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GOVERNMENT OF INDIA
Ministry of Jal Shakti
Department of Water Resources
River Development and Ganga Rejuvenation

STATUS OF TRACE AND TOXIC METALS IN RIVERS OF INDIA

(January to December 2021)

Central Water Commission

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Water is an essential resource for both ecosystems and human societies. However, human activities on land and water have significantly affected the availability and quality of water. Providing enough safe water is perhaps the most crucial issue we face today. To achieve sustainable development, it is imperative to ensure water security worldwide, which requires responsible and sustainable management of freshwater resources. Therefore, regular monitoring of the quantity and quality of water resources is essential. In India, rivers are the primary surface water resources, and the Central Water Commission has developed expertise in water resources management through hydro-meteorological observation sites across the country. As of January 2023, CWC is monitoring 782 water quality stations across the country.

River water is currently being reported as contaminated with trace and toxic metals, both due to human activity and natural resources. Their presence above the established limits in water can pose significant threats to flora and fauna due to their non-biodegradable nature. The Central Water Commission (CWC) is conducting an analysis of nine trace and toxic metals, namely: Arsenic, Cadmium, Copper, Chromium, Iron, Lead, Mercury, Nickel, and Zinc. The present study, the 5th edition of the “Status of Trace and Toxic Metals in Indian Rivers," involves the analysis of the aforementioned metals for the period of January-December 2021, in relation to 488 stations across various parts of India. The previous editions of this study were published in May 2014, April 2018, August 2019, and December 2021.

I hope that this publication proves to be useful for all stakeholders and agencies involved in taking remedial measures to conserve the quality of river water. The information presented here can also be used for the purposes of protection, management, planning, and policy-making. Additionally, it may prove useful for conducting assessments related to climate change and water security, as well as academic and scientific research.

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Water is an essential resource for sustaining life and plays a crucial role in various aspects of human civilization, including agriculture, industry, and public health. The availability of good quality water is of paramount importance. However, human intervention and climate change have posed significant challenges to the water sector, making water scarce, unpredictable, polluted, or all of the above. The effects of human activities on land and water are now extensive and profound. The availability of sufficient quantities of safe water may be the most crucial issue we face for the next generation.

To ensure a successful and sustainable rejuvenation effort, it is imperative to consider long-term measures that encompass hydrology, water quality, ecology, social dynamics, and economic aspects. This necessitates adopting holistic strategies that include infrastructure projects, fostering innovation, co-creation, and meaningful engagement of all stakeholders towards a common goal. Geographically, rivers are the lowest line in an area and ultimately disposal of waste from various sectors reach them, thereby polluting the river water beyond the permissible limits. At some places, the river water quality parameters are beyond limit even for irrigation purposes. Thus, it has become very essential to evaluate the environmental impacts of water resources to minimize the progressive deterioration in the quality of water.

Central Water Commission (CWC) has been monitoring the water quality of rivers in India since 1963. They have a network of 782 water quality stations as of January 2023, and a 3-tier laboratory system consisting of 427 Level-I, 18 Level-II, and 5 Level-III laboratories across the country. The Level-III laboratories analyze 9 trace and toxic metals, including arsenic, cadmium, copper, chromium, iron, lead, mercury, nickel, and zinc.

I would like to express my appreciation for the initiative taken by Davendra Pratap Mathuria, Chief Engineer (P&DO), and the work carried out by Shri Pankaj Kumar Sharma, Director of RDC-II Directorate, as well as the dedicated efforts of all officers of RDC-II Directorate and the scientific officers of all CWC laboratories in compiling and preparing this report. I hope that this document will be useful for all CWC offices, central/state agencies, and other stakeholders in the field of water quality.

Shri Davendra Pratap Mathuria

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Water quality is influenced by various physical, chemical, and biological factors and their effects on the water's beneficial uses. People evaluate water quality based on its physical, chemical, and biological characteristics. For example, people require their drinking water to be pure, wholesome, and potable to maintain good health.

The Central Water Commission (CWC) plays a vital role in the water quality monitoring process. As part of its integrated hydrological investigation, the CWC collects water samples from various river basins in the country. Initially, the CWC only monitored water quality for irrigation and other related purposes. However, as the amount of pollution discharged into rivers increased, it became necessary to monitor biological, trace & toxic metals, and pesticide-related parameters as well.

This publication compiles the analysis results of 9 trace & toxic metals in river water samples collected from 488 water quality monitoring stations of CWC from January to December 2021. As there are no specific standards for river water quality, the analysis results are compared with the acceptable limits prescribed by BIS: 10500-2012 as a benchmark only. The report identifies locations where the concentration of these metals exceeded the acceptable limits.

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ABBREVIATION

µg/L	Microgram per Litre
mg/L	Milligram per Litre
AAS	Atomic Absorption Spectrophotometer
APHA	American Public Health Association
As	Arsenic
BCM	Billion Cubic meter
BIS	Bureau of Indian Standards
CDS	Centers for Disease Control and Prevention
Cd	Cadmium
Cr	Chromium
Cu	Copper
EFR	East Flowing Rivers
Fe	Iron
Hg	Mercury
ICMR	Indian Council of Medical Research
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
IUPAC	International Union of Pure and Applied Chemistry
kms	kilo meters
M. ha	Million hectres
MCL	Maximum Contaminant Level
mm	milli meter
MSL	Mean Sea Level
Ni	Nickel
NRWQL	National River Water Quality Laboratory
Pb	Lead
ppb	Parts Per Billion
ppm	Parts Per Million
TEL	Tetra Ethyl Lead
USEPA	United States Environmental Protection Agency
WFR	West Flowing Rivers
WHO	World Health Organisation
WQ	Water Quality
Zn	Zinc

EXECUTIVE SUMMARY

River water is nowadays reported to be contaminated with trace & toxic metals due to anthropogenic sources as well as natural resources. Their presence above limit in water will cause serious threats to flora and fauna because of their non-biodegradability. CWC is involved in the analysis of 9 trace & toxic metals namely: Arsenic, Cadmium, Copper, Chromium, Iron, Lead, Mercury, Nickel, and Zinc. The present study involves the data analysis of 3815 samples collected during January, 2021 to December, 2021 from 10 river basins of India for the above-mentioned 9 trace & toxic metals. These samples were analyzed at one Level-III water quality laboratory of CWC namely: National River Water Quality Laboratory, Upper Yamuna Division, New Delhi. In absence of any river water-specific standards, the analysis results are compared with the prescribed limits of BIS: 10500-2012 as a benchmark only.

The parameter-wise summary of the analysis results is given below:

Arsenic (As)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 10 µg/L of arsenic in drinking water. Out of 3815 river water samples, 19 samples from 13 water quality stations were found to have arsenic concentrations beyond the acceptable limit. The arsenic concentration varies from 0.000 to 24.251 µg/L. Maximum arsenic concentration (24.251 µg/L) was observed at Banpur water quality monitoring station on Mathabhanga River (a tributary of Padma) on 16.12.2021.

As Acceptable Limit as BIS 10500: 2012	10 µg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	19
No. of Stations where metal found above acceptable limit	13
No. of Basin/Rivers where metal found above acceptable limit	1/9

Cadmium (Cd)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 3 µg/L of cadmium in drinking water. Out of total 3815 river water samples analysed, 12 samples from 7 water quality stations were found to have cadmium concentrations beyond the acceptable limit. The cadmium concentration varies from 0.000 to 12.651 µg/L. Maximum cadmium concentration (12.651 µg/L) was observed at Delhi Railway Bridge water quality monitoring station on Yamuna River on 12.04.2021.

Cd Acceptable Limit as BIS 10500: 2012	3 µg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	12
No. of Stations where metal found above acceptable limit	7
No. of Basins/Rivers where metal found above acceptable limit	2/5

Chromium (Cr)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 50 μg/L of chromium in drinking water. Out of total 3814 river water samples analysed, 7 samples from 7 water quality stations were found to have chromium concentrations beyond the acceptable limit. The chromium concentration varies from 0.000 to 86.563 μg/L. Maximum chromium concentration (86.563 μg/L) was observed at Ayodhya water quality monitoring station on Ghaghra River on 11.12.2021.

Cr Acceptable Limit as BIS 10500: 2012	50 μg/L
No. of Samples Tested	3814
No. of samples where metal found above acceptable limit	7
No. of Stations where metal found above acceptable limit	7
No. of Basin/Rivers where metal found above acceptable limit	1/6

Copper (Cu)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 50 μg/L of copper in drinking water. Out of total 3815 river water samples analysed, 3 samples from 3 water quality stations were found to have copper concentrations beyond the acceptable limit. The copper concentration varies from 0.000 to 59.974 μg/L. Maximum copper concentration (59.974 μg/L) was observed at Kidangoor water quality monitoring station on Meenachil River on 01.11.2021.

Cu Acceptable Limit as BIS 10500: 2012	50 μg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	3
No. of Stations where metal found above acceptable limit	3
No. of Basins/Rivers where metal found above acceptable limit	2/3

Iron (Fe)

BIS (Bureau of Indian Standards) 10500:2012 has recommended the acceptable limit of 1.0 mg/L (1000 μg/L) for Iron. Out of total 3815 river water samples analysed, 138 samples from 77 water quality stations were found to have iron concentrations beyond the acceptable limit. The iron concentration varies from 0.000 to 25450.91 μg/L. Maximum iron concentration (25450.91 μg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 21.09.2021.

Fe Acceptable Limit as BIS 10500: 2012	1000 μg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	138
No. of Stations where metal found above acceptable limit	77
No. of Basins/Rivers where metal found above acceptable limit	5/55

Lead (Pb)

BIS (Bureau of Indian Standards) 10500:2012 has recommended that the acceptable limit for lead is 0.01 mg/L or 10 µg/L in drinking water. Out of total 3811 river water samples analysed, 30 samples from 20 water quality stations were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 97.079 µg/L. Maximum lead concentration (97.079 µg/L) was observed at Nellipally water quality monitoring station on Kallada River on 11.08.2021.

Pb Acceptable Limit as BIS 10500: 2012	10 µg/L
No. of Samples Tested	3811
No. of samples where metal found above acceptable limit	30
No. of Stations where metal found above acceptable limit	20
No. of Basins/Rivers where metal found above acceptable limit	6/19

Mercury (Hg)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 1 µg/L of mercury in drinking water. Out of total 1598 river water samples analysed, 17 samples from 14 water quality stations were found to have mercury concentrations beyond the acceptable limit. The mercury concentration varies from 0.000 to 13.866 µg/L. Maximum mercury concentration (13.866 µg/L) was observed at Thimmanahalli water quality monitoring station on Yagachi River (a tributary of Cauvery) on 01.09.2021.

Hg Acceptable Limit as BIS 10500: 2012	1 µg/L
No. of Samples Tested	1598
No. of samples where metal found above acceptable limit	17
No. of Stations where metal found above acceptable limit	14
No. of Basins/Rivers where metal found above acceptable limit	4/14

Nickel (Ni)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 20 µg/L of nickel in drinking water. Out of total 3815 river water samples analysed, 17 samples from 12 water quality stations were found to have nickel concentrations beyond the acceptable limit. The nickel concentration varies from 0.000 to 126.046 µg/L. Maximum nickel concentration (126.046 µg/L) was observed at Hariharapura water quality monitoring station on Tunga River on 01.09.2021.

Ni Acceptable Limit as BIS 10500: 2012	20 µg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	17
No. of Stations where metal found above acceptable limit	12
No. of Basins/Rivers where metal found above acceptable limit	4/10

Zinc (Zn)

BIS (Bureau of Indian Standards) 10500:2012 has recommended acceptable limit of 5 mg/L (5000 µg/L) of Zinc in drinking water. Out of total 3815 river water samples analysed; no sample is found to have zinc concentration beyond the acceptable limit. The zinc concentration varies from 0.000 to 1306.063 µg/L. Maximum zinc concentration (1306.063 µg/L) was observed at Prang water quality monitoring station on Sind River on 01.12.2021.

Zn Acceptable Limit as BIS 10500: 2012	5000 µg/L
No. of Samples Tested	3815
No. of samples where metal found above acceptable limit	0
No. of Stations where metal found above acceptable limit	0
No. of Basins/Rivers where metal found above acceptable limit	0

The analysis results of 488 water quality monitoring stations spread over 10 river basins of CWC were considered for the study. All metals are found to be within the acceptable limits at 364 out of 488 monitored stations while at 124 stations studied, at least one metal was found to be beyond the limit.

The overall summary of the results is as under:

Sl. No.	Trace & Toxic Metal	Acceptable limit as per BIS:10500, 2012 (in µg/L)	Total No. of samples analysed	No. of samples where metal found within acceptable limit	No. of samples where metal found above acceptable limit	% of samples where metal found above acceptable limit
1	Arsenic (As)	10	3815	3796	19	0.50
2	Cadmium (Cd)	3	3815	3803	12	0.31
3	Chromium (Cr)	50	3814	3807	7	0.18
4	Copper (Cu)	50	3815	3812	3	0.08
5	Iron (Fe)	1000	3815	3677	138	3.62
6	Lead (Pb)	10	3811	3781	30	0.79
7	Mercury (Hg)	1	1598	1581	17	1.06
8	Nickel (Ni)	20	3815	3798	17	0.45
9	Zinc (Zn)	5000	3815	3815	0	0.00

1. INTRODUCTION

Environmental pollution is a pervasive issue caused by a wide array of pollutants present in water, air, and soil. Of particular concern within this complex web of pollutants are "Heavy Metals," a category encompassing metallic and metalloid elements with densities ranging from 3.5 to 7 g/cm³. In modern parlance, the term 'heavy metal' has come to signify metallic chemical elements and metalloids that exert toxicity on both the environment and human health. Notably, some metalloids and even lighter metals, such as selenium, arsenic and aluminum, are classified as heavy metals due to their toxic properties, while certain heavy metals, such as gold, are typically non-toxic.

Heavy metals represent a prevalent source of pollution in both water and soil, and the increasing concentration of these metals in the environment has raised significant public concern due to their well-documented toxicity. While defining heavy metals can vary in the literature, they are generally characterized by a high atomic number, atomic weight, and a density exceeding 5.0 g/cm³. In a broader context, metals are intrinsic components of the Earth's crust, and some, such as copper, selenium, and zinc, are essential trace elements necessary to maintain human metabolism. However, when present in higher concentrations, they can exhibit toxic effects. On the other hand, certain metals like mercury, cadmium, and lead have direct toxic impacts on human health.

The roster of common toxic 'heavy metals' includes Beryllium (Be), aluminum (Al), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), molybdenum (Mo), silver (Ag), cadmium (Cd), tin (Sn), antimony (Sb), barium (Ba), mercury (Hg), thallium (Tl), and lead (Pb). These metals have been identified as subjects of substantial public health concern by the World Health Organization (WHO).

Over the course of the last few decades, there has been a notable surge in the concentration of these heavy metals within river water and sediments. This escalating presence has the potential to exert adverse effects on crops, including grains and vegetables, grown in soil and water tainted with these heavy metals. Consequently, this situation poses a significant threat to both human health and the environment due to the inherent toxicity, non-biodegradability, and propensity for bioaccumulation associated with heavy metals.

1.1 Sources of Metal Pollution

Heavy metals are naturally occurring elements found in the Earth's crust since the planet's formation. Various natural processes can contribute to heavy metal pollution, including volcanic activity, metal corrosion, metal evaporation from soil and water, sediment re-suspension, soil erosion, and geological weathering. However, the substantial increase in the use of heavy metals has led to a significant upsurge in these metallic substances in both terrestrial and aquatic environments. The proliferation of heavy metal pollution is primarily attributed to human activities, such as metal mining, smelting, foundries, and other metal-based industries. Additionally, heavy metals are introduced into the environment through agricultural practices, including leaching from sources like landfills, waste dumps, livestock and chicken manure, runoff from automobiles, and roadwork.

Due to their chemical properties, metals often persist in the environment, undergoing chemical transformations while accumulating in the food chain. These pollutants find their way into the environment through various human activities, including mining, refining, and electroplating industries. The effluents produced by these industries contain an array of heavy metals, including cadmium, copper, chromium, nickel, lead, and zinc. The subsequent release of these effluents into water bodies significantly contributes to the increasing presence of toxic heavy metals in aquatic environments. Heavy metals, with their high-water solubility, are readily absorbed by living organisms. Their mobility within natural water ecosystems and their toxicity to living organisms have led to their classification as major inorganic contaminants in surface and ground waters. Even when present in low, almost undetectable quantities, their resistance to degradation implies that, through natural processes such as bio-magnification, their concentration may elevate to levels that trigger toxic effects.

1.2 Metal Pollution from Mining and Processing Ores

The activities involved in mining, including excavation, ore extraction, and mineral processing, can, at times, result in environmental damage. For instance, mining operations have the potential to harm the environment by destroying habitats, farmland, and homes, causing soil erosion, and contaminating waterways with toxic discharge. Smelting processes, such as those that emit toxic materials like arsenic (As), selenium (Se), lead (Pb), cadmium (Cd), and sulfur oxides, can lead to significant air pollution.

Surface mining, while producing about eight times more waste compared to underground mining, can still present environmental challenges. Deep mining, on the other hand, may exacerbate issues, including seismic activity. When underground mines collapse, it not only poses risks to miners' lives but also results in surface subsidence, potentially causing infrastructure, such as roads and houses, to collapse. As easily accessible minerals become depleted, miners are forced to dig deeper to access these resources. A study by the National Academy of Science projected that copper (Cu) mining operations in the year 2000 would generate three times more waste per ton of copper output compared to similar activities in 1978.

The exposure of pyrite (FeS) and other sulfide minerals to atmospheric oxygen and moisture leads to their oxidation and the formation of acid-mine drainage water. The release of acid-mine drainage from active and abandoned mines, especially coal mines, is widely recognized for its negative impact on water quality. This drainage dissolves toxic elements from tailings and soils, carrying them into water bodies and even groundwater. Water quality issues often involve elevated levels of metals such as iron

(Fe), manganese (Mn), zinc (Zn), copper (Cu), nickel (Ni), and cobalt (Co). Ore processing, smelting, and refining operations can result in the deposition of substantial quantities of trace metals, including lead (Pb), zinc (Zn), copper (Cu), arsenic (As), and silver (Ag), into drainage basins or their direct discharge into aquatic environments.

1.3 Metal Pollution from Domestic Wastewater Effluents

Domestic wastewater effluents typically contain substantial quantities of trace metals derived from metabolic waste byproducts, the corrosion of water pipes - copper (Cu), lead (Pb), zinc (Zn), and cadmium (Cd), and household products, including detergents - iron (Fe), manganese (Mn), chromium (Cr), nickel (Ni), cobalt (Co), zinc (Zn), boron (B), and arsenic (As). In general, wastewater treatment processes remove less than 50% of the metal content from the influent, resulting in effluents with significant metal loads. Moreover, the sludge produced as a byproduct of wastewater treatment is also enriched with metals. In essence, domestic wastewater and the disposal of both domestic and industrial sludge constitute the primary anthropogenic sources of cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), and mercury (Hg) pollution.

1.4 Metal Pollution from Stormwater Runoff

Stormwater drainage from developed urban regions is a notable contributor to the introduction of metal pollutants into the receiving bodies of water. The specific makeup of metals present in urban runoff is contingent upon numerous variables, encompassing urban layout, vehicular traffic patterns, road construction materials, land usage, and the topographical and climatic attributes of the surrounding watershed.

1.5 Metal Pollution from Industrial Wastes and Discharges

In most cases, the levels of heavy metals in industrial effluents far exceed the allowable limits set for discharges into aquatic environments. Therefore, it is imperative to implement effective treatment measures for effluents containing these metals before releasing them into water bodies. The types of metals and their concentrations in industrial wastewater vary significantly based on the specific industry's activities and processes.

Table 1: Anthropogenic sources of heavy metals in the environment

Sl. No.	Pollutant	Major sources
1.	**Arsenic**	Arsenic containing fungicides, pesticides and herbicides, metal smelters, byproducts of mining activities, chemical wastes
2	**Cadmium**	Cadmium producing industries, electroplating, welding. By-products from refining of Pb, Zn and Cu, fertilizer industry, pesticide manufacturers, cadmium–nickel batteries, nuclear fission plants.

Sl. No.	Pollutant	Major sources
3	**Chromium**	Metallurgical and chemical industries, processes using chromate compounds, cement and asbestos units
4	**Copper**	Iron and steel industry, fertilizer industry, burning of wood, discharge of mine tailings, disposal of fly ash, disposal of municipal and industrial wastes are the sources of copper in the atmosphere
5	**Iron**	Cast Iron, Wrought Iron, steel, alloys, construction, transportation, machine manufacturing
6	**Lead**	Automobile emissions, lead smelters, burning of coal and oil, lead arsenate pesticides, smoking, mining and plumbing
7	**Mercury**	Mining and refining of mercury, organic mercurials used in pesticides, laboratories using mercury
8	**Nickel**	Metallurgical industries using nickel, combustion of fuels containing nickel additives, burning of coal and oil, electroplating units using nickel salts, incineration of nickel containing substances
9	**Zinc**	Zinc refineries, galvanizing processes, brass manufacture, metal plating, plumbing

1.6 Sanitary Landfills

Sanitary landfills, where waste is carefully disposed of, can still contribute to environmental issues. The metal content and average concentrations in leachates from these landfills are notable. Specifically, you will find copper (Cu) at an average concentration of 5 parts per million (ppm), zinc (Zn) at 50 ppm, lead (Pb) at 0.3 ppm, and mercury (Hg) at 60 parts per billion (ppb). These metals can leach into the surrounding soil and potentially contaminate groundwater, posing a concern for the quality of local water sources.

1.7 Agricultural Runoff

Agricultural runoff, which occurs when water flows over cultivated fields, can carry a range of metals into the environment. These metals often originate in the sediment and soils that have absorbed residues from plants and animals, as well as various agricultural inputs. This can include the presence of copper (Cu), zinc (Zn), and other metals stemming from fertilizers, herbicides, and fungicides. Additionally, the use of sewage and sludge as fertilizers can introduce metals like copper and zinc into the agricultural ecosystem. It's crucial to manage agricultural runoff to mitigate the impact of these metals on water quality and surrounding ecosystems.

1.8 Fossil Fuel Combustion

Fossil fuel combustion, a prevalent source of energy, can have significant consequences for water quality. When fossil fuels like coal, oil, and natural gas are burned for energy, they release various metals into the atmosphere. These metals can later deposit into natural waters, including lakes and rivers. This contamination can have harmful effects on aquatic ecosystems and human health. It is essential to monitor and mitigate the release of these airborne metals to safeguard the quality of natural waters and the well-being of the environment and communities.

2. TOXICITY OF TRACE & TOXIC METALS

Heavy metals may enter the human body through various routes, including food, water, and air, or they can be absorbed through the skin when individuals come into contact with them in agriculture and various settings, including manufacturing, pharmaceutical, industrial, or residential settings. Despite the long-standing awareness of the adverse health effects of heavy metals, exposure to these substances continues and, in some parts of the world, is even increasing. Consequently, the management of heavy metal contamination and the removal of toxic heavy metals from water have become pressing challenges for the twenty-first century.

Out of the 35 metals recognized as hazardous to human health, 23 are categorized as heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. Nevertheless, the most severe health risks associated with heavy metals are linked to exposure to lead, cadmium, mercury, and arsenic (classified as a metalloid but often considered a heavy metal). Substantial quantities of any of these metals can result in acute or chronic toxicity, leading to damage or impairment of mental and central nervous functions, alterations in blood composition, lung, kidney, liver damage, and damage to other vital organs. Prolonged exposure to these heavy metals can lead to slowly progressing physical, muscular, and neurological degenerative processes that mimic diseases such as Alzheimer's, Parkinson's, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon, and repeated long-term contact with certain metals or their compounds may even lead to cancer.

The toxicity of heavy metals depends on a multitude of factors, including the specific metal present, its chemical properties, its biological role, the organism exposed, and the stage of the organism's life during exposure. When one organism is affected, it can disrupt the entire food chain. Given that humans typically occupy the top of the food chain, we are particularly vulnerable as we can accumulate higher levels of heavy metals due to their concentration increasing up the food chain. Both industrial and domestic waste is commonly discharged into sewage systems, which often contain high concentrations of heavy metals. These heavy metals are not readily broken-down during sewage treatment. Instead, they are either removed in the final effluent or retained in the sludge produced during the treatment process. The characteristics and pollutants in the sewage that enters water bodies depend on the level of sewage treatment in place. In response to the problems arising from the untreated release of sewage into rivers and seas, various regulations and improved technologies have been implemented. To mitigate the discharge of pollutants into our waters, it is imperative to establish stringent regulations and adopt advanced technologies.

Important issues related to selected toxic metals like occurrences in nature, sources of water pollution, toxic effects etc. are described here under:

2.1 Toxicity of Arsenic

Arsenic is a widely distributed element, ranking 20th in natural abundance, constituting approximately 0.00005% of the Earth's crust, 14th in seawater, and 12th in the human body (Mandal and Suzuki, 2002). Arsenic is found in various environmental compartments, including rocks, soil, water, air, and biota.

Arsenic occurs in the environment in various oxidation states, such as As(V), As (III), As (0), and As(-III). The chemical forms and oxidation states of arsenic are of particular significance in terms of toxicity. Inorganic forms are generally more toxic and mobile than organo-arsenic species, with arsenite (As(III)) considered to be more toxic than arsenate (As(V)). Research has indicated that As (III) is 4 to 10 times more soluble in water than As(V) (Squibb and Fowler 1983; Xu et al. 1988; Lambe and Hill 1996; US EPA, 2002). Moreover, it has been observed that As (III) is 10 times more toxic than As(V) and 70 times more toxic than Mono Methyl Arsonate (MMA(V)) and Di Methyl Arsinate (DMA(V)). However, trivalent methylated arsenic species, such as MMA(III) and DMA(III), have been found to be more toxic than inorganic arsenic because they are more effective at causing DNA damage (Styblo et al. 2000; Dopp et al. 2004). Arsenic can enter the human body through ingestion, inhalation, or skin absorption. Most ingested and inhaled arsenic is readily absorbed through the gastrointestinal tract and lungs into the bloodstream.

Individuals who consume arsenic-contaminated water often display arsenical skin lesions, which are a late manifestation of arsenic toxicity. Prolonged exposure to arsenic-contaminated water can lead to various diseases, including conjunctivitis, hyperkeratosis, hyperpigmentation, cardiovascular diseases, disturbances in the peripheral vascular and nervous systems, skin cancer, gangrene, leucomelanosis, non-pitting swelling, hepatomegaly, and splenomegaly (Kiping, 1977; WHO, 2001; Pershagen, 1983). Chronic symptoms resulting from long-term arsenic exposure are nonspecific, such as weight loss and chronic weakness. Prolonged exposure can lead to arsenicosis, cardiovascular diseases, skin lesions, and other organ function disorders (Bissen and Frimmel 2003). Arsenicosis is a chronic illness that arises from prolonged consumption of water with high arsenic levels over an extended period (Kapaj et al. 2006). Advanced stages of arsenic toxicity can manifest in effects on the lungs, uterus, genitourinary tract, and other parts of the body. Additionally, elevated concentrations of arsenic in drinking water have been linked to an increase in stillbirths and spontaneous abortions (Csanady and Straub, 1995).

2.2 Toxicity of Cadmium

Cadmium is a naturally occurring element in the Earth's crust, distributed uniformly at an estimated average concentration of between 0.10 and 0.50 µg/L. In nature, cadmium is found in various inorganic compounds and as complexes with naturally occurring chelating agents. Organo-cadmium compounds are highly unstable and have not been observed in the natural environment. Cadmium is produced during the extraction of zinc and finds applications in the plating industry, pigments, the manufacturing of plastic materials, batteries, and alloys. The contamination of water with cadmium results from industrial discharges and leaching from landfilled areas. Drinking water can also become contaminated when it passes through galvanized iron pipes or plated plumbing fittings used in water distribution.

Cadmium is considered highly toxic, ranking just below mercury in terms of its toxicity. Exposure to low levels of cadmium typically does not produce immediate health effects but can lead to severe health problems over extended periods. The gastrointestinal tract is the primary route of cadmium uptake in both humans and animals. Cadmium is toxic to humans, animals, microorganisms, and plants. However, only a small portion of cadmium intake is absorbed by the body, mainly accumulating in bones, the liver, and, in cases of chronic exposure, the kidneys. Recent evidence suggests that relatively low cadmium exposure may lead to skeletal damage, resulting in low bone mineral density (osteoporosis) and fractures. The toxicity of cadmium lies in its accumulation in soft tissues. Animal studies have indicated that cadmium may be a risk factor for cardiovascular disease (Jarup, 2003).

For acute exposure, absorbed cadmium can cause symptoms such as salivation, difficulty in breathing, nausea, vomiting, abdominal pain, anemia, kidney failure, and diarrhea. Inhalation of cadmium dust or smoke may lead to dryness of the throat, headache, chest pain, coughing, increased discomfort, and bronchial complications (Lu et al., 2007). Adverse health effects resulting from the ingestion or inhalation of cadmium include renal tubular dysfunction due to high urinary cadmium excretion, high blood pressure, lung damage, and lung cancer.

Furthermore, cadmium accumulates in the bodies of animals and humans throughout their lifespans. The liver and kidneys are the primary stations of cadmium accumulation. After inhalation or absorption through the gastrointestinal tract, cadmium is concentrated in the kidneys, where its half-life can exceed 10 to 20 years. One of the well-documented toxic effects of cadmium poisoning is nephrotoxicity. Adverse renal effects are more commonly observed with exposure to low levels of cadmium. These effects are manifested by the excretion of low-molecular-weight plasma proteins, such as β2-microglobulin and retinol-binding protein (RBP).

A widely reported case of cadmium poisoning, known as “itai-itai byo”, occurred in Japan after World War II. Cadmium pollution from mining and refinery factories contaminated the Jinzo River water, which was used for irrigation. Rice grown in these cadmium-affected fields absorbed the metal, and people consumed it through water and the food chain, leading to osteomalacia and skeletal deformations. Severe pain in the body and joints prompted people to cry out "ITAI-ITAI" (it hurts-it hurts).

2.3 Toxicity of Chromium

Chromium can exist in various valence states, ranging from -2 to +6, but it is predominantly found in the environment in either the trivalent (Cr [III]) or hexavalent

(Cr [VI]) state. Trivalent chromium (Cr [III]) is the most common naturally occurring state. Small amounts of chromic oxide (Cr_2O_3) are typically present in most soils and rocks. In contrast, hexavalent chromium (Cr [VI]) is frequently found in nature as chromates (CrO_4^{2-}) and dichromates ($Cr_2O_7^{2-}$). These hexavalent forms are often a result of industrial and domestic emissions.

Chromium is unique as it is considered both an essential nutrient and a potential health hazard, primarily because it can exist in different oxidation states. Specifically, chromium in the +6 oxidation state, denoted as Cr(VI), is regarded as harmful, even in small quantities. In contrast, chromium in the +3 oxidation state, written as Cr (III), is considered essential for maintaining good health when consumed in moderate amounts. Chromium (III) is recognized as an essential nutrient for humans. Shortages of this form of chromium can lead to various health issues, including heart conditions, metabolic disruptions, and diabetes. Chromium (III) plays a crucial role in fat synthesis from glucose and the oxidation of fat to carbon dioxide. However, excessive intake of chromium (III) can also result in health effects, such as skin rashes.

Individuals who smoke tobacco are at an elevated risk of exposure to chromium. Chromium (VI) is recognized for its capacity to induce various health issues. When encountered in compounds used in leather products, it can trigger allergic reactions, leading to skin rashes. Inhalation of chromium (VI) can result in irritations of the nose, often leading to nosebleeds. Other health concerns associated with chromium (VI) exposure include:

- Skin rashes
- Discomfort in the stomach and the development of ulcers
- Respiratory complications
- Weakening of the immune system
- Damage to the kidneys and liver
- Genetic material alterations
- Increased risk of lung cancer
- Mortality

The extent of health risks stemming from chromium exposure is contingent upon its specific oxidation state. The metallic form of chromium, as found in particular products, generally poses low toxicity, whereas the hexavalent form is considered toxic. Adverse effects of hexavalent chromium on the skin may manifest as ulcerations, dermatitis, and allergic skin reactions. Inhalation of hexavalent chromium compounds can lead to ulceration and perforation of the mucous membranes within the nasal septum, irritation of the pharynx and larynx, asthmatic bronchitis, bronchospasms, and edema. Respiratory symptoms may include coughing, wheezing, shortness of breath, and nasal irritation.

Hexavalent chromium is also detrimental to plant and animal life, inducing symptoms such as the yellowing of leaves in crops like wheat and paddy. The World

Health Organization (WHO) has recommended a maximum permissible limit of 0.05 mg/L for chromium in drinking water to safeguard public health and ensure safe drinking water sources.

2.4 Toxicity of Copper

Copper stands as an essential micronutrient, as recognized in studies by Underwood (1977) and Goyer (1991). The Food and Nutrition Board (FNB) recommends an adult dietary copper intake of 1.53 mg/day (NRC, 1989). Copper exhibits three significant valence states: copper metal Cu(0), Cu(I), and Cu(II). In the natural world, copper manifests both as the pure metal and within minerals, with notable occurrences in cuprite (Cu_2O) and malachite ($Cu_2CO_3(OH)_2$). Predominantly, copper is present in ores, encompassing sulphides, oxides, and carbonates.

Copper serves a dual role, being both essential and potentially toxic to living organisms. In its essential role, copper is vital for processes like proper growth, cardiovascular health, lung flexibility, neuroendocrine functions, neovascularization, and iron metabolism. On average, an adult human consumes approximately 1 mg of copper daily through their diet, with roughly half of that amount being absorbed (Harris 1997). Copper is obligatory for enzymes that partake in aerobic metabolism, including cytochrome oxidase in mitochondria, lysyl oxidase in connective tissue, dopamine mono-oxygenase in the brain, and ceruloplasmin. Acting as a co-factor for apo-copper-zinc superoxide dismutase (apoCuZnSOD), copper offers protection against free-radical damage to proteins, cell membrane lipids, and nucleic acids in a broad range of cells and organs.

While severe copper deficiencies are relatively rare in humans, they can lead to a spectrum of health issues, encompassing mental retardation, anemia, hypothermia, neutropenia, diarrhea, cardiac hypertrophy, bone fragility, impaired immune function, weakened connective tissue, compromised central-nervous-system (CNS) functions, peripheral neuropathy, and alterations in skin, fur (in animals), or hair color (Linder and Goode 1991; Uauy et al. 1998; Cordano 1998; Percival 1998).

Long-term exposure to elevated copper levels can induce irritations of the nose, mouth, and eyes, causing symptoms such as headaches, stomachaches, dizziness, vomiting, and diarrhea. Intentional high copper intake may lead to liver and kidney damage and, in extreme cases, fatal outcomes. The carcinogenic potential of copper remains undetermined, but there are scientific reports suggesting a correlation between long-term exposure to high copper concentrations and a decline in intelligence among young adolescents, a subject warranting further investigation. Industrial exposure to copper fumes, dust, or mists may lead to a condition known as metal fume fever, characterized by atrophic changes in nasal mucous membranes. Chronic copper poisoning can result in Wilson's disease, marked by hepatic cirrhosis, brain damage, demyelination, renal complications, and copper deposition in the cornea.

Moreover, excessive amounts of copper sulfate can negatively impact the botanical environment. In its ionic form, copper is highly toxic to the photosynthesis of green algae such as Chlorella pyrenoidosa and diatoms like Nitzchiz palea, even at concentrations typically found in natural waters. Soils in regions where copper fungicides are repetitively employed, notably in vineyards and orchards, may accumulate copper over time. This underlines the dual nature of copper: essential for life and health but also capable of causing adverse effects when in deficiency or excess.

2.5 Toxicity of Mercury

Mercury (Hg) is the only common metal that is liquid at room temperature. Mercury occurs naturally in the earth's crust. Although it may be found in air, water and soil, mercury is mostly present in the atmosphere as a gaseous element. Mercury's major natural source results from the degassing of the earth's crust, emissions from volcanoes and evaporation from natural bodies of water. Mining of metals also causes indirect mercury discharges to the atmosphere. Due to its long lifetime of approximately of 1 year in the atmosphere, mercury's dispersion, transport and deposition in the environment will cause harmful effects on ecosystems and human health. Mercury may be present in the environment in several forms: elemental or metallic mercury, inorganic mercury compounds and organic mercury compounds. Pure mercury is a volatile liquid metal. It has traditionally been used in products like thermometers, switches, barometers and instruments for measuring blood pressure. Mercury is naturally present in many rocks including coal. When coal is burned, mercury is released into the environment. For this reason, coal-burning power plants are one of the largest anthropogenic sources of mercury emissions to the air, in addition to all domestic human-caused mercury emissions. Burning hazardous wastes, producing chlorine, breaking mercury products, and spilling mercury, as well as the improper treatment and disposal of products or wastes containing mercury, can also contribute to its release into the environment (EPA, 2009). Mercury compounds are produced in small quantities for chemical and pharmaceutical applications. In ancient Greece mercury was used as a cosmetic to lighten the skin (Jarup, 2003): in some sub-Saharan African countries the use of cosmetic products to bleach or to lighten the skin is still frequent. The long term use of some pharmacologic compounds (hydroquinone, glucocorticoids and mercury) can cause severe health adverse effects (Jarup, 2003). Large quantities of mercury compounds are still used for amalgamation in illegal gold mining, in some developing countries. Anthropogenic sources of mercury and its compounds may result basically from the same sources as enunciated for Cadmium. In addition, underground mining, mining quarrying, opencast and, production of phytopharmaceutical products and biocides, pharmaceutical industry, landfills, urban waste treatment plants, industrial waste-water treatment plants, etc. (E-PRTR, 2010) also add to the list of sources of mercury.

