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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

8th Edition
(January to December 2024)

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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 2025, CWC is monitoring 788 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 8th 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 2024, in relation to 434 stations across various parts of India. The previous editions of this study were published in May 2014, April 2018, August 2019, December 2021, August 2024 and January, 2025.

I hope that this 8th publication of "Status of trace and toxic metals in rivers of India" 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 788 water quality stations as of January 2025, and a 3-tier laboratory system consisting of 465 Level-I, 19 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.

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River water quality monitoring is an essential component of water resource management. It involves regular collection and analysis of water samples from rivers to assess the presence and concentration of various physical, chemical, and biological parameters. This monitoring helps in understanding the health of river systems and the extent of pollution caused by natural and anthropogenic activities. One critical aspect of water quality monitoring is the assessment of metal content, particularly trace and toxic metals such as lead, mercury, cadmium, arsenic, chromium, nickel, copper, zinc, and iron. These metals, even in low concentrations, can pose serious risks to human health, aquatic life, and the overall ecosystem.

Central Water Commission (CWC) plays a vital role in the water quality monitoring in Indian rivers. As part of its integrated hydrological investigation, CWC collects water samples from various river basins in the country. Initially, CWC 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 and toxic metals in river water samples collected from 434 water quality monitoring stations of the CWC from January to December 2024. 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.

I appreciate the hard work done by Dr. Jakir Hussain, Research Officer, and Shri Lalit Kumar Morya, Assistant Research Officer of the River Data Compilation-2 Directorate. My appreciation also extends to all field Chief Engineers of the CWC for the collection and submission of water quality data to the River Data Compilation-2 Directorate, thereby paving the way to publish such a useful report.

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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
km	kilometers
M.ha	Million hectres
MCL	Maximum Contaminant Level
mm	millimeter
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 samples collected during January, 2024 to December, 2024 from 13 river basins of India (Brahmani & Baitrani, Cauvery, East Flowing Rivers between Mahanadi & Godawari, East Flowing Rivers between Pennar and Cauvery Basin and East Flowing Rivers South of Cauvery, Ganga & Yamuna, Godavari, Indus, Krishna, Mahanadi, Pennar, Subernarekha and West Flowing rivers south of Tapi Basin) for the above-mentioned 9 trace & toxic metals. These samples were analyzed at 3 water quality laboratories of CWC namely: National River Water Quality Laboratory, Upper Yamuna Division, New Delhi; Upper and Middle Ganga Water Quality Laboratory, Middle Ganga Division-3, Varanasi; Lower Cauvery Water Quality Laboraotry, Southern Region Division, Coimbatore. 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 5456 river water samples, 41 samples from 13 water quality stations were found to have arsenic concentrations beyond the acceptable limit. The arsenic concentration varies from 0.000 to 22.63 µg/L. Maximum arsenic concentration (22.63 µg/L) was observed at Palla water quality monitoring station on Yamuna River on 21.06.2024.

As Acceptable Limit as BIS 10500: 2012	10 µg/L
No. of Samples Tested	5456
No. of samples where metal found above acceptable limit	41
No. of Stations where metal found above acceptable limit	13
No. of Basin / Rivers where metal found above acceptable limit	01/05

Cadmium (Cd)

BIS (Bureau of Indian Standard) 10500:2012 has recommended an acceptable limit of 3 µg/L of cadmium in drinking water. Out of total 5459 river water samples analysed, 07 samples from 03 water quality stations were found to have cadmium concentrations beyond the acceptable limit. The cadmium concentration varies from 0.000 to 6.54 µg/L. Maximum cadmium concentration (6.54 µg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 01-10-2024.

Cd Acceptable Limit as BIS 10500: 2012	3 µg/L
No. of Samples Tested	5459
No. of samples where metal found above acceptable limit	07
No. of Stations where metal found above acceptable limit	03
No. of Basins / Rivers where metal found above acceptable limit	03/03

Chromium (Cr)

BIS (Bureau of Indian Standard) 10500:2012) has recommended an acceptable limit of 50 µg/L of chromium in drinking water. Out of total 5039 river water samples analysed, 14 samples from 09 water quality stations were found to have chromium concentrations beyond the acceptable limit. The chromium concentration varies from 0.000 to µg/L. Maximum chromium concentration (248.90 µg/L) was observed at Hogenakkal water quality monitoring station on Chinnar River on 24-10-2024.

Cr Acceptable Limit as BIS 10500: 2012	50 µg/L
No. of Samples Tested	5039
No. of samples where metal found above acceptable limit	14
No. of Stations where metal found above acceptable limit	09
No. of Basins / Rivers where metal found above acceptable limit	03/06

Copper (Cu)

BIS (Bureau of Indian Standard) 10500:2012) has recommended an acceptable limit of 50 µg/L of copper in drinking water. Out of total 5457 river water samples analysed, 07 samples from 03 water quality stations were found to have copper concentrations beyond the acceptable limit. The copper concentration varies from 0.000 to 160.41 µg/L. Maximum copper concentration (160.41 µg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 02-09-2024.

Cu Acceptable Limit as BIS 10500: 2012	50 µg/L
No. of Samples Tested	5457
No. of samples where metal found above acceptable limit	07
No. of Stations where metal found above acceptable limit	03
No. of Basins / Rivers where metal found above acceptable limit	02/02

Iron (Fe)

BIS has recommended the acceptable limit of 1.0 mg/L (1000 µg/L) for Iron. Out of total 5417 river water samples analysed, 325 samples from 78 water quality stations were found to have iron concentrations beyond the acceptable limit. The iron concentration varies from 0.000 to 29.216 mg/L. Maximum iron concentration (21.216 mg/L) was observed at Kudlur water quality monitoring station on Cauvery River on 23-10-2024.

Fe Acceptable Limit as BIS 10500: 2012	1000 µg/L
No. of Samples Tested	5417
No. of samples where metal found above acceptable limit	325
No. of Stations where metal found above acceptable limit	78
No. of Basins / Rivers where metal found above acceptable limit	07/54

Lead (Pb)

Bureau of Indian Standard (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 5265 river water samples analysed, 80 samples from 45 water quality stations were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 117.90 µg/L. Maximum lead concentration (117.90 µg/L) was observed at Hogenakkal water quality monitoring station on Chinnar River on 24-10-2024.

Pb Acceptable Limit as BIS 10500: 2012	10 µg/L
No. of Samples Tested	5265
No. of samples where metal found above acceptable limit	80
No. of Stations where metal found above acceptable limit	45
No. of Basins / Rivers where metal found above acceptable limit	06/34

Mercury (Hg)

BIS (Bureau of Indian Standard) 10500:2012) has recommended an acceptable limit of 1 µg/L of mercury in drinking water. Out of total 5361 river water samples analysed, 35 samples from 16 water quality stations were found to have mercury concentrations beyond the acceptable limit. The mercury concentration varies from 0.000 to 3.834 µg/L. Maximum mercury concentration (3.834 µg/L) was observed at Koggedoddi water quality monitoring station on Arkavathi River on 02-09-2024.

Hg Acceptable Limit as BIS 10500: 2012	1 µg/L
No. of Samples Tested	5361
No. of samples where metal found above acceptable limit	35
No. of Stations where metal found above acceptable limit	16
No. of Rivers where metal found above acceptable limit	04/12

Nickel (Ni)

BIS (Bureau of Indian Standard) 10500:2012) has recommended an acceptable limit of 20 µg/L of nickel in drinking water. Out of total 5014 river water samples analysed, 33 samples from 22 water quality stations were found to have nickel concentrations beyond the acceptable limit.The nickel concentration varies from 0.000 to 72.11 µg/L. Maximum nickel concentration (72.11 µg/L) was observed at Kudlur water quality monitoring station on Cauvery River on 22-08-2024.

Ni Acceptable Limit as BIS 10500: 2012	20 µg/L
No. of Samples Tested	5014
No. of samples where metal found above acceptable limit	33
No. of Stations where metal found above acceptable limit	22
No. of Basins / Rivers where metal found above acceptable limit	05/14

Zinc (Zn)

BIS (Bureau of Indian Standard) 10500:2012) has recommended acceptable limit of 5 mg/L (5000 µg/L) of Zinc in drinking water. Out of total 5456 river water samples analysed, no sample is found to have zinc concentration beyond the acceptable limit. The zinc concentration varies from 0.000 to 4636.728 µg/L. Maximum zinc concentration (4636.728 µg/L) was observed at Kora water quality monitoring station on Rind River on 03-12-2024

Zn Acceptable Limit as BIS 10500: 2012	5000 µg/L
No. of Samples Tested	5456
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	0/0

The analysis results of 434 water quality monitoring stations spread over 13 river basins of CWC were considered for the study. All metals are found to be within the acceptable limits at 322 out of 434 monitored stations while at 112 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	5456	5415	41	0.75
2	Cadmium (Cd)	3	5459	5452	07	0.13
3	Chromium (Cr)	50	5039	5025	14	0.28
4	Copper (Cu)	50	5457	5450	07	0.13
5	Iron (Fe)	1000	5417	5092	325	6.00
6	Lead (Pb)	10	5265	5185	80	1.52
7	Mercury (Hg)	1	5361	5326	35	0.65
8	Nickel (Ni)	20	5014	4981	33	0.66
9	Zinc (Zn)	5000	5456	5456	00	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. Byproducts 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 most 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 miscarriag-es

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 fisherman 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 adds 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, the 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, 2025, CWC is observing water quality at 788 key locations in different rivers across the country: 678 on Hydrological Observation network and 110 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 are represented in Table 8 and Figure 3; and distribution among 23 basins of CWC is represented in Table 9 and Figure 4.

