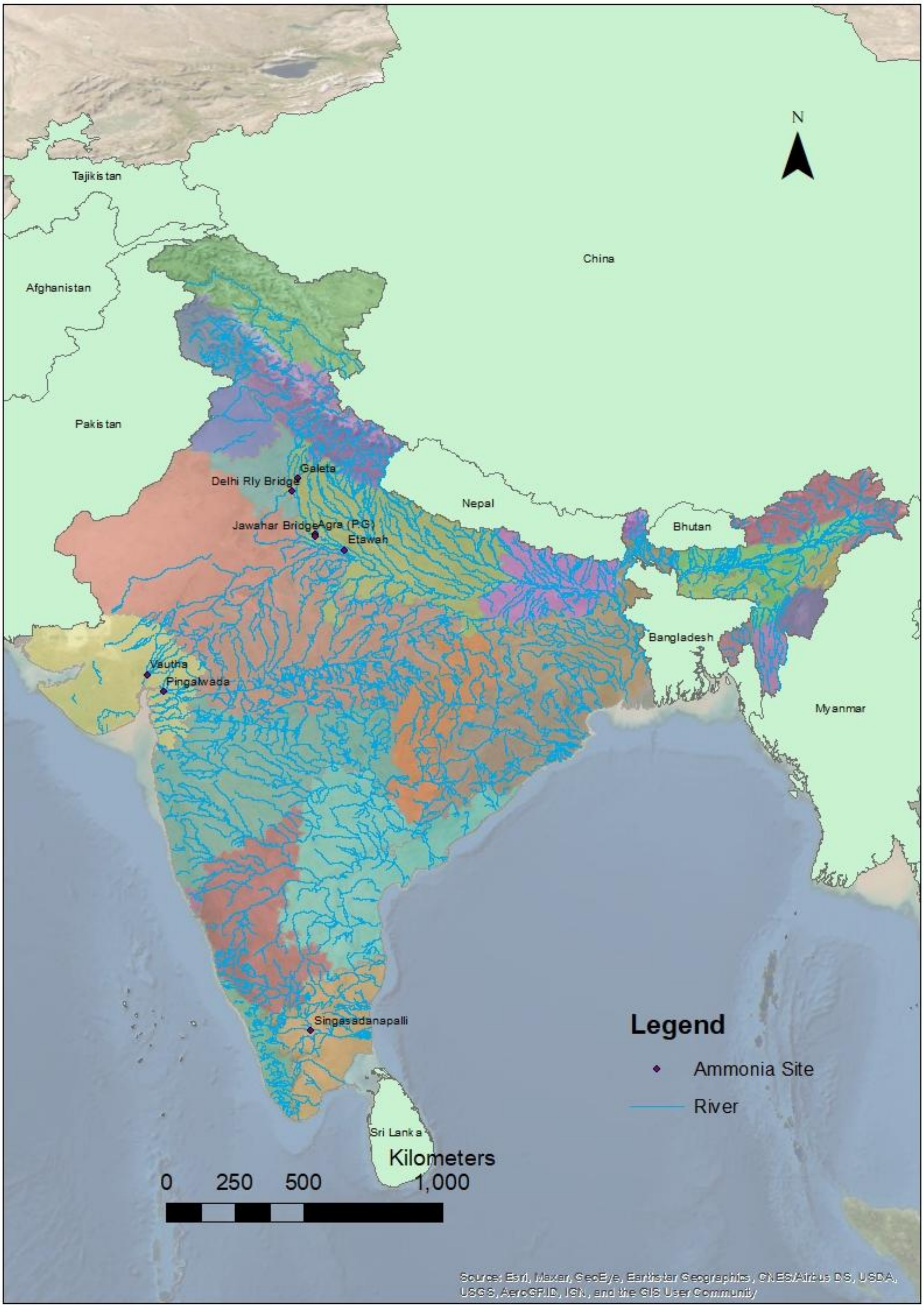


Figure 11: Stations having Ammonia (NH_3) ≥ 1.2 mg/l in River

6.2.4 Boron (B)

Boron is an element that occurs naturally in the earth's crust and can be found in fruits, vegetables, and some water sources, including bottled water. Boron often binds to oxygen, forming a group of compounds called borates (such as borax and boric acid). Boron and borates are used in manufacturing glass, ceramics, soaps, laundry detergents, bleach, cosmetics, medications, pesticides, personal care products, and other consumer products. Boron is an essential micronutrient for most plants. Evidence suggests it is likely an essential nutrient for animals and humans.

Boron enters the environment through natural and human-made processes. Natural weathering of soils and rocks can release boron into the air, water, or soil. Manufacturing plants that use boron (like glass manufacturing and coal-burning power plants) also release boron. Once boron is in the environment, it does not break down. Rather, the element changes form or attaches to or separates from soil, sediment and water particles

Elemental boron exists as a solid at room temperature, either as black monoclinic crystals or as a yellow or brown amorphous powder when impure. The amorphous and crystalline forms of boron have specific gravities of 2.37 and 2.34, respectively. Boron is a relatively inert metalloid except when in contact with strong oxidizing agents. Sodium perborates are persalts, which are hydrolytically unstable because they contain characteristic boron–oxygen–oxygen bonds that react with water to form hydrogen peroxide and stable sodium metaborate ($NaBO_2 \cdot nH_2O$). Boric acid is a very weak acid, with an acid dissociation constant (pKa) of 9.15. Therefore, boric acid and the sodium borates exist predominantly as undissociated boric acid [$B(OH)_3$] in dilute aqueous solution below pH 7, above pH 10, the metaborate anion [$B(OH)_4^-$] becomes the main species in solution. From about pH 6 to pH 11 and at high concentrations (>0.025 mol/l), highly water soluble polyborate ions such as $[B_3O_3(OH)_4]^-$, $[B_4O_5(OH)_4]^-$ and $[B_5O_6(OH)_4]^-$ are formed.

The limit prescribed by CPCB for Boron (B) in class-E: Irrigation, Industrial Cooling, Controlled Waste disposals is not greater than 2 mg/l. During the monsoon and non-monsoon seasons, average values of Boron of all water quality stations were observed within the permissible limit.

Health Concern:

In animal studies, exposure to high levels of boron caused decreased fetal weight and improper fetal development, as well as disruption to the male reproductive system. 500 ppb is designed to be protective of formula-fed infants, who may ingest more boron from food and water, on a per body weight basis, than older children or adult.

Consuming food or water with boron in it is the main way most people come in contact with boron. People can also come in contact with boron through dust, consumer products, or pesticides that contain boron. People who work in places that mine or process boron may be exposed to higher levels of boron.

In animals, the main toxic effect associated with boron involves the reproductive system. Boron caused specific adverse effects in the male reproductive tract in rats, mice and dogs, including shrunken scrota, inhibited spermiation, degeneration, and atrophy of seminiferous tubules, with an absence or loss of germ cells. Boron also caused a reduction in ovulation in female rats and renal lesions in female mice.

6.2.5 Sodium Adsorption Ratio (SAR)

The **Sodium adsorption ratio** (**SAR**) is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is also a standard diagnostic parameter for the sodicity hazard of a soil as determined from analysis of pore water extracted from the soil.SAR is a measure of the amount of sodium (Na^{+}) relative to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the water extracted from a saturated soil paste. It is the ratio of the Na+ concentration divided by the square root of one-half of the Ca^{2+} and Mg^{2+} concentration. SAR is calculated from the equation:

The formula for calculating the sodium adsorption ratio (SAR) is:

$$\mathbf{SAR = Na^{+} / [(Ca^{2+} + Mg^{2+})/2]^{0.5}}$$

Soils that have values for sodium adsorption ratio of 13 or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure

SAR allows assessment of the state of flocculation or of dispersion of clay aggregates in a soil. Sodium and potassium ions facilitate the dispersion of clay particles while calcium and magnesium promote their flocculation. The behaviour of clay aggregates influences the soil structure and affects the permeability of the soil whose directly depends the water infiltration rate. It is important to accurately know the nature and the concentrations of cations at which the flocculation occurs: critical flocculation concentration (CFC). The SAR parameter is also used to determine the stability of colloids in suspension in water.

Although SAR is only one factor in determining the suitability of water for irrigation, in general, the higher the sodium adsorption ratio, the less suitable the water is for irrigation. Irrigation using water with high sodium adsorption ratio may require soil amendments to prevent long-term damage to the soil.

If irrigation water with a high SAR is applied to a soil for years, the sodium in the water can displace the calcium and magnesium in the soil. This will cause a decrease in the ability of the soil to form stable aggregates and a loss of soil structure. This will also lead to a decrease in infiltration and permeability of the soil to water, leading to problems with crop production. Sandy soils will have less problems, but fine-textured soils will have severe problems if SAR is greater than 9. When SAR is less than 3, there will not be a problem.

The limit prescribed by CPCB for Sodium Adsorption Ratio (SAR) in class-E: Irrigation, Industrial Cooling, Controlled Waste disposals is not greater than 26 mg/l. During the monsoon and non-monsoon seasons, average values of Sodium Adsorption Ratio (SAR) of all water quality stations were observed within the permissible limit.

6.2.6 Fluoride (F^-)

Fluorine is a fairly common element but it does not occur in the elemental state in nature because of its high reactivity. Fluorine is the most electronegative and reactive of all elements that occur naturally within many types of rock. It exists in the form of fluorides in a number of minerals of which fluorspar, cryolite, fluorite and fluorapatite are the most common. Fluorite (CaF_2) is a common fluoride mineral. Most of the fluoride found in groundwater is naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. Most of the fluorides are sparingly soluble and are present in ground water in small amounts. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydro geological strata and time of contact between rock and the circulating ground water. Presence of other ions, particularly bicarbonate and calcium ions also affect the concentration of fluoride in ground water. It is well known that small amounts of fluoride (less than 1.0 mg/l) have proven to be beneficial in reducing tooth decay. Community water supplies commonly are treated with NaF or fluorosilicates to maintain fluoride levels ranging from 0.8 to 1.2 ppm to reduce the incidence of dental carries.

However, high concentrations such as 1.5 mg/l of F and above have resulted in staining of tooth enamel while at still higher levels of fluoride ranging between 5.0 and 10 mg/l, further pathological changes such as stiffness of the back and difficulty in performing natural movements may take place.

BIS has recommended an upper desirable limit of 1.0 mg/l of F as desirable concentration of fluoride in drinking water, which can be extended to 1.5 mg/l of F in case no alternative source of water is available. River/ground Water having fluoride concentration of more than 1.5 mg/l are not suitable for drinking purposes. During the monsoon and non-monsoon seasons, the average values of fluoride of all water quality stations were observed within the permissible limit.

Health Concern:

Fluorosis is a crippling disease resulted from deposition of fluorides in the hard and soft tissues of body. It is a public health problem caused by excess intake of fluoride through drinking water/food products/industrial pollutants over a long period. Ingestion of excess fluoride, most commonly in drinking-water affects the teeth and bones.

It results in major health disorders like dental fluorosis, skeletal fluorosis and non-skeletal fluorosis. People exposed to large amounts of fluoride show dental effects much earlier than the skeletal effects. Dental fluorosis affects children and discolours and disfigures the teeth. Skeletal fluorosis affects the bones and major joints of the body like neck, back bone, shoulder, hip and knee joints resulting in to severe pain, rigidity or stiffness in joints. Severe forms of skeletal fluorosis results in marked disability. Non-skeletal forms of fluorosis are earlier manifestations, which develop long before the onset of typical changes in teeth and skeletal bones these are seen as gastro-intestinal symptoms and may overlap with other diseases leading to misdiagnosis. It affects men, women and children of all age groups.

Small amounts of fluoride appear to be an essential nutrient. People in the United States ingest about 2 mg/day in water and food. A concentration of about 1 mg/L in drinking water effectively reduces dental caries without harmful effects on health. Dental fluorosis can result from exposure to concentrations above 2 mg/L in children up to about 8 years of age. In its mild form, fluorosis is characterized by white opaque mottled areas on tooth surfaces. Severe fluorosis causes brown to black stains and pitting. Although the matter is controversial, EPA has determined that dental fluorosis is a cosmetic and not a toxic or an adverse health effect. Water hardness limits fluoride toxicity to humans and fish. The severity of fluorosis decreases in harder drinking water. Crippling skeletal fluorosis in adults requires the consumption of about 20 mg or more of fluoride per day over a 20-year period. No cases of crippling skeletal fluorosis have been observed in the United States from the long-term consumption of 2 L/day of water containing 4 mg/L of fluoride. EPA has concluded that 0.12 mg/kg/day of fluoride is protective of crippling skeletal fluorosis. Fluoride therapy, where 20 mg/day is ingested for medical purposes, is sometimes used to strengthen bone, particularly spinal bones (Hussain et al., 2002; 2004).

6.2.7 Sulphate (SO_4^{-2})

Sulphur is the 14th most abundant element in the earth's crust. Sulphate is produced in the environment from the oxidation of elemental sulphur, sulphide minerals, or organic sulphur. Inorganic sulphate (SO_4^{2-}) is required for the synthesis of 3′-phosphoadenosine-5′-phosphosulfate (PAPS). PAPS is required for synthesis of many important sulphur-containing compounds, such as chondroitin sulphate and cerebroside sulphate. While significant levels of sulphate are found in foods and various sources of drinking water, the major source of inorganic sulphate for humans is from biodegradation due to body protein turnover of the sulphur amino acids methionine and cysteine. Dietary sulphate in food and water, together with sulphate derived from methionine and cysteine found in dietary protein and the cysteine component of glutathione, provides sulphate for use in PAPS biosynthesis. Sulphate requirements are thus met when intakes include recommended levels of sulphur amino acids.