Exposure to mercury may mainly occur as a consequence of the deposition from air into water or into soil. By natural biological processes certain microorganisms can change mercury into methyl mercury, a highly toxic and stable form that builds up in fish, shellfish and animals that eat fish, accumulating in the food chain. General population is exposed to methyl mercury through the food chain; fish and shellfish are the main source of exposure through the ingestion pathway (EPA, 2009). Breathing mercury vapor is another possible exposure pathway. This can occur when elemental mercury or products that contain elemental mercury break and release mercury into air, in especial in indoor spaces without enough ventilation. Nevertheless, the main exposure pathway is through food chain and not by inhalation (EPA, 2009). High level of mercury can cause harmful effects, such as nerve, brain and kidney damage, lung irritation, eye irritation, skin rashes, vomiting and diarrhea. Mercury has a number of effects on humans that can be simplified into the following main effects:

- Disruption of the nervous system
- Damage to brain functions
- DNA damage and chromosomal damage
- Allergic reactions, resulting in skin rashes, tiredness and headaches
- Negative reproductive effects, such as sperm damage, birth defects and miscar-riages

Damaged brain functions can cause degradation of learning abilities, personality changes, tremors, vision changes, deafness, muscle in coordination and memory loss. High levels of methylmercury in the bloodstream of little children may affect nervous system, affecting the normal thinking and learning (EPA, 2009). Chromosomal damage is known to cause mongolism. In Japan, human illness and death occurred in the 1950’s among fishermen who ingested fish, crabs and shellfish contaminated with a simple alkali mercury compound from Japanese coastal industries. This mercury poisoning produced a crippling and often fatal disease known as “Minamata” disease. In minamata episode, crabs contained as much as 24 ppm, while kidney’s from human victims contained 144 ppm. Chloro-alkali plants and primary mercury processing plants are known to emit mercury into the atmosphere in sufficient quantities to create a public health problem. Poisoning of mercury may cause anxiety, insomnia, muscular tremor and other psychological disturbances. Research work with plants has shown that mercury can produce genetic and chromosomal changes (Liptak, 1974).

2.6 Toxicity of Iron

Iron is essential for the well-being of nearly all life forms, ranging from micro-organisms to humans. As the fourth most abundant element in the Earth's crust, and the most prevalent heavy metal, iron mainly exists in the environment as either Fe (II) or Fe (III). In surface waters, iron typically takes the form of Fe (III) when the pH level exceeds 7, with most of these salts being insoluble. They settle out or are adsorbed onto surfaces, resulting in relatively low iron concentrations in well-aerated waters. However, under reducing conditions found in groundwater, certain lakes, reservoirs, and environments devoid of sulfides and carbonates, higher concentrations of soluble Fe(II) may emerge. The presence of iron in natural waters is attributed to processes such as rock and mineral weathering, acidic mine water drainage, landfill leachates, sewage effluents, and iron-related industries.

Iron is an indispensable component of human nutrition, playing a vital role in cytochromes, porphyrins, and metalloenzymes. Dietary iron needs vary by age and sex, with older infants, children, and menstruating women being particularly susceptible to iron deficiency. In the plant kingdom, iron is essential for metabolic processes. It is crucial for the synthesis of chlorophyll in green plants, although it is not part of the chlorophyll molecules. Most iron in plants exists within organic compounds, enzymes, and plays key roles in cellular metabolism, encompassing catalase, peroxidase, and cytochromes. Iron deficiencies in plants result in chlorosis, and it's known for its immobility within plant tissues.

Iron exists in the human body in both ionic (loosely bound, inorganic iron) and nonionic (tightly bound, organic form) states. Notably, it is a constituent of the hemoglobin molecule. Iron deficiency is linked to an increased susceptibility to lead poisoning, particularly among children. A deficiency in iron, along with other trace elements, can lead to pica, characterized by cravings for unusual or non-nutritive substances such as clay, chalk, ashes, or bricks, and it's commonly seen in individuals with hysteria, during pregnancy, or in cases of chlorosis. Iron deficiency can also affect the transport of lead within the body.
According to Dr. Ronald Hoffman, daily iron requirements vary by age, sex, and body weight, with recommendations as follows:

- Infants up to 6 months: 6 mg/day.
- Children from 6 months to 1 year: 10 mg/day.
- Children aged 1 to 10 years: 10 mg/day.
- Males aged 11 to 18 years: 12 mg/day.
- Males aged 19 to 51+ years: 10 mg/day.
- Females aged 11 to 50 years: 15 mg/day.
- Females over 51 years: 10 mg/day.
- Pregnant women: 30 mg/day.
- Lactating women: 15 mg/day.

While iron is essential in normal quantities, excessive iron intake can adversely affect the human system and may lead to conditions like hemochromatosis. Iron absorption is enhanced by factors like heme, ascorbic acid, and amino acids but is inhibited by tannins, calcium, phosphate, phytic acid, and dietary fibers.

In the human body, iron is central to life processes, with over half of it present in the form of hemoglobin, while the rest is stored mainly in the liver. Nutritional anemia, particularly iron-deficiency anemia, is a widespread deficiency condition worldwide. This condition often results from insufficient iron intake, and it is a significant public health concern in countries like India, affecting more than half of ever-married women. Addressing this issue is of utmost importance.

Natural water often contains iron in ferric and ferrous forms, with the ferric form predominating in most cases. The form of iron can change due to oxidation or reduction resulting from bacterial growth during water storage. Iron in water can be present in true solution, a colloidal state, or as relatively large suspended particles. Determining iron levels is crucial for evaluating the extent of corrosion and assisting in finding solutions to these problems. Research on corrosion and corrosion control involves various tests to assess metal loss, with iron determination being one of the most important (Sawyer, 1978). In drinking water, the highest desirable limit for iron is 1.0 mg/L.

2.7 Toxicity of Lead

Lead is among the most common heavy elements, with various stable isotopes found in nature. Notably, 208Pb is the most prevalent. Lead is primarily utilized in the production of lead-acid batteries, solder, and various alloys. Organo-lead compounds, such as tetraethyl and tetramethyl lead, were historically used as antiknock and lubricating agents in petrol, although many countries are phasing out their use for these purposes. With the diminishing use of lead-containing additives in petrol and lead-containing solder in the food processing industry, airborne and dietary lead concentrations are decreasing. As a result, the intake of lead from drinking water has become a more significant contributor to overall exposure.

Lead's toxic properties have been recognized for over two thousand years. The early Greeks used lead as a glazing material for ceramic pottery and discovered its harmful effects when it came into contact with acidic foods. There is evidence to suggest that some Roman emperors suffered illness and even death due to lead poisoning resulting from the consumption of wines contaminated with high levels of lead.

Lead is present in all human tissues and organs but is not required for nutritional purposes. It is considered a systemic poison because once it enters the bloodstream, it distributes throughout the body, affecting various organs and tissues. Lead inhibits hematopoiesis (the formation of blood or blood cells) by interfering with heme synthesis, potentially leading to anemia. It also impacts the kidneys by inducing renal tubular dysfunction, which can result in secondary complications. Gastrointestinal effects of lead poisoning include nausea, anorexia, and severe abdominal cramps (known as lead colic), often associated with constipation. Lead poisoning can also manifest as muscle and joint pain, lung damage, breathing difficulties, and conditions such as asthma, bronchitis, and pneumonia. Additionally, lead exposure can harm the immune system, impeding cell maturation and skeletal growth. Lead can cross the placental barrier and reach the fetus, increasing the risk of miscarriage, abortions, and stillbirths.

According to the CDC, lead poisoning is the most common and severe environmental health issue affecting young children. Children are more vulnerable to lead exposure than adults due to their rapid growth rate and higher metabolism. Children absorb more lead from the gastrointestinal tract (25% vs. 8% in adults), with ingested lead distributed to a smaller tissue mass. Children are also more likely to play and breathe closer to the ground, where lead dust accumulates. A significant problem arises from children ingesting lead-based paint flakes, accounting for up to 90% of childhood lead poisoning cases. The primary health concern in children exposed to lead is intellectual and brain damage, and high-level exposure can even be fatal. Plants grown in lead mining areas are known to accumulate high lead levels. Vegetation near highways can accumulate atmospheric dust containing lead as foliar deposits, originating from petrol combustion and absorption from soil.

2.8 Toxicity of Nickel

Nickel, the 24th most abundant element, accounting for approximately 0.008% of the Earth's crust, is a natural constituent of soil and water (Alloway 1995; Hostynek and Maibach 2002; Hedfi et al. 2007). It ranks as the 5th most abundant element in the biosphere and was initially discovered through the extraction of other metals. Principal nickel ores include nickelite (NiAs), millerite (NiS), and pentlandite ([Ni, Fe]S).

Nickel enters the environment from a range of natural and anthropogenic sources. Among industrial contributors, a significant portion of environmental nickel arises from the combustion of coal, oil, and other fossil fuels. Additional industrial sources of nickel emissions encompass mining and refining processes, nickel alloy production (steel), electroplating, and municipal waste incineration (Sharma 2005; Ensink et al. 2007). Wastewater discharged from municipal sewage treatment plants further add to the accumulation of environmental nickel (van der Hoek et al. 2002).

While nickel is essential in small quantities, excessive uptake poses health risks to humans. Exposure to nickel can occur through air inhalation, water consumption, food intake, or smoking. Skin contact with nickel-contaminated soil or water can also lead to nickel exposure. One of the most prevalent modes of nickel exposure for the general public is through direct skin contact with nickel-plated materials. Notably, $Ni(CO)_4$ gas stands out as the most toxic compound among nickel compounds, with documented cases of fatalities in refineries. Initial symptoms include headaches, nausea, weakness, dizziness, vomiting, and epigastric pain, with a latency period of 1 to 5 days. Subsequent symptoms encompass chest constriction, chills, sweating, shortness of breath, coughing, muscle pains, fatigue, gastrointestinal discomfort, and in severe cases, convulsions and delirium.

Nickel fumes are known respiratory irritants and can lead to pneumonitis. Exposure to nickel and its compounds may result in the development of dermatitis referred to as "nickel itch" in sensitized individuals. Typically, itching appears up to 7 days before the onset of skin eruptions. Primary skin eruptions are erythematous or follicular and may progress to skin ulceration. Once acquired, nickel sensitivity appears to persist indefinitely. High-level occupational exposure has been associated with renal problems, vertigo, and dyspnoea (Commission of European Communities, 1976). Nickel, along with certain nickel compounds, has been classified by the National Toxicology Program (NTP) as having potential carcinogenic effects. The International Agency for Research on Cancer (IARC) categorizes nickel compounds within group 1 (indicating sufficient evidence of carcinogenicity in humans) and nickel within group 2B (representing agents that are possibly carcinogenic to humans).

2.9 Toxicity of Zinc

Zinc, the twenty-fifth most abundant element, constitutes approximately 0.02% of the Earth's crust by weight (Budavari, 1989). In its natural state, zinc typically appears dull grey due to its coating with oxide or basic carbonate, making it rare to find free zinc metal in nature (Beliles, 1994). Sphalerite, smithsonite, hemimorphite, and franklinite serve as the primary sources of zinc, with erosion being the largest natural contributor to zinc emissions in water. Zinc naturally enters the air mainly through igneous emissions and forest fires. Anthropogenic and natural sources contribute to zinc emissions to a similar extent, with key human-made sources including mining, zinc production facilities, iron and steel production, corrosion of galvanized structures, coal and fuel combustion, waste disposal and incineration, as well as the use of zinc-containing fertilizers and pesticides.

Zinc is an essential element for both animals and humans, playing a vital role in various enzyme systems. Reports of nutritional zinc deficiency in humans have emerged from various countries, with Egypt documenting an endemic zinc deficiency syndrome among young men (Prasad, et al., 1961; Halsted et al., 1972). This syndrome is characterized by stunted growth, signs of immaturity, and anemia, which are likely due to reduced intestinal zinc absorption. The condition was observed to be fully treatable with the administration of substantial doses of zinc sulfate.

Acute zinc toxicity can occur when excessive amounts of zinc salts are ingested, either accidentally or deliberately, such as through the use of zinc-containing emetics or dietary supplements. Vomiting is likely to ensue after the consumption of more than 500 mg of zinc sulfate. Instances of mass poisoning have been reported when acidic beverages were stored in galvanized containers, with symptoms including fever, nausea, vomiting, stomach cramps, and diarrhea occurring 3–12 hours after ingestion. Food poisoning attributed to the use of galvanized zinc containers in food preparation has also been documented. Symptoms in such cases arose within 24 hours and included nausea, vomiting, and diarrhea, occasionally accompanied by bleeding and abdominal cramps.

Symptoms of zinc toxicity in humans encompass vomiting, dehydration, electrolyte imbalances, abdominal pain, nausea, lethargy, dizziness, and impaired muscular coordination (Prasad and Oberleas, 1976). Reports of acute renal failure resulting from zinc chloride ingestion have also been documented (Csata, 1968). Unlike substances such as mercury (Hg), lead (Pb), or cadmium (Cd), zinc is an essential trace element for organisms, playing a crucial role in various physiological and metabolic processes. However, at high concentrations, zinc can become toxic to organisms.

Zinc is an essential trace element for both plants and animals, including humans, playing vital roles in various metabolic processes. Common effects of zinc poisoning in humans include non-fatal 'metal fume' fever from inhaling zinc oxide fumes and illnesses resulting from the consumption of acidic foods prepared in zinc galvanized containers. Specifically, zinc chloride in zinc salts can cause dermatitis upon skin contact.

3. WATER QUALITY CRITERIA

It is widely acknowledged that accessible sources of water on our planet are finite, and any form of pollution in these sources further diminishes their availability. Polluted water poses inherent health risks and cannot be safely used for drinking. Water with elevated salt levels is unsuitable for agricultural purposes and most industrial applications. Water quality also has a profound impact on the aesthetic and economic aspects of water bodies, affecting marine and freshwater ecosystems. Nevertheless, water that may not meet the standards for irrigation can often be suitable for industrial cooling. Every application of water necessitates a minimum quality standard concerning the presence of dissolved and suspended materials, encompassing both chemical and biological constituents. Ensuring this desirable water quality standard is essential to prevent harm to end-users.

The need to uphold a minimum quality standard for various water uses has led to the development of water quality criteria and water quality standards. Water quality criteria represent specific requirements that serve as the basis for making decisions or judgments to support a particular use. These criteria for different uses are established based on experimental data and our current understanding of health, ecological, and other considerations, considering their overall economic impact. It's crucial to note that these criteria are not rigid, but rather subject to adjustment as scientific knowledge evolves and more data is collected. The term "standard" refers to a specific principle or guideline set by an authority to restrict the concentration of various constituents in water, ensuring the safe utilization of water and safeguarding the environment.

3.1 Drinking Water Standards

Considering that people directly use water for drinking, providing water for domestic use is the most important purpose, and ensuring safe drinking water is the top priority in the National Water Policy. In India, organizations like the Bureau of Indian Standards (BIS) and the Indian Council of Medical Research (ICMR) have created rules for what is safe to drink. The World Health Organization (WHO) has also set international rules for safe drinking water. Below, we list the rules for safe levels of certain metals in drinking water based on the BIS code 10500:2012, in Table 2.

Table 2: Drinking Water Standards for Trace & Toxic metals (BIS-10500:2012)

S.No.	Toxic metal	Requirement (Acceptable Limit)		Permissible Limit in the Absence of Alternative Source	
		(mg/L)	(µg/L)	(mg/L)	(µg/L)
1	**Total arsenic as As**	0.01	10	No Relaxation	
2	**Cadmium as Cd**	0.003	3	No relaxation	
3	**Total Chromium as Cr**	0.05	50	No relaxation	
4	**Copper as Cu**	0.05	50	1.5	1500
5	**Iron as Fe**	1.0	1000	No relaxation	
6	**Lead as Pb**	0.01	10	No relaxation	
7	**Nickel as Ni**	0.02	20	No relaxation	
8	**Zinc as Zn**	5	5000	15	15000

3.2 Regulatory Limits of Heavy Metals US Environmental Protection Agency (US EPA)

Various toxic heavy metals often contaminate surface water sources, and the maximum levels allowed, as per WHO and US EPA standards, are detailed in Table 3. These limits are compulsory for all water supply systems. In many cases, naturally occurring water, whether from surface or groundwater sources, contains some of these heavy metals at concentrations that are 100 to 1000 times higher than the recommended MCL values. As these heavy metals have various industrial uses, it becomes more important to focus on their removal, recovery, and recycling.

Table 3: Maximum acceptable limits of several toxic heavy metal ions based on WHO and US EPA regulations

Heavy Metal	Toxicity rank	WHO (µg/L)	USEPA (µg/L)
Arsenic	1	10	10
Lead	2	10	15
Mercury	3	6	2
Cadmium	7	3	5
Chromium	78	50	100
Nickel	57	70	100
Zinc	74	NGL	5000
Copper	120	2000	1300
Iron	-	-	300
Note: NGL = NO Guideline			

Based on data from human clinical studies and a range of other research, including animal experiments, governmental authorities have established drinking water standards. A concise overview of these standards can be found in Table 4, compiled by Hattingh in 1977.

Table 4: Drinking water quality criteria for trace metals which might affect public health

Parameter (unit-µg/L)	USPHS (1962)	Japan (1968)	USSR (1970)	WHO European (1970)	WHO Intern. (1971)	SABS (1971)	NAS (1972)	Australia (1973)	US EPA (1975)	FRG (1975)		BIS 10500:2012
Arsenic	10	50	50	50	50	50	100	50	50	40		10
Barium	1,000	-	4,000	1,000	-	-	1,000	1,000	1,000	-		700
Cadmium	10	-	10	10	10	50	10	10	10	6		3
Chromium	50	50	100	50	-	50	50	50	50	50		50
Copper	1,000	10,000	100	50	50	1,000	1,000	10,000	-	-		50
Lead	50	100	100	100	100	50	50	50	50	40		10
Mercury	-	1	5	-	1	-	2	-	2	4		1
Selenium	10	-	1	10	10	-	10	10	10	8		10
Silver	50	-	-	-	-	-	-	50	50	-		100
Zinc	5,000	100	1,000	5,000	5,000	5,000	5,000	5,000	-	2,000		5000

World Health Organisation (WHO)
US Public Health Service (USPHS)
South African Bureau of Standards (SABS)
Russisa (USSR)
USA National Academy of Sciences (NAS)
Australia, Japan and Environmental Protection Agency (EPA) of the USA

It is important to mention that maximum permissible concentrations (USSR) and threshold limit values (US) have been defined for occupational hygiene (as indicated by Roschin and Timofeevskaya in 1975). These values are primarily related to regulating workplace exposure to airborne particles and are not directly relevant to our current discussion.

3.3 Quality Criteria for Livestock

A safe water supply is vital for maintaining healthy livestock. Contaminated water has the potential to adversely affect the growth, reproduction, and overall productivity of animals, as well as the safety of animal products intended for human consumption. Moreover, polluted water sources for livestock and poultry have the potential to contaminate human drinking water supplies. As a result, it is essential to safeguard farm water sources from contamination by harmful agents like bacteria, nitrates, sulfates, and pesticides. While the Environmental Protection Agency has established drinking water standards for human consumption, there are currently no specific standards in place for drinking water provided to livestock or poultry. However, The National Academy of Sciences has issued recommendations for maximum allowable levels of certain contaminants.

The acceptable daily intake of various substances greatly depends on their concentrations and the overall water quality consumed. Animals' daily water requirements can vary based on several factors, including temperature, humidity, water content of their food, their level of physical activity, and the salinity of the water source.

Consequently, the recommended concentration levels for specific substances are determined considering these typical usage conditions. Excessive salinity in the drinking water provided to livestock can disrupt the animals' water balance and may even lead to fatalities. Elevated levels of certain ions in the water can result in health issues and potentially be fatal for animals. The National Academy of Sciences has established upper limits for toxic substances present in water (see Table 5).

Table 5: Recommendations for levels of toxic substances in drinking water for livestock

Sr.	Toxic metal	Upper Limit in mg/L	Sr.	Toxic metal	Upper Limit in mg/L
1.	Arsenic	0.2	5.	Iron as Fe	-
2.	Cadmium as Cd	0.05	6.	Mercury as Hg	0.01
3.	Chromium as Cr	1.0	7.	Zinc as Zn	24
4.	Copper as Cu	0.5			

Sources: Environmental Studies Board, Nat. Acad. Of Sci., Nat Acad of Eng., Water Quality Criteria, 1972
Ayers, R.S. and D.W. Wescot, Water Quality for Agriculture, Food and Agriculture Organization of the United Nations, Rome, 1976

3.4 Water Quality for Irrigation

Most water sources naturally contain dissolved salts and trace elements, with many of these substances originating from the Earth's surface weathering processes. Furthermore, water quality can be influenced by drainage from irrigated farmlands and the discharge of sewage and industrial wastewater from urban areas. In the context of irrigation, salinity levels are usually the primary concern, as high salt concentrations can have adverse effects on both soil structure and crop yields. Nevertheless, irrigation water can also contain various trace elements that may limit its suitability for agriculture.

The required quality of irrigation water can vary significantly based on factors such as salinity, soil permeability, toxicity, and other considerations like excessive nitrogen content or unusual water pH. Some elements in irrigation water can directly harm crops. Determining toxicity thresholds in water is a complex task due to chemical reactions that occur when the water interacts with the soil. When an element is introduced to the soil through irrigation, it can either be neutralized through chemical reactions or accumulate in the soil until it reaches harmful levels. If water contains a certain element at a specific concentration, it may cause immediate harm to crops through foliar effects, particularly when sprinkler irrigation is employed. Alternatively, in the case of furrow irrigation, it might take several years for the element to accumulate to toxic levels, or it could become immobilized in the soil, never reaching harmful concentrations. The recommended water quality standards for irrigation are outlined in Table 6.

Table 6: Recommended limits for constituents in reclaimed water for irrigation

Constituent	Long-term use (mg/L)	Short-term use (mg/L)	Remarks
Aluminum (Al)	5.00	20	Can cause nonproductivity in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity.
Arsenic (As)	0.10	2.0	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Beryllium (Be)	0.10	0.5	Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans.
Boron (B)	0.75	2.0	Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g., citrus) at 1 mg/L. Most grasses relatively tolerant at 2.0 to 10 mg/L.
Cadmium (Cd)	0.01	0.05	Toxic to beans, beets, and turnips at concentrations as low as 0.1 mg/L in nutrient solution. Conservative limits recommended.
Chromium (Cr)	0.1	1.0	Not generally recognized as essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.
Cobalt (Co)	0.05	5.0	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Copper (Cu)	0.2	5.0	Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution.
Fluoride (F)	1.0	15.0	Inactivated by neutral and alkaline soils.
Iron (Fe)	5.0	20.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of essential phosphorus and molybdenum.
Lead (Pb)	5.0	10.0	Can inhibit plant cell growth at very high concentrations.
Lithium (Li)	2.50	2.50	Tolerated by most crops at up to 5 mg/L; mobile in soil. Toxic to citrus at low doses recommended limit is 0.075 mg/L.
Manganese (Mg)	0.2	10.0	Toxic to a number of crops at a few-tenths to a few mg/L in acid soils.
Molybdenum (Mo)	0.01	0.05	Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum.
Nickel (Ni)	0.2	2.0	Toxic to a number of plants at 0.5 to 1.0 mg/L; reduced toxicity at neutral or alkaline pH.
Selenium (Se)	0.02	0.02	Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of added selenium.
Vanadium (V)	0.1	1.0	Toxic to many plants at relatively low concentrations.
Zinc (Zn)	2.0	10.0	Toxic to many plants at widely varying concentrations; reduced at increased pH (6 or above) and in fine textured or organic soils.

Source: Rowe and Abdel-Magid, 1995

4. WATER QUALITY MONITORING BY CWC

Central Water Commission (CWC) is playing an important role in the field of water quality monitoring of river water and is observing water quality at various rivers since 1960's. As on January, 2023, CWC is observing water quality at 782 key locations in different rivers across the country: 657 on Hydrological Observation network and 125 Water Quality Sampling Stations (WQSS). In addition, CWC has started monitoring of water quality of water bodies across India since 01.03.2023. Till date, 88 water bodies have been identified for water quality monitoring purpose across various states of the country. The GIS map of the above-mentioned water quality stations monitored by CWC is given as Figure 1.

The details of distribution of WQ stations among different states of India can be seen in Table 7 and Figure 2. Details of distribution of WQ stations among 14 organisations of CWC is represented in Table 8 and Figure 3; and distribution among 23 river basins is represented in Table 9 and Figure 4.

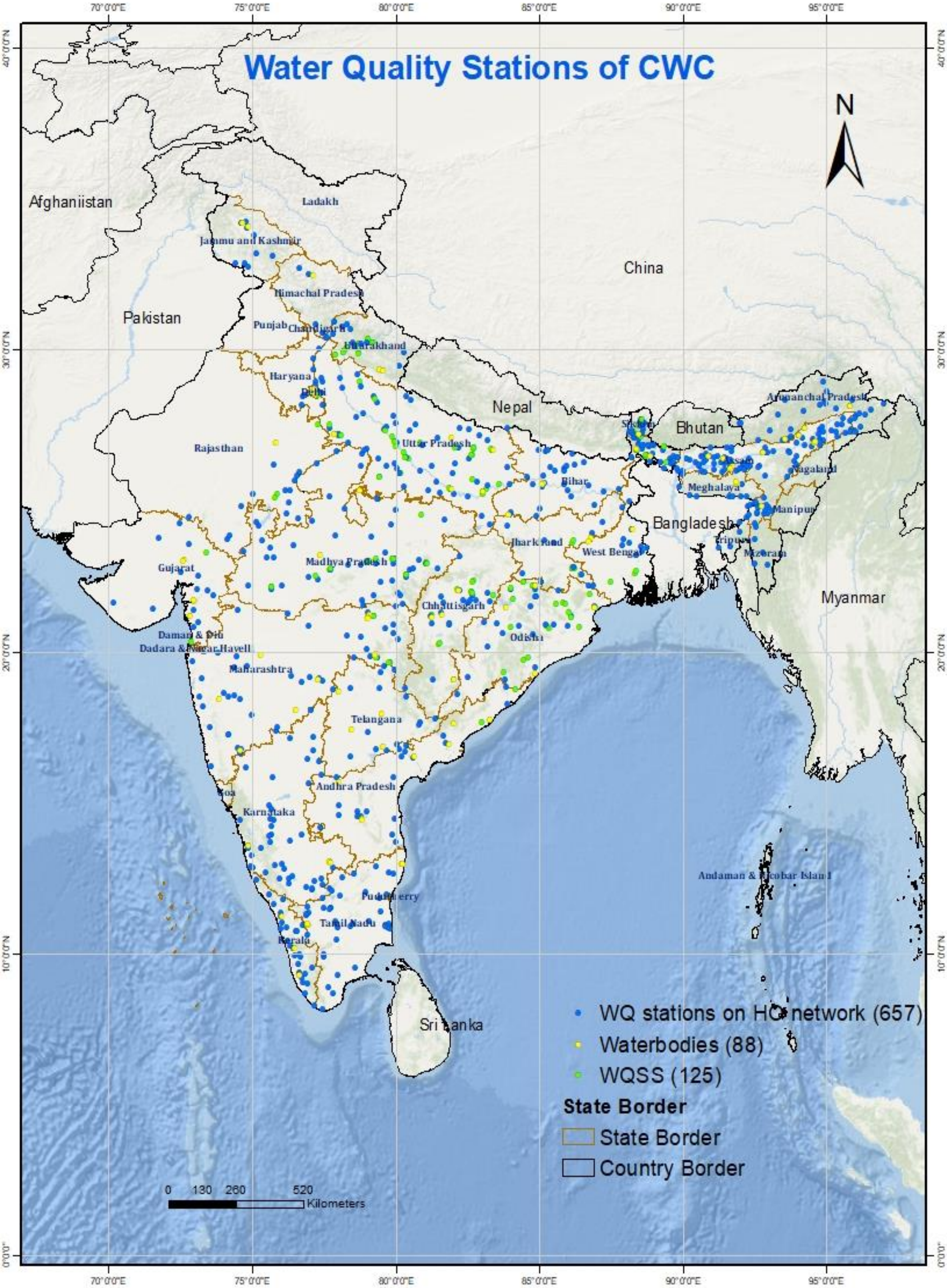

***Figure 1**: Water quality network of CWC (as on 01.01.2023)*

Table 7: State–wise distribution of Water Quality Stations of CWC

Sl. No.	State/UT	GDQ	GDSQ	GQ	WQSS	Water Bodies	Total
1	Andhra Pradesh	4	14	1	2	7	28
2	Arunachal Pradesh	9	9	10	-	2	30
3	Assam	21	26	53	-	11	111
4	Bihar	6	22	1	-	2	31
5	Chhattisgarh	2	18	-	12	4	36
6	Delhi	1	2	-	3	3	9
7	Gujarat	4	9	-	2	6	21
8	Haryana	3	1	-	-	-	4
9	Himachal Pradesh	-	6	-	-	1	7
10	Jammu & Kashmir	3	6	-	-	2	11
11	Jharkhand	4	6	1	6	2	19
12	Karnataka	17	23	2	-	4	46
13	Kerala	2	24		-	3	29
14	Madhya Pradesh	20	24	4	12	2	62
15	Maharashtra	17	25	4	6	10	62
16	Manipur	-	-	1	-	-	1
17	Meghalaya	5	3	1	-	2	11
18	Mizoram	-	5	-	-	-	5
19	Odisha	2	22	1	25	4	54
20	Puducherry	3	-	-	-	-	3
21	Rajasthan	8	8		2	1	19
22	Sikkim	-	11	6	5	1	23
23	Tamil Nadu	21	21	-	-	5	47
24	Telangana	4	8	1	-	4	17
25	Tripura	-	3	2	-	-	5
26	Uttar Pradesh	14	47	4	28	6	99
27	Uttarakhand	5	9		15	3	32
28	West Bengal	7	21	10	7	3	48
	Grand Total	**182**	**373**	**102**	**125**	**88**	**870**

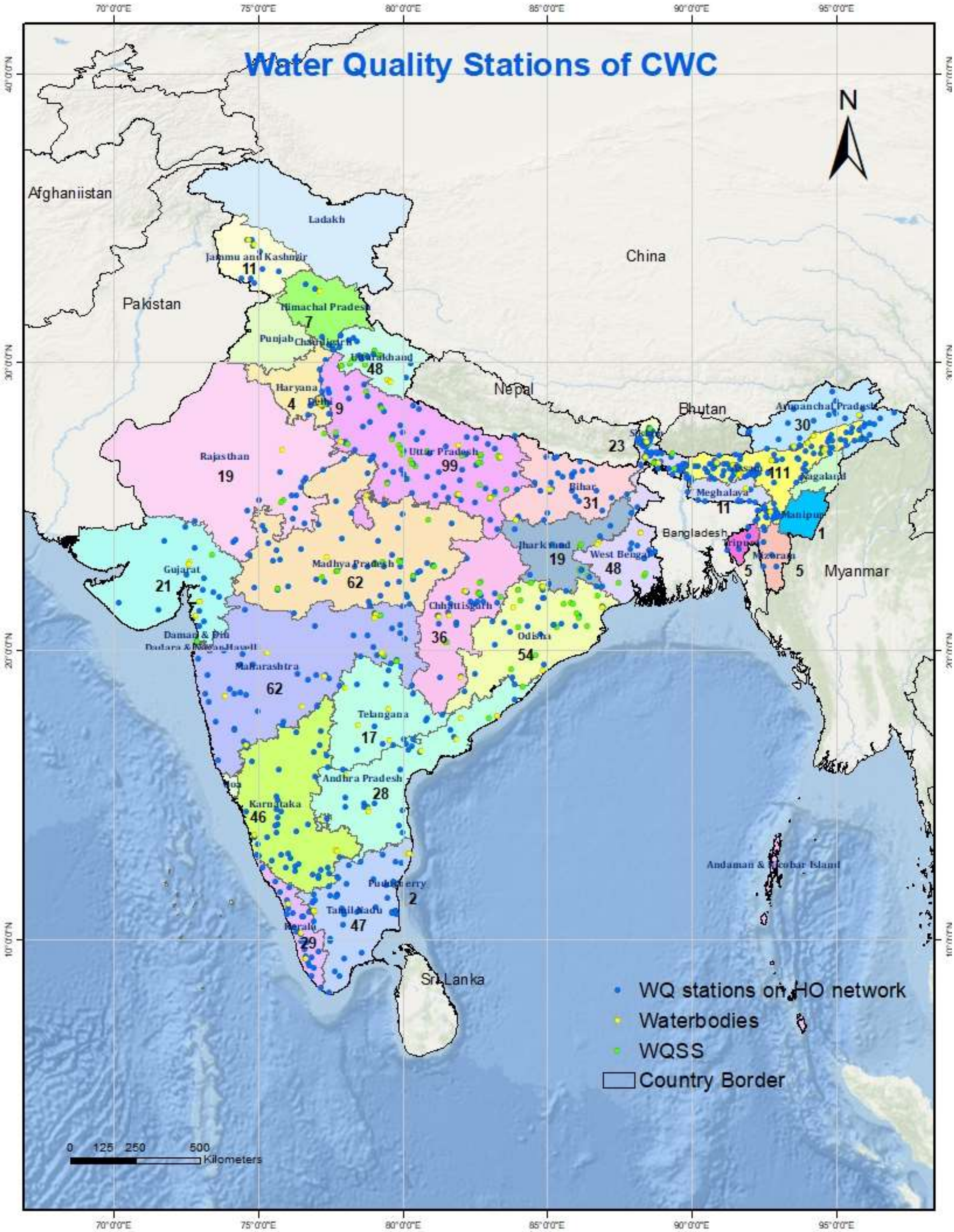

Figure 2: State-wise distribution of Water Quality Stations monitored by CWC

Table 8: Organisation–wise distribution of Water Quality Stations of CWC

Sl. No.	Organisation	GDQ	GDSQ	GQ	WQSS	Water Bodies	Total
1	Barak and Other Basins Organisation, Shillong	7	22	8	-	3	40
2	Brahmaputra Basin Organisation, Guwahati	27	24	58	-	12	121
3	Cauvery and Southern rivers Organisation, Coimbatore	35	53	-	-	11	99
4	Indus Basin Organisation, Chandigarh	3	8	-	-	3	14
5	Krishna & Godavari Basin Organisation, Hyderabad	19	34	7	-	15	75
6	Lower Ganga Basin Organisation, Patna	9	33	1	6	5	54
7	Mahanadi and Eastern Rivers Organisation, Bhubaneswar	2	43	1	43	7	96
8	Mahi & Tapi Basin Organisation, Gandhinagar	6	15		2	6	29
9	Monitoring Central Organisation, Nagpur	10	14	1	6	5	36
10	Monitoring South Organisation, Bengaluru	11	17	-	-	3	31
11	Narmada Basin Organisation, Bhopal	8	9	4	11	1	33
12	Teesta & Bhagirathi Damodar Basin Organisation, Kolkata	11	32	18	14	6	81
13	Upper Ganga Basin Organisation, Lucknow	6	32	1	33	5	77
14	Yamuna Basin Organisation, New Delhi	28	37	3	10	6	84
	Grand Total	**182**	**373**	**102**	**125**	**88**	**870**

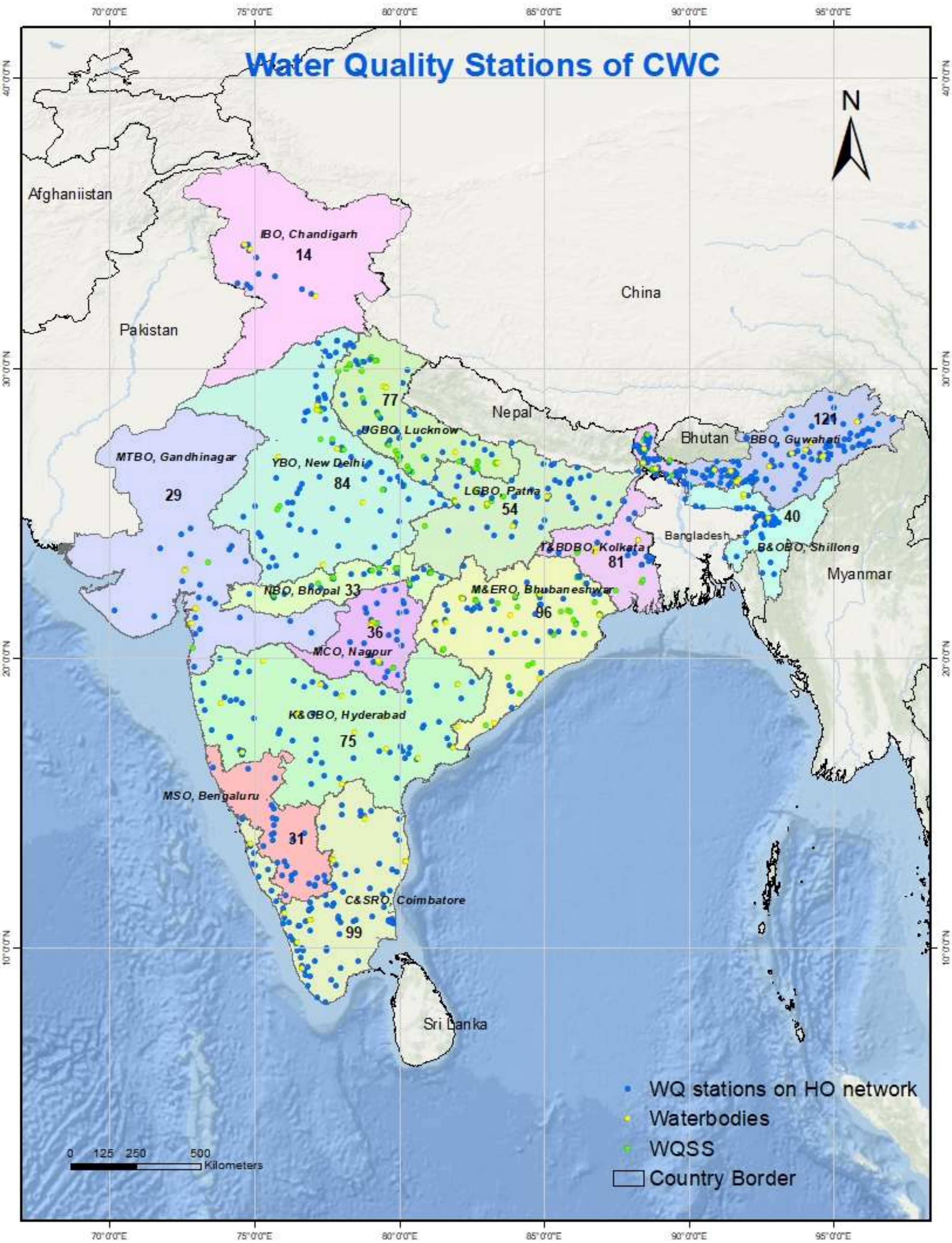

Figure 3: Organisation-Wise Distribution of Water Quality Stations Monitored by CWC