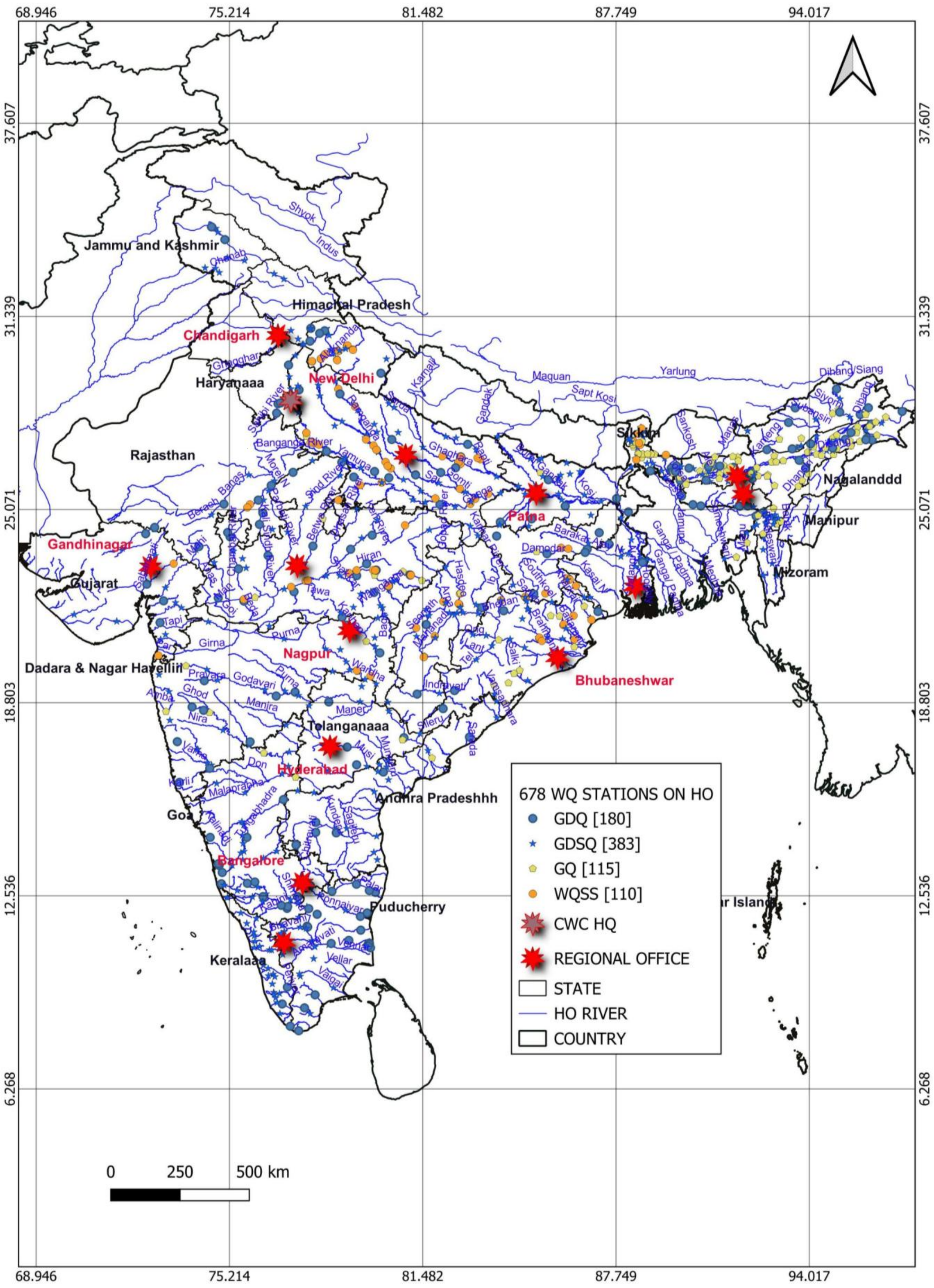

Figure 1: Water quality network of CWC (01.01.2025)

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	5	14	2	-	7	28
2	Arunachal Pradesh	11	9	10	-	3	33
3	Assam	20	26	54	-	11	111
4	Bihar	6	22	1	-	2	31
5	Chhattisgarh	3	18	2	9	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	2	7	-	-	2	11
11	Jharkhand	6	6	1	7	2	22
12	Karnataka	15	25	2	-	4	46
13	Kerala	2	24	-	-	3	29
14	Madhya Pradesh	18	26	4	12	2	62
15	Maharashtra	12	30	4	6	10	62
16	Manipur	-	-	1	-	-	1
17	Meghalaya	5	3	1	-	2	11
18	Mizoram	-	5	-	-	-	5
19	Odisha	5	22	9	14	4	54
20	Puducherry	3	-	-	-	-	3
21	Rajasthan	8	8	-	2	1	19
22	Sikkim	-	11	5	6	1	23
23	Tamil Nadu	21	21	-	-	5	47
24	Telangana	4	8	1	-	4	17
25	Tripura		3	2	-	1	6
26	Uttar Pradesh	13	48	4	30	6	101
27	Uttarakhand	5	8	1	15	3	32
28	West Bengal	8	21	11	4	3	47
29	**Total**	**180**	**383**	**115**	**110**	**90**	**878**
	Grand Total	**788**				**90**	**878**

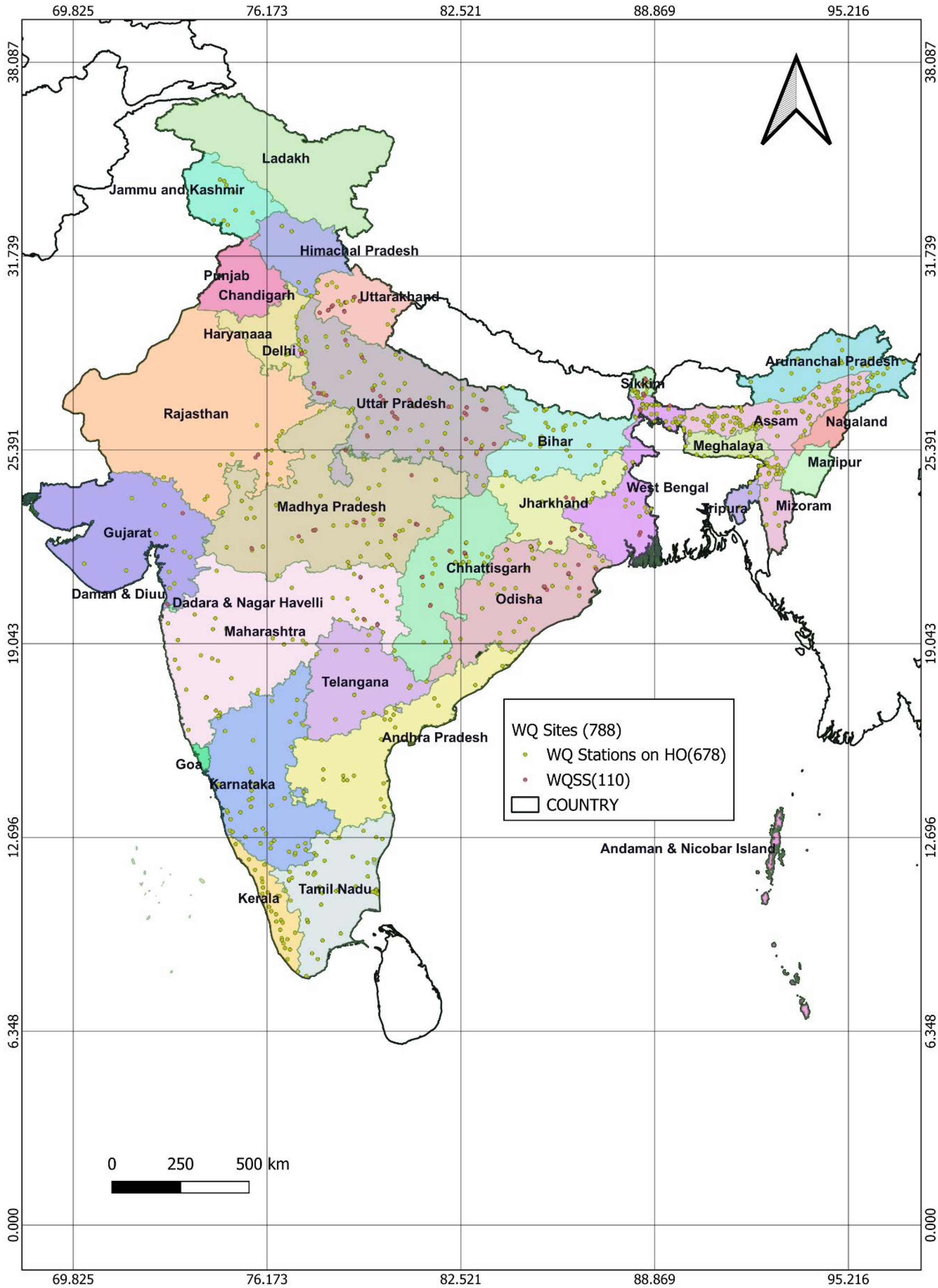

Figure 2: State-wise distribution of Water Quality Stations monitored by CWC

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	-	4	41
2	Brahmaputra Basin Organisation, Guwahati	28	24	59	-	13	124
3	Cauvery and Southern rivers Organisation, Coimbatore	35	53	-	-	11	99
4	Indus Basin Organisation, Chandigarh	2	9	-	-	3	14
5	Krishna & Godavari Basin Organisation, Hyderabad	18	35	7	-	15	75
6	Lower Ganga Basin Organisation, Patna	9	33	1	6	5	54
	Monitoring Central Organisation, Nagpur	4	20	1	6	5	36
7	Mahanadi and Eastern Rivers Organisation, Bhubaneswar	7	43	12	28	7	97
8	Monitoring South Organisation, Bengaluru	9	19	-	-	3	31
9	Mahi & Tapi Basin Organisation, Gandhinagar	6	15	-	2	6	29
10	Narmada Basin Organisation, Bhopal	8	9	4	11	1	33
11	Teesta & Bhagirathi Damodar Basin Organisation, Kolkata	14	32	18	12	6	82
12	Upper Ganga Basin Organisation, Lucknow	6	31	2	33	5	77
13	Yamuna Basin Organisation, New Delhi	27	38	3	12	6	86
15	**Total**	**180**	**383**	**115**	**110**	**90**	**878**
	Grand Total	**788**				**90**	**878**