The sulphate anion (SO_4^{-2}) is the stable, oxidized form of sulphur. Sulphate minerals are widely distributed in nature, and most sulphate compounds are readily soluble in water. All sulphate salts are very soluble except for calcium and silver sulphates, which are moderately soluble, and barium, mercury, lead, and strontium sulphates, which are insoluble.

It is estimated that about one-half of the river sulphate load arises from mineral weathering and volcanism, the other half from biochemical and anthropogenic sources. Industrial discharges are another significant source of sulphates. Mine and tailings drainage, smelter emissions, agricultural runoff from fertilized lands, pulp and paper mills, textile mills, tanneries, sulphuric acid production, and metalworking industries are all sources of sulphate-polluted water. Aluminium sulphate (alum) is used as a sedimentation agent for treating drinking water. Copper sulphate is used for controlling algae in raw and public water supplies. Air emissions from industrial fuel combustion and the roasting of sulphur-containing ores carry large amounts of sulphur dioxide and sulphur trioxide into the atmosphere, adding sulphates to surface waters through precipitation. High sulphate concentrations are also present in areas of acid mine drainage and in well waters and surface waters in arid regions where sulphate minerals are present.

BIS has recommended an upper desirable limit of 200 mg/l of SO_4^{-2} as desirable concentration of sulphate in drinking water, which can be extended to 400 mg/l of SO_4^{-2} in case no alternative source of water is available. Water having sulphate concentration of more than 400 mg/l are not suitable for drinking purposes. During the monsoon and non-monsoon seasons, the average values ofsulphate (SO_4^{-2})of all water quality stations were observed within the permissible limit.

Health Concerns

The sulphate anion is generally considered nontoxic to animal, aquatic, and plant life. It is an important source of sulphur, an essential nutrient for plants and animals. Sulphates are used as additives in the food industry, and the average daily intake of sulphate from drinking water, air, and food is approximately 500 mg. For examples, some measured sulphate concentrations in beverages are 100–500 mg/L in drinking water, 500 mg/L in coconut milk, 260 mg/L in beer (bitter), 250 mg/L in tomato juice, and 300 mg/L in red wine (FNB 2004). Available data suggest that people acclimate rapidly to the presence of sulphates in their drinking water. No upper limit likely to cause detrimental human health effects has been determined for sulphate in drinking water. However, concentrations of 500–750 mg/L may cause a temporary mild laxative effect, although doses of several thousand milligrams per litter generally do not cause any long-term ill effects. Because of the laxative effects resulting from ingestion of drinking water containing high sulphate levels, EPA recommends that health authorities be notified of sources of drinking water that contain sulphate concentrations in excess of 500 mg/L. The presence of sulphate can adversely affect the taste of drinking water. The lowest taste threshold concentration for sulphate is approximately 250 mg/L as the sodium salt but higher as calcium or magnesium salts (up to 1000 mg/L).

Biological Parameters

6.2.8 Dissolved Oxygen (DO)

To determine concentration of DO Winkler test is used. Dissolved oxygen (D.O.) is widely used in water quality testing. An excess of Mn(II) salt, iodide (I^-) and hydroxide (OH^-) ions is added to a water sample causing a white precipitate of $Mn(OH)_2$ to form. This precipitate is then oxidized by the dissolved oxygen in the water sample into a brown manganese precipitate. In the next step, a strong acid (either hydrochloric acid or sulfuric acid) is added to acidify the solution. The brown precipitate then converts the iodide ion (I^-) to iodine. The amount of dissolved oxygen is directly proportional to the titration of iodine with a thiosulfate solution. Now a day, the method is effectively used as its colorimetric modification, where the trivalent manganese produced on acidifying the brown suspension is directly reacted with EDTA to give a pink color. As manganese is the only common metal giving a color reaction with EDTA, it has the added effect of masking other metals as colorless complexes.

Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration, similar to organisms on land. Fish and crustaceans obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material at the bottom of a body of water. Microbial decomposition is an important contributor to nutrient recycling. However, if there is an excess of decaying organic material (from dying algae and other organisms), in a body of water with infrequent or no turnover (also known as stratification), the oxygen at lower water levels will get used up quicker. The variations in dissolved oxygen observed may also be because of time of the day when it is measured. In aquatic ecosystems, the DO usually occur maximum in the afternoon and minimum during night or when the sunlight is less.

Applications

Dissolved oxygen analysis can be used to determine:

1. The health or cleanliness of a lake or stream.
2. The amount and type of biomass a freshwater system can support.
3. The amount of decomposition occurring in the lake or stream.

CPCB has recommended 5.0 mg/l concentration of dissolved oxygen for outdoor bathing in Class

B. Water having below 5.0 mg/l DO concentration is not suitable for out-door bathing in river. During the monsoon season, average value of Dissolved Oxygen (DO) below 5.0 mg/l were observed at fifty-four (54) water quality stations in the state of Tami Nadu, Bihar, Uttar Pradesh, Madhya Pradesh, Jharkhand, Odisha, Gujarat, Maharashtra, Andhra Pradesh, Telangana, Himachal Pradesh, Karnataka, Sikkim, Assam, Delhi, Uttarakhand, Haryana, Kerala, Chhattisgarh and West Bengal. During the non-monsoon season average value Dissolved Oxygen (DO) below 5.0 mg/l were observed at twenty-six (26) water quality stations found in the states of Tamil Nadu, Uttar Pradesh, Himachal Pradesh, Jharkhand, Odisha, Gujarat, Maharashtra, West Bengal, Karnataka, Sikkim, Assam, Delhi and Haryana. The hot spot study and GIS map for DO parameter are given below in Table 9 and figure 12.

Stations having Dissolved Oxygen concentration below 5.0 mg/l in River Water

(During Period: 2010-2020)

S.No.	Water Quality Site	River	CWC Division Office	State	District	Monsoon	Non-Monsson
1	Agra(P.G)	Yamuna	LYD, Agra	Uttar Pradesh	Agra	1.61	1.38
2	Akbarpur	ChhotiSarju	MGD-III, Varanasi	Uttar Pradesh	Ambedkar Nagar	-	4.7
3	Ambari	Torsa	LBD, Jalpaiguri	West Bengal	Cooch Behar	4.13	4.45
4	Baladoba	Sankosh	LBD, Jalpaiguri	Assam	Dhubri	4.71	4.88
5	Baridhi Nala	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Purbi Singhbhum	3.1	3.52
6	Basti U/S	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	3.98	-
7	Bendrahalli	Suvarnavathi	CD, Bangalore	Karnataka	Chamarajanagar	3.16	-
8	Bhalwara	Gaur	ND, Bhopal	Madhya Pradesh	Jabalpur	4.26	-
9	Champua	Baitarani	ERD, Bhubaneswar	Odisha	Keonjhar	4.58	-
10	Coronation	Teesta	LBD, Jalpaiguri	West Bengal	Darjeeling	4.72	4.88
11	Chel	Chel	LBD, Jalpaiguri	West Bengal	Jalpaiguri	-	4.95
12	Daund	Bhima	UKD, Pune	Maharashtra	Pune	-	4.23
13	Delhi Rly Bridge	Yamuna	UYD, New Delhi	Delhi	North Delhi	2	1.3
14	Dindori	Narmada	ND, Bhopal	Madhya Pradesh	Dindori	4.71	-
15	Galeta	Yamuna	UYD, New Delhi	Uttar Pradesh	Meerut	0.98	0.95
16	Gatora(1)	Arpa	MD, Burla	Chhattisgarh	Bilaspur	4.28	-

S.No	Water Quality Site	River	CWC Division Office	State	District	M	NM
17	Gazoldoba	Teesta	LBD, Jalpaiguri	West Bengal	Jalpaiguri	4.88	4.57
18	Ghish	Ghish	LBD, Jalpaiguri	West Bengal	Jalpaiguri	4.76	4.62
19	Golokganj	Gadadhar	LBD, Jalpaiguri	Assam	Dhubri	4.04	-
20	Govindpur	Burhabalang	ERD, Bhubaneswar	Odisha	Balasore	4.88	-
21	Gunupur	Vamsadhara	ERD, Bhubaneswar	Odisha	Rayagada	3.78	-
22	Jamshedpur	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Purbi Singhbhum	4.76	-
23	Jawahar Bridge	Yamuna	LYD, Agra	Uttar Pradesh	Agra	3.77	3.42
24	Kakerghati	Kamla	LGD 1, Patna	Bihar	Darbhanga	4.21	-
25	Kanti	BurhiGandak	LGD 1, Patna	Bihar	Muzaffarpur	4.6	-
26	Kashinagar	Vamsadhara	ERD, Bhubaneswar	Odisha	Gajapati	4.37	-
27	Khairmal	Mahanadi	MD, Burla	Odisha	Boudh	4.38	-
28	Khanitar	Teesta	LBD, Jalpaiguri	Sikkim	East Sikkim	4.1	4.63
29	Lakhwara	Kachhua	LGD 1, Patna	Bihar	Muzaffarpur	4.37	-
30	Majhitar	Rangeet	LBD, Jalpaiguri	Sikkim	South Sikkim (Namchi)	4.26	4.72
31	Mathura	Yamuna	UYD, New Delhi	Uttar Pradesh	Mathura	2.95	2.49
32	Mawi	Yamuna	UYD, New Delhi	Uttar Pradesh	Muzaffar Nagar	4.73	-
33	MBPL	Hasdeo	MD, Burla	Chhattisgarh	Bilaspur	4.37	-
34	Mirawadi	Mula-Mutha	UKD, Pune	Maharashtra	Pune	3.71	4.91
35	Mohna	Yamuna	UYD, New Delhi	Haryana	Faridabad	2.31	1.6
36	Nawapara	Mahanadi	MD, Burla	Odisha	Gariaband	4.87	-
37	Neora	Neora	LBD, Jalpaiguri	West Bengal	Jalpaiguri	4.44	-
38	Nirmali	Kosi	LGD 1, Patna	Bihar	Supaul	3.74	-
39	Paleru Bridge	Paleru	LKD, Hyderabad	Andhra Pradesh	Krishna	4.59	-
40	Palla	Yamuna	UYD, New Delhi	Delhi	North West Delhi	4.91	-
41	Patan	Hiran	ND, Bhopal	Madhya Pradesh	Jabalpur	4.59	-
42	Pingalwada	Dhadhar	TD, Surat	Gujarat	Vadodara	3.4	2.77
43	Poanta	Yamuna	UYD, New Delhi	Himachal Pradesh	Sirmaur	4.12	4.74
44	Rangpo	Rangpochu	LBD, Jalpaiguri	Sikkim	East Sikkim	4.54	-
45	Roorkie D/S	SOLANI	HGD Haridwar	Uttarakhand	Haridwar	0	0.75
46	Roorkie U/S	SOLANI	HGD Haridwar	Uttarakhand	Haridwar	0	0.94
47	RSP	Brahamani	ERD, Bhubaneswar	Odisha	Sundergarh	-	4.71

S.No	Water Quality Site	River	CWC Division Office	State	District	M	NM
48	Sakra	BurhiGandak	LGD 1, Patna	Bihar	Muzaffarpur	4.77	-
49	Sevoke	Teesta	LBD, Jalpaiguri	West Bengal	Darjeeling	4.62	-
50	Shaladang	Torsa	LBD, Jalpaiguri	West Bengal	Cooch Behar	4.06	-
51	Singasadanapalli	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	0.13	0.34
52	Srikakulam	Nagavali	ERD, Bhubaneswar	Andhra Pradesh	Srikakulam	4.66	-
53	T Bekuppe	Arkavathy	CD, Bangalore	Karnataka	Ramanagara	2.61	2.81
54	T K Halli	Shimsha	CD, Bangalore	Karnataka	Mandya	4.83	-
55	Thottathinkadavu	Iruvazhanjippuzha	SWRD, Kochi	Kerala	Kozhikode	4.9	-
56	Valigonda	Musi	LKD, Hyderabad	Telangana	Nalgonda	4.18	-
57	Vautha	Sabarmati	MD, Gandhinagar	Gujarat	Kheda	2.36	1.49
58	Wadakbal	Sina	UKD, Pune	Maharashtra	Solapur	3.65	-

(-) means: No Hotspot

Table 09: Stations having DO < 5mg/l in River Water

Stations having DO concentration < 5.0 mg/l in River Water during period 2010-2020