Table 9: Basin-wise water-quality stations monitored by CWC

Sl. No.	Basin	GDQ	GDSQ	GQ	WQSS	Water Bodies	Total
1	Barak and Other Basins	6	18	7	-	1	32
2	Brahmani and Baitarni Basin	-	11	1	15	1	28
3	Brahmaputra Basin	34	44	76	7	17	178
4	Cauvery Basin	17	24	-	-	3	44
5	EFR between Pennar and Cauvery	8	4	-	-	5	17
6	EFR between Krishna and Pennar	-	1	-	-	-	1
7	EFR between Mahanadi and Godavari	-	4	-	5	1	10
8	EFR South of Cauvery Basin	2	4	-	-	-	6
9	Ganga Basin	48	115	6	56	19	244
10	Godavari Basin	19	26	4	6	14	69
11	Indus (up to Indo-Pak Border) Basin	3	8	-	-	3	14
12	Krishna Basin	14	27	3	-	6	50
13	Mahanadi Basin	1	22	-	15	4	42
14	Mahi Basin	2	3	-	-	-	5
15	Narmada Basin	8	11	4	11	3	37
16	Pennar Basin	4	4		-	2	10
17	Rivers Draining into Bangladesh Basin	-	1	-	-	-	1
18	Rivers Draining into Myanmar Basin	-	2	-	-	-	2
19	Sabarmati Basin	1	1	-	1	2	5
20	Subarnarekha Basin	1	6	-	8	1	16
21	Tapi Basin	1	3	-	-	2	6
22	WFR of Kutch and Saurashtra including Luni Basin	2	3	-	-	-	5
23	WFR South of Tapi Basin	11	31	1	1	4	48
	Grand Total	**182**	**373**	**102**	**125**	**88**	**870**

* EFR: East Flowing Rivers
WFR: West Flowing Rivers

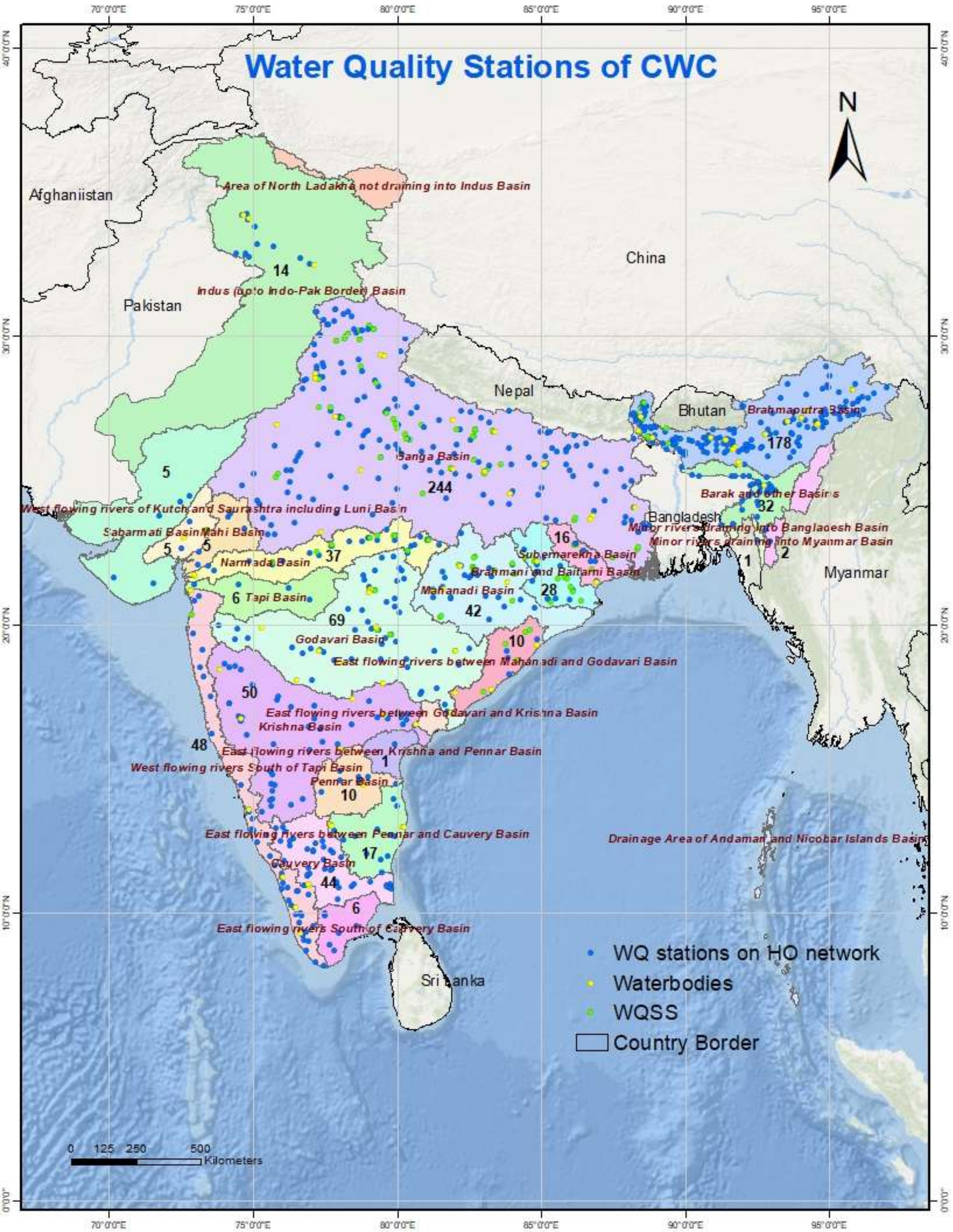

Figure 4*: *Basin-wise distribution of water quality Stations monitored by CWC

The water quality samples collected at these stations are analysed at laboratories of CWC. At present, CWC follows a three-tier laboratory system which consists of Level I, II and III types of laboratories for providing analytical facilities for the analysis of river water samples collected from water quality monitoring stations covering all the important river basins of India.

The three-tier laboratory system consists of:

1. **Level-I Laboratories:** 427 level-I laboratories located at field water quality monitoring stations on various rivers of India for monitoring of 6 in-situ parameters: Colour, Odour, Temperature pH, Electrical Conductivity and Dissolved Oxygen (a map showing 427 Level-I labs can be seen at Figure 5).

2. **Level-II Laboratories:** 18 level-II laboratories located at division offices to analyse 25 physico-chemical and bacteriological parameters of river water.

3. **Level-III Laboratories:** 5 regional labs located at New Delhi, Varanasi, Hyderabad, Coimbatore and Guwahati for analysis of 41 parameters including trace & toxic metals and pesticides.

Out of 23 level-II/III laboratories of CWC, 22 laboratories are accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) in the field of testing in accordance with Standard ISO/IEC 17025:2017. A map showing level-II/III labs can be seen at Figure 6. The details of monitoring parameters in each level labs are depicted in Table 10.

Table 10: List of Water Quality Parameters monitored by CWC

Sl. No.	Level-I	Level-II	Level-III
1	Temperature	Temperature	Temperature
2	Colour	pH	pH
3	Odour	Electrical Conductivity	Electrical Conductivity
4	pH	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)
5	Electrical Conductivity	Turbidity	Turbidity
6	Dissolved Oxygen (DO)	Biochemical Oxygen Demand (BOD)	Biochemical Oxygen Demand (BOD)
7		Chemical Oxygen Demand (COD)	Chemical Oxygen Demand (COD)
8		Total Dissolved Solids (TDS)	Total Dissolved Solids (TDS)
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		Ammoniacal Nitrogen	Ammoniacal Nitrogen
20		Nitrate	Nitrate
21		Nitrite	Nitrite
22		Phosphate	Phosphate
23		Silicate	Silicate
24		Total Coliform	Total Coliform
25		Fecal Coliform	Fecal 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			Alpha Endosulphan, Beta Endosulphan
38			Aldrin, Dieldrin
39			Carbaryl (Carbamate)
40			Malathion, Methyl Parathion
41			Anilophos, Chloropyriphos

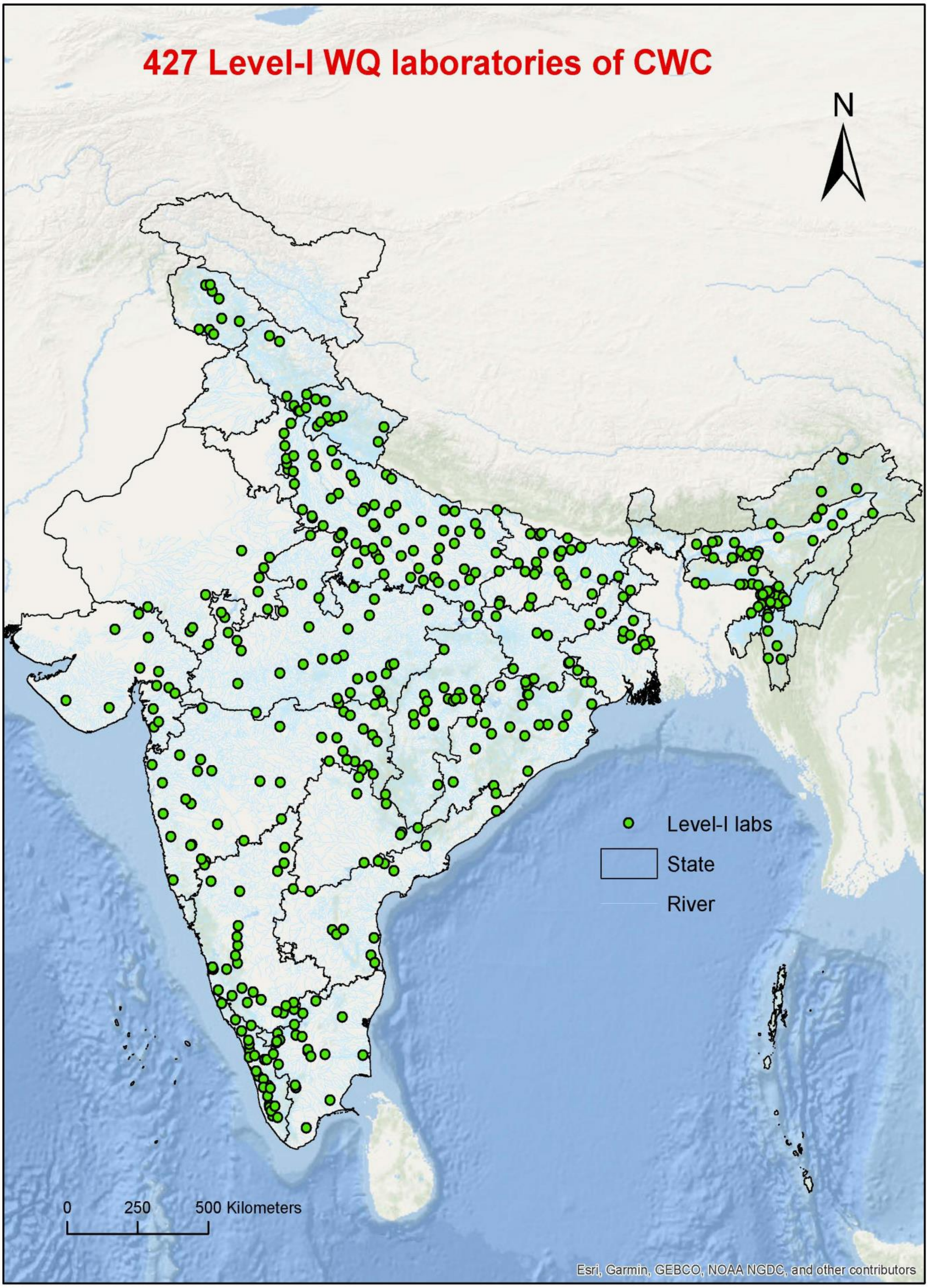

Figure 5: Level-I Water quality laboratories of CWC

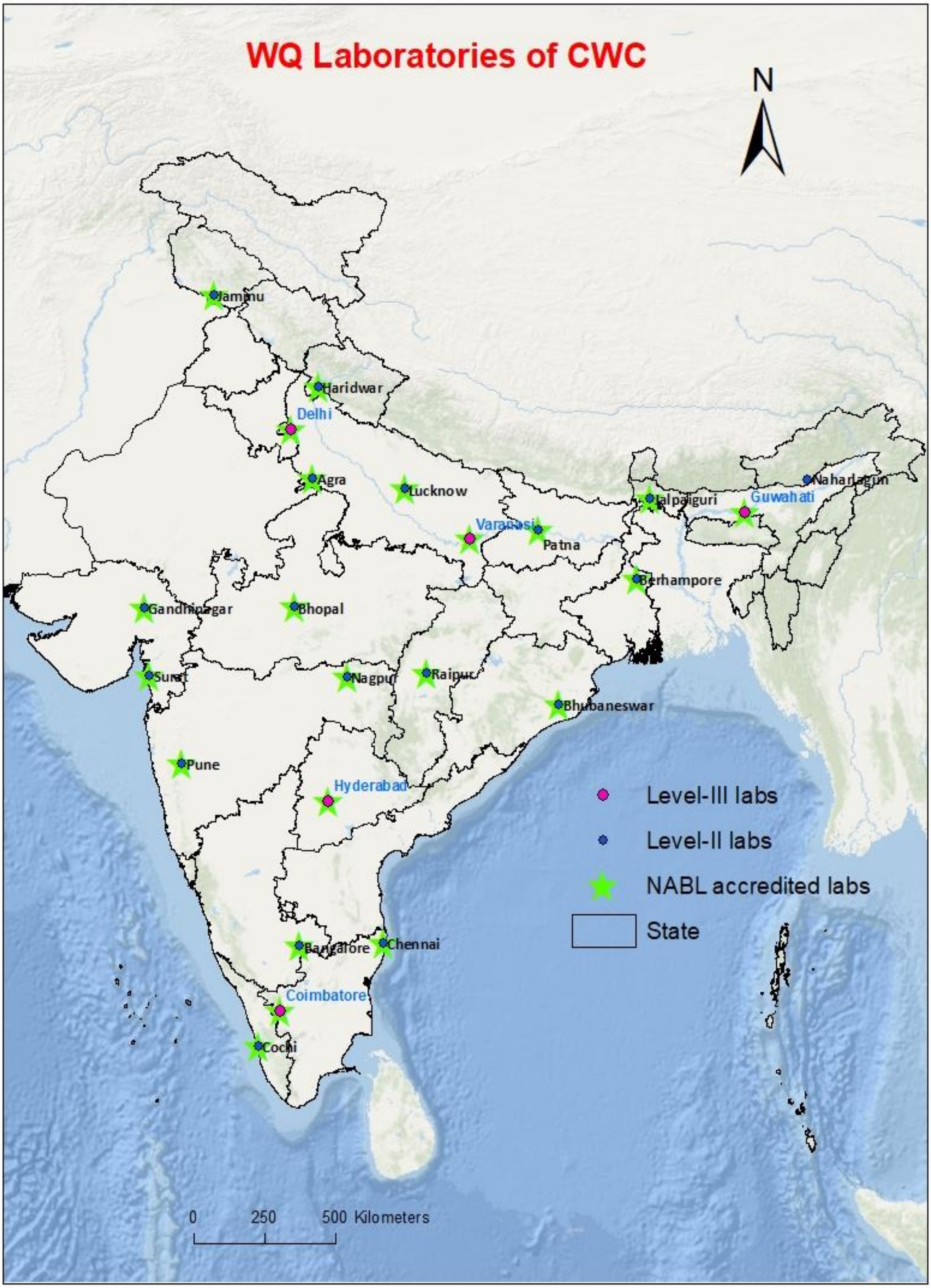

Figure 6: Level-II/III Water quality laboratories of CWC

5. STUDY AREA

The analysis results of 9 trace & toxic metals of water samples from 488 water quality monitoring stations of CWC are considered for the study (Figure 7). This involves the data analysis of 3815 samples collected during January, 2021 to December, 2021 from 10 river basins of India.

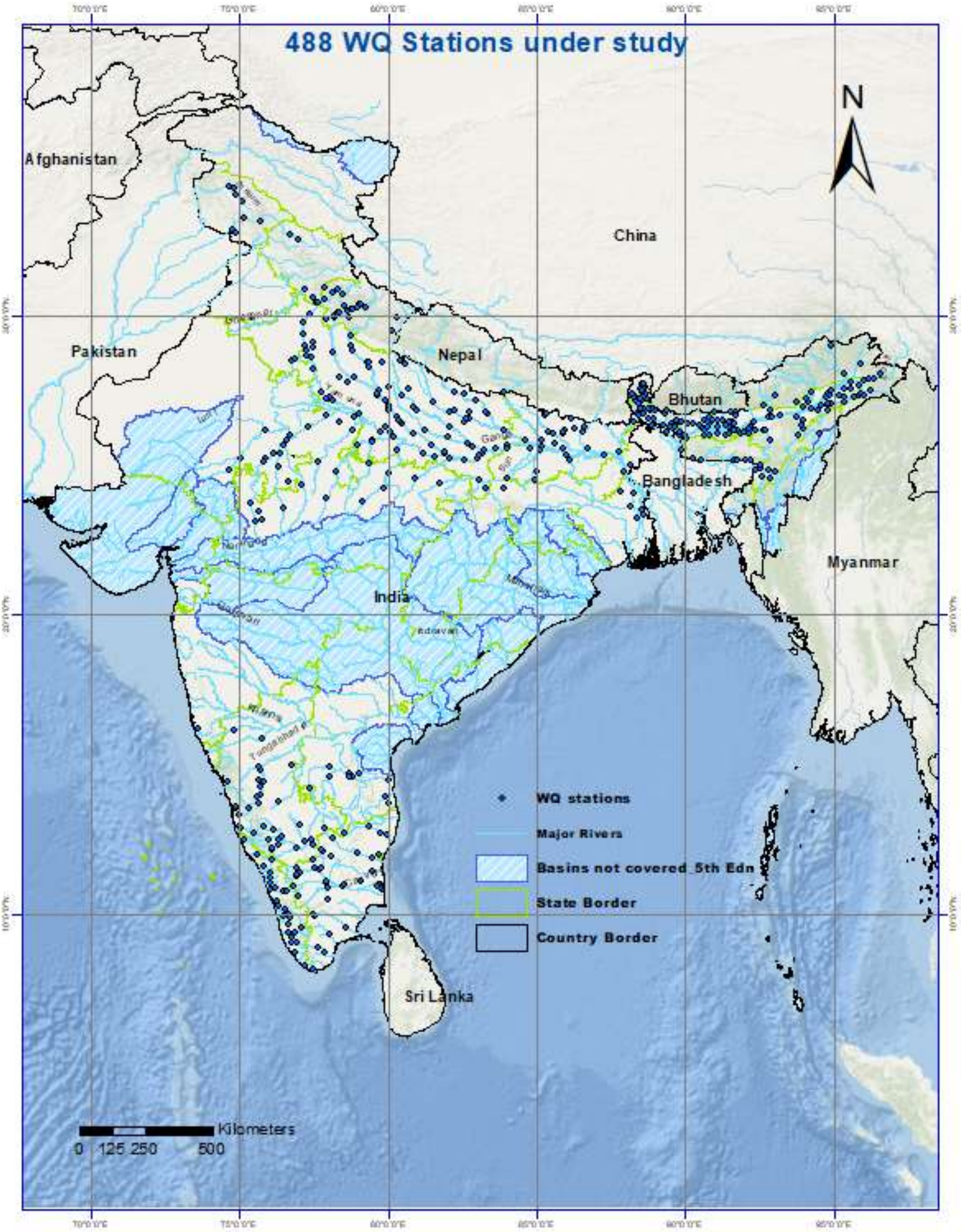

Figure 7: 488 Water quality stations monitored

The details of the 488 monitoring are enclosed as Annexure-I. The details of 10 basins considered for the study has been given below.

1. ***Brahmaputra Basin:***

The Brahmaputra River originates from the Mansarovar lake region near Mount Kailash, northern part of the Himalayas in Tibet. It fows through Tibet, India and Bangladesh. Brahmaputra basin in India stretches across the states of Arunachal Pradesh, Assam, West Bengal, Meghalaya, Nagaland, and Sikkim. The basin lies between 88°11′ - 96°57′ E longitudes and 24°44′ - 30°3′ N latitudes. After flowing through Tibet, it enters India through Arunachal Pradesh, where the river is called Siang. It is joined by two mountain streams namely the Lohit and the Dibang near Sadiya town to form the mighty Brahmaputra River. As the river follows its course through the valley, it receives a number of tributaries at its north and south banks. The principal tributaries of the river are Lohit, Dibang, Subansiri, Jiabharali, Dhansiri(North), Manas, Torsa, Sankosh, Teesta, Burhidihing, Desang, Dikhow, Dhansiri(South) Raidak-I, Raidak-II and Kopili. Torsa and Jaldhaka rivers flowing through the northern West Bengal also join the main stream of Brahmaputra but, in the plains of Bangladesh. Brahmaputra catchment is the heaviest rainfall region in the world. Brahmaputra basin, particularly the portions in Assam, is prone to annual floods and river bank erosions.

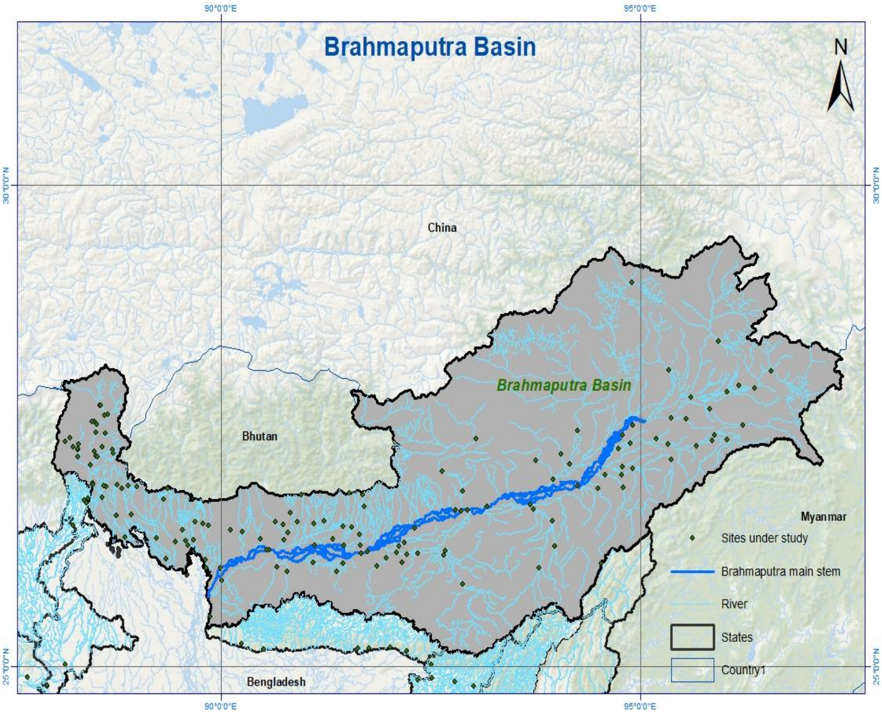

Figure 8: Brahmaputra Basin

Water quality samples collected from 144 water quality stations are being considered for the study.

2. *Barak and Other Basins:*

Barak is an important river system in North East India. The Barak basin has a catchment spread over the states of Meghalaya, Manipur, Mizoram, Assam, Tripura and Nagaland as well in the neighbouring country of Myanmar. Upto Indo-Bangladesh border in Karimganj district of Assam, the catchment area of the Barak River is 26,193 sq.km. All the other rivers draining directly into the Meghna River system are small compared to the Barak River. The Barak also has numerous tributaries within Assam and Manipur. The principal right bank tributaries are Makru, Jiri, Chiri, Madhura, Jatinga, Gumra, Harang and Badri. The principal left bank tributaries are Irang, Tuivai, Sonai, Katakhal, Singla and Longai. At the international border with Bangladesh, Barak splits into two branches: Surma in the north and Kushiyara in the south. The river Surma flows in the northern part of Sylhet district of Bangladesh before joining the Meghna River system. The south flowing rivers of the Khasi and Jaintia hills of Meghalaya drain into Surma valley. The Kushiyara River flows in the southern portion of the Sylhet district before joining the Meghna River. A few west flowing rivers from Assam and Tripura join the Kushiyara after entering Bangladesh.

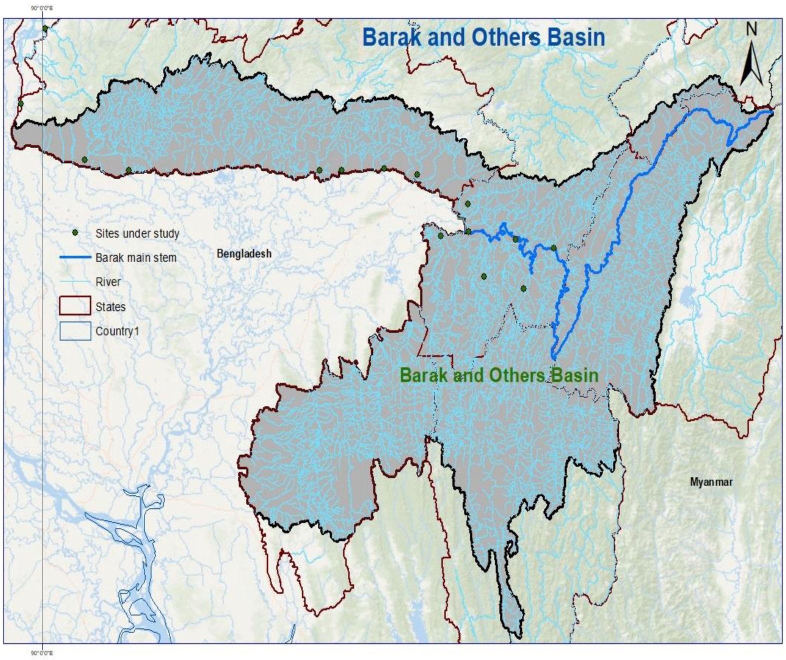

Figure 9: Barak and Other Basins

Water quality samples collected from 13 water quality stations are being considered for the study.

3. ***Cauvery Basin:***

River Cauvery is the third largest perennial river flowing in Southern India. It originates at Talakaveri on the Brahmagiri range of Hills in Kodagu District of Karnataka amidst Western Ghats at an elevation of 1,341 m above MSL and drains a total area of 81,155 Sq. kms. It flows in south-eastern direction across the Plateau of Mysore and joins the Bay of Bengal in Nagapattinam District of Tamil Nadu. The river basin lies between 75°30' –

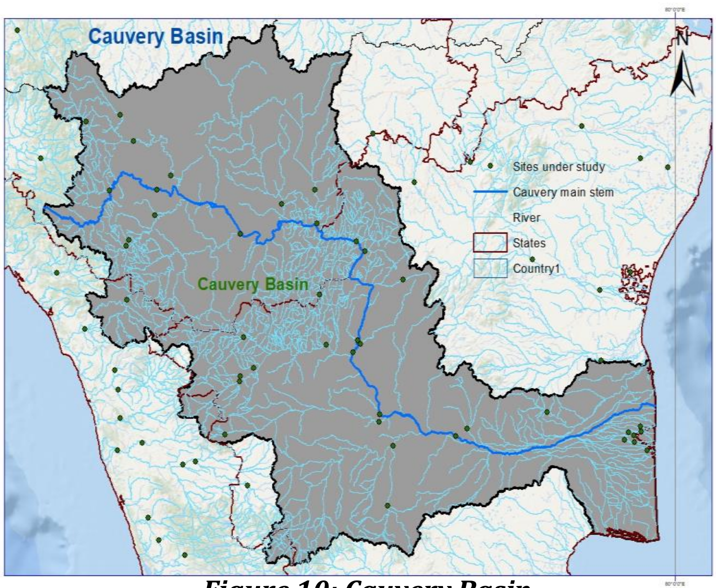

Figure 10: Cauvery Basin

79°45'E longitudes and 10°05'N – 13°30'N latitudes. Cauvery Basin covers the states of Karnataka, Tamil Nadu, Puducherry and some parts of Kerala. The Cauvery basin is fan shaped in Karnataka and leaf shaped in Tamil Nadu. The major tributaries are Harangi, Hemavati, Kabini, Bhavani, Lakshmanthirtha, Noyyal, and Arkavati.

Water quality samples collected from 41 water quality stations are being considered for the study.

4. ***East Flowing Rivers between Pennar and Cauvery Basin and East Flowing Rivers South of Cauvery Basin:***

The East Flowing Rivers (South of river Krishna excluding Cauvery and Pennar Basins) cover large areas in the states of Andhra Pradesh, Tamil Nadu and some parts of Karnataka and Union territory of Puducherry.

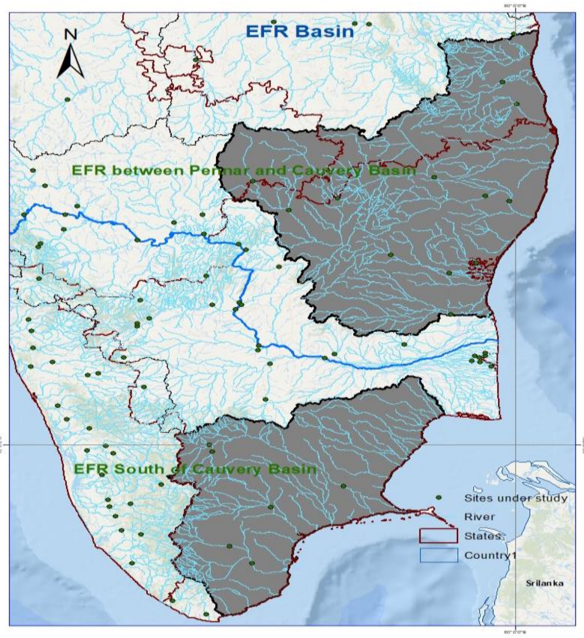

Figure 11: EFR Basin

The basin of East flowing rivers consists of a number of independent river basins of peninsular India lying to the South of Krishna basin, except Cauvery basin. The East flowing rivers are draining into the Bay of Bengal. There are eleven river basins of which Palar and Ponnaiyar are more important. Other river basins are Gundlakamma, Paleru, Swarnamukhi, Kalingi, Varahanadi, Vellar, Vaigai, Vaippar and Tambraparani.

Water quality samples collected from 18 water quality stations are being considered for the study.

5. ***Ganga Basin***

The Ganga River originates from the southern great Himalayas in Uttarakhand on the Indian side of the border with Tibet. It is formed by five headstreams, namely Bhagirathi, Alaknanda, Mandkini, Dhauliganga and Pindar. Of those, the two major headstreams are the Alaknanda and the Bhagirathi, which receives both monsoon as well as glacial melt water from the Himalayan glaciers known as Gangotri. The major tributaries of Ganga are also originating from the Himalaya excluding Sone and Damodar rivers originating from the Amarkantak hills of Maikal range and Khamarpat hill on Chotanagpur Plateau, respectively.

Alakananda and Bhagirathi Rivers join at Devprayag in Uttarakhand to form the river Ganga which acts as a single stream. At Prayagraj river Ganga receives its biggest tributary, the river Yamuna from right. The delta of the river Ganga can be said to start from Farakka in West Bengal. From the origin after traversing about 2500 km it empties into the Bay of Bengal at Ganga Sagar Island The mainstream of river Ganga falls in the States of Uttrakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. Rishikesh, Haridwar and Varanasi are important cities in the banks of the river Ganga. The main tributaries are Yamuna, Gomti, Ghaghra, Son, Gandak, Ramganga, Kosi etc.

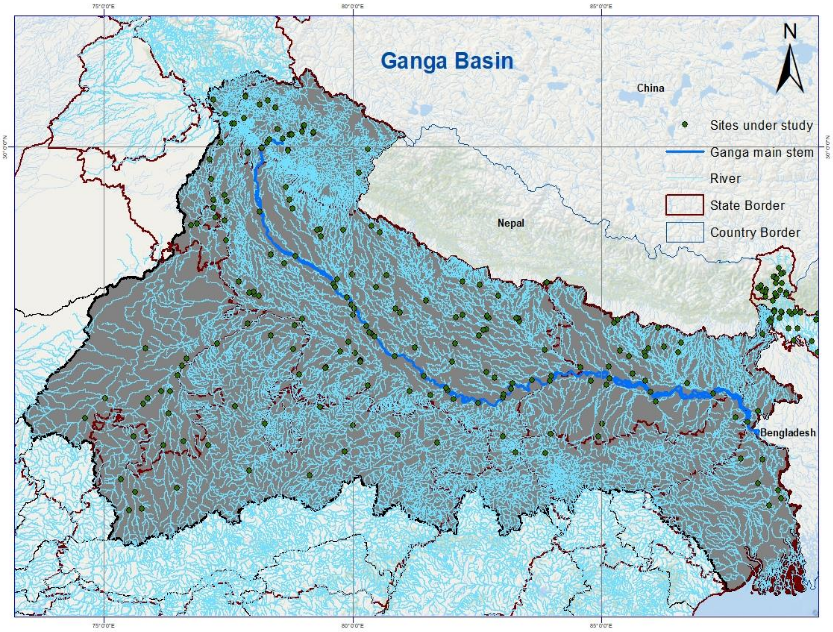

Figure 12: Ganga Basin

Water quality samples collected from 205 water quality stations are being considered for the study.

6. ***Indus(upto Indo-Pak Border) Basin***

The Indian part of Indus basin spreads over the states of Jammu & Kashmir, Ladakh, Himachal Pradesh, Punjab and a part of Rajasthan, Haryana, and Union Territory of Chandigarh. Upper part of the basin consists of mountain ranges and narrow valleys lying in Jammu and Kashmir, Ladakh and Himachal Pradesh. In Punjab, Haryana and Rajasthan the basin consists of vast plains, which are the fertile granary of the country. It was the cradle of the great Indus Valley civilization of ancient world. The Indian part of the basin consists of five major tributaries: Sutlej, Ravi, Beas, Chenab, and Jhelum which are ultimately merging with river Indus in Pakistan.

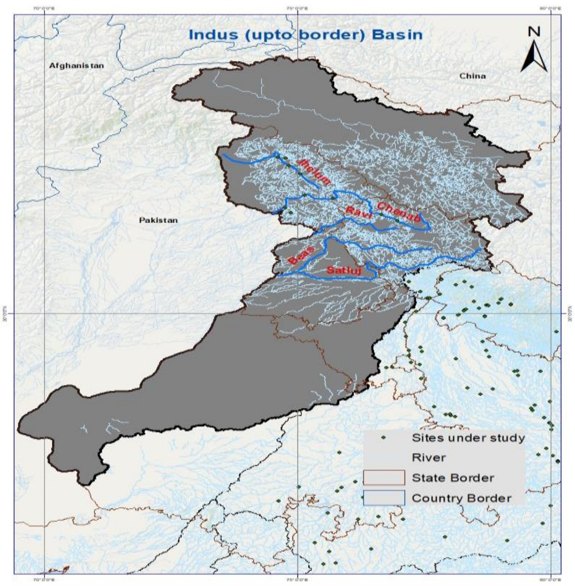

Figure 13: Indus Basin

Water quality samples collected from 10 water quality stations are being considered for the study.

7. ***Pennar Basin***

The Pennar River is one of the major East flowing rivers in Southern India. It rises in the Chennakesava hill of the Nandidurg range in Karnataka. The Pennar drains an area of 55,213 Sqs.Kms in the states of Karnataka and Andhra Pradesh. The total length of Pennar River is 597 Km of which 61 Km runs in Karnataka and the rest in Andhra Pradesh. This river has six major tributaries viz., the Jayamangali, the Kunderu and the Sagileru joining from the left, the Chitravathi, the Papagni and the Cheyyeru joining on the right.

Water quality samples collected from 8 water quality stations are being considered for the study.

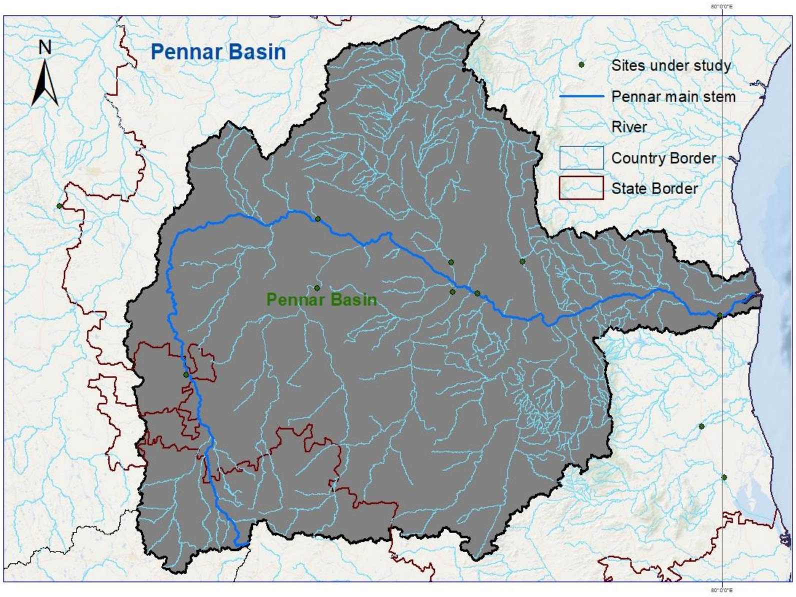

Figure 14: Pennar Basin

8. ***West Flowing Rivers South of Tapi Basin***

The West Flowing Rivers Basin consists of all the small independent river basins of peninsular India lying to the South of Krishna Basin (except Cauvery Basin) draining into the Arabian Sea. The basin is located in the South West corner of the peninsular India and covers the areas in the States of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. There are as many as 31 numbers of medium and minor river basins in this region viz., Ulhas, Bhogeshwari, Amba, Kal, Kajavi, Gad, Mandovi/Madei, Aghanashini, Haladi, Sita, Swarna, Gurupur, Netravathi, Payaswani, Valatapatnam, Kuttyadi, Chaliyar, Kadalundi, Bharathapuzha, Chalakudi, Periyar, Muvattupuzha, Meenachil, Pamba, Achankovil, Manimala, Kallada, Vamanapuram, Tambraparani and Pazhayar. All the rivers originate from the high mountains of the Western Ghats and exhibit similar characteristics. They have steep high banks which rarely overflow or cause floods.