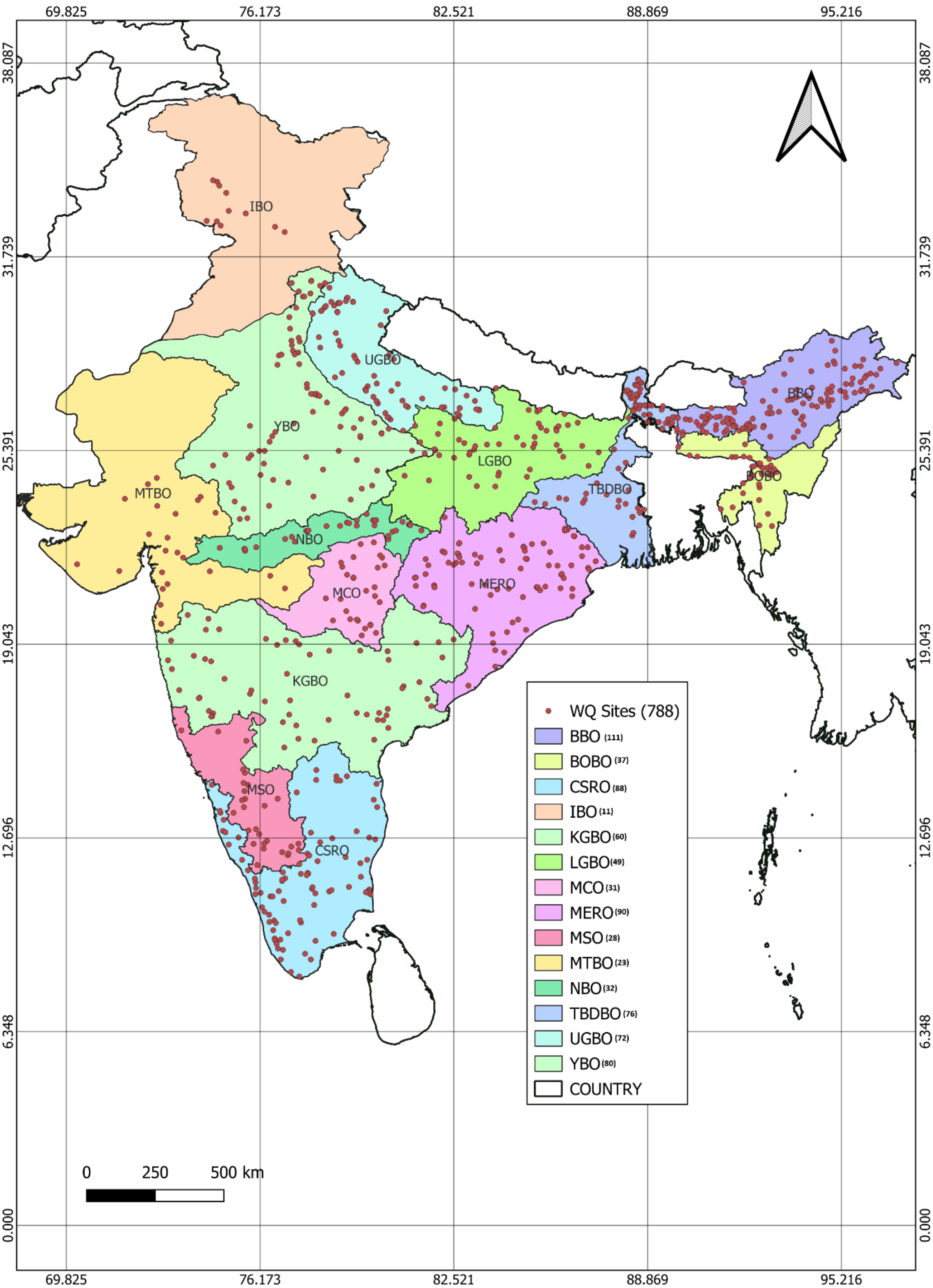

Figure 3: Organisation-Wise Distribution of Water Quality Stations Monitored by CWC

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

Sl. No.	Basin	GDQ	GDSQ	GQ	WQSS	Water Bodies	Total
1	Barak and Others Basin	7	19	8	-	2	36
2	Brahmani and Baitarni Basin	1	11	3	12	1	28
3	Brahmaputra Basin	34	43	76	7	18	178
4	Cauvery Basin	20	22	-	-	3	45
5	EFR between Pennar and Cauvery	7	5	-	-	5	17
6	EFR between Krishna and Pennar	-	1	-	-	-	1
7	EFR between Mahanadi and Godavari	1	3	5	-	1	10
8	EFR South of Cauvery	2	4	-	-	-	6
9	Ganga Basin	50	115	7	56	19	247
10	Godavari Basin	12	33	4	6	14	69
11	Indus (Up to border) Basin	2	9	-	-	3	14
12	Krishna Basin	10	31	3	-	6	50
13	Mahanadi Basin	3	22	3	10	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	River draining into Bangladesh Basin	-	1	-	-	-	1
18	River draining into Myanmar Basin	-	2	-	-	-	2
19	Sabarmati Basin	1	1	-	1	2	5
20	Subarnarekha Basin	2	6	1	6	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	11	31	1	1	4	48
24	**Total**	**180**	**383**	**115**	**110**	**90**	**878**
	Grand Total	**788**				**90**	**878**

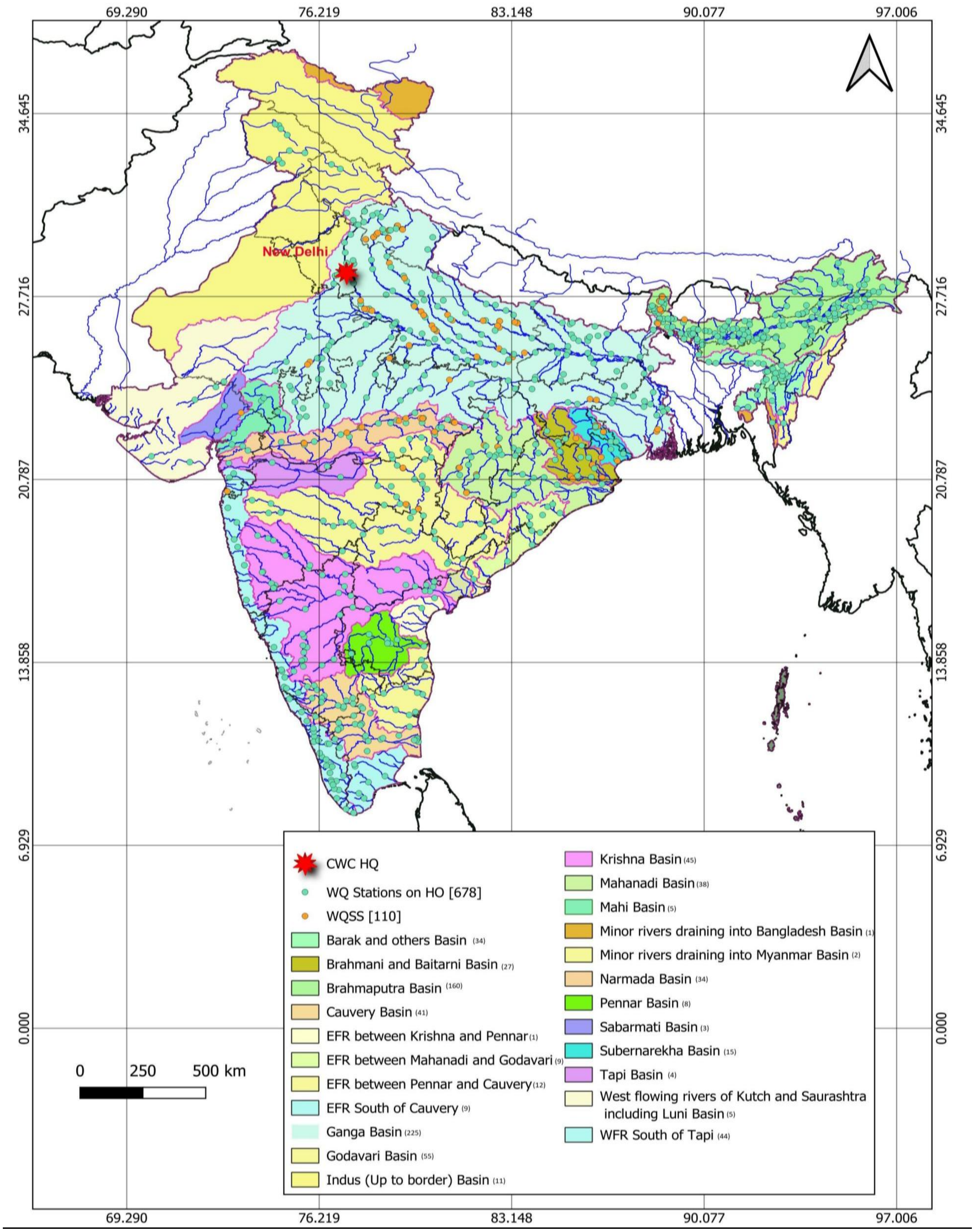

Figure 4*: *Map showing the basin-wise distribution of water quality Stations monitored by CWC

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:** 465 level-I laboratories located at field water quality monitoring stations on various rivers of India for monitoring of 14 in-situ parameters: Colour, Odour, Temperature pH, Electrical Conductivity and Dissolved Oxygen (a map showing 465 Level-I labs can be seen at Figure 5).
2. **Level-II Laboratories:** 19 level-II laboratories located at division offices to analyse 32 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 56 parameters including trace & toxic metals and pesticides.