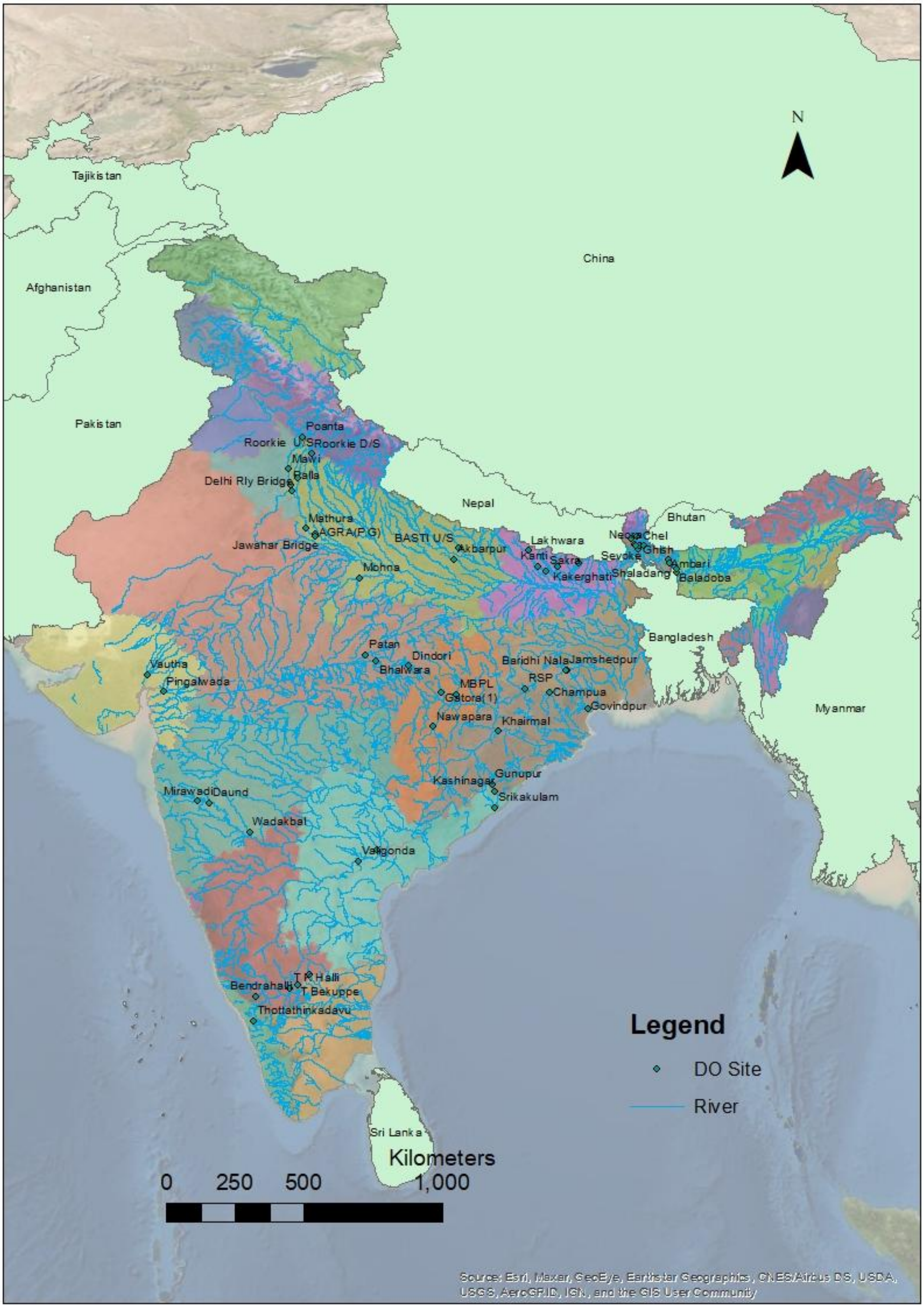


Figure 12: Stations having DO < 5mg/l in River Water

6.2.9 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is the amount of dissolved oxygen (DO) needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per litter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution. BOD reduction is used as a gauge of the effectiveness of wastewater treatment plants. BOD of wastewater effluents is used to indicate the short-term impact on the oxygen levels of the receiving water.

BOD analysis is similar in function to Chemical Oxygen Demand (COD) analysis, in that both measure the amount of organic compounds in water. However, COD analysis is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically oxidized organic matter.

The BOD test is widely used to determine the pollution strength of domestic and industrial wastes in terms of the oxygen that they will require if discharged into natural watercourses in which aerobic conditions exist. The test is one of the most important in stream-pollution-control activities. This test is of prime importance in regulatory work and in studies designed to evaluate the purification capacity of receiving bodies of water. The BOD test is essentially a bioassay procedure involving the measurement of oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in a waste, under conditions as similar as possible to those that occur in nature. CPCB has recommended 3.0 mg/l concentration of biochemical oxygen demand for out-door bathing. Water having above 3.0 mg/l BOD concentration is not suitable for the out-door bathing. During the monsoon season, average value of Biochemical Oxygen Demand (BOD) more than 3.0 mg/l were observed at seventy-three (73) water quality stations found in the state of Tamil Nadu, Rajasthan, Jharkhand, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, Telangana, West Bengal, Bihar, Odisha, Gujarat, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh. During the non-monsoon season, average value of Biochemical Oxygen Demand (BOD) more than 3.0 mg/l were observed at sixty-seven (67) water quality stations found in the state of Tamil Nadu, Rajasthan, Jharkhand, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar, Odisha, Gujarat, Karnataka, Delhi, Haryana and Chhattisgarh. The hot spot study and GIS map for BOD parameter are given below in Table 10 and figure 13.

Stations having BOD Concentration above 3.0 mg/l in River Water

(During Period: 2010-2020)

S.No.	Site	River	CWC Division Office	State	District	M	NM
1	Ab Road	Parwati	Chambal Division, Jaipur	Madhya Pradesh	Guna	-	16.9
2	Agra (P.G)	Yamuna	LYD, Agra	Uttar Pradesh	Agra	19.71	18.27
3	Akbarpur	ChhotiSarju	MGD-III, Varanasi	Uttar Pradesh	Ambedkar Nagar	5.37	6.06
4	Allahabad	Ganga	MGD-III, Varanasi	Uttar Pradesh	Prayagraj	3.28	3.23
5	Amgaon	Chulband	WD, Nagpur	Maharashtra	Chulband	3.2	3.78
6	Auraiya	Yamuna	LYD, Agra	Uttar Pradesh	Auraiya	8.81	12.86
7	Baluaghat	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	3.66	3.86
8	Bamni	Wardha	WD, Nagpur	Maharashtra	Chandrapur	15.99	10.67
9	Banda	Ken	LYD, Agra	Uttar Pradesh	Banda	5.05	5.25
10	Basti	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	3.18	-
11	Basti D/S	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	4.54	3.71
12	Basti U/S	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	9.06	6.05
13	Baridhi Nala	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Purbi Singhbhum	3.18	-
14	Bhatpalli	Peddavagu	WD, Nagpur	Telangana	Kumrambhim	4.94	-
15	Delhi Rly Bridge	Yamuna	Uyd, New Delhi	Delhi	North Delhi	28.15	40.87
16	Dholpur	Chambal	LYD, Agra	Rajasthan	Dholpur	4.14	3.86
17	Ekmighat	AdhwaraSamuh	LGD 1, Patna	Bihar	Darbhanga	-	4.31
18	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamil Nadu	Erode	9.36	6.29
19	Etawah	Yamuna	LYD, Agra	Uttar Pradesh	Etawah	16.78	33.56
20	Galeta	Yamuna	UYD, New Delhi	Uttar Pradesh	Meerut	41.35	54.86
21	Gandhi Ghat	Ganga	LGD 1, Patna	Bihar	Patna	3.22	-
22	Ganod	Bhadar	MD, Gandhinagar	Gujarat	Rajkot	3.85	3.78
23	Garrauli	Dhasan	LYD, Agra	Madhya Pradesh	Chhatarpur	4.08	3.91
24	Ghazipur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Ghazipur	3.42	3.4
25	Gopalkheda	Purna	TD, Surat	Maharashtra	Akola	-	3.71
26	Gorakhpur D/S	Rapti	MGD-I, Lucknow	Uttar Pradesh	Gorakhpur	-	3.9
27	Gorakhpur U/S	Rapti	MGD-I, Lucknow	Uttar Pradesh	Gorakhpur	5.16	-
28	Gummanur	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	10.31	8.58
29	Hamirpur	Yamuna	LYD, Agra	Uttar Pradesh	Hamirpur	5.09	7.36
30	Hivra	Wardha	WD, Nagpur	Maharashtra	Wardha	8.33	7.73
31	Jai Nagar	Kamla	LGD 1, Patna	Bihar	Madhubani	3.37	-
32	Jaunpur	Gomti	MGD-III, Varanasi	Uttar Pradesh	Jaunpur	3.52	3.65
33	Kalna Flow	Bhagirathi (Hooghly)	LGD 3, Berhampore	West Bengal	Burdwan	-	3.34
34	Keolari	Wainganga	WD, Nagpur	Madhya Pradesh	Seoni	9.14	4.65
35	Kora	Rind	LYD, Agra	Uttar Pradesh	Fatehpur	3.32	3.11
36	Kulpatang	Kharkai	ERD, Bhubaneswar	Jharkhand	Purbi Singhbhum	-	5.09
37	Kumhari	Wainganga	WD, Nagpur	Madhya Pradesh	Balaghat	3.55	-

S.No.	Site	River	CWC Division Office	State	District	M	NM
38	Kanpur	Ganga	MGD-II, Lucknow	Uttar Pradesh	Kanpur	5.58	5.67
39	Nallamaranpatty	Amaravathi	SRD, Coimbatore	Tamil Nadu	Karur	3.94	-
40	Lodhikheda	Jam	WD, Nagpur	Madhya Pradesh	Chhindwara	17.67	-
41	Luwara	Shetrunji	MD, Gandhinagar	Gujarat	Bhavnagar	-	3.43
42	Mandala	Ken	ND, Bhopal	Madhya Pradesh	Mandla	3.25	-
43	Magardhara	Wainganga	WD, Nagpur	Madhya Pradesh	Wainganga	7.3	-
44	Mahidpur	Shipra	Chambal Division, Jaipur	Madhya Pradesh	Ujjain	4.74	-
45	Maighat	Gomti	MGD-III, Varanasi	Uttar Pradesh	Jaunpur	3.15	3.05
46	Marol	Varada	CD, Bangalore	Karnataka	Haveri	3.04	-
47	Mathura	Yamuna	UYD, New Delhi	Uttar Pradesh	Mathura	20.54	23.46
48	Mawi	Yamuna	UYD, New Delhi	Uttar Pradesh	Muzaffar Nagar	5.2	6.28
49	Mbpl	Hasdeo	Md, Burla	Chhattisgarh	Bilaspur	26.48	20.87
50	Mirawadi	Mula-Mutha	UKD, Pune	Maharashtra	Pune	-	3.84
51	Mirzapur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Mirzapur	-	3.07
52	Mohana	Yamuna	UYD, New Delhi	Haryana	Faridabad	17.89	26.14
53	Mungoli	Penganga	WD, Nagpur	Maharashtra	Penganga	-	16.18
54	Nandgaon	Wena	WD, Nagpur	Maharashtra	Wardha	8.69	4.67
55	Nanded	Godavari	UGD, Hyderabad	Maharashtra	Nanded	3.1	-
56	P.G.Bridge	Penganga	Wd, Nagpur	Maharashtra	Yeotmal	3.32	-
57	Palla	Yamuna	UYD, New Delhi	Delhi	North West Delhi	5.43	5.96
58	Paramakudi	Vaigai	SRD, Coimbatore	Tamil Nadu	Ramanathapuram	-	3.85
59	Pargaon	Bhima	UKD, Pune	Maharashtra	Pune	-	3.29
60	Parsohan Ghat	Rapti	MGD-I, Lucknow	Uttar Pradesh	Siddharthnagar	3.34	-
61	Pauni	Wainganga	WD, Nagpur	Maharashtra	Bhandara	5.76	6.22
62	Pingalwada	Dhadhar	TD, Surat	Gujarat	Vadodara	8.48	9.54
63	Pratapgarh	Sai	MGD-III, Varanasi	Uttar Pradesh	Pratapgarh	4.35	3.51
64	Pratappur	Yamuna	LYD, Agra	Uttar Pradesh	Allahabad	-	3.06
65	Rajapur	Yamuna	LYD, Agra	Uttar Pradesh	Chitrakoot	3.94	4.3
66	Rajegaon	Bagh	WD, Nagpur	Madhya Pradesh	Balaghat	4.96	-
67	Rajghat	Betwa	LYD, Agra	Uttar Pradesh	Lalitpur	3.19	3.25
68	Ramakona	Kanhan	WD, Nagpur	Madhya Pradesh	Chindawara	3.94	3.14
69	Roorkie D/S	Solani	HGD Haridwar	Uttarakhand	Haridwar	85.52	60.01
70	Roorkie U/S	Solani	HGD Haridwar	Uttarakhand	Haridwar	82.98	55.88
71	Rsp	Brahamani	ERD, Bhubaneswar	Odisha	Sundergarh	3.62	4.38
72	Shahjina	Betwa	LYD, Agra	Uttar Pradesh	Hamirpur	4.51	4.64
73	Saidpur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Ghazipur	3.51	3.73
74	Sakmur	Wardha	WD, Nagpur	Maharashtra	Chandrapur	12.52	9.1
75	Satrapur	Kanhan	WD, Nagpur	Maharashtra	Nagpur	7.22	7.1
76	Seondha	Sindh	LYD, Agra	Madhya Pradesh	Datia	3.68	-
77	Shahzadpur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Kaushambi	-	3.02

S.No.	Site	River	CWC Division Office	State	District	M	NM
78	Shastri Bridge	Ganga	MGD-III, Varanasi	Uttar Pradesh	Prayagraj	3.31	3.88
79	Singasadanapalli	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	27.07	34.91
80	Sultanpur	Gomti	MGD-III, Varanasi	Uttar Pradesh	Sultanpur	3.54	3.49
81	T Bekuppe	Arkavathy	Cd, Bangalore	Karnataka	Ramanagara	13.32	12.94
82	Tal	Chambal	Chambal Division, Jaipur	Madhya Pradesh	Ratlam	4.14	-
83	Tekra	Pranhita	WD, Nagpur	Maharashtra	Gadchiroli	4.22	-
84	Tonk	Banas	Chambal Division, Jaipur	Rajasthan	Tonk	3.54	-
85	V.S.Bridge	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	3.36	3.68
86	Varanasi	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	3.15	3.16
87	Vautha	Sabarmati	MD, Gandhinagar	Gujarat	Kheda	17.41	28.22
88	Wadakbal	Sina	UKD, Pune	Maharashtra	Solapur	-	4.23

(-) means: No Hotspot

Table 10: Stations having BOD < 3mg/l in River Water

Stations having BOD Concentration > 3.0 mg/l in River Water during period 2010-2020