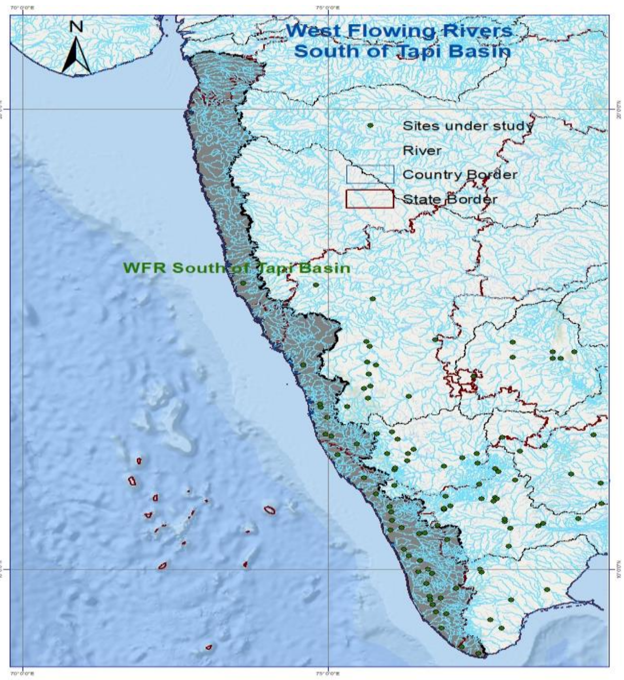

Figure 15: WFR South of Tapi Basin

Water quality samples collected from 36 water quality stations are being considered for the study.

9. Krishna Basin

The river Krishna is the second largest eastward draining interstate river in Peninsular India. The basin of Krishna is situated between East longitudes 73° 21′ to 81° 09′ and North latitudes 13° 07′ to 19° 25′ in the Deccan Plateau covering large areas in the States of Maharashtra, Karnataka, Telangana and Andhra Pradesh. The river Krishna rises in the Western Ghats at an altitude of 1337m just North of Mahabaleswar, about 64 km from the Arabian Sea and flows from West to East through the States of Maharashtra, Karnataka, Telangana and Andhra Pradesh before it joins the Bay of Bengal at down-stream of Vijayawada.

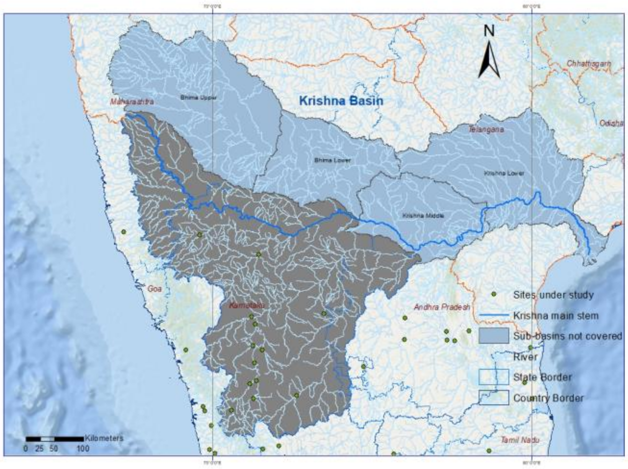

Figure 16: Krishna Basin

There are about 13 major tributaries which join the river Krishna along its 1400 km course, out of which, six tributaries are on right bank and remaining seven are on left bank. Among the major tributaries, the Ghataprabha, Malaprabha and Tunga- Bhadra are the principal right bank tributaries which together contribute 35.45% of the total catchment area, whereas the Bhima, Musi and Munneru are the principal left bank tributaries which together contribute 35.62% of the total catchment area.

The Krishna Basin is bounded on the North by the ridge, separating it from the Godavari basin and on the South and East by the Eastern Ghats and on the West by the Western Ghats. The basin is more or less triangular in shape with its base along the Western Ghats, the apex at Vijayawada and the river Krishna itself forming the median. All the major tributaries are originating in the Western Ghats and joining river Krishna at the base of the triangle in the upper two-thirds of its length.

Water quality samples collected from 13 water quality stations are being considered for the study. Theses stations belong to Krishna Upper and Thungabhadra sub-basins.

6. METHODOLOGY

Living organisms require trace amounts of certain metals, including cobalt, copper, iron, manganese, molybdenum, vanadium, strontium, and zinc, for their proper functioning. However, excessive levels of these essential metals can be harmful to organisms. On the other hand, non-essential metals like cadmium, chromium, mercury, lead, arsenic, and antimony pose more significant concerns for surface water systems, as these metals can have adverse effects on human and animal life. Once these non-essential metals enter a system, they tend to persist for longer periods. Inorganic metals, once absorbed, have the potential to interact with various binding stations within the human body and possess a strong affinity for biological tissues. While natural water contains trace amounts of toxic metals, the issue of metal pollution has been exacerbated by industrial waste containing these metals. Major contributors to metal pollution in surface water include industries such as electroplating, metallurgy, galvanizing plants, tanneries, and thermal power stations. Metals can exist in various forms in surface water, including colloidal, particulate, and dissolved forms, with dissolved concentrations typically being low. The soluble forms are generally in the form of ions, unionized compounds, organo-metallic chelates, or complexes. The solubility of trace metals in surface water is primarily influenced by factors such as pH, the type and concentration of ligands to which the metal can bind, and the oxidation state of mineral components.

6.1 Metal Detection Techniques

Various analytical methods are commonly used to estimate heavy metals in water and wastewater. These methods include:

- **Inductively Coupled Plasma Analyser (ICP):** ICP techniques are widely used and applicable over a broad linear range. They are especially sensitive when analyzing refractory elements. However, the detection limits for ICP methods are generally higher than those for Atomic Absorption Spectrophotometry (AAS).
- **Atomic Absorption Spectrophotometry (AAS):** AAS is another widely used technique for detecting heavy metals. It is known for its sensitivity and is particularly useful for measuring specific elements.
- **Colorimetric Methods:** Colorimetric methods are applied when potential interferences are known to be within the limits of the particular method. These methods rely on color changes to indicate the presence and concentration of specific heavy metals.
- **Polarographic Estimation:** Polarography is an electroanalytical method that can be used to detect heavy metals in solution based on their electrochemical behavior.
- **Ion-Selective Electrodes (ISE):** Ion-selective electrodes are used to measure the concentration of specific ions, including heavy metal ions, in a solution. These electrodes are selective for particular ions and can provide precise measurements.

6.2 Chemicals and Reagents

Chemicals and reagents used during the chemical analyses were of analytical reagent grade. Standard solutions are prepared using certified reference materials. De-ionized water was consistently utilized in the study. To ensure the accuracy of the experiments, all glassware and containers were meticulously cleaned. This cleaning process involved soaking them in detergent, followed by immersion in 10% nitric acid for 48 hours. Subsequently, the glassware was thoroughly rinsed with de-ionized water multiple times before use.

6.3 Method

In the current study, water samples were collected and stored in polyethylene containers. These water samples were then meticulously prepared for the quantification of various heavy metals: arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, and zinc. At most of the stations, 3 samples were collected at an interval of 10 days in a month. A total of 3815 samples were collected during January, 2021 to December, 2021 from 10 river basins of India. 9 trace & toxic metals namely: arsenic, cadmium, copper, chromium, iron, lead, mercury, nickel and zinc were analysed during this period. The collected samples are transported to Level-II/III laboratories and after sample preparation/preservation, sent to Level-III laboratories of CWC. These samples were analyzed at Level-III laboratory of CWC: National River Water Quality Laboratory, Upper Yamuna Division, New Delhi using AAS/ICP-MS and APHA method.

Figure 17*: *AAS

Figure 18: ICP-MS

7. RESULTS AND DISCUSSION

CWC is involved in the analysis of 9 trace & toxic metals namely: arsenic, cadmium, copper, chromium, Iron, lead, mercury, nickel and zinc. The analysis results are compared with the prescribed limits of BIS: 10500-2012. The analysis results of 488 water quality monitoring stations spread over 10 river basins of CWC were considered for the study. All metals are found to be within the acceptable limits at 364 out of 488 monitored stations while at 124 stations under study, at least one metal was found to be beyond the limit.

The overall summary of the results is as under:

Table 11: Overall summary

Sl. No.	Trace & Toxic Metal	Acceptable limit as per BIS:10500, 2012 (in µg/L)	Total No. of samples analysed	No. of samples where metal found within acceptable limit	No. of samples where metal found above acceptable limit	% of samples where metal found above acceptable limit
1	Arsenic (As)	10	3815	3796	19	0.50
2	Cadmium (Cd)	3	3815	3803	12	0.31
3	Chromium (Cr)	50	3814	3807	7	0.18
4	Copper (Cu)	50	3815	3812	3	0.08
5	Iron (Fe)	1000	3815	3677	138	3.62
6	Lead (Pb)	10	3811	3781	30	0.79
7	Mercury (Hg)	1	1598	1581	17	1.06
8	Nickel (Ni)	20	3815	3798	17	0.45
9	Zinc (Zn)	5000	3815	3815	0	0.00

The details and overall status of stations under study is given at Annexure-I.
The parameter-wise discussion of the analysis results is given in the ensuing paragraphs.

7.1 Arsenic (As)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 10 µg/L of arsenic in drinking water. Out of 3815 river water samples, 19 samples from 13 water quality stations across 9 rivers were found to have arsenic concentrations beyond the acceptable limit. The arsenic concentration varies from 0.000 to 24.251 µg/L. Maximum arsenic concentration (24.251 µg/L) was observed at Banpur water quality monitoring station on Mathabhanga River (a tributary of Padma) on 16.12.2021.

The details of stations where arsenic concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates are depicted in the table given below.

Table 12: River-wise list of WQ stations with Arsenic values above limit

Sl. No.	River/tributary	Station	Date	As(µg/L)	State	District
1	Bhagirathi/Churni	Hanskhali	16-12-2021	17.626	West Bengal	Nadia
2	Bhagirathi/Jalangi	Chapra	16-12-2021	14.933	West Bengal	Nadia
3	Ganga	Garhmukteshwar	11-11-2021	10.014	Uttar Pradesh	Hapur
	Ganga	Garhmukteshwar	11-12-2021	11.125	Uttar Pradesh	Hapur
	Ganga	Kachlabridge	11-11-2021	10.110	Uttar Pradesh	Badaun
	Ganga	Hathikhana	11-11-2021	10.110	Uttar Pradesh	Fatehgarh
	Ganga	Kannauj	11-11-2021	11.260	Uttar Pradesh	Kannauj
	Ganga	Kannauj	21-11-2021	10.083	Uttar Pradesh	Kannauj
	Ganga	Kannauj	01-12-2021	10.779	Uttar Pradesh	Kannauj
	Ganga	Mehandipur	11-11-2021	11.417	Uttar Pradesh	Kannauj
	Ganga	Mehandipur	21-11-2021	10.586	Uttar Pradesh	Kannauj
	Ganga	Mehandipur	01-12-2021	10.156	Uttar Pradesh	Kannauj
4	Ganga/Tons	Meja Road	01-12-2021	12.004	Uttar Pradesh	Allahabad
5	Ghaghra/Rapti	Kabirganj	21-11-2021	10.303	Uttar Pradesh	Pilibhit
6	Kali	Kasganj	01-11-2021	10.028	Uttar Pradesh	Etah
	Kali	Kasganj	11-11-2021	11.328	Uttar Pradesh	Etah
7	Padma/Mathabhanga	Banpur	16-12-2021	24.251	West Bengal	Nadia
8	Ramganga /Bahgul	Dhaneta	01-04-2021	10.080	Uttar Pradesh	Bareilly
9	Yamuna	Gokul Barrage D/S of Mathura	13-12-2021	10.896	Uttar Pradesh	Mathura

All the water quality stations fall in the Ganga Basin of four organization of CWC: LGBO, Patna, T&BDBO, Kolkata, UGBO, Lucknow, and YBO, New Delhi. Figure 19 represents GIS map of WQ stations where Arsenic is found above acceptable limit.

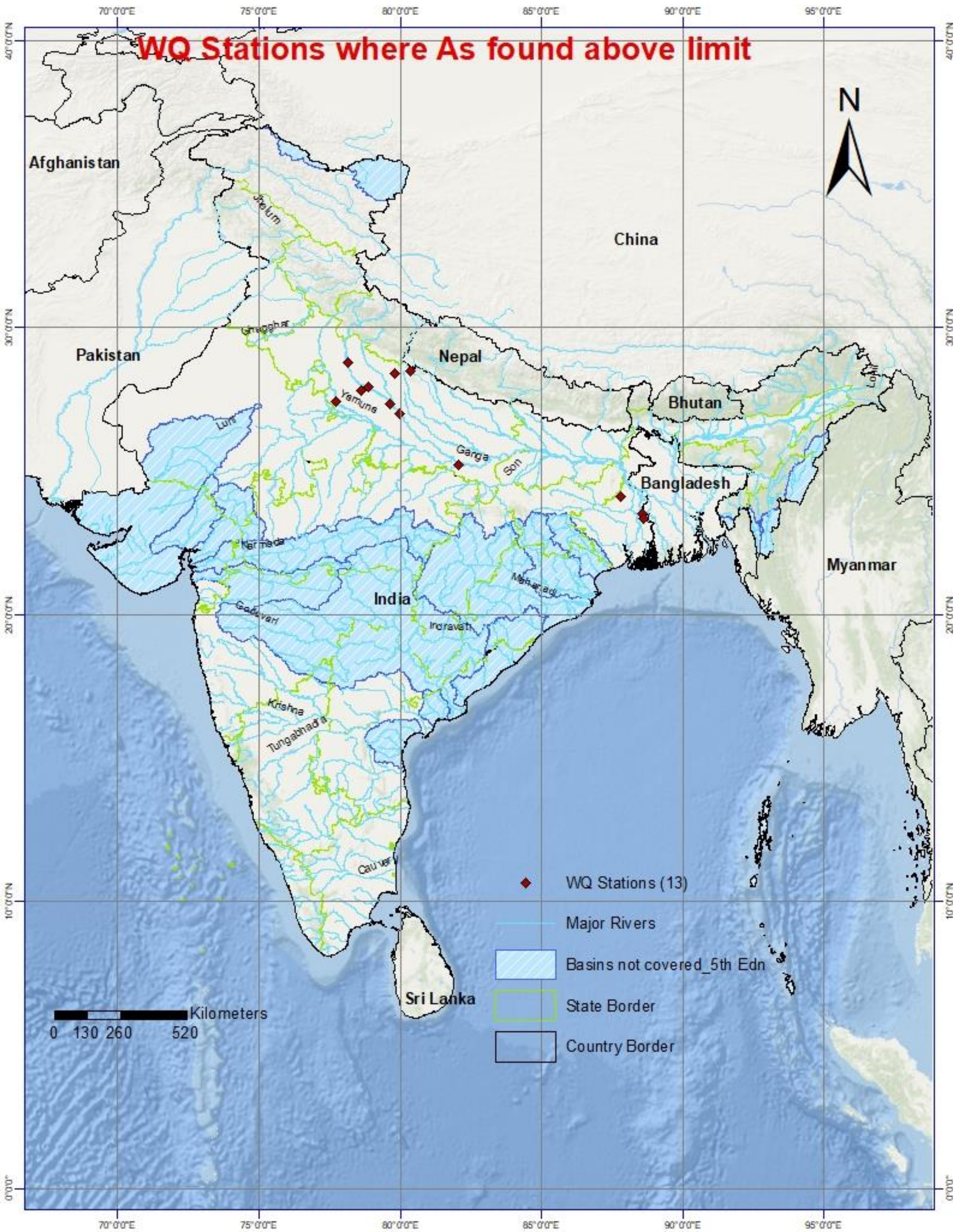

Figure 19: WQ stations where Arsenic found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

A comparison has been made between the current edition of the report and the 4th edition, which covers the period August 2018-December 2020. In the 4th edition, a total of 2834 water samples were examined and 8 samples were found to exceed the limit. The overall percentage of samples above the acceptable limit was 0.28%. The highest arsenic concentration was 13.33 µg/L, recorded at Porakudi water quality monitoring station in Arasalar River, a tributary of the Cauvery River, in December 2019. Individual station-wise analysis revealed that arsenic concentrations exceeded the acceptable limit during December, 2019 at 8 locations, specifically Bhadrachalam (Godavari), Changsari (Brahmaputra), Faizabad U/S (Ghaghra), Madamon (Pamba), Mirzapur (Ganga), Mohgaoan (Burhner), Moradabad (Ramganga), and Porakudi (Arasalar). However, it is noteworthy that for the remaining monitoring periods, the arsenic concentrations at these stations were within acceptable limits. The assessment of arsenic concentration in rivers during the study period revealed that eight rivers: Godavari, Brahmaputra, Ghaghra, Pamba, Ganga, Burhner, Ramganga and Arasalar, exhibited concentrations surpassing the acceptable limits.

During 2021, out of the 3815 samples collected and analyzed, only 19 samples, which accounts for 0.50 % of total samples; were found to be beyond the acceptable limit for arsenic concentration.

Theses samples belong to 13 water quality stations across 9 rivers, encompassing Bhagirathi/Churni, Bhagirathi/Jalangi, Ganga, Ganga/Tons, Ghaghra/Rapti, Kali, Padma/Mathabhanga, Ramganga /Bahgul and Yamuna. Notably, this extended and comprehensive monitoring revealed the widespread presence of arsenic in diverse river systems. Maximum arsenic concentration (24.251 µg/L) was observed at Banpur water quality monitoring station on Mathabhanga River (a tributary of Padma) on 16.12.2021.

A GIS map depicting the stations where arsenic values were found above the acceptable limit during both study periods is shown as Figure 20. This helps to provide a distinct understanding of the extent and distribution of the arsenic presence beyond limit.In the common study area of both study periods, there are no common stations found to have arsenic exceedance during both study periods.

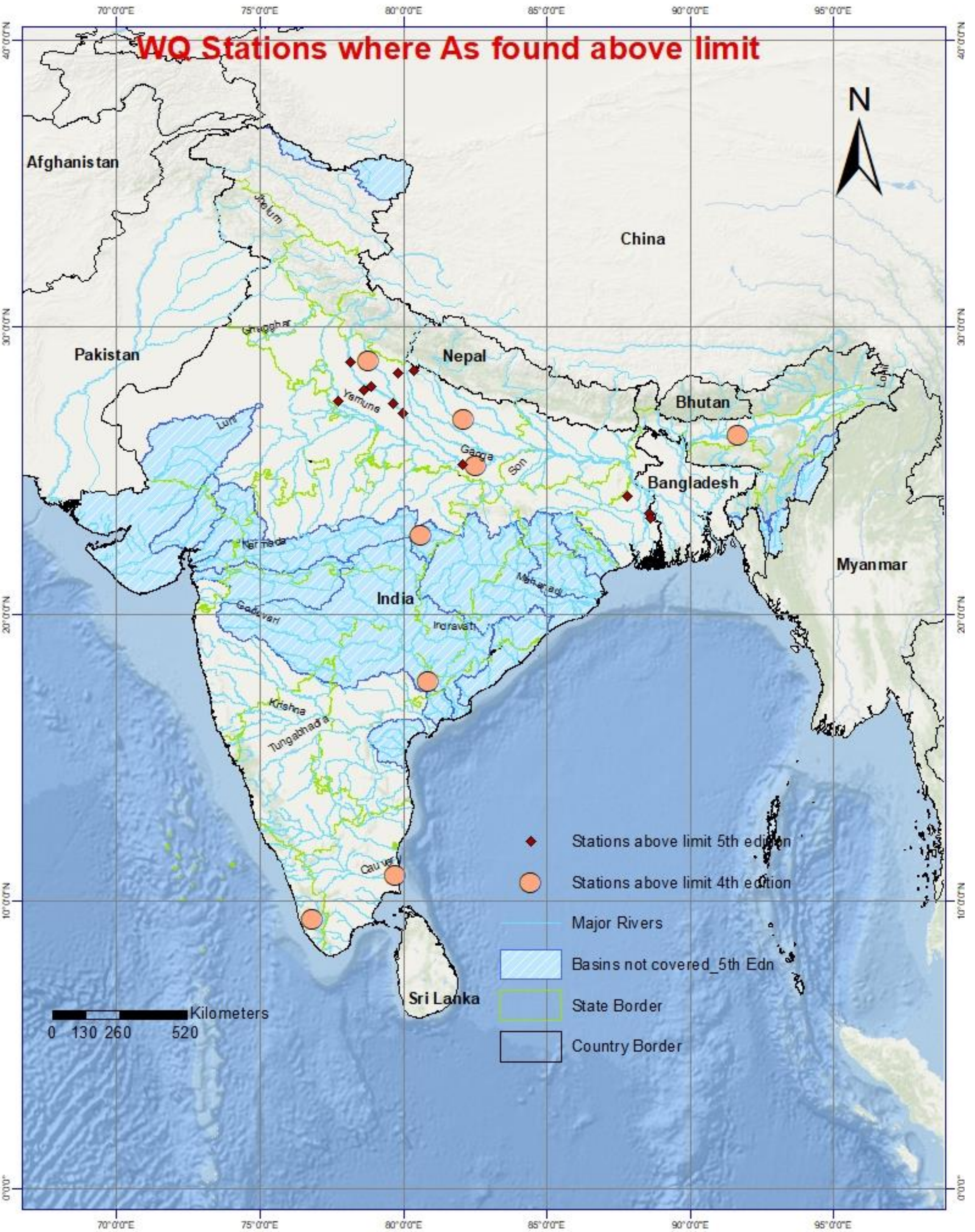

Figure 20: WQ stations where Arsenic found above acceptable limit (both study periods)

7.2 Cadmium (Cd)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 3 μg/L of cadmium in drinking water. Out of total 3815 river water samples analysed, 12 samples from 7 water quality stations across 5 rivers were found to have cadmium concentrations beyond the acceptable limit. The cadmium concentration varies from 0.000 to 12.651 μg/L. Maximum cadmium concentration (12.651 μg/L) was observed at Delhi Railway Bridge water quality monitoring station on Yamuna River on 12.04.2021.

The details of stations where cadmium concentrations (in μg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 13: River-wise list of WQ stations with Cd values above limit

Sl. No.	River/tributary	Station	Date	Cd (μg/L)	State	District
1	Gomti	Lucknow	11-11-2021	5.396	Uttar Pradesh	Lucknow
	Gomti	Lucknow	21-12-2021	3.8	Uttar Pradesh	Lucknow
2	Kamla Balan	Kakarghatti	01-12-2021	4.968	Bihar	Darbhanga
3	Ponnaiyar	Singasadanapalli	22-07-2021	3.054	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	02-08-2021	3.333	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-08-2021	5.495	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-08-2021	6.062	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-09-2021	5.872	Tamil Nadu	Krishnagiri
4	Yamuna	Baghpat	21-05-2021	12.226	Uttar Pradesh	Baghpat
	Yamuna	Delhi Railway Bridge	12-04-2021	12.651	Delhi	North Delhi
5	Yamuna/Chambal	Pali	20-05-2021	3.122	Rajasthan	Sawai-madhopur
	Yamuna/Chambal	Manderial	11-02-2021	12.380	Rajasthan	Karauli

The stations with above-limit cadmium values belong to 5 states: Bihar, Delhi, Rajasthan, Tamil Nadu, and Uttar Pradesh of Ganga and East Flowing Rivers between Pennar and Kanyakumari basins.

Figure 21 represents GIS map of WQ stations where Cadmium found above acceptable limit.

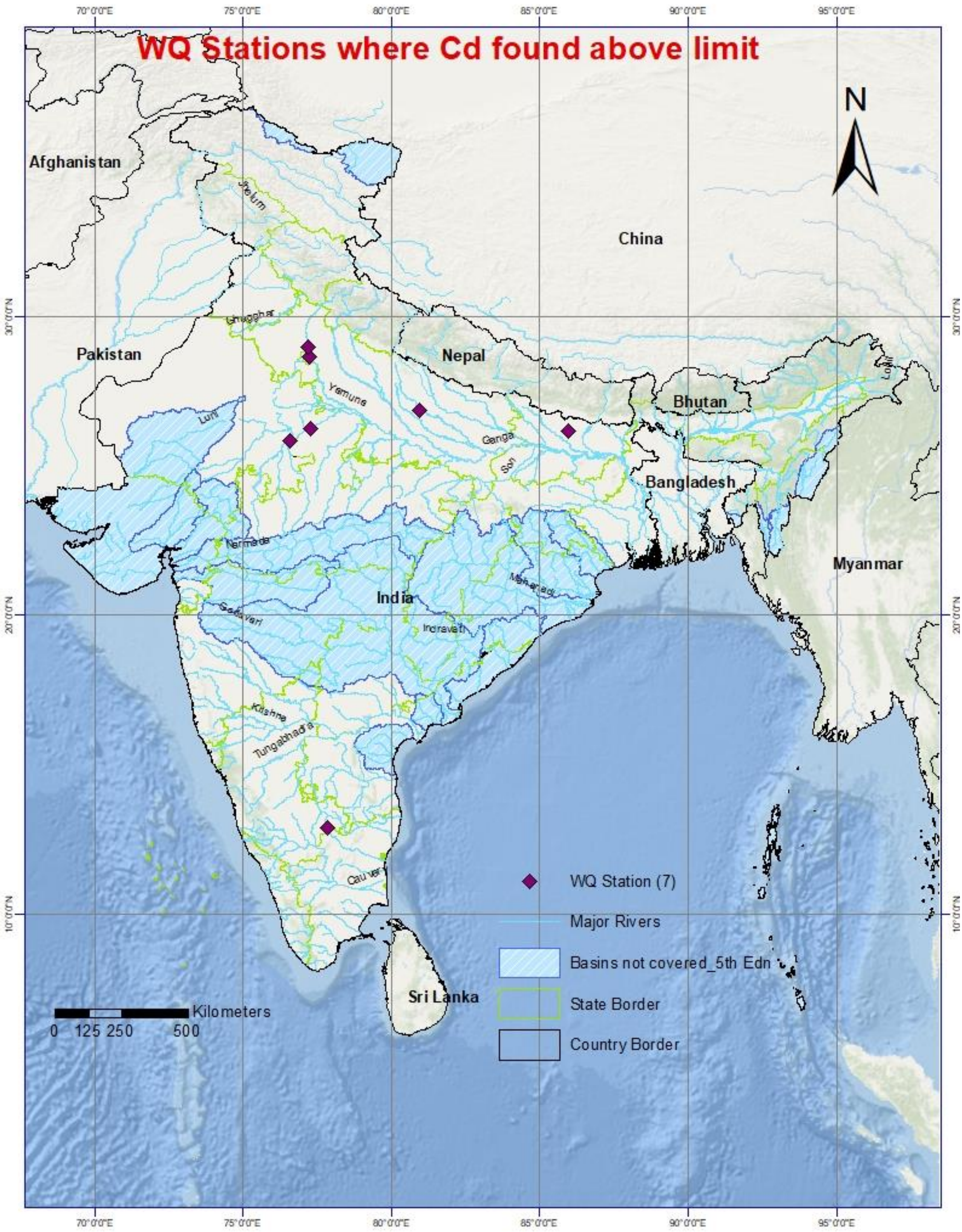

Figure 21: WQ stations where Cadmium found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

The data of cadmium found above limit in this report has been compared with the last edition of the report i.e., 4th edition, for the period August 2018-December 2020. 3113 samples were analyzed during the last study period and 11 samples were found above limit (0.35%). The cadmium content in different rivers varied from 0.00 to 12.57 µg/L during this period. The highest cadmium concentration was observed at Todarpur station in the Sukheta River in December 2020. It was found that cadmium concentrations exceeded acceptable limits at 11 stations across 11 rivers. These 11 rivers include Godavari, Bhima, Noyyal, Narmada, Indravati, Munneru, Yamuna, Moyar, Sukheta, Tons, and Damanganga. Values above acceptable limit was observed at stations: Vapi (Damanganga) in August, 2018, Bhadrachalam (Godavari), Deongaon Bridge (Bhima), Hoshangabad (Narmada), Jagdalpur (Indravati), Keesara (Munneru) in August 2019, and Elunuthimangalam (Noyyal), Kuthnuor (Yamuna), Thengumarahada (Moyar), Todarpur (Sukheta), and Tuini (Tons) in December 2020. However, it is noteworthy that for the remaining monitoring periods, the cadmium concentrations at these stations were within acceptable limits.

During the current study period of 2021, out of 3815 samples analyzed, only 12 were found to be beyond the acceptable limit (0.31 %). These samples are collected from 7 water quality stations across 5 rivers, encompassing Chambal, Gomti, Kamla Balan, Ponnaiyar and Yamuna. Maximum cadmium concentration (12.651 µg/L) was observed at Delhi Railway Bridge water quality monitoring station on Yamuna River on 12.04.2021.

A GIS map showing stations with cadmium values above limit in the last and current reports is given as Figure 22. From the figure it is clear that, there are no common water quality stations where cadmium concentrations exceeded acceptable limits in both periods. However, the river Yamuna is found to be the common river which experienced cadmium exceedance during both periods.

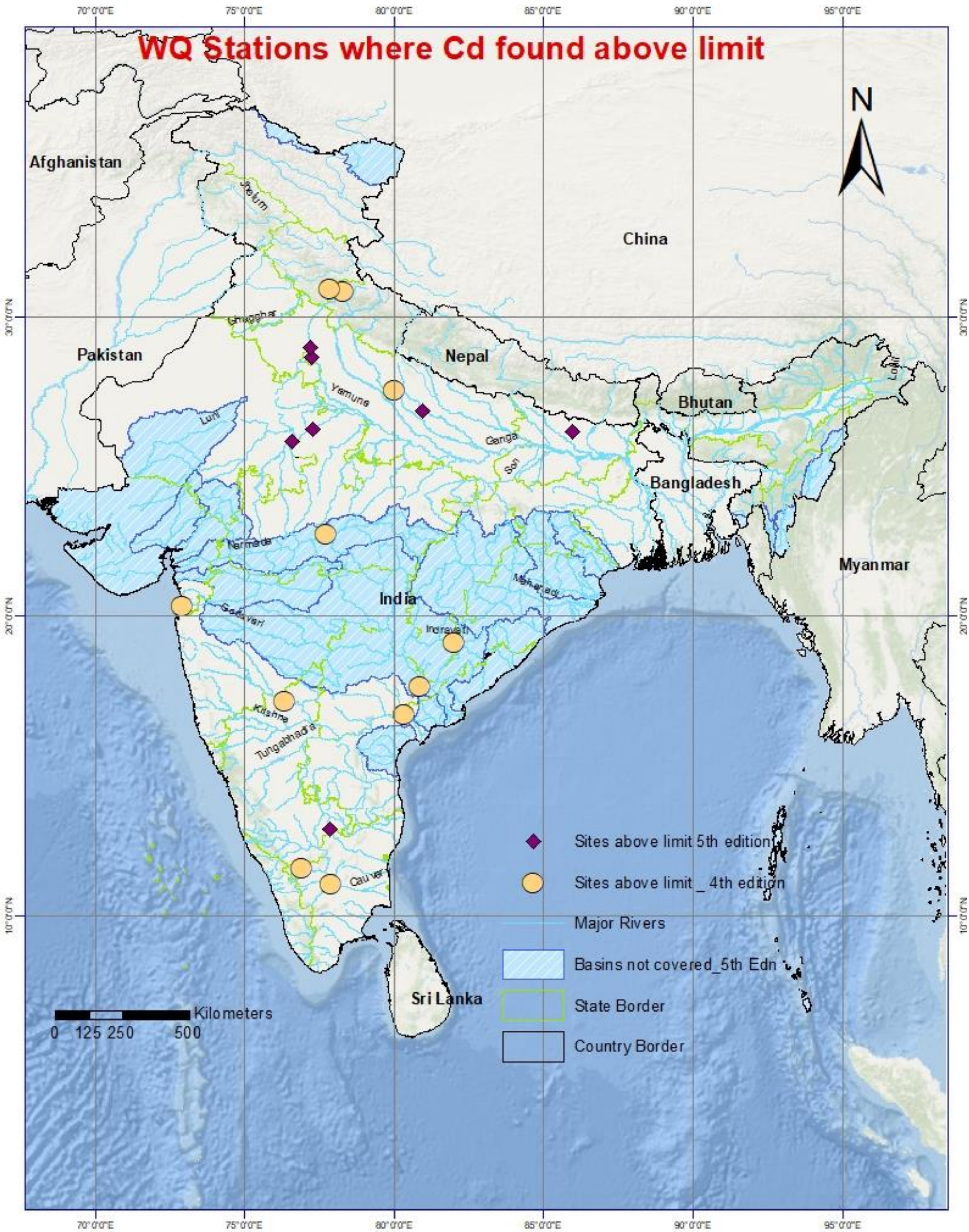

Figure 22: WQ stations where Cadmium found above acceptable limit (both study period)

7.3 Chromium (Cr)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 50 µg/L of chromium in drinking water. Out of total 3814 river water samples analysed, 7 samples from 7 water quality stations across 6 rivers were found to have chromium concentrations beyond the acceptable limit. The chromium concentration varies from 0.000 to 86.563 µg/L. Maximum chromium concentration (86.563 µg/L) was observed at Ayodhya water quality monitoring station on Ghaghra River on 11.12.2021.

Chromium (Cr) is a heavy metal that can have detrimental effects on aquatic ecosystems and human health when present in elevated concentrations.

The details of stations where chromium concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 14: River-wise list of WQ stations with Cr values above limit

Sl. No.	River/tributary	Station	Date	Cr (µg/L)	State	District
1	Ganga	Garhmukteshwar	21-09-2021	58.640	Uttar Pradesh	Hapur
	Ganga	Azmabad	01-04-2021	53.480	Bihar	Bhagalpur
2	Ghaghra	Ayodhya	11-12-2021	86.563	Uttar Pradesh	Faizabad
3	Kosi/Bagmati	Hayaghat	01-04-2021	62.010	Bihar	Darbhanga
4	Ramganga	Dabri	13-09-2021	53.700	Uttar Pradesh	Shahjahanpur
5	Rapti	Birdghat	21-09-2021	52.900	Uttar Pradesh	Gorakhpur
6	Yamuna/Ken	Banda	01-11-2021	54.970	Uttar Pradesh	Banda

The samples which exceed the limit belong to stations distributed among 2 states (Uttar Pradesh and Bihar) of India in Ganga Basin. Figure 23 represents WQ stations where Chromium is found above acceptable limit.

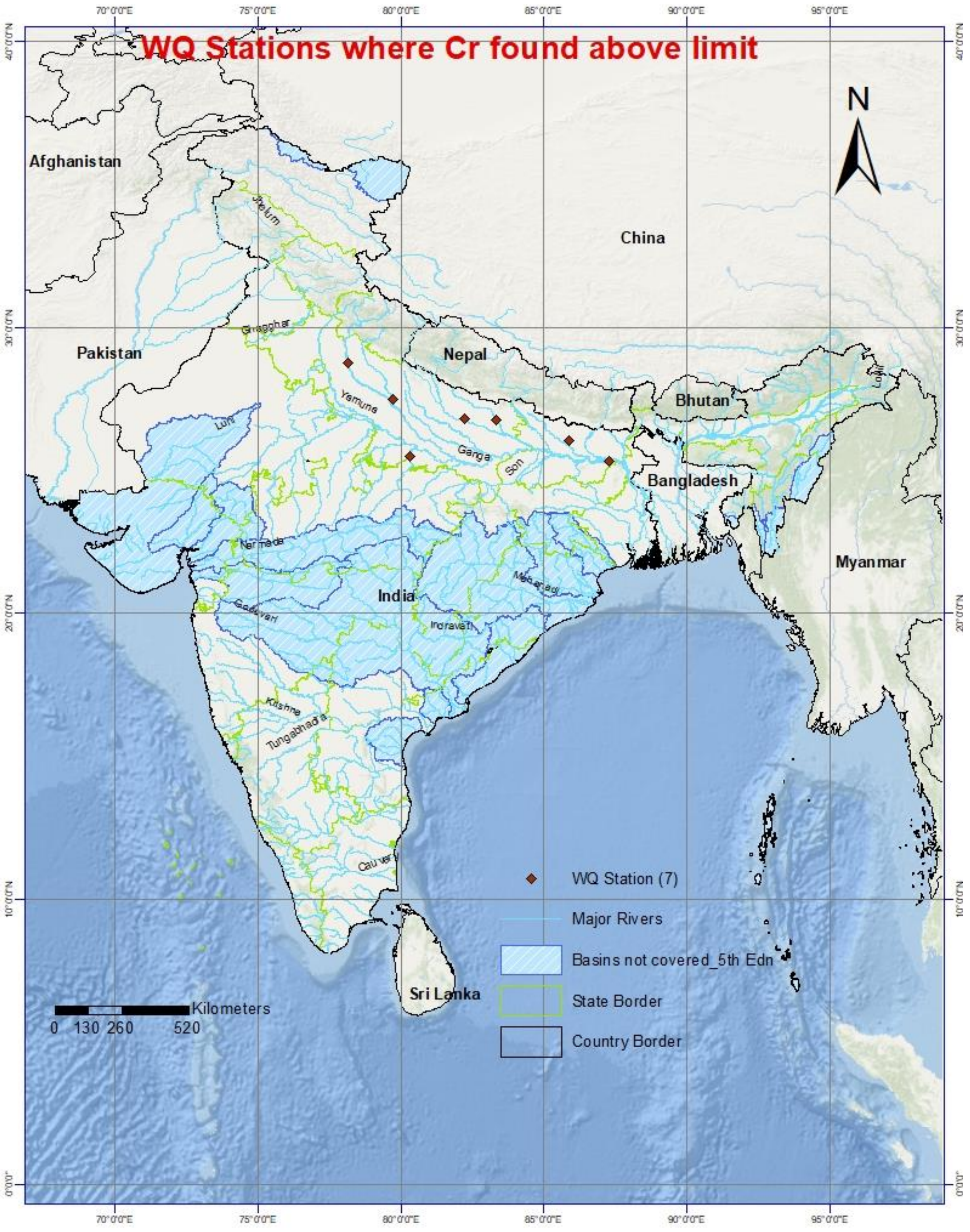

Figure 23: WQ stations where Chromium found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

The chromium concentration varied from 0.00 to 180.47 µg/L during the period from August 2018 to December 2020. The maximum chromium concentration was observed at the M.B.P.L. water quality monitoring station on the Hasdeo River in December 2019. Chromium concentrations exceeded acceptable limits at 46 stations which belong to 34 rivers: Yamuna, Kunderu, Vaigai, Chulband, Wainganga, Yamuna, Wardha, Ramganga, Mahanadi, Dhansiri (South), Hasdeo, Sone, Ghaghra, Phalgu, Dhaleswari, Torsa, Tungabhadra, Kagna, Lakshmanthirtha, Kadalundi, Teesta, Kharkai, Shetruni, Gomti, Godavari, Bharathapuzha, Brahmani, Sind, Kharun, Kinnerasani, Betwa, Digaru, Um Sohryngkew, and Iruvazhinjipuzha.