Out of 24 level-II/III laboratories of CWC, 22 laboratories got 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 (14 Parameters)	Level-II (32 Parameters)	Level-III (56 Parameters)
1	Temperature	Temperature	Temperature
2	Colour and Intensity	pH	pH
3	Odour	Electrical Conductivity	Electrical Conductivity
4	pH	Dissolved Oxygen (DO)	Dissolved Oxygen (DO)
5	Electrical Conductivity	Turbidity	Turbidity
6	Dissolved Oxygen	Biochemical Oxygen Demand (BOD)	Biochemical Oxygen Demand (BOD)
7	Weather	Chemical Oxygen Demand (COD)	Chemical Oxygen Demand (COD)
8	Depth of main stream/depth of water table	Total Dissolved Solids (TDS)	Total Dissolved Solids (TDS)
9	Visible effluent discharge	Sodium	Sodium
10	Human activities Around station	Calcium	Calcium
11	Station details	Magnesium	Magnesium
12	Velocity	Potassium	Potassium
13	Discharge	Phenolphthalein Alkalinity (Carbonate)	Phenolphthalein Alkalinity (Carbonate)
14	Water Level	Total Alkalinity	Total Alkalinity
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 MPN/100 ml	Total Coliform MPN/100 ml
25		Fecal Coliform MPN/100 ml	Fecal Coliform MPN/100 ml
26		E.Coli	E.Coli
27		Faecal Streptococci	Faecal Streptococci
28		Hardness	Hardness
29		NO_2+NO_3	NO_2+NO_3
30		Sodium Adsorption Ratio	Sodium Adsorption Ratio
31		% Sodium	% Sodium
32		Residual Sodium Carbonate	Residual Sodium Carbonate
33			Arsenic
34			Cadmium
35			Chromium
36			Copper
37			Iron
38			Lead
39			Nickel
40			Mercury
41			Zinc
42			Alpha BHC
43			Beta BHC
44			Gama BHC (Lindane)
45			OP DDT
46			PP-DDT
47			Alpha Endosulphan
48			Beta Endosulphan
49			Aldrin
50			Dieldrin
51			Carbaryl (Carbamate)
52			Malathion
53			Methyl Parathion
54			Anilophos
55			Chloropyriphos
56			2-4 D

Figure 5: Level-I Water quality laboratories of CWC

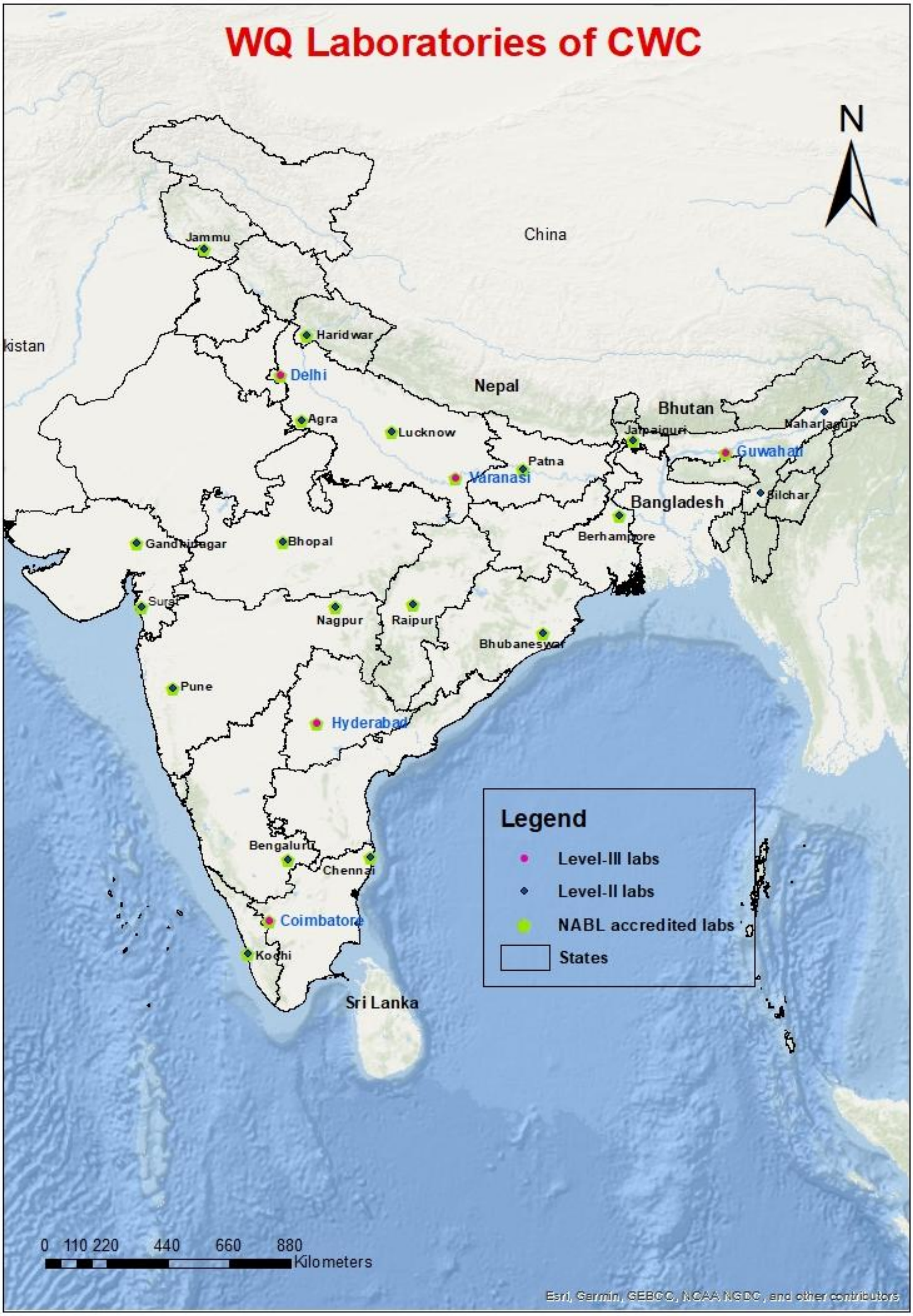

Figure 6: Level-II/III Water quality laboratories of CWC

5. STUDY AREA

The analysis results of 9 trace & toxic metals of water samples from 434 water quality monitoring stations of CWC are considered for the study (Figure 7). This involves the data analysis of 5460 samples collected during January, 2024 to December, 2024 from 13 river basins of India.

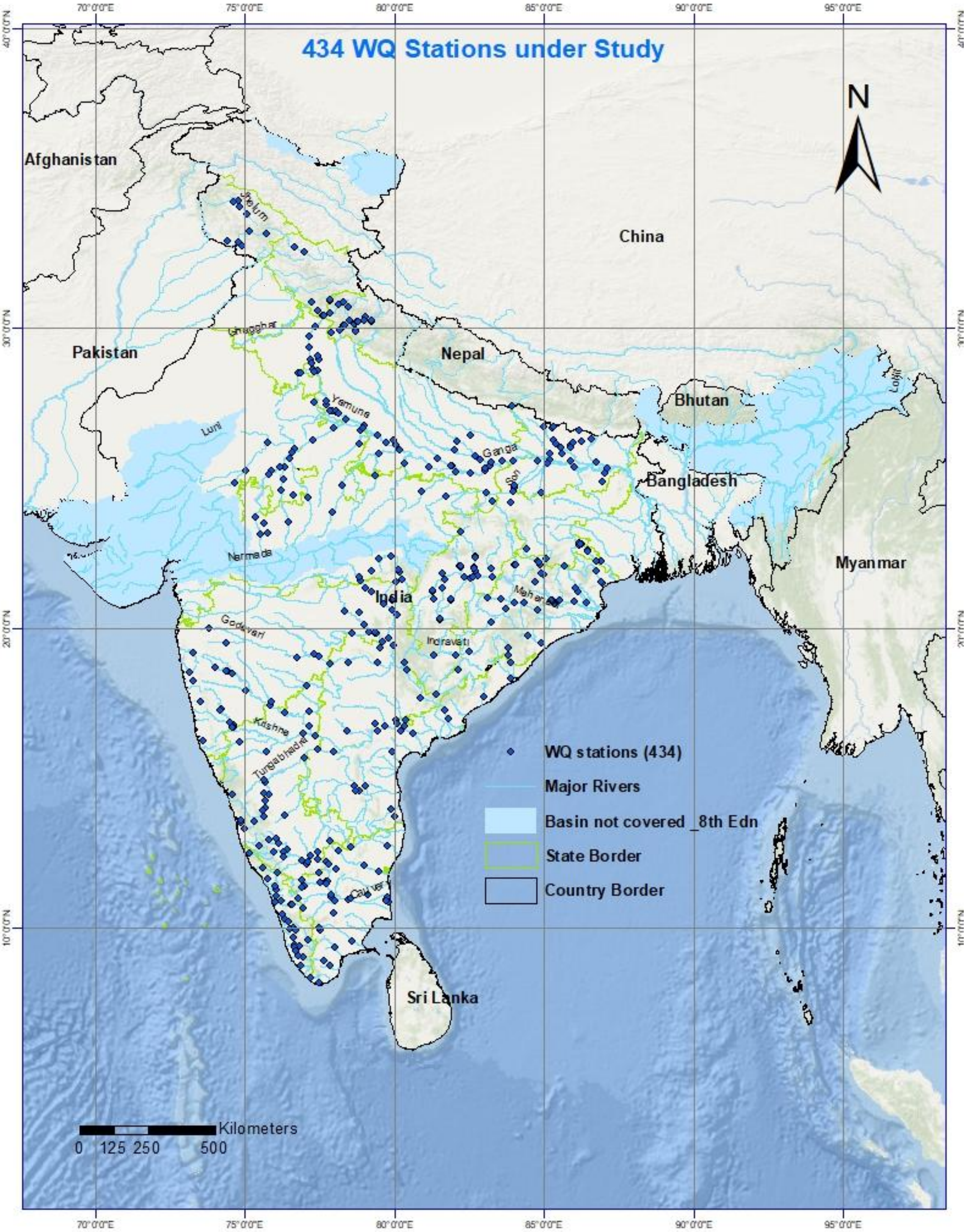

Figure 7: 434 Water quality stations monitored

The details of the 434 monitoring are enclosed as Annexure-I. The details of 13 basins considered for the study has been given below.