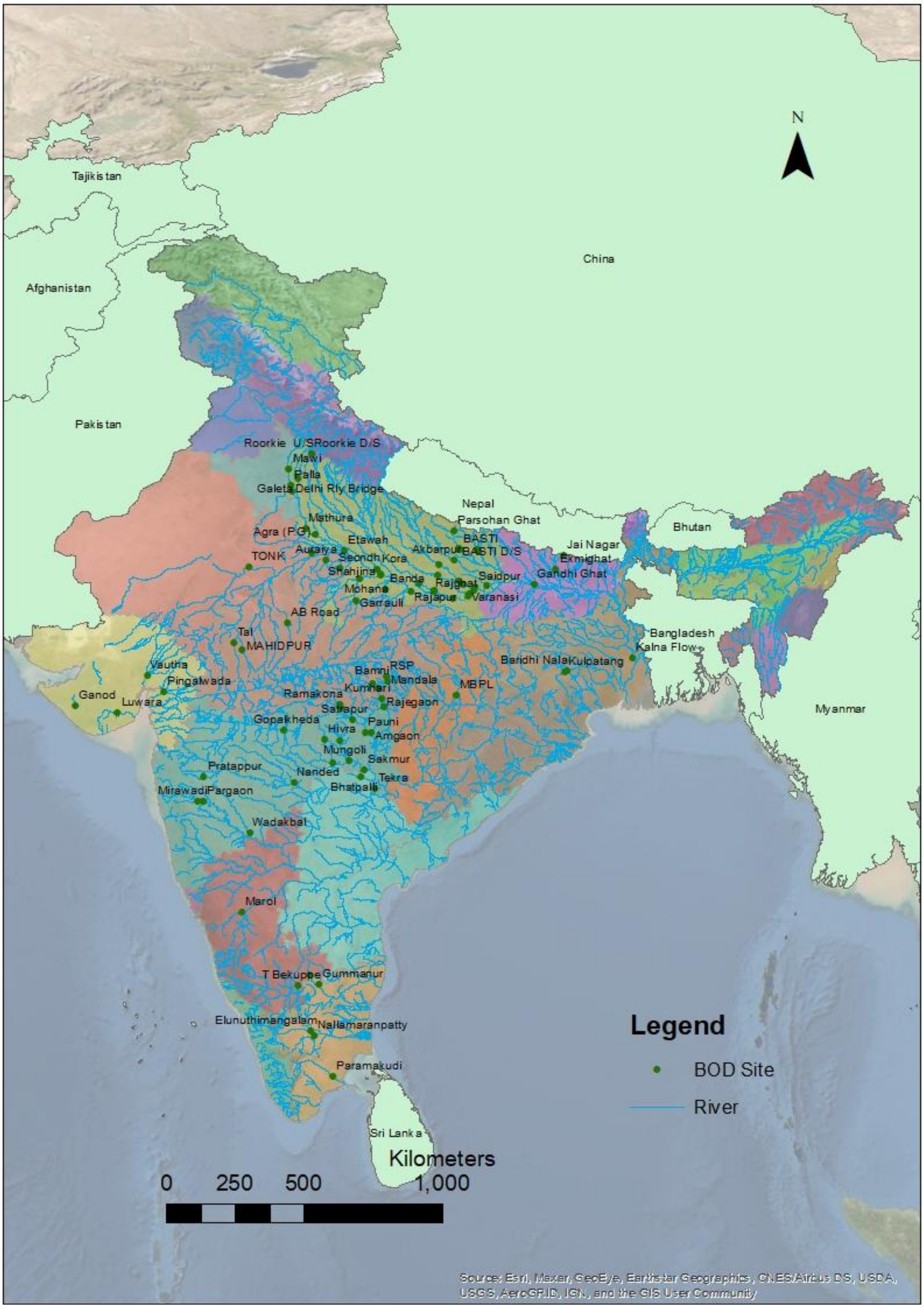


Figure 13: Stations having BOD < 3mg/l in River Water

6.2.10Total Coliforms (TC)

Water pollution caused by fecal contamination is a serious problem due to the potential for contracting diseases from pathogens (disease causing organisms). Frequently, concentrations of pathogens from fecal contamination are small, and the number of different possible pathogens is large. As a result, it is not practical to test for pathogens in every water sample collected. Instead, the presence of pathogens is determined with indirect evidence by testing for an "indicator" organism such as coliform bacteria. Coliforms come from the same sources as pathogenic organisms. Coliforms are relatively easy to identify, are usually present in larger numbers than more dangerous pathogens, and respond to the environment, wastewater treatment, and water treatment similarly to many pathogens. As a result, testing for coliform bacteria can be a reasonable indication of whether other pathogenic bacteria are present.

There are three groups of coliform bacteria. Each is an indicator of drinking water quality and each has a different level of risk. Total coliform is a large collection of different kinds of bacteria. Fecal coliform are types of total coliform that exist in feces. E. coli is a subgroup of fecal coliform. As per CPCB water quality criteria for bathing (outdoor), the Total Coliforms Organism MPN/100ml shall be 500 MPN/100 ml or less. The mainsource of Total Coliforms in Indian rivers is sewage discharge, open defecation, cattle wallowing, disposal of animal caracass and unburnt bodies.

During the monsoon season, the average value of Total Coliforms (TC) more than 500 MPN/100 ml were observed at two hundred thirty-eight (238) water quality stations found in the state of Rajasthan, Uttarakhand, Maharashtra, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Telangana, Himachal Pradesh, Gujarat, Himachal Pradesh, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh and Tamil Nadu. During the non-monsoon season, average value of Total Coliforms (TC) ofmore than 500 MPN / 100 ml were observed at two hundred thirty-three (233) water quality stations found in the state of Andhra Pradesh, Telangana, Himachal Pradesh, Gujarat, Andhra Pradesh, Karnataka, Delhi, Haryana, Chhattisgarh, Tamil Nadu, Rajasthan, Uttarakhand, Madhya Pradesh, Uttar Pradesh and Maharashtra. The hot spot study and GIS map for total coliforms parameter are given below in Table 11 and figure 14.

Environmental Impact:

The presence of Total Coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Total coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

Stations having Total Coliforms Concentration > 500 MPN/100ml in River Water

(During Period: 2010-2020)

S.No.	Site	River	CWC Division Office	State	District	M	NM
1	Abu Road	Banas	MD, Gandhinagar	Rajasthan	Sirohi	3191	5535
2	Agra(P.G)	Yamuna	LYD, Agra	Uttar Pradesh	Agra	123537	218129
3	Akbarpur	Chhotisarju	MGD-III, Varanasi	Uttar Pradesh	Ambedkar Nagar	7632	16092
4	Akkihebbal	Hemavati	CD, Bangalore	Karnataka	Mandya	3688	6851
5	Aklera	Parwan	Chambal Division, Jaipur	Rajasthan	Jhalawar	90200	*
6	Alandurai	Noyyal	SRD, Coimbatore	Tamil Nadu	Coimbatore	46425	94750
7	Allahabad	Ganga	MGD-III, Varanasi	Uttar Pradesh	Prayagraj	8641	15945
8	Ambarampalayam	Aliyar	SRD, Coimbatore	Tamil Nadu	Coimbatore	8814	12875
9	Ambasamudram	Vaigai	SRD, Coimbatore	Tamil Nadu	Theni	160000	63500
10	Arangaly	Chalakudy	SWRD, Kochi	Kerala	Trichur	1078	1425
11	Arjunwad	Krishna	UKD, Pune	Maharashtra	Kolhapur	27248	44140
12	Ashti	Wainganga	WD, Nagpur	Maharashtra	Gadchiroli	6252	1144
13	Augustmuni D/S	Mandakani	HGD Haridwar	Uttarakhand	Rudraprayag	2680	2645
14	Augustmuni D/S	Mandakani	HGD Haridwar	Uttarakhand	Rudraprayag	2080	2040
15	Auraiya	Yamuna	LYD, Agra	Uttar Pradesh	Auraiya	44629	47689
16	Ayodhya	Ghaghra	MGD-I, Lucknow	Uttar Pradesh	Faizabad	3272	2908
17	Badlapur	Ulhas	UKD, Pune	Maharashtra	Thane	39181	80159
18	Balrampur	Rapti	MGD-I, Lucknow	Uttar Pradesh	Balrampur	2111	1285
19	Baluaghat	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	59800	71290
20	Bamni	Wardha	WD, Nagpur	Maharashtra	Chandrapur	9063	6795
21	Banda	Ken	LYD, Agra	Uttar Pradesh	Banda	15025	24006
22	Bansi	Rapti	MGD-I, Lucknow	Uttar Pradesh	Siddharthnagar	2183	2042
23	Barod	Kalisindh	CD, Jaipur	Rajasthan	Kota	56583	719000
24	Basti	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	3383	2538
25	Basti D/S	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	1520	1230
26	Basti U/S	Kuwano	MGD-I, Lucknow	Uttar Pradesh	Basti	1100	990
27	Bawapuram	Tungabhadra	LKD, Hyderabad	Andhra Pradesh	Kurnool	7223	5778
28	Belne Bridge	Gad	CD, Bangalore	Maharashtra	Sindudurg	8775	11000
29	Bendrahalli	Suvarnavathi	CD, Bangalore	Karnataka	Chamarajanagar	64000	34736
30	Bhadrachalam	Godavari	LGD, Hyderabad	Telangana	Khammam	8004	6078
31	Bhatpalli	Peddavagu	WD, Nagpur	Telangana	Kumrambhim	9281	3089
32	Biligundulu	Cauvery	SRD, Coimbatore	Tamil Nadu	Krishnagiri	1565	4622
33	Birdghat	Rapti	MGD-I, Lucknow	Uttar Pradesh	Gorakhpur	4006	2677
34	Burhanpur	Tapi	TD, Surat	MP	Khandwa	1995	1997

S.No.	Site	River	CWC Division Office	State	District	M	NM
35	Chandwada	Orsang	TD, Surat	Gujarat	Vadodara	1533	1423
36	Chitrasani	Balaram	MD, Gandhinagar	Gujarat	Banaskantha	3681	4289
37	Cholachugudda	Malaprabha	CD, Bangalore	Karnataka	Bagalkot	41817	128586
38	Chepan	Raidak	LBD, Jalpaiguri	West Bengal	Alipurduar	2893	5123
39	Chunchanakatte	Cauvery	CD, Bangalore	Karnataka	Mysuru	8706	3200
40	Dameracherla	Musi	LKD, Hyderabad	Telangana	Nalgonda	6058	5546
41	Daund	Bhima	UKD, Pune	Maharashtra	Pune	9738	45600
42	Delhi Rly Bridge	Yamuna	UYD, New Delhi	Delhi	North Delhi	13039333	30052381
43	Derol Bridge	Sabarmati	MD, Gandhinagar	Gujarat	Sabarkantha	7559	7371
44	Devprayag	Ganga	HGD Haridwar	Uttarakhand	Pauri	3780	2479
45	Dhalegaon	Godavari	UGD, Hyderabad	Maharashtra	Parbhani	7607	16000
46	Dholpur	Chambal	LYD, Agra	Rajasthan	Dholpur	7678	6536
47	Duddhi	Kanhar	MGD-III, Varanasi	Uttar Pradesh	Sonbhadra	2343	4000
48	Durvesh	Vaitarna	TD, Surat	Maharashtra	Palghar	1621	2173
49	Elginbridge	Ghaghra	MGD-I, Lucknow	Uttar Pradesh	Barabanki	2517	1777
50	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamil Nadu	Erode	206200	137565
51	Etawah	Yamuna	LYD, Agra	Uttar Pradesh	Etawah	87400	126678
52	Ghatshila Rd Bridge	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Purbi Singhbhum	16000	2700
53	Gadat	Ambika	TD, Surat	Gujarat	Valsad	1979	3240
54	Galeta	Hindon	UYD, New Delhi	Uttar Pradesh	Meerut	14741333	48429444
55	Gandhavayal	Gandhayar	SRD, Coimbatore	Tamil Nadu	Coimbatore	100333	46444
56	Ganod	Bhadar	MD, Gandhinagar	Gujarat	Rajkot	6577	4542
57	Garrauli	Dhasan	LYD, Agra	MP	Chhatarpur	1850	9970
58	Garudeshwar	Narmada	TD, Surat	Gujarat	Narmada	1144	1180
59	Ghazipur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Ghazipur	43400	90240
60	Gopalkheda	Purna	TD, Surat	Maharashtra	Akola	1092	1271
61	Gorakhpur D/S	Rapti	MGD-I, Lucknow	Uttar Pradesh	Gorakhpur	5020	2000
62	Gorakhpur U/S	Rapti	MGD-I, Lucknow	Uttar Pradesh	Gorakhpur	3860	2580
63	Gummanur	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	250130	83878
64	Halia	Halia	LKD, Hyderabad	Telangana	Nalgonda	7207	5354
65	Hamirpur	Yamuna	LYD, Agra	Uttar Pradesh	Hamirpur	50930	28468
66	Haridwar	Ganga	HGD Haridwar	Uttarakhand	Haridwar	3595	3296
67	Haridwar D/S	Ganga	HGD Haridwar	Uttarakhand	Haridwar	3900	3630
68	Haridwar U/S	Ganga	HGD Haridwar	Uttarakhand	Haridwar	3710	3395
69	Hariharapura	Tunga (Thunga)	CD, Bangalore	Karnataka	Chikmagalur	7984	3500
70	Haralahalli	Tungabhadra	CD, Bangalore	Karnataka	Haveri	9398	1652
71	Hivra	Wardha	WD, Nagpur	Maharashtra	Wardha	10776	1192
72	Holehonnur	Tunga (Thunga)	CD, Bangalore	Karnataka	Shimoga	14178	6584
73	Honnali	Tungabhadra	CD, Bangalore	Karnataka	Davanagere	32471	8409
74	Huvinhedigi	Krishna	LKD, Hyderabad	Karnataka	Raichur	5497	4703
75	Jagdalpur	Indravati	LGD, Hyderabad	Chhattisgarh	Bastar	9008	6518
76	Jaunpur	Gomti	MGD-III, Varanasi	Uttar Pradesh	Jaunpur	30867	49860
77	Jawahar Bridge	Yamuna	LYD, Agra	Uttar Pradesh	Agra	315909	252867
78	K.M.Vadi	Lakshmanthirtha	CD, Bangalore	Karnataka	Mysuru	34550	13183
79	Kabirganj	Sarda	MGD-I, Lucknow	Uttar Pradesh	Pilibhit	880	692
80	Kalampur	Kaliyar	SWRD, Kochi	Kerala	Ernakulam	1170	1367
81	Kallooppara	Manimala	SWRD, Kochi	Kerala	Pathanamthitta	1094	1425
82	Kamalpur	Banas	MD, Gandhinagar	Gujarat	Banaskantha	1078	25750
83	Karad	Krishna	UKD, Pune	Maharashtra	Satara	589135	148338
84	Karathodu	Kadalundi	SWRD, Kochi	Kerala	Malappuram	1536	950