Total 3814 river water samples were analysed during 2021 and chromium concentrations above the acceptable limit of 50 µg/L were observed at 7 water quality monitoring stations across 6 rivers. This extended the widespread presence of chromium in diverse river systems: Ganga, Ghaghra, Kosi/Bagmati, Ramganga, Rapti and Yamuna/Ken. Maximum chromium concentration (86.563 µg/L) was observed at Ayodhya water quality monitoring station on Ghaghra River on 11.12.2021.

A map showing stations with chromium values above limit in the last and current reports is given as Figure 24. There is no common water quality station with chromium exceedance in both the reports.

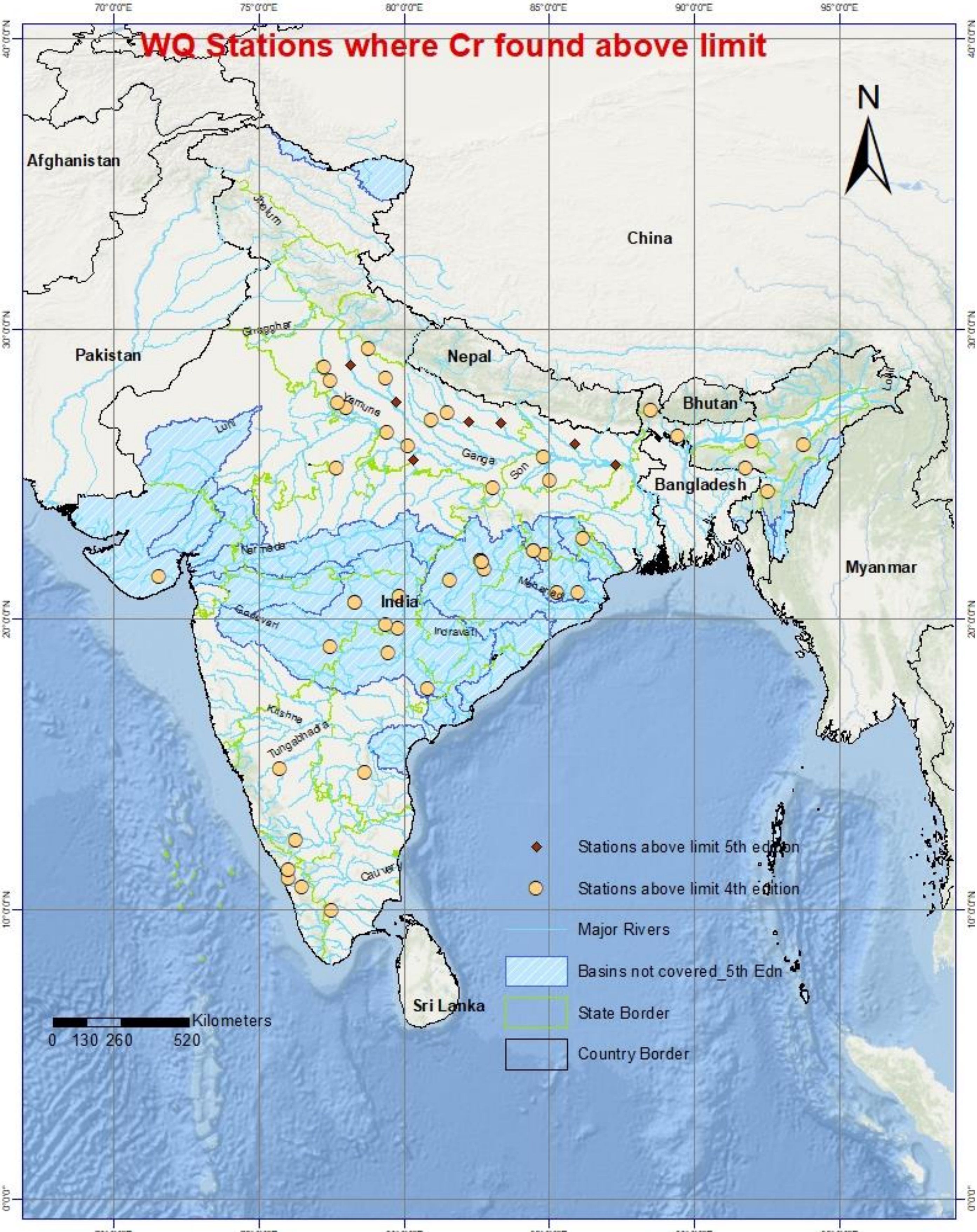

Figure 24: WQ stations where Chromium found above acceptable limit (both study periods)

7.4 Copper (Cu)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 50 µg/L of copper in drinking water. Out of total 3815 river water samples analysed, 3 samples from 3 water quality stations across 3 rivers were found to have copper concentrations beyond the acceptable limit. The copper concentration varies from 0.000 to 59.974 µg/L. Maximum copper concentration (59.974 µg/L) was observed at Kidangoor water quality monitoring station on Meenachil River on 01.11.2021.

The details of stations where copper concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 15: River-wise list of WQ stations with Cu values above limit

Sl. No.	River/tributary	Station	Date	Cu (µg/L)	State	District
1	Kallada	Nellipally	21-10-2021	53.324	Kerala	Kollam
2	Meenachil	Kidangoor	01-11-2021	59.974	Kerala	Kottayam
3	Ponnaiyar	Singasadanapalli	02-08-2021	50.234	Tamil Nadu	Krishnagiri

The samples whose values are beyond acceptable limit belong to two states: Kerala and Tamil Nadu of West Flowing Rivers from Tadri to Kanyakumari and East Flowing Rivers between Pennar and Kanyakumari basins. Figure 25 represents a GIS map of WQ stations where Copper is found above acceptable limit.

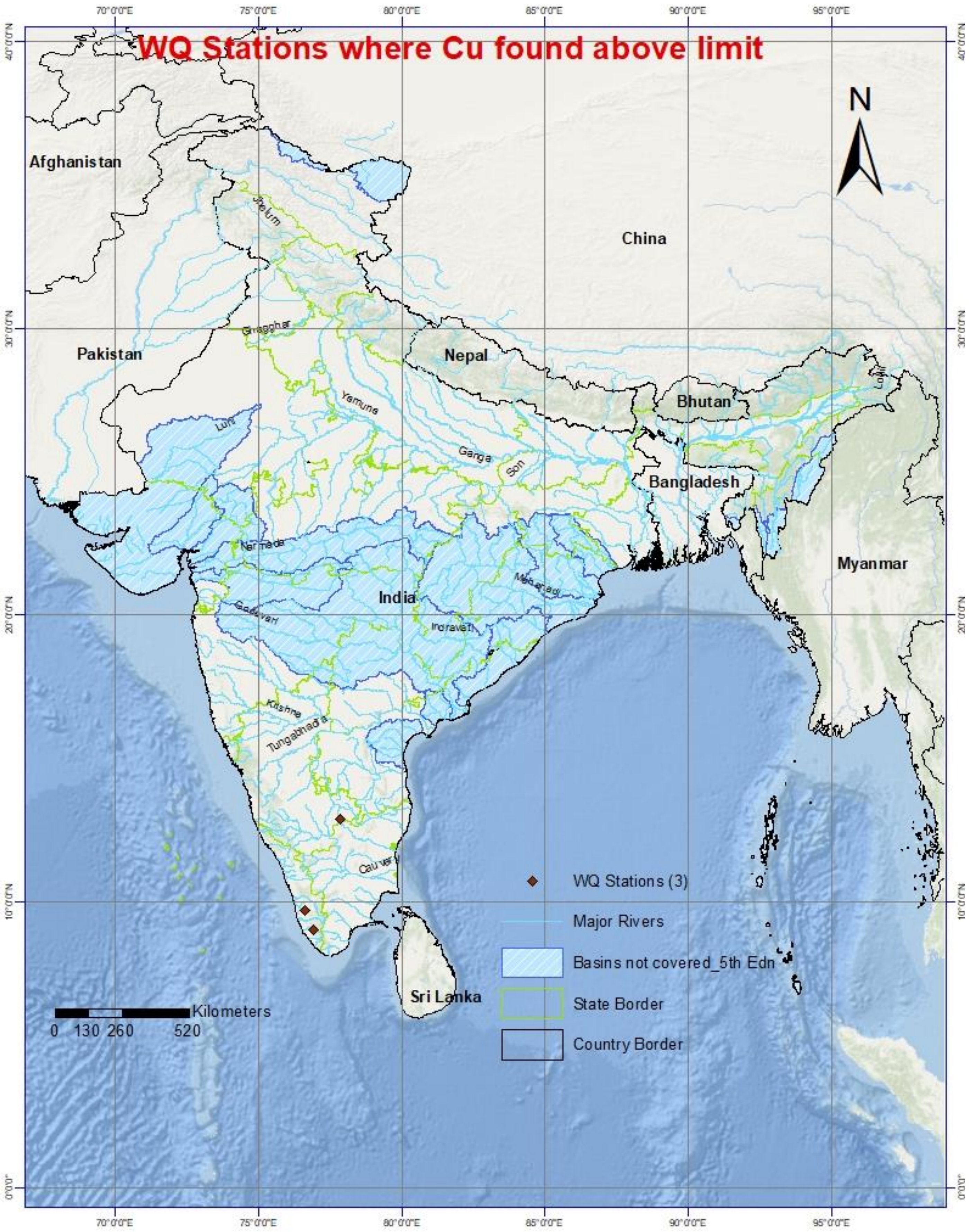

Figure 25: WQ stations where Copper found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

During the period from August 2018 to December 2020, a total of 3107 water samples were collected and analysed to assess the Copper content. 17 samples; i.e., 0.55 % of the total samples analysed were found to exceed the acceptable limit during August, 2018-December, 2020. The Copper concentration ranged from 0.00 to 132.64 µg/L. The highest Copper concentration (132.64 µg/L) was detected at Badlapur water quality monitoring station on the Ulhas River in December 2019. Notably, Copper concentrations exceeded acceptable limits at 17 stations across different rivers namely Ulhas, Rapti, Subarnarekha, Wagh, Ghaghra, Ganga, Tawi, Koel, Ramganga, Brahmani, Sai, Tons, Khannaut, Dikhow, Gandak, Periyar and Giri.

In the subsequent period of 2021, out of a total of 3815 river water samples analyzed, 3 samples exceed the limit. This comprises of only 0.08 % of total samples analysed during the study period. These samples were collected from 3 water quality stations across 3 rivers: Kallada, Meenachil, Ponnaiyar. The copper concentration varies from 0.000 to 59.974 µg/L. Maximum copper concentration (59.974 µg/L) was observed at Kidangoor water quality monitoring station on Meenachil River on 01.11.2021.

Three (03) samples of Nellipally, Kidangoor and Singasadanapalli stations exhibited Cu concentrations above 50 µg/L. Figure 26 depicts the water quality stations with copper exceedance during both the study periods. This indicates that no station is common in between the previous study period and the 2021 period. Figure also indicates a decrease in both the number of stations and rivers exceeding the acceptable limits of copper during the current study period.

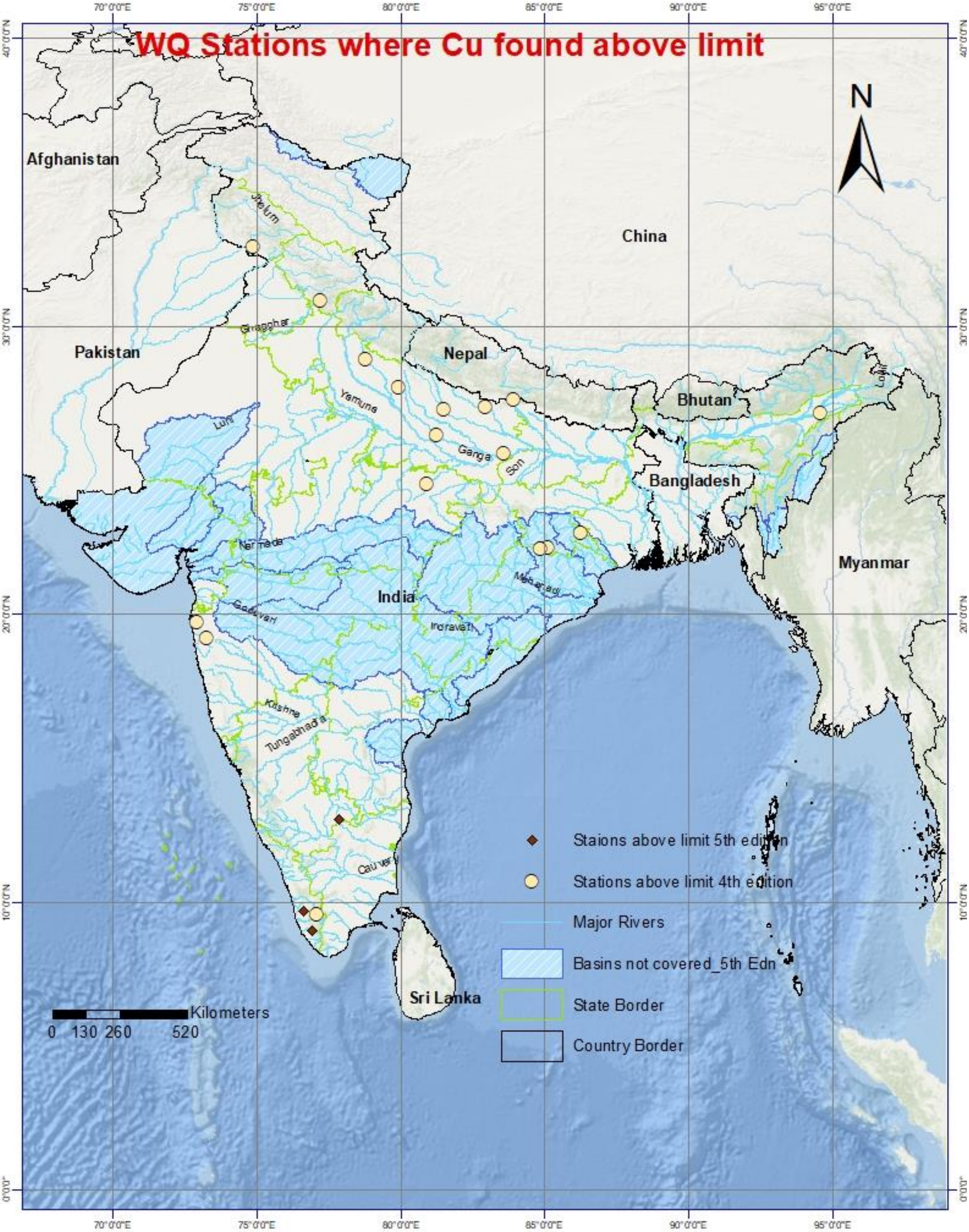

Figure 26: WQ stations where Copper found above acceptable limit (both study periods)

7.5 Iron (Fe)

BIS has recommended the acceptable limit of 1.0 mg/L (1000 µg/L) for Iron. Out of total 3815 river water samples analysed, 138 samples from 77 water quality stations across 55 rivers were found to have iron concentrations beyond the acceptable limit. The iron concentration varies from 0.000 to 25450.91 µg/L. Maximum iron concentration (25450.91 µg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 21.09.2021.

The details of stations where iron concentrations (in mg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 16: River-wise list of WQ stations with Fe values above limit

Sl. No.	River/tributary	Station	Date	Fe(mg/L)	State	District
1	Bhagirathi	Katwa	16-12-2021	1.736	West Bengal	Purba Bardhaman
	Bhagirathi	Berhampore	16-12-2021	1.081	West Bengal	Murshidabad
	Bhagirathi	Kalna (EBB)	16-12-2021	2.38	West Bengal	Purba Bardhaman
	Bhagirathi	Kalna (Flow)	16-12-2021	2.334	West Bengal	Purba Bardhaman
2	Bharathapuzha	Kumbidi	21-10-2021	1.569	Kerala	Palakkad
	Bharathapuzha	Mankara	11-11-2021	1.169	Kerala	Palakkad
3	Bharathapuzha/ Kannadipuzha	Pudur	11-11-2021	1.598	Kerala	Palakkad
4	Bharathapuzha/ Pulanthodu	Pulamanthole	21-10-2021	2.637	Kerala	Palakkad
5	Brahmaputra	Tezpur	01-08-2021	3.793	Assam	Sonitpur
	Brahmaputra	Bhomoraguri	01-08-2021	1.305	Assam	Sonitpur
	Brahmaputra	Neamatighat	01-08-2021	1.05	Assam	Jorhat
	Brahmaputra	Bogibeel	01-08-2021	3.949	Assam	Dibrugarh
	Brahmaputra	Pancharatna	01-12-2021	1.338	Assam	Goalpara
	Brahmaputra	Guwahati D.C Court	01-04-2021	1.324	Assam	Kamrup (Metro)
	Brahmaputra	Dibrugarh	01-08-2021	4.963	Assam	Dibrugarh
	Brahmaputra	Desangpani	01-08-2021	1.904	Assam	Sivasagar
6	Brahmaputra/ Buridehing	Naharkatia	01-08-2021	4.745	Assam	Dibrugarh
	Brahmaputra/ Buridehing	Margherita	01-08-2021	2.064	Assam	Tinsukia
	Brahmaputra/ Buridehing	Udaipur (Brahmaputra)	01-08-2021	1.062	Assam	Tinsukia
7	Brahmaputra/Dhansiri (South)	Numaligarh	01-08-2021	2.057	Assam	Golaghat
	Brahmaputra/Dhansiri (South)	Golaghat	01-08-2021	2.057	Assam	Golaghat
8	Brahmaputra/Dikhow	Bihubar	01-04-2021	1.76	Assam	Sivasagar
	Brahmaputra/Dikhow	Bihubar	01-08-2021	5.93	Assam	Sivasagar
9	Brahmaputra/Dikrong	Doimukh	01-08-2021	2.097	Arunachal Pradesh	Papumpare
10	Brahmaputra/Disang	Nanglamoraghat	01-08-2021	1.295	Assam	Sivasagar
11	Brahmaputra/ Jaldhaka/Diana	Diana	01-04-2021	1.056	West Bengal	Jalpaiguri
12	Brahmaputra/Jiabharali	Bhalukpong	29-10-2021	8.111	Arunachal Pradesh	West Kameng
	Brahmaputra/Jiabharali	Bhalukpong	30-10-2021	7.989	Arunachal Pradesh	West Kameng
	Brahmaputra/Jiabharali	Bhalukpong	31-10-2021	8.004	Arunachal Pradesh	West Kameng
	Brahmaputra/Jiabharali	Jiabharali NT Road -Xing	01-08-2021	3.52	Assam	Lakhimpur
	Brahmaputra/Jiabharali	Jiabharali NT Road -Xing	30-10-2021	1.085	Assam	Sonitpur
	Brahmaputra/Jiabharali	Jiabharali NT Road -Xing	31-10-2021	1.57	Assam	Sonitpur
13	Brahmaputra/Kameng	Seppa	05-11-2021	2.305	Arunachal Pradesh	East Kameng
	Brahmaputra/Kameng	Seppa	29-10-2021	1.936	Arunachal Pradesh	East Kameng

Sl. No.	River/tributary	Station	Date	Fe(mg/L)	State	District
14	Brahmaputra/ Kopili	Jagibhakatgaon	01-08-2021	1.91	Assam	Morigaon
	Brahmaputra/ Kopili	Kampur	01-08-2021	3.068	Assam	Nagaon
	Brahmaputra/ Kopili	Dharamtul	01-08-2021	1.839	Assam	Morigaon
15	Brahmaputra/Noa-dehing	Namsai	01-08-2021	3.098	Arunachal Pradesh	Namsai
16	Brahmaputra/Ranganadi	Ranganadi NT-Road crossing	01-08-2021	7.63	Assam	Lakhimpur
17	Brahmaputra/Siang	Pasighat	01-08-2021	3.059	Arunachal Pradesh	East Sinag
18	Brahmaputra/Subansiri	Chouldhowaghat	01-08-2021	2.496	Assam	Lakhimpur
	Brahmaputra/Subansiri	Balighat	01-08-2021	1.956	Assam	Lakhimpur
19	Brahmaputra/Torsa	Suldagiri (Deocharai)	02-08-2021	1.96	West Bengal	Koch Bihar
20	Brahmaputra/Torsa/Kaljani	Shaladang	02-08-2021	1.306	West Bengal	Koch Bihar
	Brahmaputra/Torsa/Kaljani	Ambari	02-08-2021	3.596	West Bengal	Coochbehar
21	Brahmaputra/ Umtru	Byrnihat	01-04-2021	1.457	Meghalaya	Ri-Bhoi
22	Cauvery	Urachikottai	13-09-2021	1.214	Tamil Nadu	Erode
23	Cauvery/Bhavani	Nellithurai	23-07-2021	2.524	Tamil Nadu	Coimbatore
24	Cauvery/Bhavani/Moyar	Thengumarahada	22-07-2021	8.299	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	02-08-2021	1.656	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	11-08-2021	2.911	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	21-08-2021	1.299	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	21-10-2021	1.523	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	11-11-2021	1.876	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	25-11-2021	1.085	Tamil Nadu	Nilgiris
	Cauvery/Bhavani/Moyar	Thengumarahada	01-12-2021	1.409	Tamil Nadu	Nilgiris
25	Cauvery/Chinnar	Hogenakkal	12-11-2021	1.699	Tamil Nadu	Dharmapuri
	Cauvery/Chinnar	Hogenakkal	22-11-2021	2.918	Tamil Nadu	Dharmapuri
26	Cauvery/Gandhayar	Gandhavayal	21-10-2021	1.2	Tamil Nadu	Coimbatore
27	Cauvery/Kallar	Odandurai	06-08-2021	1.12	Tamil Nadu	Coimbatore
	Cauvery/Kallar	Odandurai	21-09-2021	2.011	Tamil Nadu	Coimbatore
	Cauvery/Kallar	Odandurai	21-10-2021	1.294	Tamil Nadu	Coimbatore
	Cauvery/Kallar	Odandurai	01-12-2021	1.694	Tamil Nadu	Coimbatore
28	Cauvery/Marudaiyar	Varanavasi	11-10-2021	1.01	Tamil Nadu	Ariyalur
29	Cauvery/Noyyal	Alandurai	22-07-2021	2.453	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	02-08-2021	7.142	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	11-08-2021	2.554	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	01-09-2021	1.058	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	13-09-2021	1.572	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	21-09-2021	1.151	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	21-10-2021	1.076	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	01-11-2021	1.963	Tamil Nadu	Coimbatore
	Cauvery/Noyyal	Alandurai	11-11-2021	1.224	Tamil Nadu	Coimbatore
30	Cauvery/Palar	Avarankuppam	22-07-2021	1.352	Tamil Nadu	Vellore
	Cauvery/Palar	Avarankuppam	11-08-2021	1.417	Tamil Nadu	Vellore
	Cauvery/Palar	Avarankuppam	23-08-2021	1.57	Tamil Nadu	Vellore
	Cauvery/Palar	Avarankuppam	21-09-2021	1.837	Tamil Nadu	Vellore
	Cauvery/Palar	Avarankuppam	22-11-2021	1.773	Tamil Nadu	Vellore
	Cauvery/Palar	Kudlur	04-09-2021	1.161	Karnataka	Chamarajanagara
	Cauvery/Palar	Kudlur	24-09-2021	5.844	Karnataka	Chamarajanagara

Sl. No.	River/tributary	Station	Date	Fe(mg/L)	State	District
	Cauvery/Palar	Kudlur	01-10-2021	1.562	Karnataka	Chamarajanagara
	Cauvery/Palar	Kudlur	11-10-2021	3.726	Karnataka	Chamarajanagara
	Cauvery/Palar	Kudlur	21-10-2021	3.205	Karnataka	Chamarajanagara
31	Ganga	C.S-97 A, Farakka	16-12-2021	1.297	West bengal	Murshidabad
32	Ganga/Feeder Canal	Farakka/(HR)	16-12-2021	1.524	West bengal	Murshidabad
33	Iruvazhinjipuzha	Thottathinkadavu	21-10-2021	1.717	Kerala	Kozhikode
34	Kallada	Pattazhy	11-11-2021	5.726	Kerala	Kollam
35	Kamla Balan	Kakarghatti	01-04-2021	1.046	Bihar	Darbhanga
36	Karuvannur	Palakadavu	01-11-2021	3.852	Kerala	Thrissur
37	Kolong	Diprang Gaon	02-12-2021	1.996	Assam	Morigaon
38	Kumaradhara	Pulikukku	21-10-2021	1.028	Karnataka	South Kannada
39	Mahananda (Fulahar)	Labha	16-12-2021	1.552	Bihar	Katihar
40	Muvattupuzha	Ramamangalam	11-11-2021	1.126	Kerala	Ernakulam
41	Muvattupuzha/ Kaliyar	Kalampur	11-11-2021	4.878	Kerala	Ernakulam
42	Padma/Mahananda	Englishbazar	16-12-2021	1.21	West Bengal	Malda
43	Padma/Mathabhanga	Banpur	01-04-2021	1.096	West Bengal	Nadia
	Padma/Mathabhanga	Banpur	16-12-2021	1.242	West Bengal	Nadia
44	Pamba	Madamon	21-10-2021	5.262	Kerala	Pathanamthitta
	Pamba	Malakkara	21-10-2021	1.141	Kerala	Pathanamthitta
	Pamba	Malakkara	11-11-2021	1.395	Kerala	Pathanamthitta
45	Payaswani	Erinjipuzha	21-10-2021	1.047	Kerala	Kasargod
46	Pazhayar	Ashramam	21-10-2021	1.077	Tamil Nadu	Kanyakumari
47	Periyar	Neeleswaram	21-10-2021	1.031	Kerala	Ernakulam
48	Ponnaiyar	Singasadanapalli	22-07-2021	8.236	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	02-08-2021	7.447	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-08-2021	20.027	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-08-2021	20.234	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	01-09-2021	4.371	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	13-09-2021	2.343	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-09-2021	25.451	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-10-2021	1.495	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-10-2021	2.686	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-11-2021	1.253	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	22-11-2021	1.409	Tamil Nadu	Krishnagiri
	Ponnaiyar	Gummanur	22-07-2021	1.178	Tamil Nadu	Krishnagiri
	Ponnaiyar	Gummanur	02-08-2021	1.223	Tamil Nadu	Krishnagiri
	Ponnaiyar	Gummanur	01-09-2021	1.0005	Tamil Nadu	Krishnagiri
	Ponnaiyar	Gummanur	11-10-2021	1.219	Tamil Nadu	Krishnagiri
49	Tambraparani/Chittar	A.P. Puram	18-10-2021	1.9	Tamil Nadu	Tirunelveli
	Tambraparani/Chittar	A.P. Puram	01-12-2021	1.037	Tamil Nadu	Tirunelveli
50	Tambraparni	Murappanadu	02-08-2021	1.014	Tamil Nadu	Tuticorin
	Tambraparni	Murappanadu	13-09-2021	1.522	Tamil Nadu	Tuticorin
	Tambraparni	Murappanadu	11-11-2021	1.005	Tamil Nadu	Tuticorin
	Tambraparni	Murappanadu	01-12-2021	1.004	Tamil Nadu	Tuticorin
51	Teesta	Domohani	02-08-2021	1.234	West Bengal	Jalpaiguri
52	Thodupuzha	Manakkad	11-11-2021	1.626	Kerala	Idukki

Sl. No.	River/tributary	Station	Date	Fe(mg/L)	State	District
53	Vaigai	Ambasamudram	22-10-2021	1.353	Tamil Nadu	Theni
	Vaigai	Ambasamudram	11-11-2021	1.326	Tamil Nadu	Theni
	Vaigai	Ambasamudram	01-12-2021	1.658	Tamil Nadu	Theni
54	Vaigai/Suruliar	Theni	22-07-2021	2.367	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	02-08-2021	2.784	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	11-08-2021	1.416	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	21-08-2021	1.032	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	01-09-2021	1.345	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	21-10-2021	1.595	Tamil Nadu	Theni
	Vaigai/Suruliar	Theni	01-12-2021	1.265	Tamil Nadu	Theni
55	Yamuna	Delhi Railway Bridge	22-04-2021	4.876	Delhi	North Delhi
	Yamuna	Delhi Railway Bridge	01-05-2021	1.455	Delhi	North Delhi

Iron is the element analysed which is found to exceed the limit at maximum number of stations and samples despite of the comparatively higher acceptable limit of 1 mg/L. This shows the abundance of the metals across various rivers of five river basins: Ganga, Brahmaputra, Cauvery, East Flowing Rivers between Pennar and Kanyakumari, and West Flowing Rivers from Tadri to Kanyakumari. Figure 27 depicts the GIS map of WQ stations where Iron is found to be above limit.

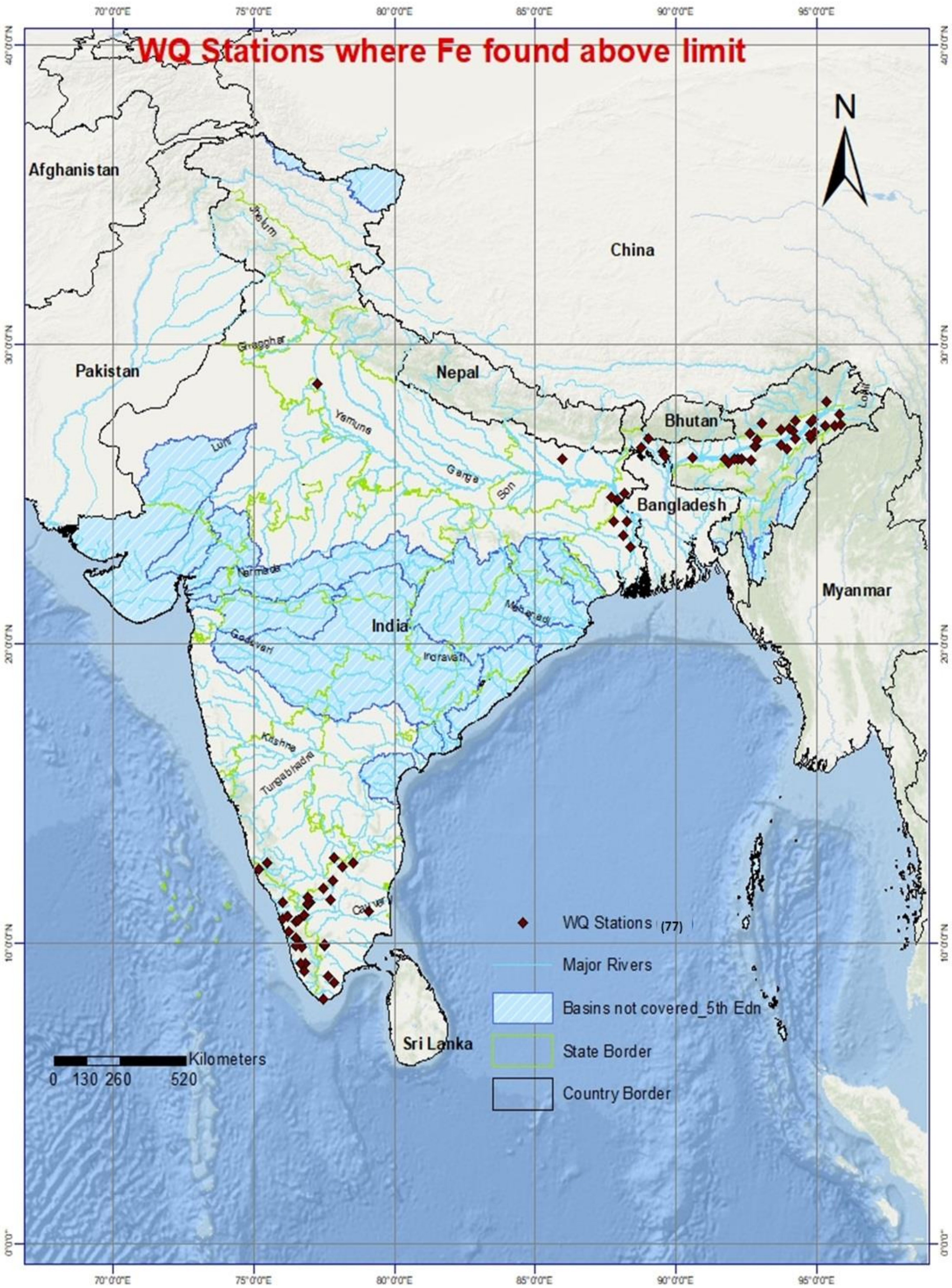

Figure 27: WQ stations where Iron found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

In the 4th edition, the acceptable limit of 0.3 mg/L and in the current edition of the report, the revised limit of 1.0 mg/L is being considered. However, 6.87% of the total samples analysed were observed to exceed the iron concentration of 1.0 mg/L during August 2018-December 2020 (214 samples out of 3113). These samples belong to 153 water quality stations across 103 rivers. Maximum Iron concentration (11.24 mg/L) was observed at Farakka/ (HR) water quality monitoring station on Feeder Canal during Aug, 2019.

During 2021, 138 water quality stations were identified with iron concentrations surpassing the acceptable limits. However, only 3.62 % of the total samples analysed are found to exceed the limit (138 samples out of 3815). These samples were collected from 138 water quality monitoring stations across 77 rivers. Maximum iron concentration (25.451 mg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 21.09.2021.

There are 59 common stations: Ambari, Ashramam, Balighat, Banpur, Berhampore, Bhalukpong, Bhomoraguri, Bihubar, Byrnihat, C.S-97 A, Farakka, Chouldhowaghat, Delhi Railway Bridge, Desangpani, Dharamtul, Diana, Dibrugarh, Domohani, Englishbazar, Erinjipuzha, Farakka/(HR), Golaghat, Gummanur, Guwahati D.C Court, Jagibhakatgaon, Jiabharali NT Road –Xing, Kakarghatti, Kalampur, Kalna (EBB), Kalna (Flow), Kampur, Katwa, Kumbidi, Labha, Madamon, Malakkara, Manakkad, Mankara, Margherita, Naharkatia, Namsai, Nanglamoraghat, Neamatighat, Neeleswaram, Numaligarh, Palakadavu, Pancharatna, Pasighat, Pattazhy, Pudur, Pulamanthole, Pulikukku, Ramamangalam, Ranganadi NT-Road crossing, Seppa, Shaladang, Tezpur, Thottathinkadavu, Udaipur (Brahmaputra) and Varanavasi during both study periods. Figure 28 is the GIS map of stations with iron exceedance in both study periods.

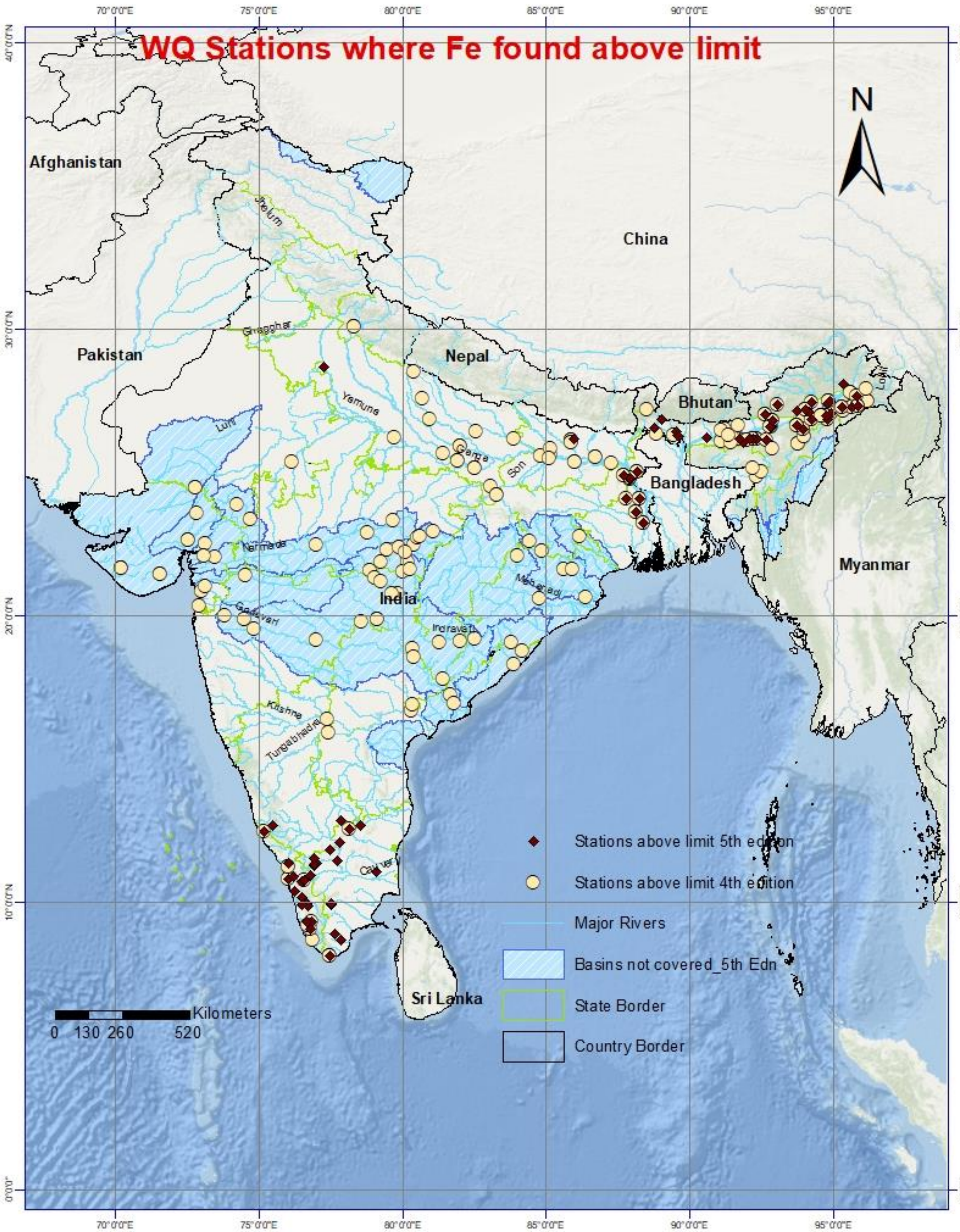

Figure 28: WQ stations where Iron found above acceptable limit (both study periods)

7.6 Lead (Pb)

Bureau of Indian Standards (10500:2012) has recommended the acceptable limit of 0.01 mg/L or 10 µg/L in drinking water for lead. Out of total 3811 river water samples analysed, 30 samples from 20 water quality stations across 19 rivers were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 97.079 µg/L. Maximum lead concentration (97.079 µg/L) was observed at Nellipally water quality monitoring station on Kallada River on 11.08.2021. The samples whose values are beyond acceptable limit belong to six basin Ganga, Brahmaputra, Cauvery, Krishna, East Flowing rivers between Pennar and Kanyakumari and West Flowing rivers from Tadri to Kanyakumari

The details of stations where lead concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates are depicted in the table given below.