1. ***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 Tamilnadu. The river basin lies between 75°30' – 79°45'E longitudes and 10°05'N – 13°30'N latitudes. Cauvery Basin covers the states of Karnataka, Tamilnadu, Puducherry and some parts of Kerala. The Cauvery basin is fan shaped in Karnataka and leaf shaped in Tamilnadu. The major tributaries are Harangi, Hemavati, Kabini, Bhavani, Lakshmanthirtha, Noyyal, and Arkavati.

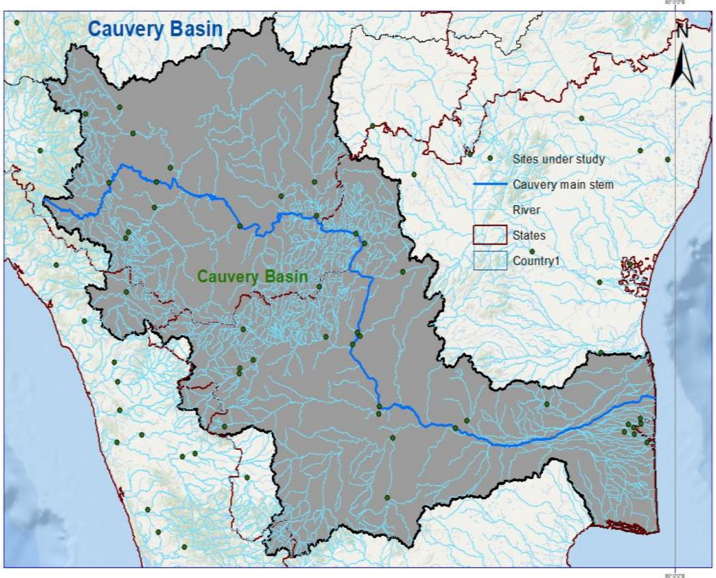

Figure 8: Cauvery Basin

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

2-3. East Flowing Rivers between Pennar & 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, Tamilnadu and some parts of Karnataka and Union territory of Puducherry.

The basin of East flowing rivers consists of several 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.

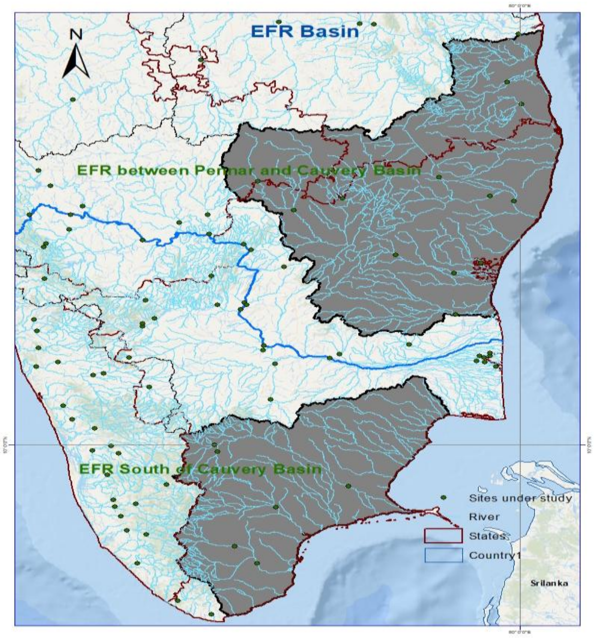

Figure 9: EFR Basin

Water quality samples collected from 17 water quality stations are being considered for the study.

4-5. ***Ganga Basin & Yamuna 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 head-streams, namely Bhagirathi, Alaknanda, Mandkini, Dhauliganga and Pindar. Of those, the two major head-streams 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 Chota Nagpur Plateau, respectively.

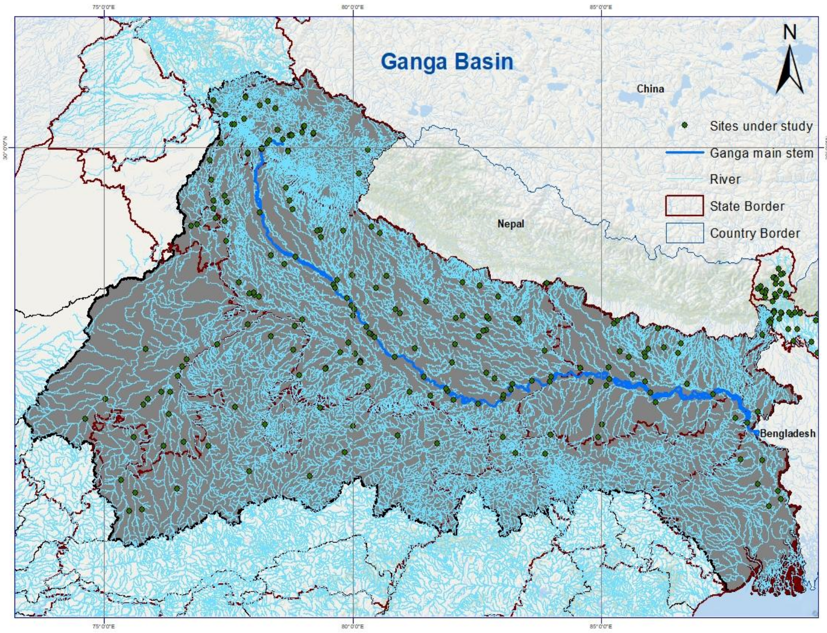

Figure 10: Ganga Basin

Alaknanda 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. Water quality samples collected from 161 water quality stations are being considered for the study.

6. ***Indus(upto) 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

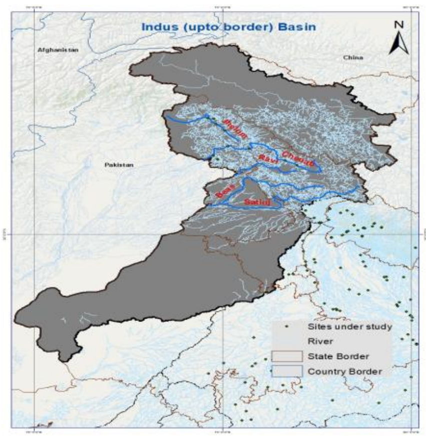

Figure 11: Indus Basin

Indian part of the basin consistts of five major tributaries: Satluj, Ravi, Beas, Chenab, and Jhelum which are ultimately merging with river Indus in Pakistan.

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.

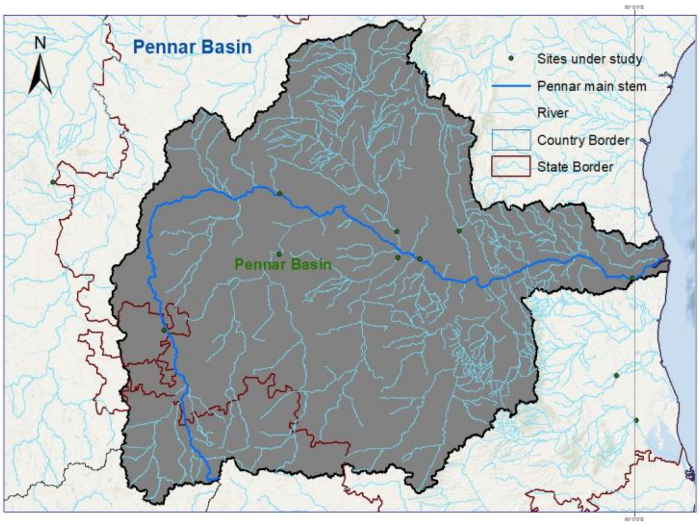

Figure 12: Pennar Basin

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

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 Nos 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. Maps showing these basins are presented as Plates - I to III. All the rivers originate from the high

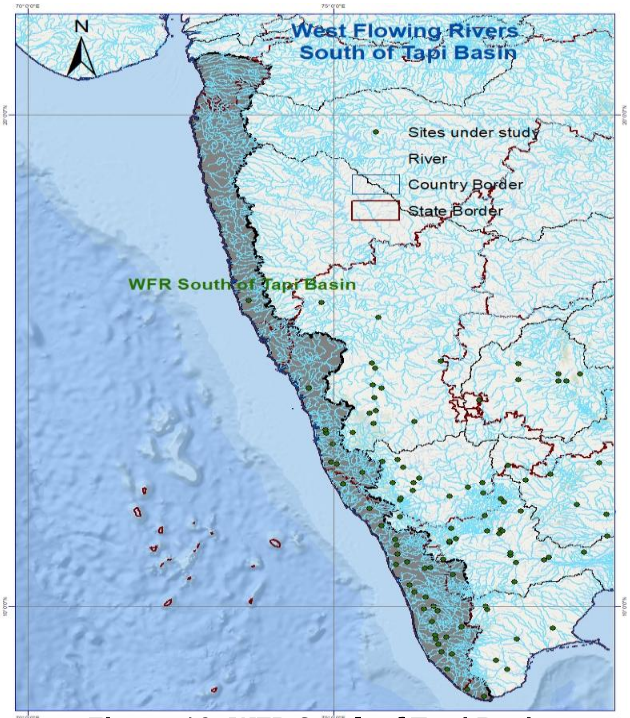

Figure 13: WFR South of Tapi Basin

mountains of the Western Ghats and exhibit similar characteristics. They have steep high banks which rarely overflow or cause floods.