S.No.	Site	River	CWC Division Office	State	District	M	NM
85	Karnparayag	Pinder	HGD Haridwar	Uttarakhand	Chamoli	3140	2711
86	Keesara	Krishna/Munneru	LKD, Hyderabad	Andhra Pradesh	Krishna	9685	5341
87	Kellodu	Vedavathi	CD, Bangalore	Karnataka	Chitradurga	11700	6567
88	Keolari	Wainganga	WD, Nagpur	Madhya Pradesh	Seoni	4518	1867
89	Kanpur	Ganga	MGD-II, Lucknow	Uttar Pradesh	Kanpur	7565	4054
90	Khanpur	Mahi	MD, Gandhinagar	Gujarat	Anand	11981	5551
91	Khatoli	Parwati	Chambal Division, Jaipur	Rajasthan	Kota	238667	315167
92	Kidangoor	Meenachil	SWRD, Kochi	Kerala	kottayam	1421	1500
93	Kirtinagar U/S	Alkananda	HGD Haridwar	Uttarakhand	Tehri	2940	2430
94	Kirtinagar D/S	Alkananda	HGD Haridwar	Uttarakhand	Tehri	2372	2590
95	Kodumudi	Cauvery	SRD, Coimbatore	Tamil Nadu	Erode	8916	25625
96	Kollegal	Cauvery	CD, Bangalore	Karnataka	Chamarajanagar	9646	6070
97	Konta	Sabari	LGD, Hyderabad	Chhattisgarh	Dantewara	7056	4893
98	Kopergaon	Godavari	UGD, Hyderabad	Maharashtra	Ahmednagar	10079	4563
99	Kora	Rind	LYD, Agra	Uttar Pradesh	Fatehpur	4163	2433
100	Koteshwar	Bhagirathi	HGD Haridwar	Uttarakhand	Tehri	3200	2346
101	Kudige	Cauvery	CD, Bangalore	Karnataka	Kodagu	4400	6271
102	kudlur	Palar	SRD, Coimbatore	Karnataka	Chamarajanagar	190000	24133
103	Kuldah Bridge	Sone	MGD-III, Varanasi	Madhya Pradesh	Sidhi	3696	5926
104	Kumbidi	Bharathapuzha	SWRD, Kochi	Kerala	Palakkad	1206	1299
105	Kumhari	Wainganga	WD, Nagpur	Madhya Pradesh	Balaghat	4020	1113
106	Kuniyil	Chaliyar	SWRD, Kochi	Kerala	Malappuram	1306	1475
107	Kuppellur	Kumudavathi	CD, Bangalore	Karnataka	Haveri	17817	2260
108	Kurundwad	Krishna	UKD, Pune	Maharashtra	Kolhapur	93755	2160
109	Kuttyadi	Kuttyadi	SWRD, Kochi	Kerala	Kozhikode	1233	1250
110	Lakkavalli	Bhadra	CD, Bangalore	Karnataka	Shimoga	2804	2844
111	Lakshmananpatti	Kodaganar	SRD, Coimbatore	Tamil Nadu	Dindigul	65667	8050
112	Luwara	Shetrunji	MD, Gandhinagar	Gujarat	Bhavnagar	3562	6600
113	M.H.Halli	Hemavati	CD, Bangalore	Karnataka	Hassan	21066	7076
114	Madla	Ken	LYD, Agra	Madhya Pradesh	Panna	1336	4640
115	Madhira	Wyra	LKD, Hyderabad	Telangana	Khammam	9990	4734
116	Magardharra	Wainganga	WD, Nagpur	Madhya Pradesh	Wainganga	16000	*
117	Mahidpur	Shipra	Chambal Division, Jaipur	Madhya Pradesh	Ujjain	220000	*
118	Mahuwa	Purna	TD, Surat	Gujarat	Surat	1564	1733
119	Maighat	Gomti	MGD-III, Varanasi	Uttar Pradesh	Jaunpur	6890	11630
120	Malakkara	Pampa	SWRD, Kochi	Kerala	Pathanamthitta	1151	1400
121	Malkhed	Kagna	LKD, Hyderabad	Karnataka	Gulbarga	8094	5962
122	Mancherial	Godavari	UGD, Hyderabad	Telangana	Adilabad	7609	5577
123	Mangaon	Kal	UKD, Pune	Maharashtra	Raigad	39003	15578
124	Mankara	Bharathapuzha	SWRD, Kochi	Kerala	Palakkad	1104	1187
125	Mantralayam	Tungabhadra	LKD, Hyderabad	Andhra Pradesh	Kurnool	6589	3727
126	Marol	Varada	CD, Bangalore	Karnataka	Haveri	25602	3500
127	Mataji	Mahi	MD, Gandhinagar	Madhya Pradesh	Ratlam	9423	3716
128	Mathura	Yamuna	UYD, New Delhi	Uttar Pradesh	Mathura	1247933	2177368

S.No.	Site	River	CWC Division Office	State	District	M	NM
129	Mawi	Yamuna	UYD, New Delhi	Uttar Pradesh	Muzaffar Nagar	171562	328100
130	Meja Road	Tons	MGD-III, Varanasi	Uttar Pradesh	Allahabad	3406	5837
131	Mirawadi	Mula-Mutha	UKD, Pune	Maharashtra	Pune	24514	38080
132	Mirzapur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Mirzapur	8202	13857
133	Mohana	Betwa	LYD, Agra	Uttar Pradesh	Jalaun	1982867	5994211
134	Motinaroli	Kim	TD, Surat	Gujarat	Surat	1525	1755
135	Munugodu	Edduvagu	LKD, Hyderabad	Andhra Pradesh	Guntur	7094	3920
136	Muradpur	Vashishti	UKD, Pune	Maharashtra	Ratnagiri	44675	11000
137	Murappanadu	Tambraparni	SRD, Coimbatore	Tamil Nadu	Tuticorin	9020	8058
138	Musiri	Cauvery	SRD, Coimbatore	Tamil Nadu	Thiruchirapalli	14400	9562
139	Muthankera	Kabini	CD, Bangalore	Kerala	Wynad	7510	2702
140	Nagothane	Amba	UKD, Pune	Maharashtra	Raigad	9156	53080
141	Nandgaon	Wunna	WD, Nagpur	Maharashtra	Wardha	13864	6115
142	Nanded	Godavari	UGD, Hyderabad	Maharashtra	Nanded	6630	7011
143	Neeleswaram	Periyar	SWRD, Kochi	Kerala	Ernakulam	1229	1065
144	Nellithurai	Bhavani	SRD, Coimbatore	Tamil Nadu	Coimbatore	13000	160000
145	Nowrangpur	Indravati	LGD, Hyderabad	Odisha	Nowrangpur	6984	3798
146	Odanthurai	Cauvery/Kallar	SRD, Coimbatore	Tamil Nadu	Coimbatore	63667	90600
147	P.G.Bridge	Penganga	WD, Nagpur	Maharashtra	Yeotmal	8504	1483
148	Pachegaon	Pravara	UGD, Hyderabad	Maharashtra	Ahmednagar	5157	7983
149	Paderdibadi	Mahi	MD, Gandhinagar	Rajasthan	Dungarpur	9495	5291
150	Paleru Bridge	Paleru	LKD, Hyderabad	Andhra Pradesh	Krishna	7390	5636
151	Paliakalan	Sarda	MGD-I, Lucknow	Uttar Pradesh	Lakhimpur Khiri	3411	2373
152	Palla	Yamuna	UYD, New Delhi	Delhi	North West Delhi	227600	452105
153	Paramakudi	Vaigai	SRD, Coimbatore	Tamil Nadu	Ramanathapuram	*	17000
154	Pargaon	Bhima	UKD, Pune	Maharashtra	Pune	26725	7400
155	Parsohan Ghat	Rapti	MGD-I, Lucknow	Uttar Pradesh	Siddharthnagar	1040	809
156	Pathagudem	Indravati	LGD, Hyderabad	Chhattisgarh	Dantewara	5077	3812
157	Pattazhy	Kallada	SWRD, Kochi	Kerala	Quilon	1180	1280
158	Pauni	Wainganga	WD, Nagpur	Maharashtra	Bhandara	14218	5951
159	Pen	Bhogeswari	UKD, Pune	Maharashtra	Raigad	35913	28233
160	Perumannu	Valapatnam	SWRD, Kochi	Kerala	Cannanore	998	1087
161	Perur	Godavari	UGD, Hyderabad	Telangana	Khammam	6480	4951
162	Phulgaon	Bhima	UKD, Pune	Maharashtra	Pune	31333	900
163	Pingalwada	Dhadhar	TD, Surat	Gujarat	Vadodara	3728	4493
164	Poanta	Yamuna	UYD, New Delhi	Himachal Pradesh	Sirmaur	58556	75275
165	Polavaram	Godavari	LGD, Hyderabad	Andhra Pradesh	West Godavari	7538	6293
166	Pratapgarh	Sai	MGD-III, Varanasi	Uttar Pradesh	Pratapgarh	8746	16730
167	Pratappur	Pravara	UGD, Hyderabad	Maharashtra	Ahmednagar	4641	6187
168	Pudur	Kannadipuzha	SWRD, Kochi	Kerala	Palakkad	1088	1600
169	Pulamanthole	Pulanthodu	SWRD, Kochi	Kerala	Palakkad	1433	1243
170	Rajapur	Yamuna	LYD, Agra	Uttar Pradesh	Chitrakoot	12600	13836
171	Rajegaon	Bagh	WD, Nagpur	Madhya Pradesh	Balaghat	10296	2412
172	Rajghat	Subarnarekha	ERD, Bhubaneswar	Odisha	Mayurbhanj	1709	3669
173	Ramakona	Kanhan	WD, Nagpur	Madhya Pradesh	Chindawara	3606	955
174	Ramamangalam	Muvattupuzha	SWRD, Kochi	Kerala	Ernakulam	1600	1367
175	Rangeli	Som	MD, Gandhinagar	Rajasthan	Dungarpur	7180	2845
176	Rishikesh	Ganga	HGD Haridwar	Uttarakhand	Dehradun	3955	3391
177	Rishikesh D/S	Ganga	HGD Haridwar	Uttarakhand	Rishikesh	4000	3300