Table 17: River-wise list of WQ stations with Pb values above limit

Sl. No.	River/tributary	Station	Date	Pb (µg/L)	State	District
1	Bharathapuzha	Kumbidi	21-10-2021	15.805	Kerala	Palakkad
	Bharathapuzha	Mankara	01-10-2021	18.112	Kerala	Palakkad
2	Brahmaputra/Jaldhaka	Jaldhaka NH-31	01-04-2021	36.280	West Bengal	Jalpaiguri
3	Cauvery	Urachikottai	13-09-2021	10.42	Tamil Nadu	Erode
4	Cauvery /Arkavathi	T. Bekuppe	11-11-2021	27.881	Karnataka	Ramanagara
5	Cauvery/Amaravathi	Nallamaranpatty	13-09-2021	10.718	Tamil Nadu	Karur
6	Cauvery/Gandhayar	Gandhavayal	01-12-2021	15.915	Tamil Nadu	Coimbatore
7	Cauvery/Kallar	Odandurai	06-08-2021	10.938	Tamil Nadu	Coimbatore
8	Cauvery/Noyyal	Alandurai	01-09-2021	10.189	Tamil Nadu	Coimbatore
9	Cauvery/Palar	Kudlur	04-09-2021	10.548	Karnataka	Chamarajanagara
10	Cauvery/Shimsha	T.K. Halli	02-08-2021	61.314	Karnataka	Mandya
11	Cauvery/Yagachi	Thimmanahalli	01-09-2021	49.068	Karnataka	Hassan
12	Ganga/Sone	Koelwar	01-04-2021	10.440	Bihar	Bhojpur
13	Kallada	Nellipally	02-08-2021	73.64	Kerala	Kollam
	Kallada	Nellipally	11-08-2021	97.079	Kerala	Kollam
	Kallada	Nellipally	23-08-2021	20.627	Kerala	Kollam
	Kallada	Nellipally	11-10-2021	82.143	Kerala	Kollam
14	Karuvannur	Palakadavu	21-10-2021	92.682	Kerala	Thrissur
15	Ponnaiyar	Singasadanapalli	22-07-2021	12.867	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	02-08-2021	16.348	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-08-2021	18.956	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-08-2021	29.846	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-09-2021	15.785	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-10-2021	16.989	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	22-11-2021	13.006	Tamil Nadu	Krishnagiri
16	Ramganga	Bareilly	21-11-2021	10.116	Uttar Pradesh	Bareilly
17	Tambraparni	Murappanadu	13-09-2021	11.652	Tamil Nadu	Tuticorin
18	Thodupuzha	Manakkad	01-10-2021	33.218	Kerala	Idukki
	Thodupuzha	Manakkad	11-11-2021	18.594	Kerala	Idukki
19	Tungabhadra/Varada	Marol	23-08-2021	24.89	Karnataka	Haveri

A GIS map of WQ stations where lead is found above acceptable limit is depicted in Figure 29.

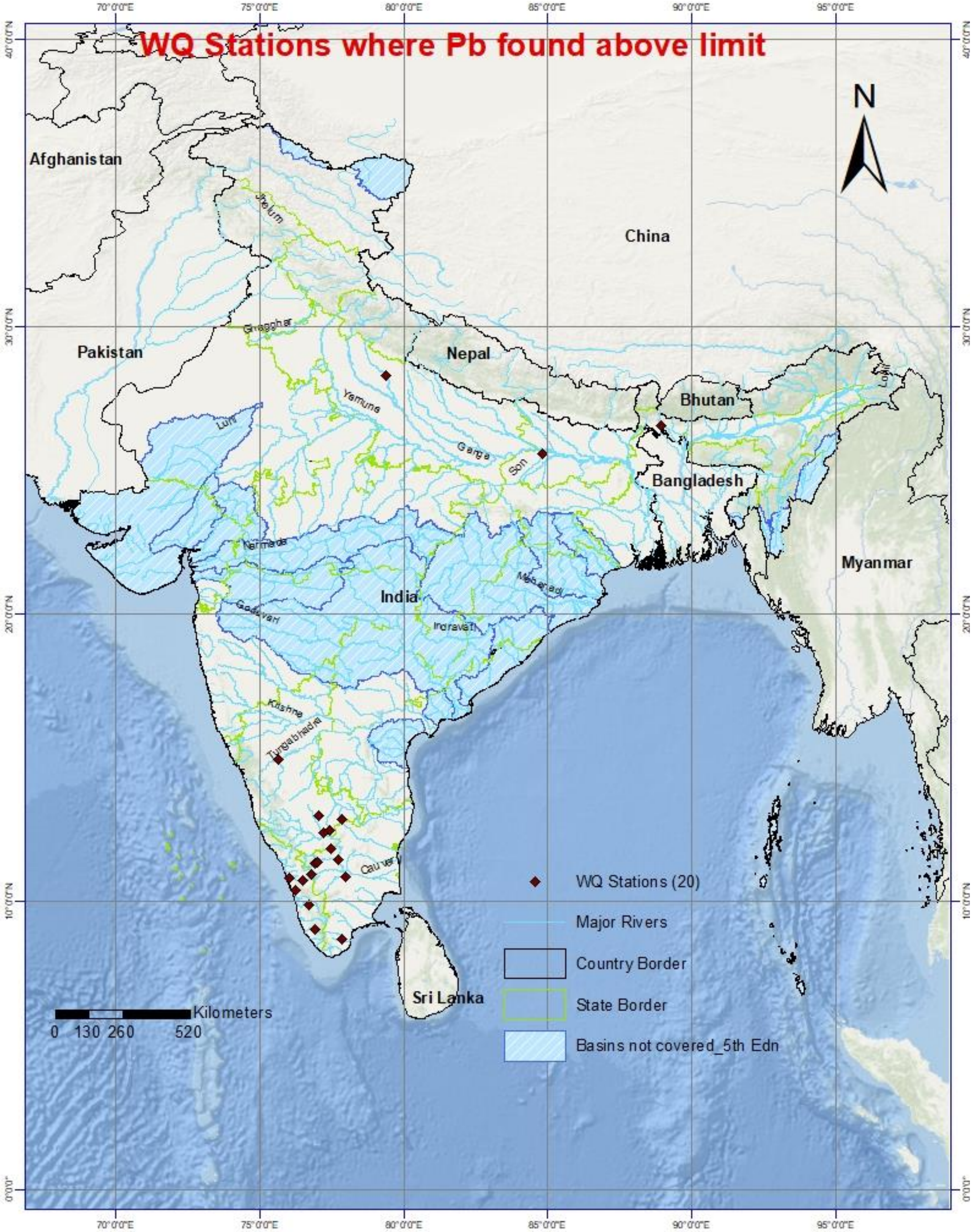

Figure 29: WQ stations where Lead found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

During the period from August 2018 to December 2020, a total of 3111 water samples were collected and analysed and 36 samples were found to exceed the acceptable limit (1.16%). The Lead concentration in 3113 samples varied from 0.00 to 67.55 µg/L. The highest concentration (67.55 µg/L) was recorded at Chopan water quality monitoring station in the Sone River, in May 2020. The data reveals that a total number of 34 water quality stations namely Agra (J.B.), Agra (P.G.), Ankinghat, Berhampore, Bhalwara, Chaklagaon, Chel, Chenimari, Chopan, Dindori, Domohani, Englishbazar, Farakka/(HR), Garhmukteshwar, Hanskhali, Hoshangabad, Kalanaur, Karnal, Katwa, Kumarapalayam, Lowara, Manakkad, Manot, Mawi, Miao, Muthankera, Naugaon, Nellipally, Rudraprayag, Sitapur, Thimmanahalli, Tuini/tons, Varanasi, and Yashwant Nagar. These stations belong to 24 rivers, namely Alaknanda, Bhagirathi, Buridehing, Chel, Churni, Feeder Canal, Ganga, Gaur, Giri, Kabini, Kallada, Mahananda, Manas, Narmada, Noa-dehing, Sarayan, Shetruni, Sone, Teesta, Thodupuzha, Tons, Varahanadhi, Yagachi, and Yamuna, exceeded the acceptable lead concentration limit.

Subsequently, during 2021, out of total 3811 river water samples analysed, 30 samples from 20 water quality stations across 19 rivers surpassed the acceptable limit for lead levels. Maximum lead concentration (97.079 µg/L) was observed at Nellipally water quality monitoring station in Kallada River on 11.08.2021.

Figure 30 represents the GIS map of stations affected with Pb in both reports. The common water quality monitoring stations where lead is found to exceed the acceptable limit of 10 µg/L are Manakkad in Thodupuzha river, Nellipally in Kallada, and Thimmanahalli in Yagachi river.

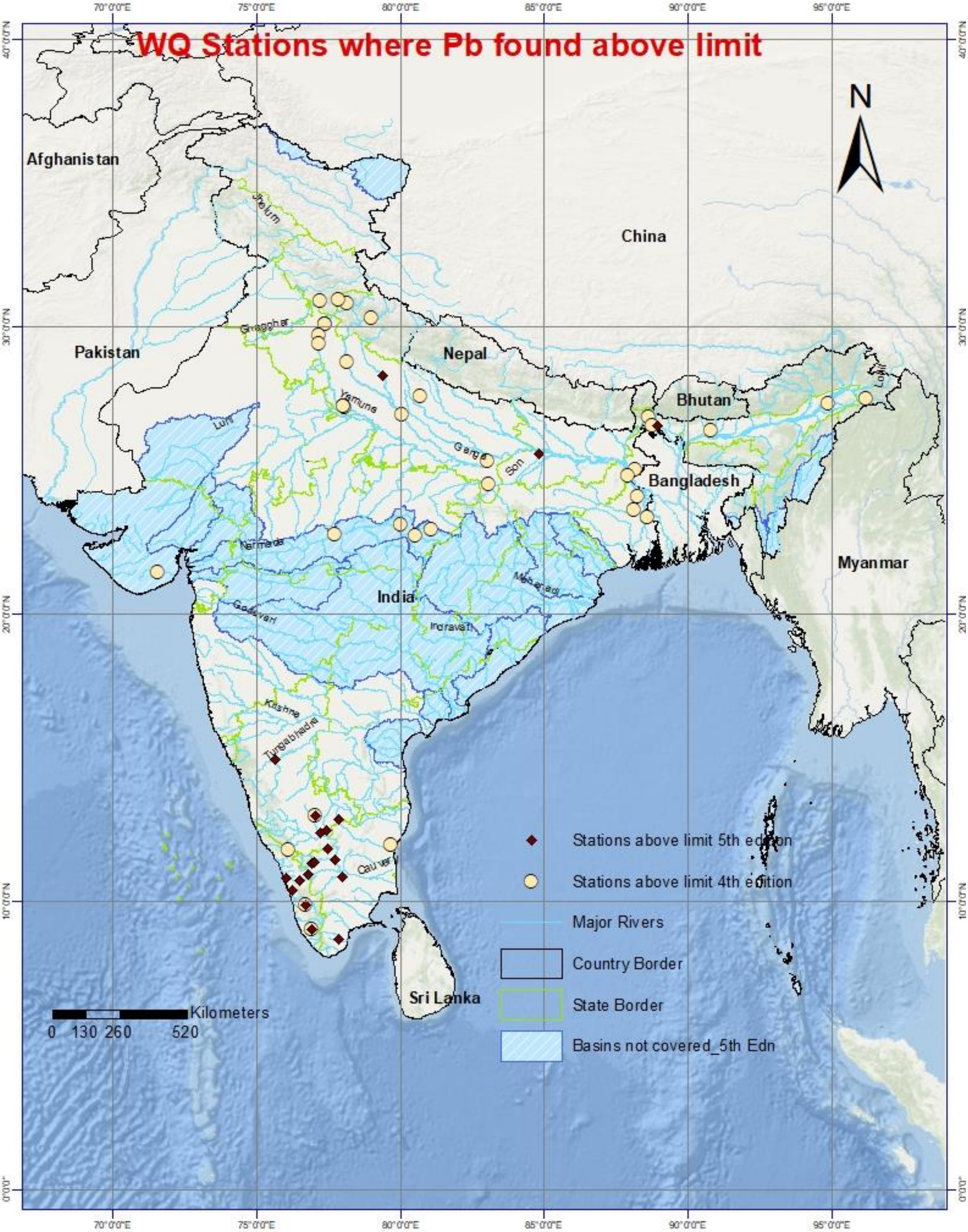

Figure 30: WQ stations where Lead found above acceptable limit (both study period)

7.7 Mercury (Hg)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 1 µg/L of mercury in drinking water. Out of total 1598 river water samples analysed, 17 samples from 14 water quality stations across 14 rivers were found to have mercury concentrations beyond the acceptable limit. The mercury concentration varies from 0.000 to 13.866 µg/L. Maximum mercury concentration (13.866 µg/L) was observed at Thimmanahalli water quality monitoring station on Yagachi River (a tributary of Cauvery) on 01.09.2021.

The details of stations where mercury concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 18: River-wise list of WQ stations with Hg values above limit

Sl. No.	River/tributary	Station	Date	Hg (µg/L)	State	District
1	Cauvery/Yagachi	Thimmanahalli	01-09-2021	13.866	Karnataka	Hassan
2	Gad	Belne Bridge	01-09-2021	2.981	Maharashtra	Sindudurg
3	Ganga	Kachlabridge	21-12-2021	7.065	Uttar Pradesh	Badaun
4	Ghaghra	Elginbridge	01-11-2021	1.374	Uttar Pradesh	Barabanki
5	Ghaghra/Rapti	Bansi	21-12-2021	1.487	Uttar Pradesh	Siddarthnagar
6	Gomti/Sarayan	Sitapur	01-12-2021	2.012	Uttar Pradesh	Sitapur
7	Krishna/Malaprabha	Cholachugudda	11-08-2021	1.506	Karnataka	Bagalkot
	Krishna/Malaprabha	Cholachugudda	01-09-2021	6.214	Karnataka	Bagalkot
8	Ramganga	Tiharkheda	11-12-2021	1.118	Uttar Pradesh	Bareilly
9	Ramganga /Bahgul	Dhaneta	01-12-2021	3.821	Uttar Pradesh	Bareilly
10	Tungabhadra	Haralahalli	11-08-2021	1.38	Karnataka	Haveri
	Tungabhadra	Haralahalli	01-09-2021	2.695	Karnataka	Haveri
11	Tungabhadra/Kumudavathi	Kuppellur	01-09-2021	2.275	Karnataka	Haveri
12	Tungabhadra/Varada	Marol	11-08-2021	1.642	Karnataka	Haveri
	Tungabhadra/Varada	Marol	01-09-2021	2.271	Karnataka	Haveri
	Tungabhadra/Tunga	Byaladahalli	01-09-2021	1.249	Karnataka	Davanagere
13	Yamuna/Betwa	Rajghat (Yamuna)	23-11-2021	1.503	Uttar Pradesh	Lalitpur

The samples whose values are beyond acceptable limit belong to four basins: Cauvery, Ganga, Krishna, and West flowing Rivers from Tapi to Tadri.

Figure 31 represents GIS map of WQ stations where mercury is found above acceptable limit.

Comparison with 4th edition (period: August 2018-December, 2020)

Comparison cannot be done as the parameter Mercury was not included in the last edition due to the unavailability of instrument component (mercury lamp).

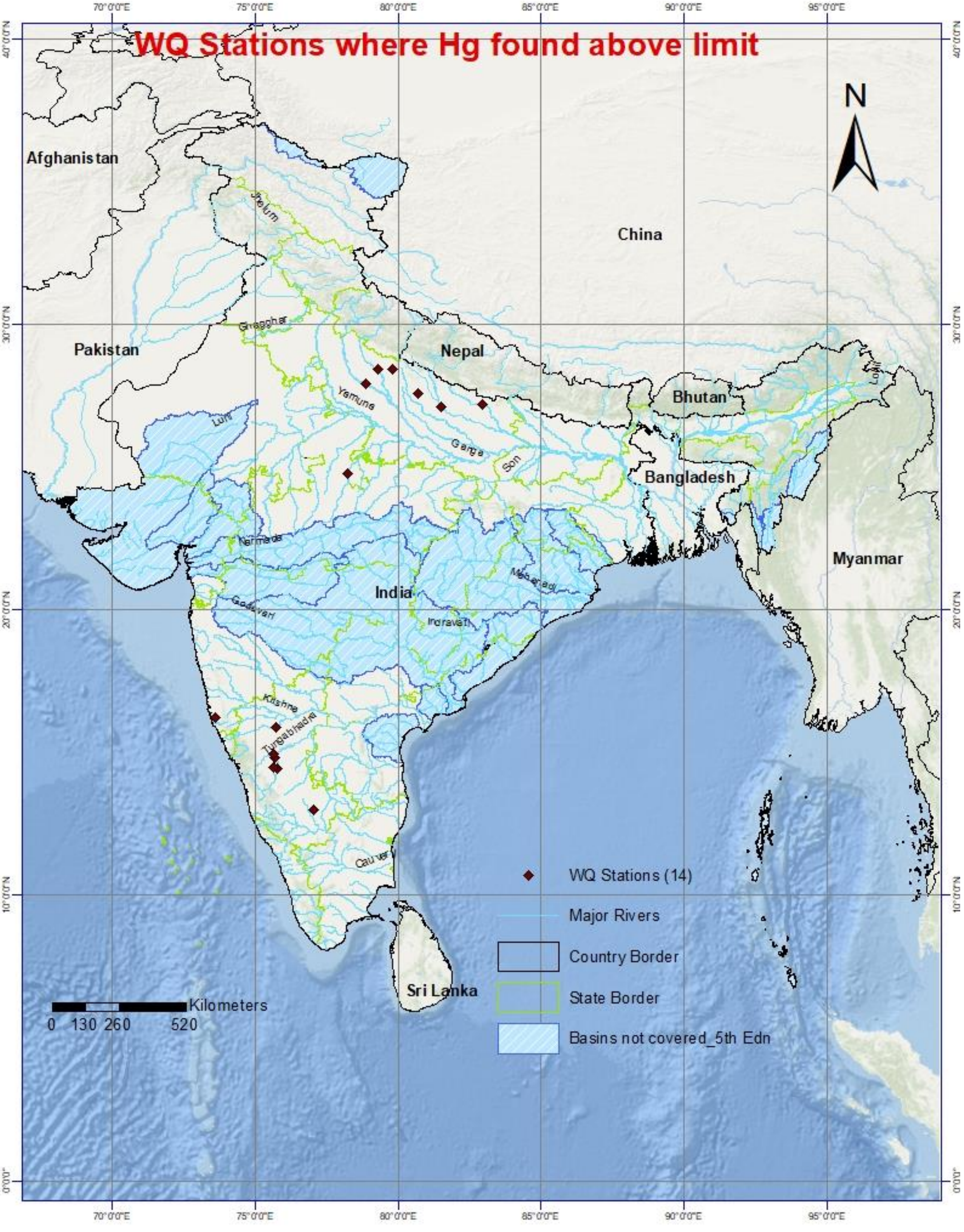

Figure 31: WQ stations where Mercury found above acceptable limit

7.8 Nickel (Ni)

BIS (Bureau of Indian Standards) 10500:2012 has recommended an acceptable limit of 20 µg/L of nickel in drinking water. Out of total 3815 river water samples analysed, 17 samples from 12 water quality stations across 10 rivers were found to have nickel concentrations beyond the acceptable limit. The nickel concentration varies from 0.000 to 126.046 µg/L. Maximum nickel concentration (126.046 µg/L) was observed at Hariharapura water quality monitoring station on Tunga River on 01.09.2021.

The details of stations where nickel concentrations (in µg/L) were found to be beyond acceptable limit, categorized by their respective rivers and dates is depicted in the table given below.

Table 19: River-wise list of WQ stations with Ni values above limit

Sl. No.	River/tributary	Station	Date	Ni(µg/L)	State	District
1	Cauvery/Bhavani	Nellithurai	23-07-2021	32.258	Tamil Nadu	Coimbatore
2	Cauvery/Marudaiyar	Varanavasi	11-10-2021	24.047	Tamil Nadu	Ariyalur
3	Cauvery/Noyyal	Alandurai	02-08-2021	78.048	Tamil Nadu	Coimbatore
4	Cauvery/Palar	Kudlur	04-09-2021	51.562	Karnataka	Chamarajanagara
	Cauvery/Palar	Kudlur	01-10-2021	28.592	Karnataka	Chamarajanagara
	Cauvery/Palar	Kudlur	11-10-2021	24.792	Karnataka	Chamarajanagara
5	Cauvery/Yagachi	Thimmanahalli	01-09-2021	119.038	Karnataka	Hassan
6	Kali	Kasganj	16-07-2021	29.170	Uttar Pradesh	Etah
7	Ponnaiyar	Singasadanapalli	02-08-2021	34.92	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	11-08-2021	31.711	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-08-2021	23.337	Tamil Nadu	Krishnagiri
	Ponnaiyar	Singasadanapalli	21-09-2021	26.066	Tamil Nadu	Krishnagiri
8	Ramganga	Moradabad	21-11-2021	26.448	Uttar Pradesh	Moradabad
9	Tungabhadra/Tunga	Hariharapura	01-09-2021	126.046	Karnataka	Chikmagalur
10						
	Yamuna	Kailash Mandir Benpur U/S of Agra	23-11-2021	20.018	Uttar Pradesh	Agra
	Yamuna	Agra (P.G.)	23-11-2021	23.149	Uttar Pradesh	Agra (P.G)
	Yamuna	Agra (J.B.)	23-11-2021	22.462	Uttar Pradesh	Agra (J.B)

Figure 32 represents the GIS map of WQ stations with nickel values above limit.

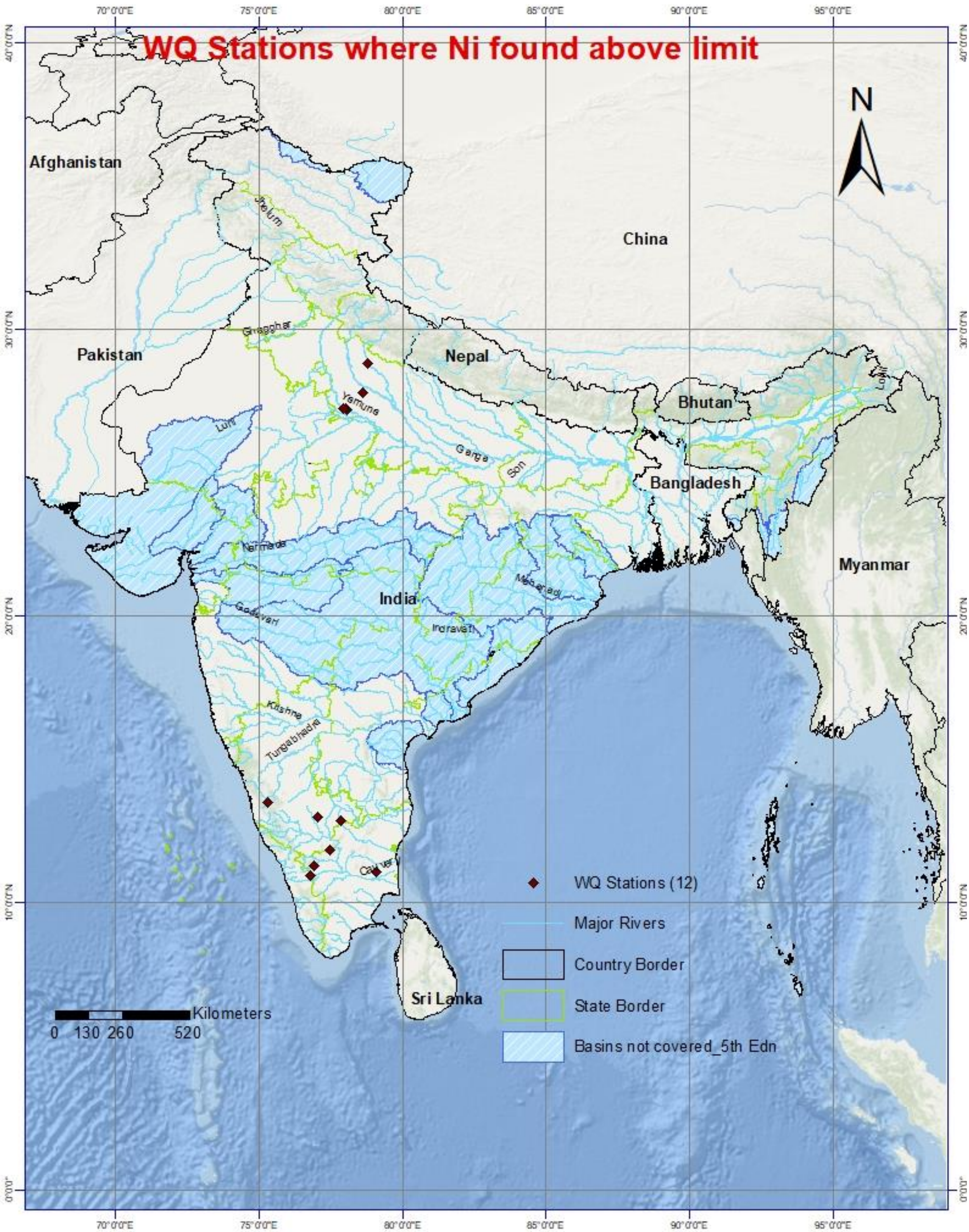

Figure 32: WQ stations where Nickel found above acceptable limit

Comparison with 4th edition (period: August 2018-December, 2020)

The comprehensive analysis of water quality during two distinct periods: from August 2018 to December 2020 and subsequently January-December 2021, has provided valuable insights into nickel concentrations in Indian rivers.

In the 4th edition of the report, out of 3111 water samples collected, nickel concentrations exceeded acceptable limits at 265 samples collected from 199 stations across 120 rivers. The maximum nickel concentration (242.90 µg/L) was observed at Elunuthimangalam water quality monitoring station in Noyyal River during December 2020.

In the subsequent period of 2021, out of 3815 water samples analyzed, 17 samples from 12 water quality stations across 10 rivers were found to have nickel concentrations beyond the acceptable limit.

The GIS map in Figure 39 illustrates the stations which have exceeded the nickel limit in both the current and previous study periods. Eight (08) stations: Agra (P.G.), Agra (J.B.), Delhi Railway Bridge, Hariharapura, Kalish Mandir Benpur (U/S), Kasganj, Moradabad, and Singasadanapalli are common to both periods: August 2018 to December 2020, as well as 2021. Figure 33 depicts the stations exceeding nickel limit during both study periods.

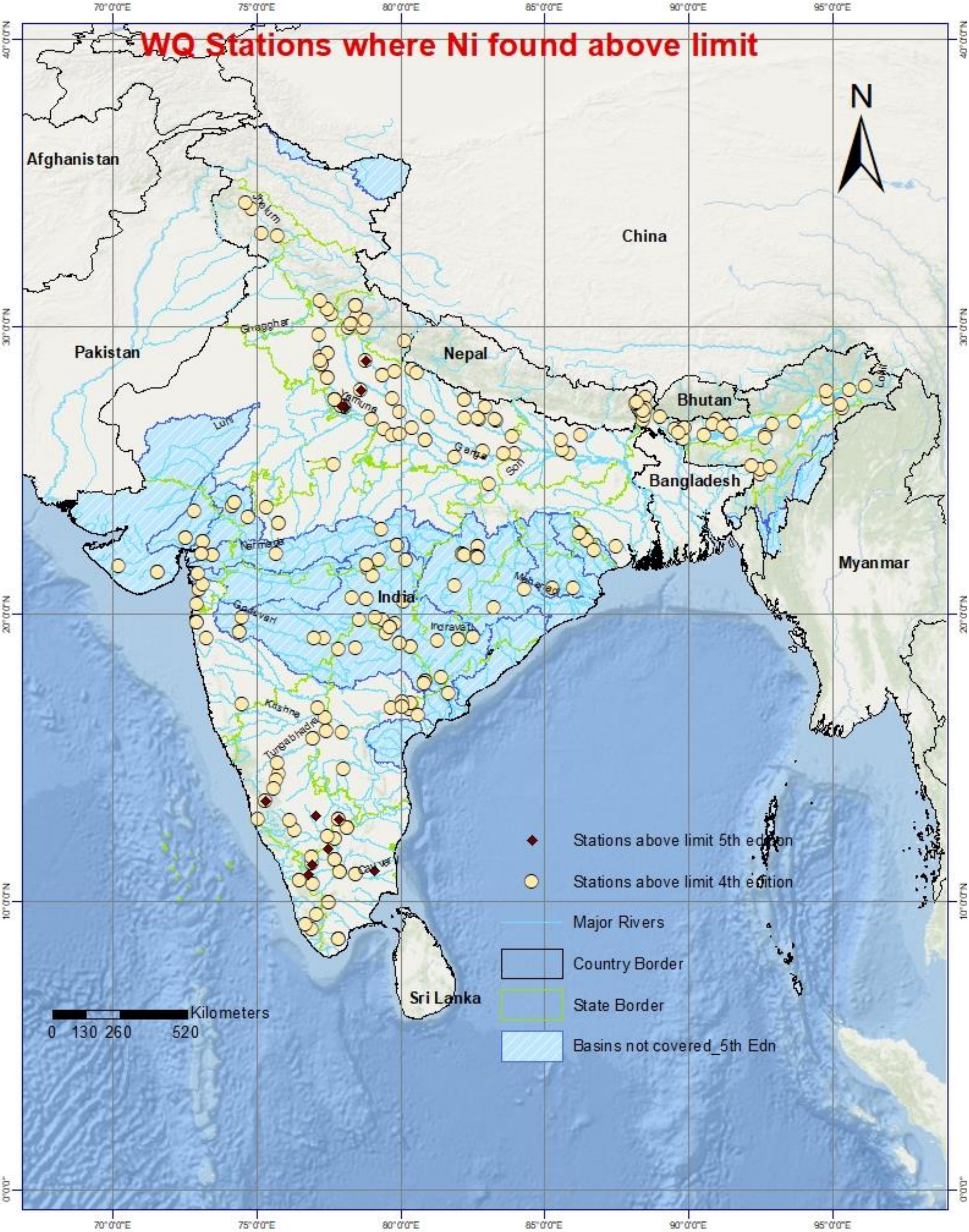

Figure 33: WQ stations where Nickel found above acceptable limit (both study period)

7.9 Zinc (Zn)

BIS (Bureau of Indian Standards) 10500:2012 has recommended acceptable limit of 5 mg/L (5000 µg/L) of Zinc in drinking water. Out of total 3815 river water samples analysed; no sample is found to have zinc concentration beyond the acceptable limit. The zinc concentration varies from 0.000 to 1306.063 µg/L. Maximum zinc concentration (1306.063 µg/L) was observed at Prang water quality monitoring station on Sind River on 01.12.2021.

Comparison with 4th edition (period: August 2018-December, 2020)

The comprehensive analysis of water quality during two distinct periods, from August 2018 to December 2020 and subsequently in 2021, has provided valuable insights into zinc concentrations in Indian rivers. During the initial period, encompassing 3113 water samples, the highest zinc concentration of 1.70 mg/L was recorded at the Belkheri water quality monitoring station on the Sher River in May 2020. Notably, all river water quality stations within the study area adhered to the acceptable limits set by the Bureau of Indian Standards (BIS).

The subsequent period, 2021, involved the analysis of a significantly larger number of 3815 samples. The maximum zinc concentration observed in the second period is 1.306 mg/L at Prang water quality monitoring station on Sind River on 01.12.2021. During the current study period also, all river water quality stations within the study area adhered to the acceptable limits set by the Bureau of Indian Standards (BIS).

8. CONCLUSION

The analysis results of 9 metals analysed in samples collected from 488 water quality monitoring stations spread over 10 river basins were considered for the study. Drinking water standard; BIS: 10500:2012 is used as a benchmark due to the absence of any river-specific water quality standards.

- The comprehensive analysis of water samples across numerous stations has revealed concerning levels of various heavy metals, each governed by specific acceptable limits prescribed by BIS (10500:2012).
- All metals are found to be within the acceptable limits at 364 monitored stations while at 124 stations, at least one metal was found to be beyond the acceptable limits prescribed by BIS (10500:2012).
- The results underscore the pervasive nature of water pollution, with multiple stations showing elevated concentrations of arsenic, cadmium, chromium, copper, iron, lead, mercury, and nickel.
- Arsenic, with an acceptable limit of 10 µg/L, exhibited elevated levels in 19 samples from 13 stations among the 3815 samples analysed.
- Similarly, cadmium surpassed the acceptable limit of 3 µg/L in 12 samples from 7 stations.
- Chromium, copper, and nickel also presented challenges, exceeding their respective limits in 7, 3, and 12 stations across various rivers.
- The significant concern arises with iron, where 138 samples from 77 stations surpassed the acceptable limit of 1000 µg/L (1 mg/L). Iron is observed to have highest abundance showing beyond - limit concentrations at maximum number of samples and stations.
- Lead, with a limit of 10 µg/L, demonstrated elevated levels in 30 samples from 20 stations.
- Mercury breached the acceptable limit of 1 µg/L in 17 samples from 14 stations, emphasizing the widespread presence of this toxic element.
- Singasadanapalli in Ponnaiyar River is found to be the most-affected station. A total of 15 samples were collected and analysed from this station and 5 metals: Cadmium, Copper, Lead, Nickel, and Iron are found to exceed their acceptable limits at least once in 11 samples. The other 4 samples are safe in terms of all metals. Iron is found to breach the acceptable limit of 1.0 mg/L in 11 samples, lead in 7 samples and cadmium in 5 samples. The metals above limit may be contributed from the industrial park of Hosur and Bangalore city.

These findings emphasize the immediate need for proactive measures to address water quality issues and implement effective remediation strategies. It is imperative to prioritize the protection of water resources to ensure the well-being of ecosystems and safeguard public health from the detrimental effects of heavy metal contamination.

The overall summary of the results is given in the tables given below:

Table 20: Overall Statistics of Analysis

Sl. No	Parameters	No. of Stations where metal found above acceptable limit
1	Arsenic only	**8**
2	Cadmium only	**4**
3	Chromium only	**6**
4	Copper only	**1**
5	Iron only	**61**
6	Lead only	**6**
7	Mercury only	**11**
8	Nickel only	**5**
9	Zinc only	**0**
10	Two or More metals	**22**
Total WQ stations where one or more metals found above acceptable limits		**124**
Total WQ Stations where all toxic metals found within acceptable limits		**364**
Total WQ Stations under study		**488**

Table 21: Overall Status of 124 stations where one or more metals found above acceptable limits

No. of stations where 5 metals found to be above limit	**1**
No. of stations where 3 metals found to be above limit	**3**
No. of stations where 2 metals found to be above limit	**18**
No. of stations where only 1 metal found to be above limit	**102**

- Tables above show that there is one station where five metals were found to exceed the limit, three stations where three metals exceeded the limit, and eighteen stations where two metals exceeded the limit.
- It is evident from the tables that, out of 124 stations where one or more metals are found above acceptable limits, 102 stations have only 1 metal which exceeds the limit. Among these 102 stations, 61 stations have only Iron exceeding the limit. This means that, only Iron metal is found to breach the limit at 59.80 % of the 124 stations affected.
- However, it is important to note that there are 364 WQ stations where all the toxic metals are found within acceptable limits.

Table 22: Basin-wise Summary of Analysis

Sl. No.	Basin	No. of WQ stations studied	WQ stations where one or more metals found above acceptable limits
1	Brahmaputra	144	35
2	Cauvery	41	13
3 & 4	East Flowing Rivers between Pennar and Cauvery Basin and East Flowing Rivers South of Cauvery Basin	18	7
5	Ganga	205	44
6	Indus	10	0
7	Krishna	13	6
8	Meghna/Barak	13	0
9	Pennar	8	0
10	West Flowing Rivers South of Tapi Basin	36	19

Table 30 above shows the total number of water quality (WQ) stations monitored and the number of stations where one or more metals were found above acceptable limits across different basins. The Ganga basin has the highest number of WQ stations monitored, with 205 stations, out of which 44 stations are reported metal exceedance. The Brahmaputra basin is at second place, with 35 out of 144 stations with beyond-limit metals concentrations. The West Flowing Rivers south of Tapi Basin comes at third place with 19 out of 36 stations reporting metal exceedance.

The high level of metal concentration observed at several WQ stations across different basins may be attributed to both industrial and geogenic reasons. Industrial activities such as mining, manufacturing, and waste disposal can release large amounts of toxic metals into the rivers. Geogenic factors such as natural weathering and erosion of rocks and soils can also contribute to metal contamination in rivers.