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 730 21’ to 810 09’ and North latitudes 130 07’ to 190 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 downstream of Vijayawada.

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.

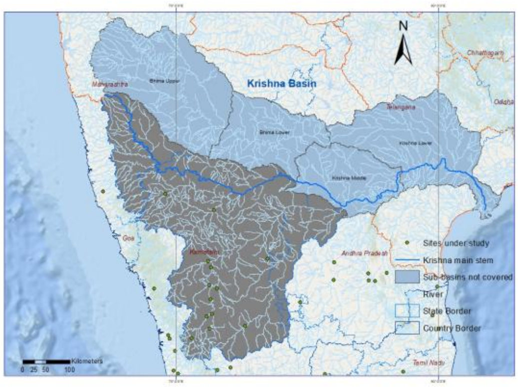

Figure 14: Krishna Basin

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 12 water quality stations are being considered for the study. Theses stations belong to Krishna Upper and Thungabhadra sub-basins.

10. *Godavari Basin*

The Godavari basin extends over states of Maharashtra, Andhra Pradesh, Chhattisgarh and Odisha in addition to smaller parts in Madhya Pradesh, Karnataka and Union territory of Puducherry having a total area of 3,12,812 Sq.km with a maximum length and width of about 995 km and 583 km.

It lies between 73°24′ to 83°4′ east longitudes and 16°19′ to 22°34′ north latitudes and accounts for nearly 9.5% of the total geographical area of the country. The basin is bounded by Satmala hills, the Ajanta range and the Mahadeo hills on the north, by the Eastern Ghats on the south and the east and by the Western Ghats on the west.

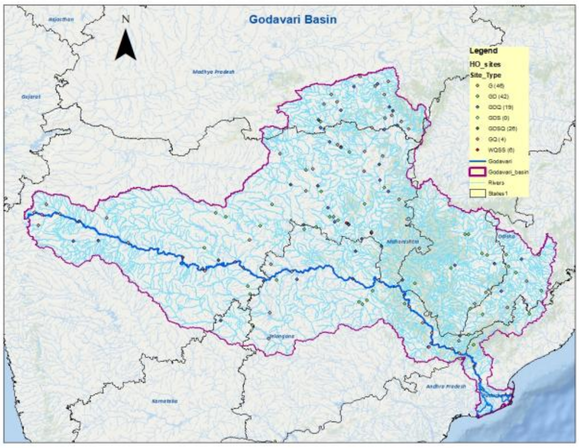

Figure 15: Godavari Basin

The Godavari River rises from Trimbakeshwar in the Nashik district of Maharashtra about 80 km from the Arabian Sea at an elevation of 1,067 m. The total length of Godavari from its origin to outfall into the Bay of Bengal is 1,465 km. Its principal tributaries joining from right are the Pravara and the Manjra whereas the Purna, the Penganga, the Wardha, the Wainganga, the Indravati and the Kolab joins from left.

Water quality samples collected from 12 water quality stations i.e. Bhadrachalam, Dhalegaon, GR Bridge, Kopergaon, Mancherial, Nanded, Nashik, Perur, Polavaram, Rajahmundry, Saloora and Yelli are being considered for the study.

11. ***Mahanadi Basin***

The River Mahanadi is one of the major inter-state east flowing Rivers in peninsular India. In the course of its traverse, it drains fairly large areas of Madhya Pradesh & Odisha and comparatively small areas in the States of Bihar & Maharashtra.

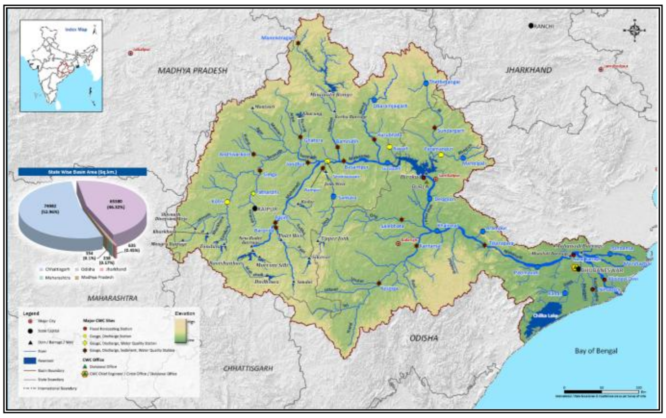

Figure 16: Mahanadi Basin.

The basin is physically bounded in the north by the Central India hills, in the south and east by the Eastern Ghats and in the West by Maikala Hill Range. The total catchment area of the basin is 1,41,589 km2. The River Mahanadi originates at an elevation of about 442 m above MSL near Pharsiya village in Raipur district of Madhya Pradesh. The total length of the River from its origin to its out fall into the Bay of Bengal is about 851 kms, of which, 357 kms is in Madhya Pradesh and the remaining 494 kms is in Odisha. During its traverse, a number of tributaries join the River on both the banks. The important tributaries are the Seonath, the Hasdeo, the Mand, the Ib, the Bhadar, the Jonk, the Ong and the Tel.

12. ***Subernarekha and Burhabalang River Basin***

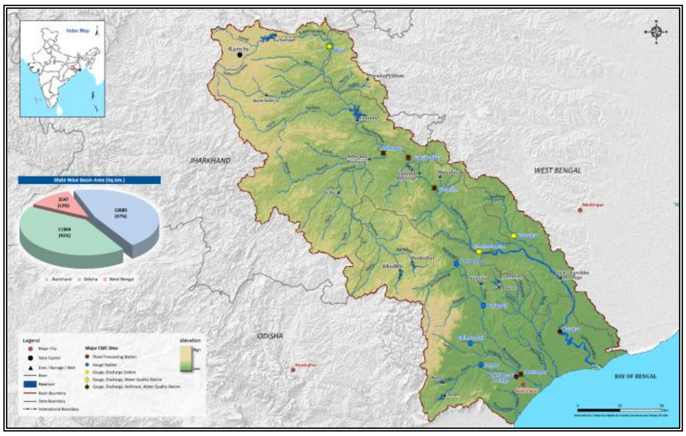

Figure 17: Subernrekha and Burhabalang River Basin.

The Subernarekha & Burhabalang basin extends in an area of 23,751 km2. The Subernarekha River drains large areas of Bihar and some parts of West Bengal and Odisha and the Burhabalang covers parts of the areas in Mayurbhanj and Balasore districts of Odisha. The basins lie between latitude 21°- 22' N to 23°- 32' N and longitude 85°- 09 E to 87°- 27 E and is situated in the north-east corner of the peninsular India. It is bounded on the north-west by the Chhotanagpur Plateau, in the south-west by Brahmani basin, in the south by the Baitarni basin and in the south-east by the Bay of Bengal.

The Subernarekha River originates near Nagri village in Ranchi district of Bihar at an elevation of 600 m. The total length of the River is about 395 kms. The principal tributaries of the River are the Kanchi, the Kharkai and the Karkari. The Burhabalang is a flashy River which originates at an elevation of 800 m and after traversing a distance of 125 kms drops into the Bay of Bengal. The River drains parts of areas in Mayurbhanj and Balasore districts of Odisha.

13. ***East Flowing Rivers between Mahanadi and Pennar***

The basin spreads over states of Andhra Pradesh and Odisha having an area of 86,643 km2 and stretches between 78°40′ to 85°1′ east longitudes and 14°34′ to 20°22′ north latitudes. It is bounded by the Eastern Ghats on the north and west, by Nallamala Range and Andhra plains on the south and by the Bay of Bengal on the east. This composite basin comprises of three river systems. The river systems between Mahanadi and Godavari covers an area of 49,685 km2 and the river systems between Krishna and Pennar extends over an area of 24,669 km2. In addition, there is also a small area between Godavari and Krishna drained mainly by the small stream of Palleru. This minor portion of the basin has an area of about 12,289 km2.

The independent rivers (directly draining into Bay of Bengal) in the basin from north to south are the Rushikulya, the Bahuda, the Vamsadhara, the Nagavali, the Sarada, the Varaha, the Tandava, the Eluru, the Gundlakamma, the Musi, the Paleru and the Manneru.

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. The-

se 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 5460 samples were collected during January, 2024 to December, 2024 from 13 river basins of India. Nine (09) 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 of CWC after sample preparation/preservation, sent to four Level-III laboratories of CWC. These samples were analyzed at three Level-III laboratories of CWC: NRWQL, New Delhi, LCWQL, Coimbatore and UMGWQL, Varanasi using ICP-MS and APHA method.