S.No.	Site	River	CWC Division Office	State	District	M	NM
178	Rishikesh U/S	Ganga	HGD Haridwar	Uttarakhand	Rishikesh	3770	3041
179	Roorkee D/S	Saloni	HGD Haridwar	Uttarakhand	Haridwar	46000	37000
180	Roorkee U/S	Saloni	HGD Haridwar	Uttarakhand	Haridwar	44000	34300
181	Rudraprayag	Alaknanda	HGD Haridwar	Uttarakhand	Rudraprayag	3590	2562
182	Shahjina	Betwa	LYD, Agra	Uttar Pradesh	Hamirpur	27044	19242
183	Saidpur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Ghazipur	21875	19800
184	Saigaon	Manjira	UGD, Hyderabad	Karnataka	Bidar	7801	8171
185	Sakleshpur	Hemavati	CD, Bangalore	Karnataka	Hassan	6377	7773
186	Sakmur	Wardha	WD, Nagpur	Maharashtra	Chandrapur	2700	682
187	Saloora	Manjira	UGD, Hyderabad	Telangana	Nizamabad	2100	11333
188	Samdoli	Varna	UKD, Pune	Maharashtra	Sangli	10371	18000
189	Sangam	Jhelum	Chenab Division, Jammu	Jammu & Kashmir	Anantnag	4998	2776
190	Sangod	Parwan	Chambal Division, Jaipur	Rajasthan	Kota	85083	*
191	Saradaput	Sabari	LGD, Hyderabad	Odisha	Malkangiri	2700	7980
192	Sarangkheda	Tapi	TD, Surat	Maharashtra	Nandurbar	1389	1600
193	Sarati	Nira	UKD, Pune	Maharashtra	Pune	14575	5240
194	Satna	Tons	MGD-III, Varanasi	Madhya Pradesh	Satna	29000	42000
195	Satpuli D/S	Nayar	HGD Haridwar	Uttarakhand	Pauri	3260	2885
196	Satpuli U/S	Nayar	HGD Haridwar	Uttarakhand	Pauri	3580	3110
197	Satrapur	Kanhan	WD, Nagpur	Maharashtra	Nagpur	24546	10042
198	Savandapur	Bhavani	SRD, Coimbatore	Tamil Nadu	Erode	39516	12508
199	Seondha	Sindh	LYD, Agra	Madhya Pradesh	Datia	8366	9542
200	Sevanur	Chittar	SRD, Coimbatore	Tamil Nadu	Erode	39367	33878
201	Shahzadpur	Ganga	MGD-III, Varanasi	Uttar Pradesh	Kaushambi	6186	11226
202	Shastri Bridge	Ganga	MGD-III, Varanasi	Uttar Pradesh	Prayagraj	26333	85423
203	Shimoga	Tunga (Thunga)	CD, Bangalore	Karnataka	Shimoga	15967	12017
204	Singasadanapalli	Ponnaiyar	SRD, Coimbatore	Tamil Nadu	Krishnagiri	2861933	4999564
205	Srinagar	Alaknanda	HGD Haridwar	Uttarakhand	Pauri	4168	2737
206	Sultanpur	Gomti	MGD-III, Varanasi	Uttar Pradesh	Sultanpur	7535	12232
207	T. Bekuppe	Arkavathy	Cd, Bangalore	Karnataka	Ramanagara	321567	143865
208	T.K.Halli	Shimsha	Cd, Bangalore	Karnataka	Mandya	24407	15693
209	T Narasipura	Kabini	Cd, Bangalore	Karnataka	Mysuru	13113	6858
210	T.Ramapuram	Hagari	Lkd, Hyderabad	Karnataka	Bellary	7513	7566
211	Takli	Bhima	UKD, Pune	Maharashtra	Solapur	12838	1950
212	Tal	Chambal	Chambal Division, Jaipur	Madhya Pradesh	Ratlam	235167	*
213	Tanda D/S	Ghaghra	MGD-I, Lucknow	Uttar Pradesh	Ambedkar Nagar	4240	1450
214	Tanda U/S	Ghaghra	MGD-I, Lucknow	Uttar Pradesh	Ambedkar Nagar	3640	1160
215	Tekra	Pranhita	WD, Nagpur	Maharashtra	Gadchiroli	4774	*
216	Terwad	Panchganga	UKD, Pune	Maharashtra	Kolhapur	20538	9675
217	Thengumarahada	Moyar	SRD, Coimbatore	Tamil Nadu	Nilgiris	24840	22405
218	Theni	Suruliar	SRD, Coimbatore	Tamil Nadu	Theni	16180	46250
219	Thevur	Sarabenga	SRD, Coimbatore	Tamil Nadu	Salem	48050	55983
220	Thimmanahalli	Yagachi	CD, Bangalore	Karnataka	Hassan	7489	6865
221	Thumpamon	Achankovil	SWRD, Kochi	Kerala	Pathanamthitta	1377	1240
222	Tuini	Tons	UYD, New Delhi	Uttarakhand	Dehradun	90667	57388
223	Turtipar	Ghaghra	MGD-I, Lucknow	Uttar Pradesh	Ballia	3756	1977
224	Udi	Chambal	LYD, Agra	Uttar Pradesh	Etawah	11820	10129

S.No.	Site	River	CWC Division Office	State	District	M	NM
225	Urachikottai	Cauvery	SRD, Coimbatore	Tamil Nadu	Erode	16808	96643
226	Uttarkashi	Bhagirathi	HGD Haridwar	Uttarakhand	Uttarkashi	3485	2611
227	V.S. Bridge	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	26267	60683
228	Valigonda	Musi	LKD, Hyderabad	Telangana	Nalgonda	6875	5948
229	Vandiperiyar	Periyar	SWRD, Kochi	Kerala	Idukki	1600	1500
230	Varanasi	Ganga	MGD-III, Varanasi	Uttar Pradesh	Varanasi	9914	16156
231	Vautha	Sabarmati	MD, Gandhinagar	Gujarat	Kheda	58444	144316
232	Vijayawada	Krishna	LKD, Hyderabad	Andhra Pradesh	Krishna	10333	7326
233	Wadakbal	Sina	UKD, Pune	Maharashtra	Solapur	31340	46000
234	Wadenapally	Krishna	LKD, Hyderabad	Telangana	Nalgonda	6372	6489
235	Wairagarh	Khobragarhi	WD, Nagpur	Maharashtra	Gadchiroli	4501	1829
236	Warunji	Koyna	UKD, Pune	Maharashtra	Satara	47638	47800
237	Yadgir	Bhima	LKD, Hyderabad	Karnataka	Gulbarga	10576	8850
238	Yashwant Nagar	Giri	Uyd, New Delhi	Himachal Pradesh	Simaur	100111	403038
239	Yelli	Godavari	UGD, Hyderabad	Maharashtra	Nanded	3086	5166

(*) means: No hotspots as data is not available.

Table 11: Stations having TC < 500mg/l in River Water

Stations having Total Coliforms Concentration > 500 MPN/100ml in River Water during period 2010-2020

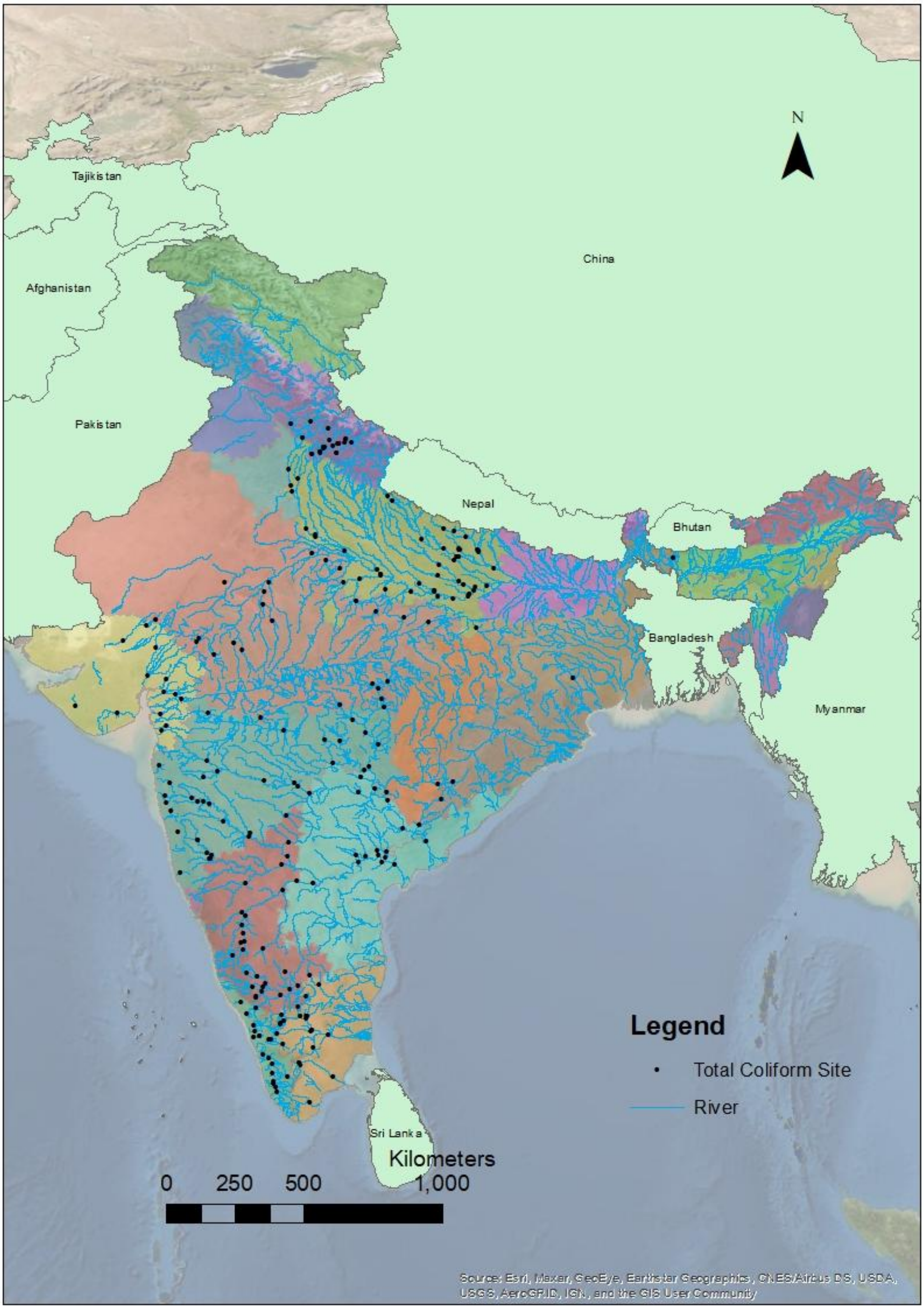


Figure 14: Stations having TC < 500mg/l in River Water

Chapter-7

Conclusion

The study has been done from water quality data taken from 588 out of 764 water quality stations of central water commission (CWC) covering important rivers of India. The study report is based on the average values observed at above stations during the last 10 years from 2010 to 2020. As per analysis, Water Quality data the following observations have been found:

1. pH:

Two (2) water quality stations have recorded average pH concentration above 8.5 in river water. Only one (1) water quality station Manakkad on Thodupuzha River in Idukki has reported pH 6.49. During the monsoon and non-monsoon period, the Elunuthimangalam water quality station on Noyyal River in Erode, Tamil Nadu has reported the highest average pH value of 8.56 and 8.60 respectively. Fifty-four (54) % samples of Elunuthimangalam site were recorded as a hot spot samples (pH values falls outside the range 6.5-8.5) for pH parameter during 2010-2020.

2. Electrical Conductivity (EC):

Three (3) water quality stations have recorded EC average value above 2250 µS/cm on the rivers: Noyyal, Sabarmati and Shetrunji. And at Lowara water quality station on Shetrunji River in Gujarat has reported the highest average EC value of 7764.88 µS/cm. Sixty Six (66) % samples of lowara site were recorded as a hot spot samples -EC values above 2250 µS/cm during 2010-2020.

3. Ammonia as N (NH_3-N):

Eight (8) water quality stations were recorded average ammonia concentration above 1.2 mg/l on the rivers: Yammuna, Dhadar, Ponniyar and Sabarmati. During the monsoon season, highest average ammonia concentration observed at Singasadanapalli, Krishnagiri site on Ponnaiyar River in Tamil Nadu (15.89 mg/l). Seventy Nine (79) %samples of Singasadanapalli site were recored as hotspot for ammonia (values greater than 1.2 mg/l). During the non-monsoon season, the Vautha water quality station on Sabarmati River in Gujarat reported the highest average Ammonia values of 23.92 mg/L. 97% samples of Vautha were recorded hotspot samples (values greater than 1.2 mg/l).

4. Boron (B):

During the **monsoon** and **non-monsoon seasons**, average values of Boron of all water quality stations were observed within the permissible limit of Class E of CPCB standard.

5. Sodium Absorption Ratio (SAR):

During the **monsoon** and **non-monsoon seasons**, average values of Sulphate of all water quality stations were observed within the permissible limit of Class E of CPCB standard.

6. Fluoride (F^-):

During the **monsoon** and **non-monsoon seasons**, the average values of fluoride of all water quality stations were observed within the permissible limit as per BIS drinking water Standard (BIS:10500:2012).

7. Sulphate (SO_4^{-2}):

During the **monsoon** and **non-monsoon seasons**, average values of Sulphate of all water quality stations were observed within the permissible limit as per BIS drinking water Standard (BIS:10500:2012).

8. Dissolved Oxygen (DO):

Fifty-Eight(58) water quality stations recorded average Dissolved Oxygen concentration below 5.0 mg/l on different river water in monsoon and non-monsoon seasons. Lowest DO concentrations were recorded at Roorkie D/S site, in district Haridwar on Solani River:0.00mg/l in monsoon season and 0.75 mg/l in non-monsoon season. For DO parameter, 100 % samples of Roorkie D/S site were recorded as hotspot samples (values below 5.0 mg/l). Low concentration of DO were recorded on the following water quality stations: Delhi Rly Bridge, North Delhi on Yamuna river (2.00 mg/l – monsoon, 1.30 mg/l – non monsoon. 70% - hotspot samples), Galeta, Meerut on Yamuna river (0.98 mg/l–monsoon, 0.95mg/l – non-monsoon, 89% - hotspot samples) and Singasadanapalli, Krishnagiri on Ponnaiyar river(0.13 mg/l – monsoon, 0.34 mg/l – non monsoon. 100% - hotspot samples)

9. Biochemical Oxygen Demand (BOD):

Eighty-Eight (88) water quality stations reported Biochemical Oxygen Demand concentration above 3.0 mg/l on different rives. Very High cconcentrations of BOD were recorded on the following water quality stations: Singasadanapalli, Krishnagiri on Poniyar river (27.07mg/l – monsoon, 34.91mg/l – non monsoon, 100% - hotspot samples), Delhi Rly Bridge, North Delhi on Yamuna river (28.15 mg/l – monsoon, 40.87mg/l – non monsoon, 97% - hotspot samples), Mohana, Faridabad, on Yamuna river (17.89 mg/l – monsoon, 26.14 mg/l – non monsoon, 79% - hotspot samples), Vautha, Kheda on Sabarmati river (17.41 mg/l – monsoon, 28.22 mg/l – non monsoon, 98% - hotspot samples), Galeta, Meerut on Hindon river (41.35 mg/l – monsoon, 54.86 mg/l – non monsoon, 92% - hotspot samples). Seventeen (17) water quality stations on the Yamuna River and its tributaries (Betwa, Hindon, Rind, Chambal, Sind, Dhasan and Parvati) recorded maximum hotspot samples of BOD.

10. Total Coliform (TC):

Two Hundred Thirty-Nine (239) water quality stations reported Total Coliform (TC) concentration above 500 MPN/100ml in Indian rivers water. High concentration of TC were recorded on the following water quality station: Delhi Railway Bridge in district North Delhi on Yamuna River (13039333 MPN/100ml – monsoon, 30052381 MPN/100ml – non monsoon, 100% - hot samples), Mohana site in district Faridabad on Yamuna river (1982867MPN/100ml -monsoon, 5994211 MPN/100ml – non monsoon, 100% - hot samples), Singasadanapalli, Krishnagiri on Ponnaiyar river (2861933 mg/l – monsoon, 4999564mg/l – non monsoon. 100% - hotspot samples) and Galeta, Meerut on Hindon river (14741333 mg/l – monsoon, 48429444 mg/l – non monsoon, 100% - hotspot samples).