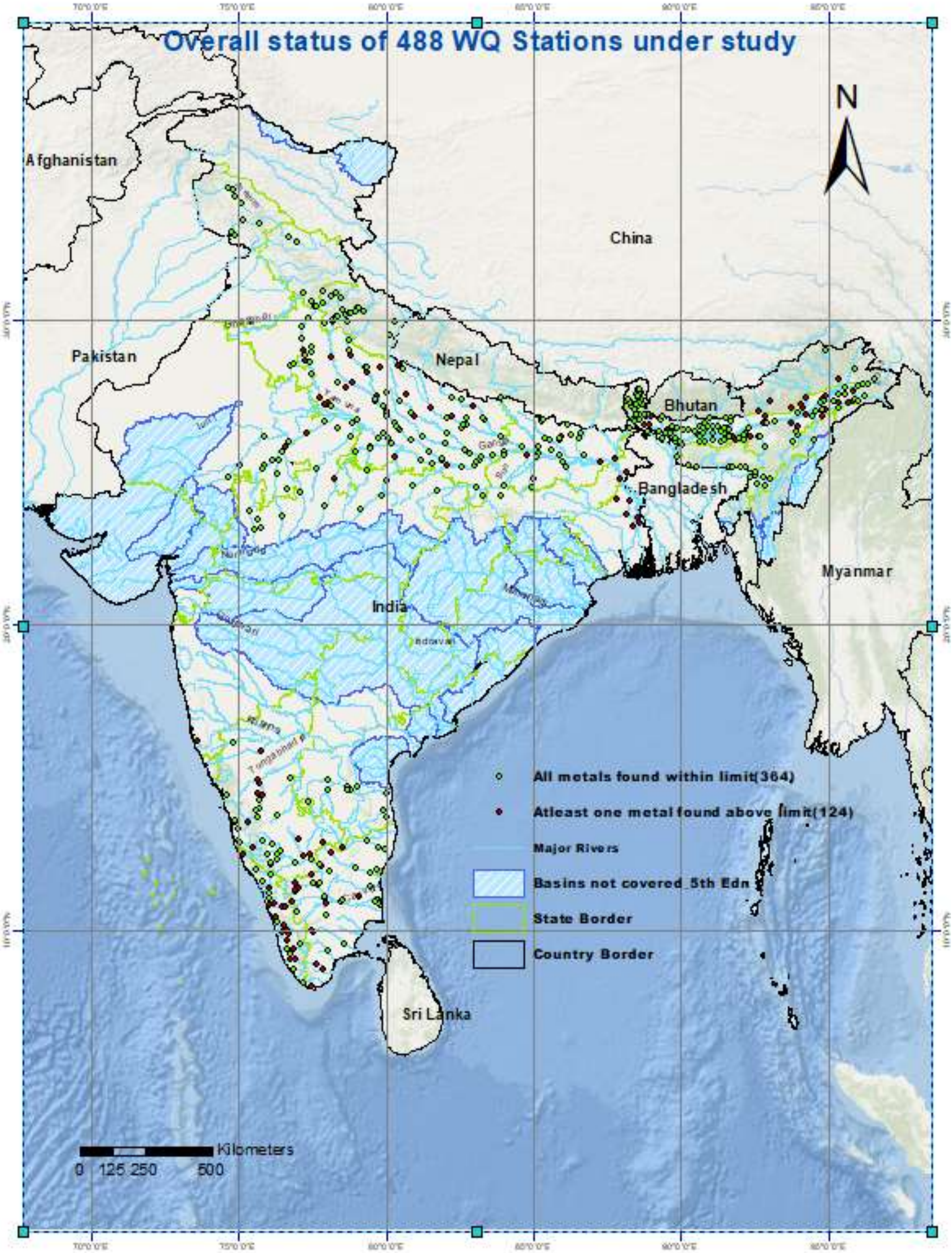

Figure 34: Overall status of 488 stations under study

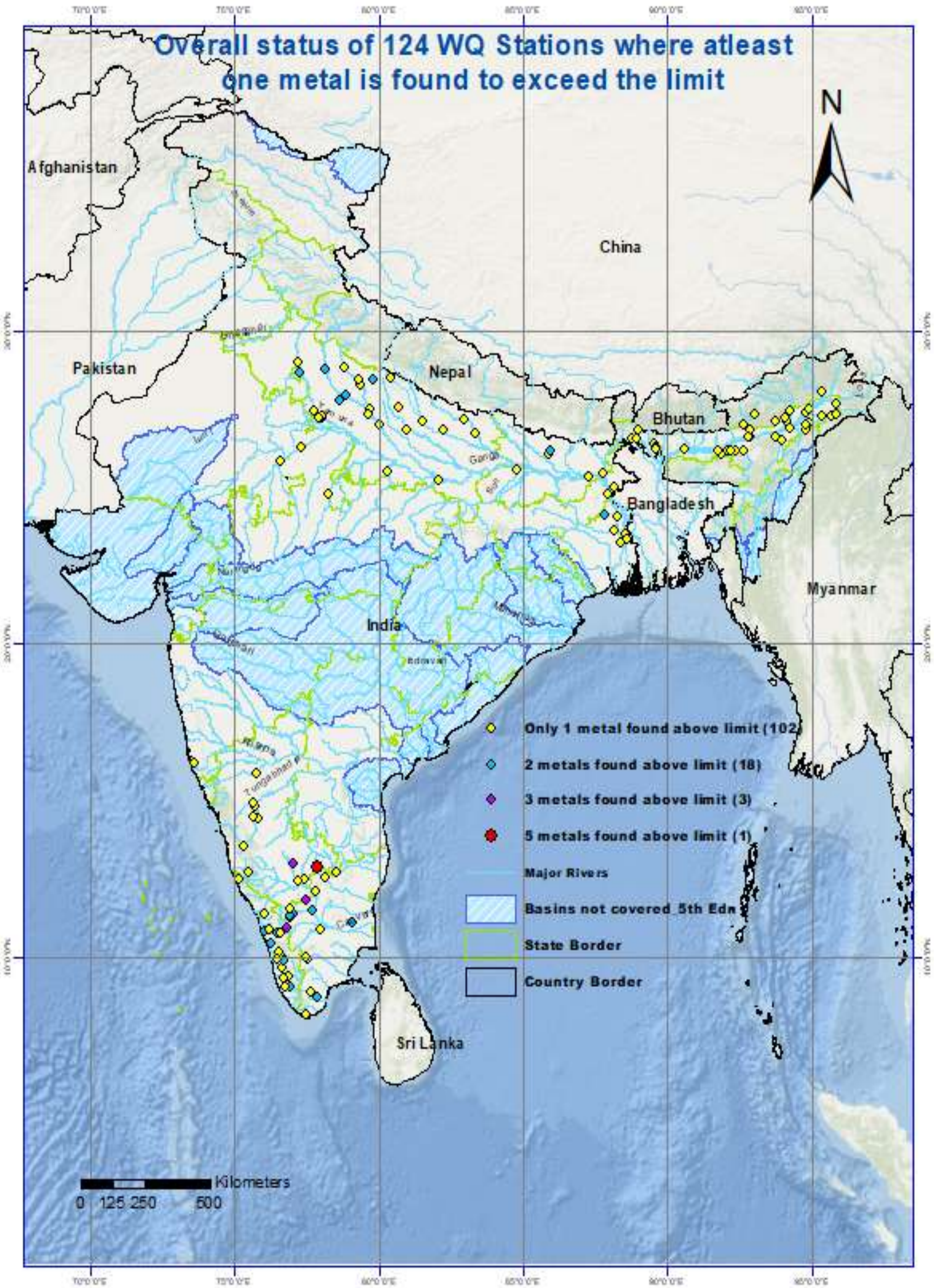

Figure 35: Overall status of 124 stations where at least one metal is found above the limit

Comparison with 4th edition

Table 23: Comparison of Metal-wise Analysis Result

Analysis result (2021)							Analysis result (Aug 2018-Dec 2020)			
Sl. No.	Heavy metal	Acceptable limit as per BIS:10500, 2012 (in µg/L)	No. of samples analysed	No. of samples where metal found within acceptable limit	No. of samples where metal found above acceptable limit	% of samples where metal found above acceptable limit	No. of samples analysed	No. of samples where metal found within acceptable limit	No. of samples where metal found above acceptable limit	% of samples where metal found above acceptable limit
1	Arsenic (As)	10	3815	3796	19	0.50	2834	2826	8	**0.28**
2	Cadmium (Cd)	3	3815	3803	12	0.31	3113	3102	11	**0.35**
3	Chromium (Cr)	50	3814	3807	7	0.18	3106	3056	50	**1.61**
4	Copper (Cu)	50	3815	3812	3	0.08	3107	3090	17	**0.55**
5	Lead (Pb)	10	3811	3781	30	0.79	3111	3075	36	**1.16**
6	Nickel (Ni)	20	3815	3798	17	0.45	3099	2834	265	**8.55**
7	Iron (Fe)	1000	3815	3677	138	3.62	3113	2357	214	**6.87**
8	Zinc (Zn)	5000	3815	3815	0	0.00	3113	3113	0	**0.00**
9	Mercury (Hg)	1	1598	1581	17	1.06	-	-	-	-

Table 152: Overall Comparison of 2 reports

WQ stations	2021	Aug 2018-Dec 2020	WQ samples	2021	Aug 2018-Dec 2020
No. of stations where no metal found above acceptable limit	364	180	No. of samples where no metal found above acceptable limit	3605	2058
No. of stations where at least one metal found above acceptable limit	124	508	No. of samples where at least one metal found above acceptable limit	210	1055
Total stations under study	**488**	**688**	**Total stations under study**	**3815**	**3113**

9. MEASURES & WAY FORWARD

Metal contamination is a serious problem that needs immediate attention to protect our environment. Below are some measures and ways to move forward with tackling metal contamination:

1. **Continued Surveillance & Analysis:** Conduct regular water quality testing to identify the specific trace and toxic metals present in the river water. This information will help to design an appropriate mitigation strategy.
2. **Identify pollution sources:** At the first stage, it is important to identify the sources of metal pollution to prevent further contamination of rivers.
3. **Control measures for the release of pollutants to rivers:** various control measures can be implemented to mitigate the release of pollutants into rivers, promoting sustainable water quality. These measures encompass a range of strategies:
   - The effluent treatment system can be improved by enhancing both the treatment processes and the overall management of wastewater discharge. This may involve upgrading existing treatment facilities, adopting advanced technologies, and implementing stringent monitoring protocols. Additionally, exploring new metal technologies for water treatment and incorporating innovative approaches to enhance the efficiency and effectiveness of water treatment processes is necessary. It involves staying abreast of advancements in technology to continually improve the treatment of water contaminated with metals.
   - Agricultural field practices related to irrigation can be enhanced to minimize the introduction of metal contaminants into rivers. This may include adopting precision irrigation techniques, optimizing fertilizer usage, and promoting sustainable farming practices.
   - Recycling and reuse of wastewater after proper treatment can be implemented to reduce the overall demand for freshwater resources and prevent the discharge of untreated or inadequately treated wastewater into rivers.
   - Research studies on metal pollution in sediment can be conducted to gain a deeper understanding of the dynamics and sources of metal accumulation.
   - Heavy metals can be removed through various methods such as chemical-based filtration, electrochemical treatments, membrane-based processes, biosorbents, etc. These techniques aim to selectively extract or neutralize metal pollutants from water, ensuring cleaner discharge.
   - Controlling the release of metals from soils through excavation, in-situ fixing or/and phytoremediation practices can be implemented. These methods target contaminated soil, preventing the further leaching of metals into rivers.

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11. ANNEXURE I

List of 488 Water Quality Monitoring Stations

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
1	A.B. Road Crossing	no metals found above limit	Madhya Pradesh	Guna	Ganga	Yamuna/Chambal/Parwati	24.37	77.10
2	A.P. Puram	Fe	Tamil Nadu	Tirunelveli	East Flowing Rivers between Pen-nar and Kanyakumari	Tambraparani/ Chittar	8.90	77.65
3	Addoor	no metals found above limit	Karnataka	Dakshina Kannada	West Flowing Rivers from Tadri to Kanyakumari	Gurupur	12.93	74.95
4	Agra (J.B.)	Ni	Uttar Pradesh	Agra (J.B)	Ganga	Yamuna	27.20	78.04
5	Agra (P.G.)	Ni	Uttar Pradesh	Agra (P.G)	Ganga	Yamuna	27.25	78.02
6	Aie NH Crossing	no metals found above limit	Assam	Barpeta	Brahmaputra	Aie	26.50	90.65
7	Akabarpur	no metals found above limit	Uttar Pradesh	Ambedkar Nagar	Ganga	Ganga/Chhoti Sarju	26.43	82.55
8	Akhnoor	no metals found above limit	Jammu & Kashmir	Jammu	Indus	Chenab	32.90	74.76
9	Akkihebbal	no metals found above limit	Karnataka	Mandya	Cauvery	Cauvery/Hemavati	12.60	76.40
10	Aklera	no metals found above limit	Rajasthan	Jhalawar	Ganga	Yamuna/Chambal/Kalisindh/Parwan	24.43	76.60
11	Alandurai	Pb, Ni, Fe	Tamil Nadu	Coimbatore	Cauvery	Cauvery/Noyyal	10.95	76.79
12	Alladupalli	no metals found above limit	Andhra Pradesh	Kadapa	Pennar	Pennar/Kunderu	14.72	78.67
13	Ambarampalayam	no metals found above limit	Tamil Nadu	Coimbatore	West Flowing Rivers from Tadri to Kanyakumari	Bharathapuzha/Kannadipuzha/ Aliyar	10.63	76.95
14	Ambari	Fe	West Bengal	Coochbehar	Brahmaputra	Brahmaputra/Torsa/Kaljani	26.42	89.54
15	Ambasamudram	Fe	Tamil Nadu	Theni	East Flowing Rivers between Pen-nar and Kanyakumari	Vaigai	9.93	77.51
16	Ankinghat	no metals found above limit	Uttar Pradesh	Kanpur Nagar	Ganga	Ganga	26.93	80.04
17	Anna Purna Ghat	no metals found above limit	Assam	Cachar	Meghna/Barak	Barak	24.83	92.79

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
18	Annavasal	no metals found above limit	Puducherry	Karaikal	Cauvery	Cauvery/Nattar	10.97	79.76
19	Arangaly	no metals found above limit	Kerala	Thrissur	West Flowing Rivers from Tadri to Kanyakumari	Periyar/Chalakudy	10.28	76.32
20	Arcot	no metals found above limit	Tamil Nadu	Ranipet	East Flowing Rivers between Pen-nar and Kanyakumari	Palar	12.91	79.33
21	Arnota	no metals found above limit	Uttar Pradesh	Agra	Ganga	Yamuna/Uttangan	27.96	78.36
22	Ashramam	Fe	Tamil Nadu	Kanyakumari	West Flowing Rivers from Tadri to Kanyakumari	Pazhayar	8.16	77.46
23	Augustmuni D/S	no metals found above limit	Uttarakhand	Rudraprayag	Ganga	Mandakani	30.39	79.02
24	Augustmuni U/S	no metals found above limit	Uttarakhand	Rudraprayag	Ganga	Mandakani	30.40	79.04
25	Auraiya	no metals found above limit	Uttar Pradesh	Auraiya	Ganga	Yamuna	26.43	78.36
26	Avarankuppam	Fe	Tamil Nadu	Vellore	East Flowing Rivers between Pen-nar and Kanyakumari	Palar	12.68	78.54
27	Avershe	no metals found above limit	Karnataka	Udupi	West Flowing Rivers from Tadri to Kanyakumari	Seetha	13.52	74.88
28	Ayilam	no metals found above limit	Kerala	Thiruvananthapu-ram	West Flowing Rivers from Tadri to Kanyakumari	Vamanapuram	8.72	76.85
29	Ayodhya	Cr	Uttar Pradesh	Ayodhya	Ganga	Ghaghra	26.81	82.21
30	Azmabad	Cr	Bihar	Bhagalpur	Ganga	Ganga	25.33	87.25
31	Bachhwara	no metals found above limit	Bihar	Begusarai	Ganga	Baya	25.57	85.88
32	Badar Pur Ghat	no metals found above limit	Assam	Karimganj	Meghna/Barak	Barak	24.87	92.52
33	Badatighat	no metals found above limit	Assam	Lakhimpur	Brahmaputra	Brahmaputra/Subansiri	26.93	93.96
34	Baghpat	Cd	Uttar Pradesh	Baghpat	Ganga	Yamuna	28.99	77.20
35	Bahalpur	no metals found above limit	Assam	Barpeta	Brahmaputra	Champamati	26.32	90.47

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
36	Bairgania	no metals found above limit	Bihar	Sitamarhi	Ganga	Lalbekia	26.67	85.25
37	Bakcha Chu	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta/Dikchu/BakchaChu	27.42	88.63
38	Baladoba	no metals found above limit	Assam	Dhubri	Brahmaputra	Brahmaputra/Sankosh (Ganghadhar)	26.02	89.83
39	Baleni U/S of Gha-ziabad	no metals found above limit	Uttar Pradesh	Baghpat	Ganga	Yamuna/Hindon	28.96	77.47
40	Balighat	Fe	Assam	Lakhimpur	Brahmaputra	Brahmaputra/Subansiri	27.10	94.16
41	Balijagaon	no metals found above limit	Assam	Dibrugarh	Brahmaputra	Brahmaputra/Buri Dihing	27.36	95.19
42	Balrampur	no metals found above limit	Uttar Pradesh	Balrampur	Ganga	Ghaghra/Rapti	27.45	82.21
43	Baltara	no metals found above limit	Bihar	Khagaria	Ganga	Ganga/Kosi	25.54	86.72
44	Baluaghat	no metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.42	83.18
45	Banda	Cr	Uttar Pradesh	Banda	Ganga	Yamuna/Ken	25.48	80.31
46	Bangapani (Mun-syari)	no metals found above limit	Uttarakhand	Pithoragarh	Ganga	Mahalai/Gauri Ganga	29.96	80.30
47	Banglabasti	no metals found above limit	Assam	Nagaon	Brahmaputra	Harianadi	26.20	92.67
48	Banjari	no metals found above limit	Bihar	Rohtas	Ganga	Sone	25.67	84.00
49	Banka	no metals found above limit	Bihar	Banka	Ganga	Chandan	26.11	86.55
50	Banpur	As,Fe	West Bengal	Nadia	Ganga	Padma/Mathabhanga	24.11	87.8
51	Bansi	Hg	Uttar Pradesh	Siddarthnagar	Ganga	Ghaghra/Rapti	27.18	82.93
52	Bantwal	no metals found above limit	Karnataka	Dakshina Kannada	West Flowing Rivers from Tadri to Kanyakumari	Nethravathi	12.88	75.04
53	Baranwada	no metals found above limit	Rajasthan	Sawai-madhopur	Ganga	Yamuna/ Chambal/Banas	26.00	76.67
54	Bareilly	Pb	Uttar Pradesh	Bareilly	Ganga	Ganga/Ramganga	28.30	79.37

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
55	Barobisha	no metals found above limit	West Bengal	Alipurduar	Brahmaputra	Brahmaputra / Sankosh / Raidak-II	26.47	89.79
56	Barod	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/Chambal/Kalisindh	25.38	76.33
57	Basantpur (Ganga)	no metals found above limit	Uttar Pradesh	Bijnaur	Ganga	Ganga	28.43	79.35
58	Basoda	no metals found above limit	Madhya Pradesh	Vidisha	Ganga	Yamuna/Betwa	23.88	77.92
59	Basti	no metals found above limit	Uttar Pradesh	Basti	Ganga	Ghaghra/Kwano	26.78	82.71
60	Basti D/S	no metals found above limit	Uttar Pradesh	Basti	Ganga	Ghaghra/Kwano	26.77	82.73
61	Basti U/S	no metals found above limit	Uttar Pradesh	Basti	Ganga	Ghaghra/Kwano	26.80	82.71
62	Beki Road Bridge	no metals found above limit	Assam	Barpeta	Brahmaputra	Beki	26.49	90.92
63	Belne Bridge	Hg	Maharashtra	Sindudurg	West Flowing Rivers from Tapi to Tadri	Gad	16.22	73.61
64	Bendrahalli	no metals found above limit	Karnataka	Chamarajanagar	Cauvery	Cauvery/Suvarnavathi	12.15	76.08
65	Berhampore	Fe	West Bengal	Murshidabad	Ganga	Bhagirathi	24.09	88.24
66	Bhadana Village D/s of Kota City	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/Chambal/Parwati	25.24	75.88
67	Bhalukpong	Fe	Arunachal Pra-desh	West Kameng	Brahmaputra	Brahmaputra/Jiabharali	27.02	92.64
68	Bhind	no metals found above limit	Madhya Pradesh	Bhind	Ganga	Yamuna/Sind/Kunwari	26.62	78.84
69	Bhitaura	no metals found above limit	Uttar Pradesh	Fatehpur	Ganga	Ganga	26.04	80.85
70	Bhitoor	no metals found above limit	Uttar Pradesh	Kanpur	Ganga	Ganga	26.62	80.28
71	Bhomoraguri	Fe	Assam	Sonitpur	Brahmaputra	Brahmaputra	26.61	92.86

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
72	Bigod	no metals found above limit	Rajasthan	Bhilwara	Ganga	Yamuna/ Chambal/Banas	25.25	75.04
73	Bihubar	Fe	Assam	Sivasagar	Brahmaputra	Brahmaputra/Dikhow	26.86	94.80
74	Biligundulu	no metals found above limit	Tamil Nadu	Krishnagiri	Cauvery	Cauvery	12.18	77.72
75	Birdghat	Cr	Uttar Pradesh	Gorakhpur	Ganga	Ghaghra/Rapti	26.74	83.34
76	Biswanath Ghat	no metals found above limit	Assam	Biswanath	Brahmaputra	Brahmaputra	26.66	93.17
77	Bogibeel	Fe	Assam	Dibrugarh	Brahmaputra	Brahmaputra	27.40	94.79
78	Bokajan	no metals found above limit	Assam	Karbi Anglong	Brahmaputra	Brahmaputra/Dhansiri (South)	26.02	93.79
79	Bop	no metals found above limit	Sikkim	West Sikkim	Brahmaputra	Lachung Chu	27.61	88.66
80	Buxar	no metals found above limit	Bihar	Buxar	Ganga	Ganga	25.58	83.97
81	Byaladahalli	Hg	Karnataka	Davanagere	Krishna	Krishna/Tungabhadra/ Haridra	14.43	75.78
82	Byrnihat	Fe	Meghalaya	Ri-Bhoi	Brahmaputra	Umtru/ Brahmaputra	26.04	91.87
83	C.S-97 A, Farakka	Fe	West Bengal	Murshidabad	Ganga	Ganga	24.79	87.94
84	Chaklagaon	no metals found above limit	Assam	Bongaigaon	Brahmaputra	Manas	26.38	90.81
85	Champasari	no metals found above limit	West Bengal	Darjeeling	Ganga	Ganga/Mahananda	26.74	88.42
86	Chandrika Devi	no metals found above limit	Uttar Pradesh	Lucknow	Ganga	Gomti	26.93	80.86
87	Changsari	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Kurijani	26.25	91.66
88	Chapra	As	West Bengal	Nadia	Ganga	Bhagirathi/Jalangi	23.50	88.55
89	Chel	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/ Teesta/Chel	26.86	88.64
90	Chengalpet	no metals found above limit	Tamil Nadu	Chengalpet	East Flowing Rivers between Pen-nar and Kanyakumari	Palar	12.65	79.95

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
91	Chenimari	no metals found above limit	Assam	Dibrugarh	Brahmaputra	Brahmaputra/Buridehing	27.31	94.88
92	Chennur	no metals found above limit	Andhra Pradesh	Kadapa	Pennar	Pennar	14.57	78.80
93	Chepan	no metals found above limit	West Bengal	Alipurduar	Brahmaputra	Brahmaputra/ Torsa/Raidak-I	26.49	89.70
94	Chhatnag Allahabad	no metals found above limit	Uttar Pradesh	Prayagraj	Ganga	Ganga	25.39	81.92
95	Chittorgarh	no metals found above limit	Rajasthan	Chittorgarh	Ganga	Yamuna/Chambal/Banas/Gambhiri	24.87	74.64
96	Cholachugudda	Hg	Karnataka	Bagalkot	Krishna	Krishna/Malaprabha	15.87	75.72
97	Chopan	no metals found above limit	Uttar Pradesh	Sonbhadra	Ganga	Ganga/Sone	24.53	83.02
98	Chotogorjan/Kaliajari	no metals found above limit	Assam	Morigaon	Brahmaputra	Udori	26.28	92.19
99	Chouldhowaghat	Fe	Assam	Lakhimpur	Brahmaputra	Brahmaputra/Subansiri	27.45	94.25
100	Chowkhamghat	no metals found above limit	Assam	Lohit	Brahmaputra	Brahmaputra/Lohit	27.85	96.03
101	Chujachen (Rangpo Chu)	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta/Rangpo-Chu	27.24	88.71
102	Chujachen (Rongli Chu)	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta/ Rongli-Chu	27.21	88.72
103	Chunchankatte	no metals found above limit	Karnataka	Mysuru	Cauvery	Cauvery	12.51	76.30
104	Coronation	no metals found above limit	West Bengal	Darjeeling	Brahmaputra	Brahmaputra/ Teesta	26.90	88.47
105	D.R. F	no metals found above limit	Assam	Baksa (BTAD)	Brahmaputra	Puthimari	26.78	91.69
106	Dabri	Cr	Uttar Pradesh	Shahjahanpur	Ganga	Ramganga	27.50	79.70
107	Dadahu (Renuka)	no metals found above limit	Himachal Pradesh	Sirmaur	Ganga	Yamuna/Giri	30.60	77.44

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
108	Dadri	no metals found above limit	Haryana	Jhajjar	Ganga	Yamuna/Sahibi	28.52	76.76
109	Dawki	no metals found above limit	Meghalaya	Jaintia Hills	Meghna/Barak	Meghna/Umngot	25.19	92.02
110	Delhi Railway Bridge	Cd, Fe	Delhi	North Delhi	Ganga	Yamuna	28.66	77.25
111	Devprayag(G)	no metals found above limit	Uttarakhand	Pauri Garhwal	Ganga	Ganga	30.14	78.60
112	Desangpani	Fe	Assam	Sivasagar	Brahmaputra	Brahmaputra	27.05	94.91
113	Dhamkund	no metals found above limit	Jammu & Kashmir	Ramban	Indus	Chenab	33.24	75.15
114	Dhaneta	As, Hg	Uttar Pradesh	Bareilly	Ganga	Ramganga / Bahgul	28.42	79.81
115	Dhansa	no metals found above limit	Delhi	South West Delhi	Ganga	Yamuna/Sahibi	28.54	76.87
116	Dharamtul	Fe	Assam	Morigaon	Brahmaputra	Brahmaputra/Kopili	26.16	92.35
117	Dhareri	no metals found above limit	Madhya Pradesh	Ujjain	Ganga	Yamuna/ Chambal	23.13	75.51
118	Dheng Bridge	no metals found above limit	Bihar	Sitamarhi	Ganga	Ganga/Kosi/Bagmati	26.72	85.33
119	Dherabhabari/ Simul-tala	no metals found above limit	Assam	Morigaon	Brahmaputra	Pokoriya	26.25	92.13
120	Dholabazar	no metals found above limit	Assam	Tinsukia	Brahmaputra	Brahmaputra/Lohit	27.79	95.60
121	Dholai	no metals found above limit	Assam	Cachar	Meghna/Barak	Barak/Rukni	24.59	92.84
122	Dholpur	no metals found above limit	Rajasthan	Dholpur	Ganga	Yamuna/Chambal	26.66	77.90
123	Dhubri	no metals found above limit	Assam	Barpeta	Brahmaputra	Brahmaputra	26.01	89.99
124	Diana	Fe	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/ Jaldhaka/Diana	26.86	89.00
125	Dibrugarh	Fe	Assam	Dibrugarh	Brahmaputra	Brahmaputra	27.50	94.91
126	Dickchu	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta	27.42	88.51

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
127	Dihingmukh	no metals found above limit	Assam	Sivasagar	Brahmaputra	Brahmaputra/Buri Dihing	27.26	94.74
128	Dillighat	no metals found above limit	Assam	Dibrugarh	Brahmaputra	Brahmaputra/Desang	27.14	95.37
129	Dimapara	no metals found above limit	Meghalaya	South Garo Hills	Meghna/Barak	Meghna/Bugi	25.23	90.25
130	Diprang Gaon	Fe	Assam	Morigaon	Brahmaputra	Kolong	26.18	92.10
131	Dobhi	no metals found above limit	Bihar	Gaya	Ganga	Phalgu	24.52	84.94
132	Doimukh	Fe	Arunachal Pradesh	Papumpare	Brahmaputra	Brahmaputra/Dikrong	27.14	93.75
133	Domohani	Fe	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/ Teesta	26.56	88.76
134	Doomduma	no metals found above limit	Assam	Tinsukia	Brahmaputra	Brahmaputra/Dibru	27.57	95.55
135	Duddhi	no metals found above limit	Uttar Pradesh	Sonbhadra	Ganga	Ganga/Kanhar	24.23	83.27
136	Dudhnoi	no metals found above limit	Assam	Goalpara	Brahmaputra	Dhudnoi	25.98	90.79
137	Ebranli	no metals found above limit	Arunachal Pradesh	Lower Dibang Valley	Brahmaputra	Brahmaputra/Dibang	28.38	95.93
138	Ekmighat	no metals found above limit	Bihar	Darbhanga	Ganga	Ganga/Kosi/Bagmati/Adhwara	26.12	85.88
139	Elginbridge	Hg	Uttar Pradesh	Barabanki	Ganga	Ganga/Ghaghra	27.10	81.48
140	Elunuthimangalam	no metals found above limit	Tamil Nadu	Erode	Cauvery	Cauvery/Noyyal	11.03	77.89
141	Englishbazar	Fe	West Bengal	Malda	Ganga	Padma/Mahananda	25.01	88.15
142	Erinjipuzha	Fe	Kerala	Kasargod	West Flowing Rivers from Tadri to Kanyakumari	Payaswani	12.48	75.15
143	Etawah	no metals found above limit	Uttar Pradesh	Etawah	Ganga	Yamuna	26.75	78.99
144	Faizabad U/S	no metals found above limit	Uttar Pradesh	Faizabad	Ganga	Ghaghra	26.78	82.08

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
145	Fakirabazar	no metals found above limit	Assam	Karimganj	Meghna/Barak	Kushiyara/Longai	24.85	92.35
146	Farakka/(HR)	Fe	West Bengal	Murshidabad	Ganga	Feeder Canal	24.80	87.93
147	Fatehgarh	no metals found above limit	Uttar Pradesh	Farukhabad	Ganga	Ganga	27.40	79.63
148	Fulertal	no metals found above limit	Assam	Cachar	Meghna/Barak	Barak	24.79	93.02
149	Gadwa road	no metals found above limit	Jharkhand	Palamu	Ganga	North Koel	24.21	83.88
150	Gaisabad	no metals found above limit	Madhya Pradesh	Damoh	Ganga	Yamuna/Ken/Bearma	24.24	79.84
151	Galeta	no metals found above limit	Uttar Pradesh	Bhagpat	Ganga	Yamuna/ Hindon	29.08	77.44
152	Gandhavayal	Fe, Pb	Tamil Nadu	Coimbatore	Cauvery	Cauvery/Gandhayar	11.37	76.99
153	Gandhighat	no metals found above limit	Bihar	Patna	Ganga	Ganga	25.62	85.17
154	Ganguwala	no metals found above limit	Himachal Pradesh	Sirmaur	Ganga	Yamuna/Bata	30.44	77.58
155	Garhakota	no metals found above limit	Madhya Pradesh	Sagar	Ganga	Yamuna/Ken/Sonar	23.78	79.14
156	Garhmukteshwar	As, Cr	Uttar Pradesh	Hapur	Ganga	Ganga	28.77	78.14
157	Garrauli	no metals found above limit	Madhya Pradesh	Chhatarpur	Ganga	Yamuna/Betwa/Dhasan	25.08	79.34
158	Gaya	no metals found above limit	Bihar	Gaya	Ganga	Ganga/Phalgu	24.77	85.02
159	Gazoldoba	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/ Teesta	26.75	88.59
160	Gelabil	no metals found above limit	Assam	Sivasagar	Brahmaputra	Brahmaputra/Dhansiri (South)/Doyang	26.24	93.98
161	Ghat	no metals found above limit	Uttarakhand	Pithoragarh	Ganga	Ghaghra/Sharda/Sarju	29.50	80.13
162	Ghazipur	no metals found above limit	Uttar Pradesh	Ghazipur	Ganga	Ganga	25.59	83.61

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
163	Ghish	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/ Teesta/Ghish	26.87	88.61
164	Ghugumari	no metals found above limit	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/ Torsa	26.29	89.46
165	Goalpara	no metals found above limit	Assam	Goalpara	Brahmaputra	Brahmaputra	26.20	90.58
166	Gokak Falls	no metals found above limit	Karnataka	Belgaum	Krishna	Krishna/Ghatprabha	16.17	74.80
167	Gokul Barrage D/S of Mathura	As	Uttar Pradesh	Mathura	Ganga	Yamuna	27.44	77.71
168	Golaghat	Fe	Assam	Golaghat	Brahmaputra	Brahmaputra/Dhansiri (South)	26.50	93.95
169	Golokganj	no metals found above limit	Assam	Dhubri	Brahmaputra	Brahmaputra/Sankosh	26.11	89.82
170	Gomti Nagar	no metals found above limit	Uttar Pradesh	Lucknow	Ganga	Gomti	26.82	80.01
171	Gopurajapuram	no metals found above limit	Tamil Nadu	Nagapattinam	Cauvery	Cauvery/Puravidaiyanar	10.85	79.80
172	Gorakhpur D/S	no metals found above limit	Uttar Pradesh	Gorakhpur	Ganga	Ghaghra/Rapti	26.71	83.35
173	Gorakhpur U/S	no metals found above limit	Uttar Pradesh	Gorakhpur	Ganga	Ghaghra/Rapti	26.75	83.32
174	Guma Phoolbari (Tarabari)	no metals found above limit	Assam	Barpeta	Brahmaputra	Brahmaputra	26.26	91.12
175	Gummanur	Fe	Tamil Nadu	Krishnagiri	East Flowing Rivers between Pen-nar and Kanyakumari	Ponnaiyar	12.56	78.14
176	Gumrabazar	no metals found above limit	Assam	Cachar	Meghna/Barak	Meghna/Surma/Gumra	25.01	92.51
177	Gutang	no metals found above limit	Assam	Tinsukia	Brahmaputra	Brahmaputra/Dibru	27.57	95.37
178	Guwahati D.C Court	Fe	Assam	Kamrup(Metro)	Brahmaputra	Brahmaputra	26.19	91.75
179	Halady	no metals found above limit	Karnataka	Udupi	West Flowing Rivers from Tadri to Kanyakumari	Halady	13.58	74.86

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
180	Hamirpur	no metals found above limit	Uttar Pradesh	Hamirpur	Ganga	Yamuna	25.96	80.15
181	Hanskhali	As	West Bengal	Nadia	Ganga	Bhagirathi/Churni	23.36	88.61
182	Haralahalli	Hg	Karnataka	Haveri	Krishna	Krishna/Tungabhadra	14.83	75.67
183	Haridwar	no metals found above limit	Uttarakhand	Haridwar	Ganga	Ganga	29.98	78.19
184	Haridwar D/S	no metals found above limit	Uttarakhand	Haridwar	Ganga	Ganga	29.96	78.17
185	Haridwar U/S	no metals found above limit	Uttarakhand	Haridwar	Ganga	Ganga	29.97	78.18
186	Hariharapura	Ni	Karnataka	Chikmagalur	Krishna	Krishna/Tungabhadra/Tunga	13.52	75.30
187	Haripur	no metals found above limit	Uttarakhand	Dehradun	Ganga	Yamuna/ Tons	30.54	77.83
188	Hasimara	no metals found above limit	West Bengal	Alipurduar	Brahmaputra	Brahmaputra/ Torsa	26.73	89.32
189	Hathidah	no metals found above limit	Bihar	Patna	Ganga	Ganga	25.37	85.99
190	Hathikhana	As	Uttar Pradesh	Fatehgarh	Ganga	Ganga	27.35	79.64
191	Hayaghat	Cr	Bihar	Darbhanga	Ganga	Ganga/Kosi/Bagmati	26.04	85.89
192	Hayuliang	no metals found above limit	Arunachal Pra-desh	Anjaw	Brahmaputra	Brahmaputra/Lohit	28.07	96.55
193	Hogenakkal	Fe	Tamil Nadu	Dharmapuri	Cauvery	Cauvery/Chinnar	12.12	77.79
194	Holehonnur	no metals found above limit	Karnataka	Shimoga	Krishna	Krishna/Tungabhadra/ Bhadra	13.98	75.69
195	Honnali	no metals found above limit	Karnataka	Davangere	Krishna	Krishna/Tungabhadra	14.24	75.66
196	Hoovinahole	no metals found above limit	Karnataka	Chitradurga	Krishna	Krishna/Swarnamukhi	14.98	76.75
197	Irrukkankudi	no metals found above limit	Tamil Nadu	Virudhunagar	East Flowing Rivers between Pen-nar and Kanyakumari	Vaigai/Vaippar	9.32	77.99
198	Jagibhakatgaon	Fe	Assam	Morigaon	Brahmaputra	Brahmaputra/ Kopili	26.16	92.22
199	Jagunghat	no metals found above limit	Assam	Tinsukia	Brahmaputra	Brahmaputra/Buri Dihing	27.40	95.89