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 434 water quality monitoring stations spread over 13 river basins of CWC were considered for the study. All metals are found to be within the acceptable limits at 322 out of 434 monitored stations while at 112 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	5456	5415	41	0.75
2	Cadmium (Cd)	3	5459	5452	07	0.13
3	Chromium (Cr)	50	5039	5025	14	0.28
4	Copper (Cu)	50	5457	5450	07	0.13
5	Iron (Fe)	1000	5417	5092	325	6.00
6	Lead (Pb)	10	5265	5185	80	1.52
7	Mercury (Hg)	1	5361	5326	35	0.65
8	Nickel (Ni)	20	5014	4981	33	0.66
9	Zinc (Zn)	5000	5456	5456	00	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)

Bureau of Indian Standards (BIS) 10500:2012 has recommended an acceptable limit of 10 µg/L of arsenic in drinking water. Out of 5456 river water samples, 41 samples from 13 water quality stations were found to have arsenic concentrations beyond the acceptable limit. The arsenic concentration varies from 0.000 to 22.63 µg/L. Maximum arsenic concentration (22.63 µg/L) was observed at Palla water quality monitoring station on Yamuna River on 21.06.2024.

The details of stations where arsenic 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. Figure 19 represents GIS map of WQ stations where Arsenic found above acceptable limit.

Table 12: River-wise list of WQ stations with Arsenic values above limit (8th Edition) January-December, 2024

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	As (µg/L)	State	District
1	Hindon	Baleni	21.08.2024	13.625	Uttar Pradesh	Baghpat
2	Lalbekia	Baigania	30.09.2024	11.212	Bihar	Sitamarhi
3	Rind	Kora	22.05.2024	10.927	Uttar Pradesh	Fatehpur
			02.06.2024	15.834	Uttar Pradesh	Fatehpur
			02.07.2024	13.783	Uttar Pradesh	Fatehpur
4	Sengar	Lalpur	23.04.2024	12.477	Uttar Pradesh	Kanpur Dehat
			12.05.2024	11.631	Uttar Pradesh	Kanpur Dehat
			22.05.2024	13.511	Uttar Pradesh	Kanpur Dehat
			02.06.2024	15.439	Uttar Pradesh	Kanpur Dehat
			12.06.2024	16.595	Uttar Pradesh	Kanpur Dehat
			22.06.2024	10.042	Uttar Pradesh	Kanpur Dehat
5	Yamuna	Baghpat	01.06.2024	12.737	Uttar Pradesh	Baghpat
			11.06.2024	16.089	Uttar Pradesh	Baghpat
			21.06.2024	22.577	Uttar Pradesh	Baghpat
		Etawah	13.04.2024	10.873	Uttar Pradesh	Etawah
			23.04.2024	11.293	Uttar Pradesh	Etawah
			02.05.2024	11.595	Uttar Pradesh	Etawah
			12.05.2024	10.679	Uttar Pradesh	Etawah
			02.06.2024	13.835	Uttar Pradesh	Etawah
			12.06.2024	12.050	Uttar Pradesh	Etawah
		Gokul Barrage	01.04.2024	10.510	Uttar Pradesh	Mathura
			22.04.2024	11.089	Uttar Pradesh	Mathura
			01.06.2024	13.431	Uttar Pradesh	Mathura
			11.06.2024	14.396	Uttar Pradesh	Mathura
			21.06.2024	15.391	Uttar Pradesh	Mathura
		Jawahar Bridge, Agra	12.06.2024	10.599	Uttar Pradesh	Agra

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	As (µg/L)	State	District
			22.06.2024	10.109	Uttar Pradesh	Agra
		Kailash Mandir (Agra U/S	22.05.2024	10.113	Uttar Pradesh	Agra
5	Yamuna	Palla	13.05.2024	10.372	Delhi	North West Delhi
			01.06.2024	17.618	Delhi	North West Delhi
			11.06.2024	15.235	Delhi	North West Delhi
			21.06.2024	22.634	Delhi	North West Delhi
		Poiyaghat, Agra	02.05.2024	10.210	Uttar Pradesh	Agra
			22.05.2024	11.294	Uttar Pradesh	Agra
			12.06.2024	10.194	Uttar Pradesh	Agra
		Vrindawan Bridge	01.04.2024	10.185	Uttar Pradesh	Mathura
			22.04.2024	11.549	Uttar Pradesh	Mathura
			01.06.2024	13.042	Uttar Pradesh	Mathura
			11.06.2024	14.133	Uttar Pradesh	Mathura
			21.06.2024	15.616	Uttar Pradesh	Mathura
		Yamuna Expessway Road Bridge, Etamadpur	12.06.2024	10.137	Uttar Pradesh	Agra

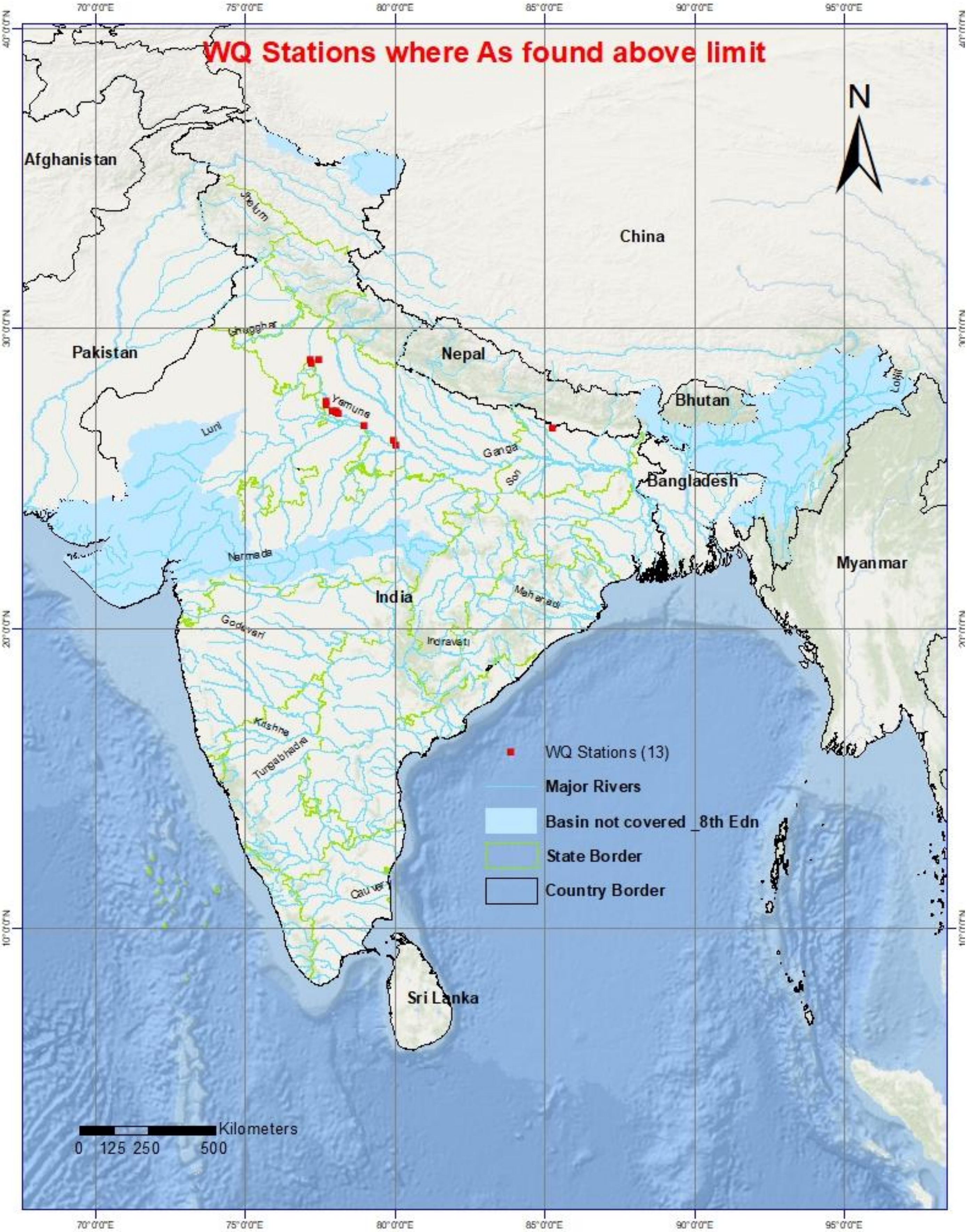

Figure 19: WQ stations where Arsenic found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

A comparison has been conducted between the 7th edition of the report (January – December 2023) and the 8th edition (January – December 2024) concerning arsenic concentrations in river water samples.

In 2023, a total of 5911 samples were collected and analyzed. Of these, 10 samples exceeded the BIS acceptable limit of 10 µg/L for arsenic in drinking water. The samples exceeding the limit were reported from 3 water quality stations located on 3 rivers: Rind, Sengar, and Yamuna. The highest arsenic concentration was recorded at the Lalpur station on the Sengar River, reaching 17.59 µg/L on 21-06-2023.

In contrast, the year 2024 saw a significant escalation in both the number of samples exceeding the acceptable limit and the number of affected monitoring stations. From 5456 samples collected, 41 samples exceeded the acceptable arsenic limit — more than four times the number recorded in 2023. These samples were distributed across 13 water quality stations on 5 rivers: Hindon, Lalbekia, Rind, Sengar, and Yamuna. The maximum arsenic concentration observed was 22.63 µg/L at the Palla station on the Yamuna River (Delhi) on 21-06-2024.

A GIS map depicting the stations where arsenic values were found above the acceptable limit during both study periods is shown as Figure 20.