Comparison Study - Hot Spots in 2011 with 2021

The comparison has been done of 6 parameters (pH, EC, DO, BOD, Fluoride, Sulphate). The summary is as under:

1. pH

Hotspots of April, 2011 report are compared with this report. After comparison of water quality data of pH parameter, it is found thatduring the monsoon season, two (2) water quality sites have emerged as no hotspots are located at Sindh(Madhya Pradesh), Ponniyar (Tamil Nadu). During the non-monsoon period, twelve (12) water quality stations have emerged as no hotspots. They are located at Parwati, Sindh, Dhasan(Madhya Pradesh), Rind, Gomti (Uttar Pradesh), Parwan, Parawati, Kalisindh, (Rajasthan), Pranhita (Maharashtra), Sankh (Jharkhand) and Tungabhadra (Andhra Pradesh).

S. No.	Water Quality Site	River	CWC Division Office	State	District	M (2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
1	Seondha	Sindh	LYD, Agra	M.P.	Datia	8.55	8.54	8.08	8.34	No Hotspot	No Hotspot
2	Kora	Rind	LYD, Agra	U.P.	Fatehpur	-	8.51	-	8.42	-	No Hotspot
3	Garauli	Dhasan	LYD, Agra	M.P.	Chhattarpur	-	8.53	-	8.47	-	No Hotspot
4	AB Road Xing	Parwati	CD, Jaipur	M.P.	Guna	-	8.63	-	8.44	-	No Hotspot
5	Aklera	Parwan	CD, Jaipur	Rajasthan	Jhalarwar	-	8.51	-	8.50	-	No Hotspot
6	Barod	Kalisind	CD, Jaipur	Rajasthan	Kota	-	8.66	-	8.28	-	No Hotspot
7	Khatoli	Parwati	CD, Jaipur	Rajasthan	Kota	-	8.51	-	8.13	-	No Hotspot
8	Tekra	Pranhita	WGD, Nagpur	Maharashtra	Gadchiroli	-	8.54	-	8.40	-	No Hotspot
9	Gummanur	Ponniyar	SRD, Coimbatore	Tamilnadu	Dharmapuri	9.91	8.78	8.10	7.96	No Hotspot	No Hotspot
10	Maighat	Gomti	MGD-III, Varanasi	U.P.	Jaunpur	-	8.6	-	8.28	-	No Hotspot
11	Bawapuram	Tungabhadra	LKD, Hyderabad	A.P.	Kurnool	-	8.6	-	8.39	-	No Hotspot
12	Tilga	Sankh	E.R.D. Bhbaneswar	Jharkhand	Shindega	-	8.65	-	7.42	-	No Hotspot

(-) means: No Hotspot

2. Electrical Conductivity (EC):

Hotspots of April, 2011 report are compared with this report. Three (3) water quality sites of EC parameter are common in both reports. During the monsoon season, two (2) water quality sites have emerged as no hotspots are located at Chambal (Madya Pradesh) and Sabarmati (Gujarat). During the monsoon season, one (1) site located on Noyyal river in Erode District of Tamil Nadu has been improved. During the non-monsoon season, two (2) water quality sites are considerably improved located on river Noyyal (Madhya Pradesh) and Sabarmati (Gujarat).

S. No.	Water Quality Site	River	Division	State	District	M (2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
1	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamil nadu	Erode	5910	4602	3265	2841	Improved but Hotspot	Improved but Hotspot
2	Tal	Chambal	CD, Jaipur	M.P.	Ratlam	4062	-	813	-	No Hotspot	-
3	Vautha	Sabarmati	MD, Ahemadabad	Gujarat	Kheda	2530	3214	1608	2376	No Hotspot	Improved but Hotspot

(-) means: No Hotspot

3. Sulphate (SO_4^{-2}):

After comparison of water quality data of sulphate parameter, it is found that during monsoon one (1) site locate on river Tal in Ratlam District of Madhya Pradesh has been improved and emerged as no hotspot.

S. No.	Water Quality Site	River	Division	State	District	M(2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
1	Tal	Chambal	CD, Jaipur	M.P.	Ratlam	672	-	87	-	No Hotspot	-

(-) means: No Hotspot

4. Fluoride (F^-):

After comparison of water quality data of fluoride parameter, it is found that during the monsoon season, ten (10) water quality sites are improved and emerged as no hotspots, located on river Yamuna (Delhi, Uttar Pradesh), Chaliyar (Kerala), Yagachi(Karnataka), Thoppaiyar (Tamil Nadu), Ganga (Bihar), Thoppaiyar (Tamil Nadu), Musi (Andhra Pradesh), Hasdeo (Chhattisgarh) and Subarnarekha (Jharkhand). During the non-monsoon season, nine (9) water quality sites are improved and emerged as no hotspots, located on Yamuna (Delhi, Uttar Pradesh), Chinnar, Yagachi

(Karnataka), Ganga (Bihar), Punpun (Patna) Tungabhadra (Andhra Pradesh), and Hasdeo (Chhattisgarh).

S. No.	Water Quality Site	River	CWC Division Office	State	District	M (2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
1	Delhi	Yamuna	UYD, Delhi	Delhi	Delhi	1.52	-	0.45	0.59	No Hotspot	No Hotspot
2	Mohana	Yamuna	UYD, Delhi	Haryana	Faridabad	1.92	-	0.42	0.58	No Hotspot	No Hotspot
3	Mathura	Yamuna	UYD, Delhi	U.P.	Mathura	1.72	-	0.40	-	No Hotspot	-
4	Kuniyil	Chaliyar	SWR, Cochin	Kerala	Mallapuram	2	-	0.08	-	No Hotspot	-
5	Hogenakkal	Chinnar	CD, Bangalore	Karnataka	Dharmapuri	-	1.7	-	0.15	-	No Hotspot
6	Thimmanahalli	Yagachi	CD, Bangalore	Karnataka	Hassan	4.08	5.07	0.20	0.26	No Hotspot	No Hotspot
7	Thoppur	Thoppaiyar	SRD, Coimbatore	Tamil Nadu	Salem	1.76	-	1.34	-	No Hotspot	-
8	Azamabad	Ganga	MGD-V, Patna	Bihar	Bhagalpur	1.57	1.6	0.07	0.08	No Hotspot	No Hotspot
9	Gandhighat	Ganga	MGD-V, Patna	Bihar	Patna	-	14.71	-	0.98	-	No Hotspot
10	Sripalpur	Punpun	MGD-V, Patna	Bihar	Patna	-	1.57	-	1.12	-	No Hotspot
11	Damercharla	Musi	LKD, Hyderabad	A.P.	Nalgonda	1.83		1.26	-	No Hotspot	-
12	Bawapuram	Tungabhadra	LKD, Hyderabad	A.P.	Kurnool	-	1.6		1.00	-	No Hotspot
13	MBPL	Hasdeo	M.D., Burla	Chhattisgarh	Bilaspur	2.72	2.22	0.87	0.64	No Hotspot	No Hotspot
14	Baridhinala	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Paschimsingbhum	2.26	-	0.47	-	No Hotspot	-

(-) means: No Hotspot

5. Dissolved Oxygen (DO):

After comparison of water quality data of DO parameter, it is found that during the monsoon season, one (1) site-Galeta located on Yamuna river in Faridabad district of Uttar Pradesh emerges as a new hotspot. During the monsoon season, ten (10) water quality sites are improved located on Wardha (Maharashtra), Yennehole (Karnataka), Bhima (Maharashtra), Sabarmati (Gujarat), Banas (Rajasthan), Balaram (Gujarat) Arpa, Hasdeo (Chhattisgarh) and Yamuna (Delhi) . Further out of 10 water quality sites, 7 water quality sites emerged as no hotspots. During the monsoon period, at two (2) water quality sites , water quality are deteriorate, which are located on Yamuna (Uttar

Pradesh), and Arkavathi(Karnataka). During the non-monsoon season, Nine(9) water quality sites are improved located on Wardha (Maharashtra), Balaram(Gujarat), Banas(Rajasthan), Yamuna (Delhi), Subarnarekha (Jharkhand) and Arpa(Chhattisgarh). And out of 9 , 7 water quality sites are emerged as no hotspots. During the non-monsoon period, three (3) water quality sites are deteriorate located on Yamuna (Haryana, Uttar Pradesh), and Arkavati (Karnataka).

S. No.	**Water Quality**	**River**	**Division**	**State**	**District**	**M (2011)**	**NM (2011)**	**M (2021)**	**NM (2021)**	**Comparison of Hot Spots during year 2011 with 2021**	
										M	**NM**
1	Delhi	Yamuna	UYD, Delhi	Delhi	Delhi	3.31	1.07	2.00	1.30	Improved but Hotspot	Improved but Hotspot
2	Galeta	Yamuna	UYD, Delhi	Haryana	Faridabad	-	3.81	0.98	0.95	New Hotspot	Deteriorate
3	Mathura	Yamuna	UYD, Delhi	U.P.	Mathura	4.90	4.27	2.95	2.45	Deteriorate	Deteriorate
4	Bishnur	Wardha	WGD, Nagpur	Maharashtra	Wardha	4.76	4.88	5.32	5.62	No Hotspot	No Hotspot
5	T. Bekuppe	Arkavathi	CD, Bangalore	Karnataka	Bangalore	4.65	4.65	2.61	2.81	Deteriorate	Deteriorate
6	Yennehole	Yennehole	CD, Bangalore	Karnataka	Udupi	4.90	-	7.24	-	No Hotspot	-
7	Bantwal	Netravathi	CD, Bangalore	Karnataka	Dakshinakannada	-	3.90	-	6.50	-	No Hotspot
8	Bareilly	Ramganga	MGD-II, Lucknow	U.P.	Bareilly	-	4.70	-	7.21	-	No Hotspot
9	Takli	Bhima	UKD, Hyderabad	Maharashtra	Sholapur	4.88	-	6.28	-	No Hotspot	-
10	Derol Bridge	Sabarmati	MD, Ahemadabad	Gujarat	Sabarkantha	3.70	-	6.40	-	No Hotspot	-
11	Luwara	Shetrunji	MD, Ahemadabad	Gujarat	Bhavnagar	-	3.78	-	7.98	-	No Hotspot
12	Abu Road	Banas	MD, Ahemadabad	Rajasthan	Sirohi	2.68	-	8.85	-	No Hotspot	-
13	Chitrasani	Balaram	MD, Ahemadabad	Gujarat	Banaskantha	3.10	-	6.80	-	No Hotspot	-
14	Darrighat	Arpa	Mahanadi Div. Burla	Chhattisgarh	Bilaspur	0.80	0.90	5.21	5.23	No Hotspot	No Hotspot
15	Ghatora	Arpa	Mahanadi Div. Burla	Chhattisgarh	Bilaspur	-	4.70	-	6.05	-	No Hotspot
16	MBPL	Hasdeo	Mahanadi Div. Burla	Chhattisgarh	Bilaspur	0.30	0.50	4.37	5.07	Improved but Hotspot	No Hotspot
17	Baridhinala	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Paschim-singbhum	0.80	0.90	3.10	3.52	Improved but Hotspot	Improved but Hotspot

(-) means: No Hotspot

6. Biochemical Oxygen Demand (BOD):

After comparison of water quality data of BOD parameter, it is found that during the monsoon-season, two (2) water quality sites have emerged as a new hotspot located on Akaravathi and Noyyal (Tamilnadu). During the monsoon-season, sixteen (16) water quality sites are improved located in the state of Uttar Pradesh, Madhya Pradesh, Rajasthan, Delhi, Haryana, Maharashtra, Karnataka, Kerala, Chhattisgarh, Gujarat, Jharkhand and Orissa. Further out of 16 water quality sites, 8 water quality sites emerged as no hotspots. During the monsoon period, thirteen (13) water quality sites are deteriorate located on Yamuna (Uttar Pradesh, Delhi), Betwa (Uttar Pradesh), Dhasan (Madhya Pradesh), Hindon (Uttar Pradesh), Wardha (Maharashtra), Ponniyar (Tamil Nadu),Dhadar(Gujarat) Ganga (Uttar Pradesh) and Sabarmati (Gujarat).

During the non-monsoon season, twenty (20) water quality sites are improved located in the state of Uttar Pradesh, Delhi, Haryana, Maharashtra, Karnataka, Kerala, Chhattisgarh, Jharkhand and Orissa. Further out of 20 water quality sites, 11 water quality sites emerged as no hotspots. During the non-monsoon season, fourteen (14) water quality sites are deteriorated located on Yamuna (Uttar Pradesh, Delhi), Betwa (Uttar Pradesh), Dhasan (Madhya Pradesh), Hindon (Uttar Pradesh), Wardha (Maharashtra),Akaravathi(Tamil Nadu),Noyyal (Tamil Nadu), Ponniyar (Tamil Nadu),Dhadar(Gujarat) Ganga (Uttar Pradesh) and Sabarmati (Gujarat).