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
200	Jai Nagar	no metals found above limit	Bihar	Madhubani	Ganga	Ganga/Kosi/Kamla-Balan	26.59	86.15
201	Jaigaon	no metals found above limit	West Bengal	Alipurduar	Brahmaputra	Teesta/Torsa	26.85	89.37
202	Jairampur	no metals found above limit	Arunachal Pradesh	Changlang	Brahmaputra	Brahmaputra/Buri Dihing	27.35	96.03
203	Jajmau	no metals found above limit	Uttar Pradesh	Kanpur	Ganga	Ganga	26.41	80.44
204	Jaldhaka NH-31	Pb	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/Jaldhaka	26.57	88.94
205	Jammu (Sidhra)	no metals found above limit	Jammu & Kashmir	Jammu	Indus	Chenab/Tawi	32.76	74.88
206	Japla	no metals found above limit	Jharkhand	Palamu	Ganga	Ganga/Sone	24.57	83.98
207	Jaunpur	no metals found above limit	Uttar Pradesh	Jaunpur	Ganga	Gomti	25.74	82.69
208	Jhanjharpur	no metals found above limit	Bihar	Madhubani	Ganga	Ganga/Kosi/Kamla-Balan	26.22	86.26
209	Jhanji/Teok	no metals found above limit	Assam	Jorhat	Brahmaputra	Jhanji	26.85	94.49
210	Jhansi- Mirjapur Highway Road Bridge D/S of Sahijna	no metals found above limit	Uttar Pradesh	Hamirpur	Ganga	Betwa	25.94	80.16
211	Jiabharali NT Road - Xing	Fe	Assam	Lakhimpur	Brahmaputra	Jiabharali	26.81	92.88
212	K.M. Vadi	no metals found above limit	Karnataka	Mysuru	Cauvery	Cauvery/Lakshmanthirtha	12.35	76.29
213	Kabirganj	As	Uttar Pradesh	Pilibhit	Ganga	Rapti	28.50	80.38
214	Kachlabridge	As, Hg	Uttar Pradesh	Badaun	Ganga	Ganga	27.93	78.86
215	Kailash Mandir Benpur U/S of Agra	Ni	Uttar Pradesh	Agra	Ganga	Yamuna	27.24	77.93
216	Kakarghatti	Cd, Fe	Bihar	Darbhanga	Ganga	Kamla Balan	26.18	85.95
217	Kakripara	no metals found above limit	Assam	Southsalmara-Mankachar	Brahmaputra	Nadi(Jinjiram)	25.51	89.87

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Latitude (E)	Longitude (N)
218	Kalampur	Fe	Kerala	Ernakulam	West Flowing rivers from Tadri to Kanyakumari	Muvattupuzha/ Kaliyar	9.99	76.63
219	Kalanaur	no metals found above limit	Uttar Pradesh	Saharanpur	Ganga	Yamuna	30.07	77.35
220	Kallooppara	no metals found above limit	Kerala	pathanamthitta	West Flowing Rivers from Tadri to Kanyakumari	Pamba/Manimala	9.40	76.65
221	Kalna (EBB)	Fe	West Bengal	Purba Bardhaman	Ganga	Bhagirathi	23.23	88.37
222	Kalna (Flow)	Fe	West Bengal	Purba Bardhaman	Ganga	Bhagirathi	23.23	88.37
223	Kalpi	no metals found above limit	Uttar Pradesh	Jalaun	Ganga	Yamuna	26.13	79.76
224	Kamalapuram	no metals found above limit	Andhra Pradesh	Kadapa	Pennar	Pennar/Papagani	14.58	78.68
225	Kampur	Fe	Assam	Nagaon	Brahmaputra	Brahmaputra/ Kopili	26.15	92.66
226	Kannauj	As	Uttar Pradesh	Kannauj	Ganga	Ganga	27.01	79.98
227	Kanpur	no metals found above limit	Uttar Pradesh	Kanpur Nagar	Ganga	Ganga	26.47	80.38
228	Kanti	no metals found above limit	Bihar	Muzaffarpur	Ganga	Burhi Gandak	26.27435	85.30232
229	Karathodu	no metals found above limit	Kerala	Malappuram	West Flowing Rivers from Tadri to Kanyakumari	Kadalundi	11.06	76.04
230	Karnal	no metals found above limit	Haryana	Karnal	Ganga	Yamuna	29.76	77.13
231	Karnaprayag	no metals found above limit	Uttarakhand	Chamoli	Ganga	Pinder	30.26	79.22
232	Karnaprayag Confluence D/S	no metals found above limit	Uttarakhand	Chamoli	Ganga	Alakananda	30.26	79.22
233	Karnaprayag Confluence U/S	no metals found above limit	Uttarakhand	Chamoli	Ganga	Alakananda	30.26	79.22
234	Kasganj	As, Ni	Uttar Pradesh	Etah	Ganga	Kali	27.79	78.63
235	Katri Umrauli	no metals found above limit	Uttar Pradesh	Kannauj	Ganga	Ganga	27.15	79.88
236	Katwa	Fe	West Bengal	Purba Bardhaman	Ganga	Bhagirathi	23.64	88.15

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
237	Kazipura	no metals found above limit	Uttar Pradesh	Moradabad	Ganga	Gomti	28.99	78.74
238	Kellodu	no metals found above limit	Karnataka	Chitradurga	Krishna	Krishna/Tungabhadra/Vedavathi	13.75	76.32
239	Khanitar	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Brahmaputra/ Teesta	27.18	88.51
240	Kharkhana	no metals found above limit	Meghalaya	West Jaintia Hills	Meghna/Barak	Myntdu/ Meghna	25.16	92.21
241	Khatoli	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/Chambal/Parwati	25.68	76.48
242	Kheronighat	no metals found above limit	Assam	Karbi Anglong	Brahmaputra	Brahmaputra/ Kopili	25.85	92.89
243	Khudrakhowa	no metals found above limit	Assam	Barpeta	Brahmaputra	Manas	26.31	90.75
244	Kidangoor	Cu	Kerala	kottayam	West Flowing Rivers from Tadri to Kanyakumari	Meenachil	9.68	76.61
245	Kirtinagar D/S	no metals found above limit	Uttarakhand	Tehri	Ganga	Alaknanda	30.23	78.73
246	Kirtinagar U/S	no metals found above limit	Uttarakhand	Tehri	Ganga	Alaknanda	30.23	78.77
247	Kodumudi	no metals found above limit	Tamil Nadu	Erode	Cauvery	Cauvery	11.08	77.89
248	Koelwar	Pb	Bihar	Bhojpur	Ganga	Ganga/Sone	25.57	84.80
249	Kokkedoddy	no metals found above limit	Karnataka	Mandya	Cauvery	Cauvery/Arkavathy	12.30	77.44
250	Kokrajhar	no metals found above limit	Assam	Kokrajhar	Brahmaputra	Gaurang	26.40	90.25
251	Kollegal	no metals found above limit	Karnataka	Chamarajanagar	Cauvery	Cauvery	12.19	76.10
252	Kora	no metals found above limit	Uttar Pradesh	Fatehpur	Ganga	Yamuna/Rind	26.11	80.05

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Latitude (E)	Longitude (N)
253	Kota-By Pass Hanging Road Bridge u/s of Kota City	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/Chambal/Parwati	25.14	75.80
254	Koteshwar	no metals found above limit	Uttarakhand	Tehri	Ganga	Ganga/Bhagirath	30.33	78.49
255	Krishnabihari/Machaigaon	no metals found above limit	Assam	Golaghat	Brahmaputra	Dirai	27.07	94.79
256	Krishnai	no metals found above limit	Assam	Goalpara	Brahmaputra	Krishnai	26.03	90.67
257	Kudalaiyathur	no metals found above limit	Tamil Nadu	Cuddalore	East Flowing Rivers between Pennar and Kanyakumari	Vellar	11.42	79.47
258	Kudige	no metals found above limit	Karnataka	Kodagu	Cauvery	Cauvery	12.50	75.96
259	Kudlur	Pb,Ni,Fe	Karnataka	Chamarajanagara	Cauvery	Cauvery/Palar	11.84	77.46
260	Kuldah Bridge	no metals found above limit	Madhya Pradesh	Sidhi	Ganga	Ganga/Sone	24.41	81.70
261	Kulsi	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Kulsi	25.98	91.39
262	Kumarapalayam	no metals found above limit	Puducherry	Puducherry	East Flowing Rivers between Pennar and Kanyakumari	Varahanadhi	11.98	79.68
263	Kumbidi	Pb,Fe	Kerala	Palakkad	West Flowing Rivers from Tadri to Kanyakumari	Bharathapuzha	10.85	76.02
264	Kuniyil	no metals found above limit	Kerala	Malappuram	West Flowing Rivers from Tadri to Kanyakumari	Chaliyar	11.24	76.02
265	Kuppellur	Hg	Karnataka	Haveri	Krishna	Krishna/Tungabhadra/Kumudavathi	14.50	75.63
266	Kurua/Polaguri	no metals found above limit	Assam	Darrang	Brahmaputra	Brahmaputra	26.43	92.31
267	Kuruabahi/Ririgaon	no metals found above limit	Assam	Golaghat	Brahmaputra	Dhansiri (South)	26.67	93.69
268	Kusumbil (Nayachara)	no metals found above limit	Assam	Kokrajhar	Brahmaputra	Tipkai	26.42	90.11

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
269	Kuthnuor	no metals found above limit	Uttarakhand	Uttarkashi	Ganga	Yamuna	30.87	78.30
270	Kuttyadi	no metals found above limit	Kerala	Kozhikode	West Flowing Rivers from Tadri to Kanyakumari	Kuttyadi	11.63	75.78
271	Kuzhithurai	no metals found above limit	Tamil Nadu	Kanyakumari	West Flowing Rivers from Tadri to Kanyakumari	Thambraparni	8.31	77.19
272	Labha	Fe	Bihar	Katihar	Ganga	Mahananda (Fulahar)	24.88	87.70
273	Lachen	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta/Lachen Chu	27.71	88.56
274	Lakhisarai	no metals found above limit	Bihar	Lakhisarai	Ganga	Ganga/Kiul	25.18	86.10
275	Lakhoura	no metals found above limit	Bihar	Muzaffarpur	Ganga	Kachhua	25.72	85.63
276	Lakkavalli	no metals found above limit	Karnataka	Chikmagalur	Krishna	Krishna/Tungabhadra/ Bhadra	13.71	75.65
277	Lakshmananpatti	no metals found above limit	Tamil Nadu	Dindigul	Cauvery	Cauvery/Kodaganar	10.50	77.95
278	Lalganj	no metals found above limit	Bihar	Vaishali	Ganga	Ganga/Gandak	25.85	85.15
279	Lalpur	no metals found above limit	Uttar Pradesh	Kanpur Dehat	Ganga	Yamuna/Sengar	26.31	79.92
280	Laven	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta/Talangchu	27.54	88.49
281	Ligribari/B. G Road	no metals found above limit	Assam	Sivasagar	Brahmaputra	Brahmaputra/Pakaria	26.07	94.53
282	Lingdem Hot Spring	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta/Talangchu	27.53	88.47
283	Lucknow	Cd	Uttar Pradesh	Lucknow	Ganga	Ganga/Gomti	26.86	80.95
284	M.H. Halli	no metals found above limit	Karnataka	Hassan	Cauvery	Cauvery/Hemavathi	12.82	76.13
285	Madamon	Fe	Kerala	pathanamthitta	West Flowing Rivers from Tadri to Kanyakumari	Pamba	9.36	76.84

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
286	Madla	no metals found above limit	Madhya Pradesh	Panna	Ganga	Yamuna/Ken	24.73	80.01
287	Magaral	no metals found above limit	Tamil Nadu	Kancheepuram	East Flowing Rivers between Pen-nar and Kanyakumari	Palar/Cheyyar	12.71	79.75
288	Mahidpur	no metals found above limit	Madhya Pradesh	Ujjain	Ganga	Yamuna/ Chambal/Shipra	23.48	75.64
289	Maighat	no metals found above limit	Uttar Pradesh	Jaunpur	Ganga	Ganga/Gomti	25.64	82.86
290	Malakkara	Fe	Kerala	Pathanamthitta	West Flowing Rivers from Tadri to Kanyakumari	Pampa	9.33	76.66
291	Malibari	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Jaljoli	26.08	91.11
292	Manakkad	Pb, Fe	Kerala	Idukki	West Flowing Rivers from Tadri to Kanyakumari	Thodupuzha	9.91	76.70
293	Manas NH Crossing	no metals found above limit	Assam	Barpeta	Brahmaputra	Manas	26.46	90.75
294	Mandawara	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/ Chambal	25.39	76.15
295	Manderial	Cd	Rajasthan	Karauli	Ganga	Yamuna/ Chambal	26.27	77.28
296	Manghi	no metals found above limit	Bihar	Saran	Ganga	Ganga/Ghaghra	25.83	84.58
297	Mankara	Fe, Pb	Kerala	Palakkad	West Flowing Rivers from Tadri to Kanyakumari	Bharathapuzha	10.76	76.49
298	Margherita	Fe	Assam	Tinsukia	Brahmaputra	Brahmaputra/ Buridehing	27.28	95.66
299	Marol	Hg	Karnataka	Haveri	Krishna	Krishna/Tungabhadra/ Varada	14.94	75.62
300	Mathabhanga	no metals found above limit	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/Jaldhaka	26.33	89.24
301	Mathanguri Beki	no metals found above limit	Assam	Barpeta	Brahmaputra	Beki	26.78	90.96
302	Matigara	no metals found above limit	West Bengal	Darjeeling	Ganga	Ganga/Mahananda/Balason	26.72	88.38

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
303	Matijuri	no metals found above limit	Assam	Hailakandi	Meghna/Barak	Barak/Katakhal/ Dhaleshwari	24.65	92.61
304	Matunga	no metals found above limit	Assam	Baksa (BTAD)	Brahmaputra	Kalanadi	26.79	91.54
305	Mawi	no metals found above limit	Uttar Pradesh	Muzaffar Nagar	Ganga	Yamuna	29.38	77.15
306	Mehandipur	As	Uttar Pradesh	Kannauj	Ganga	Ganga	27.01	79.99
307	Meja Road	As	Uttar Pradesh	Allahabad	Ganga	Ganga/Tons	25.23	82.04
308	Mekhliganj Right Bank	no metals found above limit	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/ Teesta	26.33	88.86
309	Melli Bazar	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta River	27.09	88.45
310	Menangudi	no metals found above limit	Tamil Nadu	Thiruvarur	Cauvery	Cauvery/Noolar	10.95	79.70
311	Miao	no metals found above limit	Arunachal Pradesh	Changlang	Brahmaputra	Brahmaputra/Noa-dehing	27.50	96.22
312	Mirzapur	no metals found above limit	Uttar Pradesh	Mirzapur	Ganga	Ganga	25.15	82.53
313	Mohana (Betwa)	no metals found above limit	Uttar Pradesh	Jalaun	Ganga	Yamuna/Betwa	25.82	79.46
314	Mohana (Yamuna)	no metals found above limit	Haryana	Faridabad	Ganga	Yamuna	28.22	77.46
315	Moradabad	Ni	Uttar Pradesh	Moradabad	Ganga	Ganga/Ramganga	28.83	78.80
316	Murappanadu	Pb, Fe	Tamil Nadu	Tuticorin	East Flowing Rivers between Pennar and Kanyakumari	Tambraparni	8.71	77.84
317	Murti	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/Jaldhaka/Murti	26.84	88.83
318	Musiri	no metals found above limit	Tamil Nadu	Thiruchirapalli	Cauvery	Cauvery	10.94	78.44
319	Muthankera	no metals found above limit	Kerala	Wayanad	Cauvery	Cauvery/Kabini	11.81	76.08
320	Nagalamedike	no metals found above limit	Karnataka	Tumkur	Pennar	Pennar	14.19	77.37

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
321	Nagrakata	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/Jaldhaka	26.87	88.90
322	Naharkatia	Fe	Assam	Dibrugarh	Brahmaputra	Brahmaputra/ Buridehing	27.30	95.33
323	Naidupet	no metals found above limit	Andhra Pradesh	Nellore	East Flowing Rivers between Pennar and Kanyakumari	Swarnamukhi	13.95	79.90
324	Nallamaranpatty	Pb	Tamil Nadu	Karur	Cauvery	Cauvery/ Amaravathi	10.88	77.98
325	Nallathur	no metals found above limit	Puducherry	Karaikal	Cauvery	Cauvery/Nandalar	11.00	79.75
326	Namsai	Fe	Arunachal Pradesh	Namsai	Brahmaputra	Brahmaputra/ Noa-dehing	27.67	95.83
327	Nandipalli	no metals found above limit	Andhra Pradesh	Kadapa	Pennar	Pennar/Sagaileru	14.72	79.02
328	Nanglamoraghat	Fe	Assam	Sivasagar	Brahmaputra	Brahmaputra/ Disang	26.99	94.78
329	Naugaon	no metals found above limit	Uttarakhand	Uttarakashi	Ganga	Yamuna	30.79	78.14
330	Neamatighat	Fe	Assam	Jorhat	Brahmaputra	Brahmaputra	26.87	94.25
331	Neeleswaram	Fe	Kerala	Ernakulam	West Flowing Rivers from Tadri to Kanyakumari	Periyar	10.18	76.50
332	Neemsar	no metals found above limit	Uttar Pradesh	Sitapur	Ganga	Gomti	27.35	80.48
333	Nellipally	Cu, Pb	Kerala	Kollam	West Flowing Rivers from Tadri to Kanyakumari	Kallada	9.03	76.925 000
334	Nellithurai	Ni, Fe	Tamil Nadu	Coimbatore	Cauvery	Cauvery/Bhavani	11.29	76.89
335	Nellore	no metals found above limit	Andhra Pradesh	Nellore	Pennar	Pennar	14.47	79.99
336	Neora	no metals found above limit	West Bengal	Jalpaiguri	Brahmaputra	Brahmaputra/Teesta/ Naora	26.88	88.77
337	Nirmali	no metals found above limit	Bihar	Supaul	Ganga	Kosi	26.30	86.61
338	Noida D/S of Ghaziabad	no metals found above limit	Uttar Pradesh	Gautam Budh Nagar	Ganga	Yamuna/Hindon	28.60	77.42

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
339	Nona	no metals found above limit	Assam	Nalbari	Brahmaputra	Nona	26.44	91.56
340	Noukaghat	no metals found above limit	West Bengal	Jalpaiguri	Ganga	Ganga/Mahananda	26.69	88.41
341	Numaligarh	Fe	Assam	Golaghat	Brahmaputra	Brahmaputra/ Dhansiri(South)	26.63	93.73
342	Odandurai	Pb, Fe	Tamil Nadu	Coimbatore	Cauvery	Cauvery/Kallar	11.32	76.89
343	Orai -Rath Marg RoadBridge Chikasi U/S of Sahijna city	no metals found above limit	Uttar Pradesh	Jalaun	Ganga	Betwa	25.81	79.46
344	Pachauli	no metals found above limit	Madhya Pradesh	Shivpuri	Ganga	Yamuna/Sind	25.10	77.65
345	Pagladiya N.T. Road Crossing	no metals found above limit	Assam	Nalbari	Brahmaputra	Pagladiya	26.45	91.46
346	Palakadavu	Fe, Pb	Kerala	Thrissur	West Flowing Rivers from Tadri to Kanyakumari	Karuvannur	10.43	76.24
347	Pali	Cd	Rajasthan	Sawai-madhopur	Ganga	Yamuna/ Chambal	25.86	76.58
348	Paliakalan	no metals found above limit	Uttar Pradesh	Lakhimpur Khiri	Ganga	Ghaghra/Sharda	28.38	80.55
349	Palla U/S Delhi	no metals found above limit	Delhi	North West Delhi	Ganga	Yamuna	28.85	77.21
350	Panbari	no metals found above limit	Assam	Barpeta	Brahmaputra	Burisuti	26.59	90.83
351	Pancharatna	Fe	Assam	Goalpara	Brahmaputra	Brahmaputra	26.21	90.55
352	Pandu	no metals found above limit	Assam	Kamrup (Metro)	Brahmaputra	Brahmaputra	26.17	91.67
353	Paonta	no metals found above limit	Himachal Pradesh	Simaur	Ganga	Yamuna	30.43	77.62
354	Paramakudi	no metals found above limit	Tamil Nadu	Ramanathapuram	East Flowing Rivers between Pen-nar and Kanyakumari	Vaigai	9.55	78.59
355	Parmarth Ghat	no metals found above limit	Uttar Pradesh	Kanpur	Ganga	Ganga	26.49	80.34

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
356	Parshuramkund	no metals found above limit	Arunachal Pra-desh	Lohit	Brahmaputra	Brahmaputra/Lohit	27.88	96.36
357	Parsohan Ghat	no metals found above limit	Uttar Pradesh	Sidharthnagar	Ganga	Ratpi/Burhi Rapti	27.40	82.56
358	Pasighat	Fe	Arunachal Pra-desh	East Siang	Brahmaputra	Siang	28.07	95.34
359	Patacharkuchi	no metals found above limit	Assam	Barpeta	Brahmaputra	Kalodiya	26.51	91.24
360	Pattazhy	Fe	Kerala	Kollam	West Flowing Rivers from Tadri to Kanyakumari	Kallada	9.07	76.76
361	Peralam	no metals found above limit	Tamil Nadu	Thiruvarur	Cauvery	Cauvery/Vanjiyar	10.97	79.66
362	Perumannu	no metals found above limit	Kerala	Kannoor	West Flowing Rivers from Tadri to Kanyakumari	Valapatnam	11.98	75.59
363	Phurtshachu Hot Spring	no metals found above limit	Sikkim	Namchi	Brahmaputra	Teesta/Rangit	27.25	88.30
364	Pohumara	no metals found above limit	Assam	Goalpara	Brahmaputra	Brahmaputra	26.48	91.11
365	Porakudi	no metals found above limit	Tamil Nadu	Nagapattinam	Cauvery	Cauvery/Arasalar	10.90	79.71
366	Prang	no metals found above limit	Jammu & Kashmir	Gandarbal	Indus	Sind	34.26	74.78
367	Pratapgarh	no metals found above limit	Uttar Pradesh	Pratapgarh	Ganga	Gomti/Sai	25.93	82.00
368	Pratappur (Yamuna)	no metals found above limit	Uttar Pradesh	Allahabad	Ganga	Yamuna	25.30	81.57
369	Prem Nagar	no metals found above limit	Jammu & Kashmir	Doda	Indus	Chenab	33.16	75.70
370	Pudur	Fe	Kerala	Palakkad	West Flowing Rivers from Tadri to Kanyakumari	Bharathapuzha/ Kannadipuzha	10.78	76.58
371	Pulamanthole	Fe	Kerala	Palakkad	West Flowing Rivers from Tadri to Kanyakumari	Bharathapuzha/ Pulanthodu	10.90	76.20

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
372	Pulikukku	Fe	Karnataka	Dakshina Kannada	West Flowing Rivers from Tadri to Kanyakumari	Kumaradhara	12.71	75.47
373	Puthimari NH Road Crossing	no metals found above limit	Assam	Kamrup	Brahmaputra	Puthimari	26.37	91.65
374	Raebareli	no metals found above limit	Uttar Pradesh	Raebareli	Ganga	Gomti/Sai	26.20	81.25
375	Rajapur	no metals found above limit	Uttar Pradesh	Chitrakoot	Ganga	Yamuna	25.39	81.15
376	Rajghat (Yamuna)	Hg	Uttar Pradesh	Lalitpur	Ganga	Yamuna/Betwa	24.77	78.24
377	Ram Munshi Bagh	no metals found above limit	Jammu & Kashmir	Sirnagar	Indus	Jhelum	34.06	74.83
378	Ramamangalam	Fe	Kerala	Ernakulam	West Flowing Rivers from Tadri to Kanyakumari	Muvattupuzha	9.94	76.48
379	Ramdia	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Barsali	26.26	91.47
380	Ranganadi NT-Road crossing	Fe	Assam	Lakhimpur	Brahmaputra	Brahmaputra/ Ranganadi	27.20	94.06
381	Rangit Nagar	no metals found above limit	Sikkim	Namchi	Brahmaputra	Teesta/Rangit	27.30	88.31
382	Rangma Range	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta/Lachen Chu	27.60	88.62
383	Rangpo	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Brahmaputra/ Teesta/Rangpochu	27.17	88.53
384	Rangpo Check Post	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta/Rangpo Chu	27.17	88.53
385	Ranipool	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Ranikhola/Teesta	27.28	88.59
386	Regauli	no metals found above limit	Uttar Pradesh	Gorakhpur	Ganga	Ganga/Ghaghra	26.76	83.29
387	Rishikesh	no metals found above limit	Uttarakhand	Dehradun	Ganga	Ganga	30.10	78.30
388	Rishikesh D/S	no metals found above limit	Uttarakhand	Dehradun	Ganga	Ganga	30.08	78.29

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
389	Rishikesh U/S	no metals found above limit	Uttarakhand	Dehradun	Ganga	Ganga	30.13	78.33
390	Roorkee D/S	no metals found above limit	Uttarakhand	Haridwar	Ganga	Saloni	29.88	77.90
391	Roorkee U/S	no metals found above limit	Uttarakhand	Haridwar	Ganga	Saloni	29.89	77.89
392	Rothak (Jorthang)	no metals found above limit	Sikkim	Namchi	Brahmaputra	Teesta/Rangit	27.17	88.30
393	Rudraprayag (A)	no metals found above limit	Uttarakhand	Rudraprayag	Ganga	Alaknanda	30.29	78.98
394	Safapora	no metals found above limit	Jammu & Kashmir	Baramulla	Indus	Jhelum	34.30	74.62
395	Sagbari	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta/Rangit	27.25	88.30
396	Saidpur	no metals found above limit	Uttar Pradesh	Ghazipur	Ganga	Ganga	25.53	83.22
397	Sakleshpur	no metals found above limit	Karnataka	Hassan	Cauvery	Cauvery/Hemavathi	12.94	75.79
398	Sakra	no metals found above limit	Bihar	Muzaffarpur	Ganga	Burhi Gandak	26.04	85.56
399	Sangam (Jhelum)	no metals found above limit	Jammu & Kashmir	Anantnag	Indus	Jhelum	33.83	75.07
400	Sangod	no metals found above limit	Rajasthan	Kota	Ganga	Yamuna/ Chambal/ Kalisindh/Parwan	24.96	76.30
401	Sankalang	no metals found above limit	Sikkim	Mangan	Brahmaputra	Teesta River	27.51	88.53
402	Sankosh LRP	no metals found above limit	West Bengal	Alipurduar	Brahmaputra	Brahmaputra/Sankosh	26.46	89.86
403	Santheguli	no metals found above limit	Karnataka	Uthara Kannada	West Flowing Rivers from Tadri to Kanyakumari	Aghnanashini	14.43	74.59
404	Sarangpur	no metals found above limit	Madhya Pradesh	Rajgarh	Ganga	Yamuna/ Chambal/Kalisindh	23.55	76.47

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Latitude (E)	Longitude (N)
405	Satna	no metals found above limit	Madhya Pradesh	Satna	Ganga	Tons	24.56	80.91
406	Satpokholi	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Koa	26.07	91.46
407	Satpuli D/S	no metals found above limit	Uttarakhand	Pauri Garhwal	Ganga	Nayar	29.94	78.70
408	Satpuli U/S	no metals found above limit	Uttarakhand	Pauri Garhwal	Ganga	Nayar	29.92	78.71
409	Savandapur	no metals found above limit	Tamil Nadu	Erode	Cauvery	Cauvery/Bhavani	11.52	77.51
410	Seohara	no metals found above limit	Uttar Pradesh	Bijnaur	Ganga	Ramganga	29.24	78.66
411	Seondha	no metals found above limit	Madhya Pradesh	Datia	Ganga	Yamuna/Sind	26.17	78.80
412	Seppa	Fe	Arunachal Pradesh	East Kameng	Brahmaputra	Brahmaputra/ Kameng	27.36	93.04
413	Sevanur	no metals found above limit	Tamil Nadu	Erode	Cauvery	Cauvery/Chittar	11.55	77.73
414	Sevoke	no metals found above limit	West Bengal	Darjeeling	Brahmaputra	Brahmaputra/Teesta	26.88	88.48
415	Shahjina	no metals found above limit	Uttar Pradesh	Hamirpur	Ganga	Yamuna/Betwa	25.94	80.15
416	Shahzadpur	no metals found above limit	Uttar Pradesh	Kaushambi	Ganga	Ganga	25.67	81.43
417	Shaladang	Fe	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/ Torsa/ Kaljani	26.30	89.59
418	Shastri Bridge	no metals found above limit	Uttar Pradesh	Prayagraj	Ganga	Ganga	25.44	81.89
419	Shella	no metals found above limit	Meghalaya	East Khasi Hills	Meghna/Barak	Umiew/ Surma/ Meghna	25.18	91.64
420	Shimoga	no metals found above limit	Karnataka	Shimoga	Krishna	Krishna/Tungabhadra/Tunga	13.93	75.59
421	Sholmari	no metals found above limit	Assam	Nalbari	Brahmaputra	Chaulkhoa	26.31	91.34

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
422	Sibbari	no metals found above limit	Meghalaya	South Garo Hills	Meghna/Barak	Meghna/ Dareng	25.18	90.51
423	Sikandarpur	no metals found above limit	Bihar	Muzaffarpur	Ganga	Ganga/Burhi Gandak	26.14	85.38
424	Silghat	no metals found above limit	Assam	Nagaon	Brahmaputra	Brahmaputra	26.62	92.94
425	Singasadanapalli	Cd, Cu, Pb, Ni, Fe	Tamil Nadu	Krishnagiri	East Flowing Rivers between Pen-nar and Kanyakumari	Ponnaiyar	12.87	77.84
426	Singavaram	no metals found above limit	Andhra Pradesh	Anantapur	Pennar	Pennar/Chitravathi	14.60	78.01
427	Singimari	no metals found above limit	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/ Jaldhaka	26.11	89.35
428	Singtam	no metals found above limit	Sikkim	Gangtok	Brahmaputra	Teesta/Ranikhola	27.23	88.50
429	Sitapur	Hg	Uttar Pradesh	Sitapur	Ganga	Gomti / Sarayan	27.57	80.69
430	Sivasagar	no metals found above limit	Assam	Sivasagar	Brahmaputra	Brahmaputra/ Dikhow	26.98	94.58
431	Sonapur (Digaru)	no metals found above limit	Assam	Kamrup (Rural)	Brahmaputra	Digaru	26.12	91.98
432	Sonapur (Ma-hananda)	no metals found above limit	West Bengal	North Dinajpur	Ganga	Ganga/Mahananda	26.46	88.24
433	South Salmara	no metals found above limit	Assam	Southsalmara-Mankachar	Brahmaputra	Brahmaputra	25.89	90.02
434	Srinagar	no metals found above limit	Uttarakhand	Pauri Garhwal	Ganga	Alaknanda	30.23	78.78
435	Sripalpur	no metals found above limit	Bihar	Patna	Ganga	Ganga/Punpun	25.50	85.11
436	Suklai	no metals found above limit	Assam	Baksa (BTAD)	Brahmaputra	Suklai	26.65	91.72
437	Suldagiri (Deocharai)	Fe	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/ Torsa	26.25	89.62
438	Sultanpur	no metals found above limit	Uttar Pradesh	Sultanpur	Ganga	Ganga/Gomti	26.28	82.07

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Latitude (E)	Longitude (N)
439	Sulurpet	no metals found above limit	Andhra Pradesh	Nellore	East Flowing Rivers between Pennar and Kanyakumari	Kalingi	13.71	80.01
440	T. Bekuppe	Pb	Karnataka	Mandya	Cauvery	Cauvery/Arkavathi	12.51	77.43
441	T.K. Halli	Pb	Karnataka	Mandya	Cauvery	Cauvery/Shimsha	12.42	77.19
442	T. Narasipur	no metals found above limit	Karnataka	Mysuru	Cauvery	Cauvery/Kabini	12.23	76.89
443	Tadapatri	no metals found above limit	Andhra Pradesh	Anantapur	Pennar	Pennar	14.92	78.02
444	Tal	no metals found above limit	Madhya Pradesh	Ratlam	Ganga	Yamuna/ Chambal	23.72	75.35
445	Tanda D/S	no metals found above limit	Uttar Pradesh	Ambedkar Nagar	Ganga	Ghaghra	26.54	82.70
446	Tanda U/S	no metals found above limit	Uttar Pradesh	Ambedkar Nagar	Ganga	Ghaghra	26.53	82.63
447	Tandi	no metals found above limit	Himachal Pradesh	Lahoul & Spiti	Indus	Chandrabhaga/Bhaga	32.55	76.98
448	Taramchu	no metals found above limit	Sikkim	Mangan	Brahmaputra	Lachen Chu/Taramchu	27.70	88.57
449	Tezpur	Fe	Assam	Sonitpur	Brahmaputra	Brahmaputra	26.62	92.80
450	Tezu	no metals found above limit	Arunachal Pradesh	Lohit	Brahmaputra	Brahmaputra/ Lohit	27.91	96.17
451	Thandalaiputhur	no metals found above limit	Tamil Nadu	Thiruchirapalli	Cauvery	Cauvery/Ayyar	10.99	78.51
452	Thengudi	no metals found above limit	Tamil Nadu	Thiruvarur	Cauvery	Cauvery/Thirumalairajanar	10.92	79.64
453	Thengumarahada	Fe	Tamil Nadu	Nilgiris	Cauvery	Cauvery/Bhavani/Moyar	11.57	76.92
454	Theni	Fe	Tamil Nadu	Theni	East Flowing Rivers between Pennar and Kanyakumari	Vaigai/Suruliar	10.00	77.49
455	Therriaghat	no metals found above limit	Meghalaya	East Khasi Hills	Meghna/Barak	Um Sohryngkew	25.18	91.77
456	Thevur	no metals found above limit	Tamil Nadu	Salem	Cauvery	Cauvery/Sarabenga	11.53	77.75
457	Thimmanahalli	Pb, Ni, Hg	Karnataka	Hassan	Cauvery	Cauvery/Hemavathi/Yagachi	12.99	76.04

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
458	Thoppur	no metals found above limit	Tamil Nadu	Salem	Cauvery	Cauvery/Thoppaiyar	11.94	78.06
459	Thottathinkadavu	Fe	Kerala	Kozhikode	West Flowing Rivers from Tadri to Kanyakumari	Iruvazhinjipuzha	11.36	76.00
460	Thumpamon	no metals found above limit	Kerala	pathanamthitt	West Flowing Rivers from Tadri to Kanyakumari	Pamba/ Achankovil	9.22	76.71
461	Tiharkheda	Hg	Uttar Pradesh	Bareilly	Ganga	Ramganga	28.42	79.29
462	Todarpur	no metals found above limit	Uttar Pradesh	Hardoi	Ganga	Ganga/Deoha/Sukheta	27.58	80.00
463	Tonk	no metals found above limit	Rajasthan	Tonk	Ganga	Yamuna/ Chambal/Banas	26.20	75.84
464	Toyum	no metals found above limit	Sikkim	Gyalshing	Brahmaputra	Teesta/Rangit/ Kalez Khola	27.27	88.24
465	Triveni	no metals found above limit	Bihar	West Champaran	Ganga	Ganga/Gandak	27.44	83.91
466	Tufanganj	no metals found above limit	West Bengal	Koch Bihar	Brahmaputra	Brahmaputra/Torsa/Raidak-i	26.31	89.68
467	Tuini (Pabar)	no metals found above limit	Himachal Pradesh	Dehradun	Ganga	Yamuna/Pabar	30.95	77.85
468	Tuini (Tons)	no metals found above limit	Uttarakhand	Dehradun	Ganga	Yamuna/Tons	30.94	77.85
469	Turtipar	no metals found above limit	Uttar Pradesh	Ballia	Ganga	Ghaghra	26.17	83.86
470	Tuting	no metals found above limit	Arunachal Pra-desh	Upper Siang	Brahmaputra	Brahmaputra/ Siang	28.98	94.90
471	Udaipur (Brahmapu-tra)	Fe	Assam	Tinsukia	Brahmaputra	Brahmaputra/ Buridehing/	27.34	95.85
472	Udaipur (Chan-drabhaga)	no metals found above limit	Himachal Pradesh	Lahoul & Spiti	Indus	Chandrabhaga	32.72	76.67
473	Udi	no metals found above limit	Uttar Pradesh	Etawah	Ganga	Yamuna/Chambal	25.70	78.94
474	Ujjain	no metals found above limit	Madhya Pradesh	Ujjain	Ganga	Yamuna/ Chambal/Shipra	23.17	75.77

Sl. No.	Station	Metals found above limit	State/UT	District	Basin	River/Tributary	Lati-tude (E)	Longi-tude (N)
475	Umsiang	no metals found above limit	Meghalaya	Ri- Bhoi	Brahmaputra	Umsiang	26.07	92.17
476	Upper Rimbi	no metals found above limit	Sikkim	Gyalshing	Brahmaputra	Teesta/Rangit/Rimbikhola	27.33	88.15
477	Urachikottai	Pb, Fe	Tamil Nadu	Erode	Cauvery	Cauvery	11.48	77.70
478	Uttarkashi	no metals found above limit	Uttarakhand	Uttarkashi	Ganga	Ganga/Bhagirathi	30.73	78.45
479	V.S. Bridge	no metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.26	83.03
480	Vandiperiyar	no metals found above limit	Kerala	Idukki	West Flowing Rivers from Tadri to Kanyakumari	Periyar	9.57	77.09
481	Varanasi	no metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.32	83.04
482	Varanavasi	Ni, Fe	Tamil Nadu	Ariyalur	Cauvery	Cauvery/Marudaiyar	11.09	79.08
483	Vazhavachanur	no metals found above limit	Tamil Nadu	Thiruvannamalai	East Flowing Rivers between Pen-nar and Kanyakumari	Ponnaiyar	12.07	78.98
484	Villupuram	no metals found above limit	Tamil Nadu	Villupuram	East Flowing Rivers between Pen-nar and Kanyakumari	Ponnaiyar	11.87	79.46
485	Yamuna Expressway Road Bridge-Etmad-pur D/S of Agra city	no metals found above limit	Uttar Pradesh	Agra	Ganga	Yamuna	27.18	78.12
486	Yashwant nagar	no metals found above limit	Himachal Pradesh	Simaur	Ganga	Yamuna/Giri	30.88	77.21
487	Yennehole	no metals found above limit	Karnataka	Dakshina Kannada	West Flowing Rivers from Tadri to Kanyakumari	Swarna	13.29	74.98
488	Yuksum	no metals found above limit	Sikkim	Gyalshing	Brahmaputra	Teesta/Rangit/Rothangchu	27.37	88.21

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