S. No.	Water Quality Site	River	Division	State	District	M (2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
1	Agra	Yamuna	LYD, Agra	U.P.	Agra	17.59	21.07	19.71	18.27	Improved but Hotspot	Improved but Hotspot
2	Etawah	Yamuna	LYD, Agra	UP	Etawah	7.96	15.51	16.78	33.56	Deteriorate	Deteriorate
3	Seondha	Sindh	LYD, Agra	M.P.	Datia	4.54	3.33	3.68	2.56	Improved but Hotspot	No Hotspot
4	Sahijana	Betwa	LYD, Agra	U.P.	Hamirpur	3.67	3.68	4.51	4.64	Deteriorate	Deteriorate
5	Auraiya	Yamuna	LYD, Agra	U.P.	Auraiya	3.04	4.63	8.81	12.86	Deteriorate	Deteriorate
6	Garauli	Dhasan	LYD, Agra	M.P.	Chhattisgarh	3.31	3.11	4.08	3.91	Deteriorate	Deteriorate
7	Hamirpur	Yamuna	LYD, Agra	U.P.	Hamirpur	3.1	4.02	5.09	7.36	Deteriorate	Deteriorate
8	Khatoli	Parwati	CD, Jaipur	Rajasthan	Kota	3.36	-	1.86	-	No Hotspot	-
9	Mawi	Yamuna	UYD, Delhi	U.P.	Muzaffarnagar	12.06	10.77	5.20	6.28	Improved but Hotspot	Improved but Hotspot
10	Delhi	Yamuna	UYD, Delhi	Delhi	Delhi	28.24	39.83	28.51	40.87	Deteriorate	Deteriorate
11	Galeta	Hindon	UYD, Delhi	U.P.	Meerut	21.91	32.18	41.35	54.86	Deteriorate	Deteriorate
12	Mohana	Yamuna	UYD, Delhi	Haryana	Faridabad	24.27	30.55	17.89	26.14	Improved but Hotspot	Improved but Hotspot
13	Mathura	Yamuna	UYD, Delhi	U.P.	Mathura	17.56	28.53	20.54	23.46	Deteriorate	Improved but Hotspot
14	Bamni	Wardha	WGD, Nagpur	Maharashtra	Chandrapur	6.74	10.05	15.99	10.67	Deteriorate	Deteriorate
15	Bishnur	wardha	WGD, Nagpur	Maharashtra	Wardha	5.74	8.63	1.85	2.14	No Hotspot	No Hotspot

S. No.	Water Quality Site	River	Division	State	District	M (2011)	NM (2011)	M (2021)	NM (2021)	Comparison of Hot Spots during year 2011 with 2021	
										M	NM
16	Pudur	Kannadipuza	SWR, Cochin	Kerala	Palakkad	7.3	6	1.2	1	No Hotspot	No Hotspot
17	Kanakapura	Akaravathi	CD, Bangalore	Karnataka	Bangalore	4.28	3.5	2.23	1.82	No Hotspot	No Hotspot
18	T.Bekuppe	Akaravathi	CD, Bangalore	Tamilnadu	Bangalore	-	3.65	13.32	12.94	New Hotspot	Deteriorate
19	Thimmanahalli	Yagachi	CD, Bangalore	Karnataka	Hassan	10.08	8.62	1.9	2.03	No Hotspot	No Hotspot
20	Elunuthimangalam	Noyyal	SRD, Coimbatore	Tamilnadu	Erode	-	3.1	9.36	6.29	New Hotspot	Deteriorate
21	Gummanur	Ponniyar	SRD, Coimbatore	Tamilnadu	Dharmapuri	3.03	3.1	10.31	8.58	Deteriorate	Deteriorate
22	Kanpur	Ganga	MGD-II, Lucknow	U.P.	Kanpur	3.1	3.4	5.58	5.67	Deteriorate	Deteriorate
23	Shahzadpur	Ganga	MGD-III, Varanasi	U.P.	Allahabad	-	3.1	-	3.02	-	Deteriorate
24	Allahabad	Ganga	MGD-III, Varanasi	U.P	Allahabad	3.5	3.8	3.28	3.23	Improved but Hotspot	Improved but Hotspot
25	Pingalwada	Dhadar	TD, Surat	Gujarat	Vadodra	3.38	4.76	8.48	9.54	Deteriorate	Deteriorate
26	Vautha	Sabarmati	MD, Ahemadabad	Gujarat	Kheda	17.21	29.59	17.41	28.22	Deteriorate	Improved but Hotspot
28	Ghatora	Arpa	M.D. Burla	Chhattisgarh	Bilaspur	3.8	19.4	1.42	1.39	No Hotspot	No Hotspot
29	MBPL	Hasdeo	M.D. Burla	Chhattisgarh	Bilaspur	276.3	259.8	26.48	20.87	Improved but Hotspot	Improved but Hotspot
30	Adityapur	Kharakai	ERD, Bhubaneswar	Bihar	Bilaspur	-	8	-	1.3	-	No Hotspot
31	Baridhinala	Subarnarekha	ERD, Bhubaneswar	Jharkhand	Paschim-singbhum	76.6	88.8	3.18	2.43	Improved but Hotspot	No Hotspot
32	Jamshedpur	Subarnarekha	ERD, Bhubaneswar	Jharkhand	PurbiSinghbhum	-	9.3	-	2.25	-	No Hotspot
33	Kulpatanga	Kharkai	ERD, Bhubaneswar	Jharkhand	Dumka	6.3	8	1.22	5.09	No Hotspot	Improved but Hotspot
34	Gomlai	Brahmani	ERD, Bhubaneswar	Orissa	Sundergarh	-	3.2	-	0.98	-	No Hotspot
35	Kamalanga	Brahmani	ERD, Bhubaneswar	Orissa	Angul	6.8	7.3	1.3	0.96	No Hotspot	No Hotspot
36	RSP Nalla	Brahmani	ERD, Bhubaneswar	Orissa	Sundergarh	5.6	5.8	3.62	4.38	Improved but Hotspot	Improved but Hotspot

(-) means: No Hotspot

ABBREVIATION

Ammonia	= NH_3
Andhra Pradesh	= AP
Alpha Benzenehexachloride	= BHC
Biochemical Oxygen Demand	= BOD
Bureau of Indian Standards	= BIS
Boron	= B
Calcium	= Ca^{+2}
Cauvery Division	= CD
Central Pollution Control Board	= CPCB
Central Water Commission	= CWC
Chambal Division	= CD
Chenab Division	= CD
Chloride	= Cl^-
Dissolved Oxygen	= DO
Dichlorodiphenyltrichloroethane	= DDT
Eastern River Division	= ERD
Electrical Conductance	= EC
Godavari Division	= GD
Himachal Pradesh	= HP
Himalayan Ganga Division	= HGD
Hydrology Division	= HD
Iron	= Fe
Lower Krishna Division	= LKD
Lower Yamuna Division	= LYD
Madhya Pradesh	= MP
Magnesium	= Mg^{+2}
Mahanadi Division	= MD
Mahanadi Division	= MD
Mahi Division	= MD
Middle Brahmaputra Division	= MBD
Middle Ganga Division	= MGD
Monsoon Season	=M
Narmada Division	= ND
Nitrate	= NO_3^-
Non-Monsoon Season	=NM
Sodium Absorption Ratio	= SAR
South Western Division	= SWR
Southern River Division	= SRD
Sulphate	= SO_4^{-2}
Tapi Division	= TD
Total Dissolved Solids	= TDS
Total Coliforms	= TC
Total Hardness	= TH
Upper Yamuna Division	= UYD
Uttar Pradesh	= UP
Wainganga Division	= WGD
Rourkela Steel Plant	= RSP
Madhya Bharat Paper Ltd	=MBPL

Annexure-I

Water Quality Laboratories of CWC& NABL accreditation Status

Out of 23 Water Quality Laboratories in CWC, 16 laboratories got accredited by NABL as on October, 2021.

Table 4: List of Water Quality Labs in CWC

S. No.	Location of laboratory	Level of Laboratory	Organisation
1	National River Water Quality Laboratory (NRWQL), New Delhi	III	YBO, New Delhi
2	Lower Cauvery Water Quality Laboratory (LCWQL), Coimbatore	III	C&SRO, Coimbatore
3	Upper and Middle Ganga Water Quality Laboratory, Varanasi	III	LGBO, Patna
4	Krishna and Godavari River Water Quality, Hyderabad	III	K&GBO, Hyderabad
5	Upper Cauvery Water Quality Laboratory, Bangalore	II	MSO, Bangalore
6	South Western Flowing Rivers Water Quality Laboratory (SWFRWQL), Kochi	II	C&SRO, Coimbatore
7	Upper Krishna Division Water Quality Laboratory (UKDWQL), Pune	II	K&GBO, Hyderabad
8	Mahi Division Water Quality Laboratory (MDWQL), Gandhinagar	II	MTBO, Gangdinagar
9	Lower Yamuna Water Quality Laboratory, (LYWQL), Agra	II	YBO, New Delhi
10	Eastern Rivers Water Quality Laboratory (ERWQL), Bhubaneswar	II	M&ERO, Bhubaneswar
11	Hydrology Division, Chennai	II	C&SRO, Coimbatore
12	WainGanga Division, Nagpur	II	MCO, Nagpur
13	Chenab Division, Jammu	II	IBO, Chandigarh
14	Middle Ganga Division -I, Lucknow	II	UGBO, Lucknow
15	Mahanadi Division, Raipur	II	M&ERO, Bhubaneswar
16	Middle Brahmaputra Division, Guwahati	III	BBO, Guwahati
17	Lower Brahmaputra Division, Jalpaiguri	II	T&BDBO, Kolkata
18	U.B. Division, Dibrugarh	II	BBO, Guwahati
19	Lower Ganga Division, Berhampore	II	T&BDBO, Kolkata
20	Middle Ganga Division-5, Patna	II	LGBO, Patna
21	Narmada Division, Bhopal	II	NBO, Bhopal
22	Tapi Division, Surat	II	MTBO, Gangdinagar
23	Himalayan Ganga Division, Dehradun	II	UGBO, Lucknow

Annexure-II

List of Parameters analyzed in different levels of Water Quality Labs of CWC

S. No.	Level-I	Level-II	Level-III
1	Temperature	Temperature	Temperature
2	Colour	Ph	pH
3	Odour	Electrical Conductivity	Electrical Conductivity
4	pH	Total Dissolved Solids	Total Dissolved Solids
5	Electrical Conductivity	Turbidity	Turbidity
6	Dissolved Oxygen	Dissolved Oxygen	Dissolved Oxygen
7		Biochemical Oxygen Demand	Biochemical Oxygen Demand
8		Chemical Oxygen Demand	Chemical Oxygen Demand
9		Sodium	Sodium
10		Calcium	Calcium
11		Magnesium	Magnesium
12		Potassium	Potassium
13		Carbonate	Carbonate
14		Bicarbonate	Bicarbonate
15		Chloride	Chloride
16		Sulphate	Sulphate
17		Fluoride	Fluoride
18		Boron	Boron
19		Ammonia (Nitrogen)	Ammonia (Nitrogen)
20		Nitrate	Nitrate
21		Nitrite	Nitrite
22		Silicate	Silicate
23		Phosphate	Phosphate
24		Total Coliform	Total Coliform
25		F. Coliform	F. Coliform
26			Arsenic
27			Cadmium
28			Chromium
29			Copper
30			Iron
31			Lead
32			Nickel
33			Mercury
34			Zinc
35			Alpha Benzenehexachloride (BHC), Beta BHC, Gama BHC (Lindane)
36			OP-Dichlorodiphenyltrichloroethane (OP DDT), PP-DDT
37			AlphaEndosulphan, Beta Endosulphan,
38			Aldrin, Dieldrin,
39			Carbaryl (Carbamate),
40			Malathian, Methyl parathion
41			Anilophos, Chloropyriphos

REFERENCES

1. *APHA, "Standard Methods for the Examination of Water and Wastewater", American Public Health Association.*
2. *Trivedi, R.C., 2007. "Water Quality Issues and Status in India", Lecture Notes, NIH-CSMRS Five Days Training Workshop on Water Quality and Its Management, 16–20 July,*
3. *Jain, C. K. and Sharma, M. K., 2001. "Distribution of trace metals in Hindon river system, India", J. Hydrol., 253, 81-90, 2001.*
4. *Lokesh, K. S., 1996. "Studies of Heavy Metals in Water and Sediment of Hindon River", Ph.D. Thesis, Department of Civil Engineering, University of Roorkee, Roorkee, India.*
5. *Weiner, E.R. (2013), Applications of Environmental Aquatic Chemistry, CRC Press*
6. *Water Framework Directive (2000/60/EC), Official Journal of the European Community, vol. L327, 2000.*
7. *Int. Journal Environ. Res. Public Health 2018, 15, 1557; doi:10.3390/ijerph15071557.*
8. *https://www.nhp.gov.in/disease/non-communicable-disease/fluorosis*
9. *CPCB Guidelines Water Quality Monitoring-2017.*
10. *A. Ienciu, S. Oncia, L. S¸muleac, P. Fazakas, and C. A. Nicolici, "Te quality of the Timis River Waters," Research Journal of Agricultural Science, vol. 45*
11. *Hussain, J., Sharma, K. C., & Hussain, I. 2004. Fluoride in drinking water and its ill effect on Human Health: A review. Journal of Tissue Research, 4(2), 263–273.*
12. *https://www.cdc.gov/healthywater/drinking/private/wells/disease/nitrate.html*
13. *Institute of Medicine. 2005. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: The National Academies Press. https://doi.org/10.17226/10925*
14. *J. DeZuane, Handbook of Drinking Water Quality, John Wiley & Sons, 1997.*
15. *Gambhir R, Kapoor V, Nirola A, Sohi R Bansal V (2012). Water Pollution: Impact of Pollutants and New Promising Techniques in Purification Process. J. Hum. Ecol. 37.*
16. *Cordy, Gail E. (18 February 2014)" A Primer on Water Quality"*
17. *http://cgwb.gov.in/WQ/Ground%20Water%20Book-F.pdf*
18. *Report on Water Quality Hot-Spots In Rivers of India, August, 2011.*

River Data Compilation-II Directorate,
Central Water Commission, West Block-2,
R.K. Puram, New Delhi-110066

WWW.CWC.GOV.IN