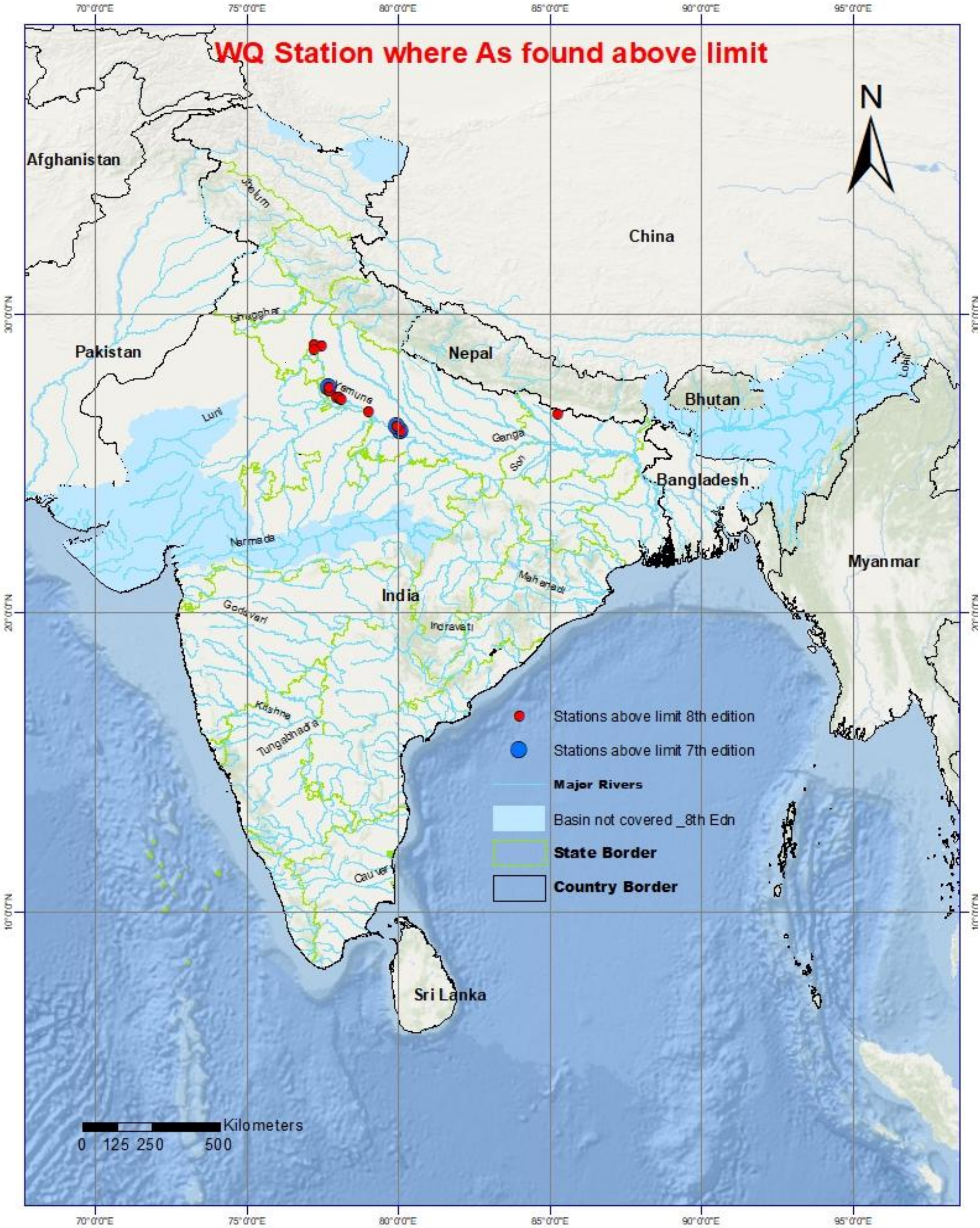

Figure 20: WQ stations where Arsenic found above acceptable limit (both study periods)

7.2 Cadmium (Cd)

Bureau of Indian Standards (BIS) has recommended an acceptable limit of 3 µg/L of cadmium in drinking water. Out of total 5459 river water samples analysed, 07 samples from 03 water quality stations were found to have cadmium concentrations beyond the acceptable limit. The cadmium concentration varies from 0.000 to 6.54 µg/L. Maximum cadmium concentration (6.54 µg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 01-10-2024.

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

S.No.	River/ Reser-voir	Water Quality Stations	Date of Sampling	Cd (µg/L)	State	District
1	Baghmati	Ekmighat	03.06.2024	3.981	Bihar	Darbhanga
2	Kabini	Muthankera	13.02.2024	3.100	Kerala	Wayanad
3	Ponnaiyar	Singasadanapalli	21-06-2024	4.768	Tamil Nadu	Dharmapuri
			11-07-2024	4.035	Tamil Nadu	Dharmapuri
			02-09-2024	5.240	Tamil Nadu	Dharmapuri
			21-09-2024	5.450	Tamil Nadu	Dharmapuri
			01-10-2024	6.540	Tamil Nadu	Dharmapuri

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

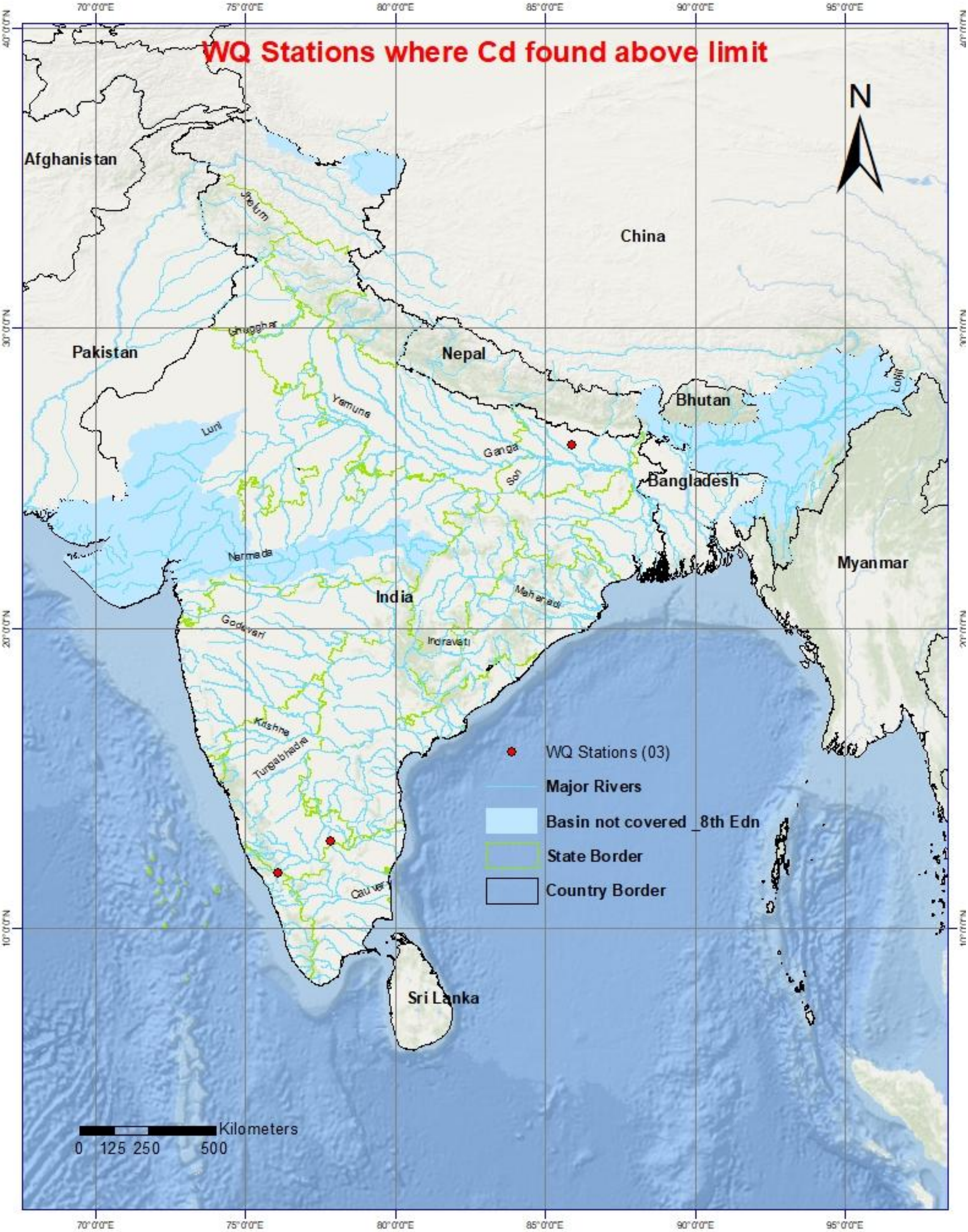

Figure 21: WQ stations where Cadmium found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

The data on cadmium concentrations exceeding the acceptable limit in this report have been compared with the previous edition, i.e., the 7th edition covering the period January–December 2023. During the study period of 2023, out of a total of 5,940 river water samples analyzed, 1 sample from 1 water quality station was found to have cadmium levels above the acceptable limit. Cadmium concentrations ranged from 0.000 to 10.59 µg/L, with the maximum concentration of 10.59 µg/L recorded at the Thevur water quality monitoring station on the Sarabenga River on 01-02-2023.

In contrast, 2024 showed a notable increase in exceedances. Out of 5,459 samples analyzed, 7 samples from 3 different stations across 3 rivers were found to have cadmium concentrations above the acceptable limit. The cadmium levels ranged from 0.000 to 6.54 µg/L, with the highest concentration of 6.54 µg/L observed at the Singasadanapalli station on the Ponnaiyar River on 01-10-2024. In 2024, the rivers where cadmium levels exceeded the acceptable limit were Baghmati, Kabini, and Ponnaiyar. Both the number of samples and the number of affected stations increased in 2024 compared to 2023.

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 no river is found to be the common river which experienced cadmium exceedance during both periods. The comparative analysis between the two periods indicates increase in cadmium exceedance, both in terms of the number of water quality stations and the diversity of rivers impacted during the period of 2024 compared to the preceding period (January- December 2023).

A GIS map depicting the stations where cadmium values were found above the acceptable limit during both study periods is shown as Figure 22.

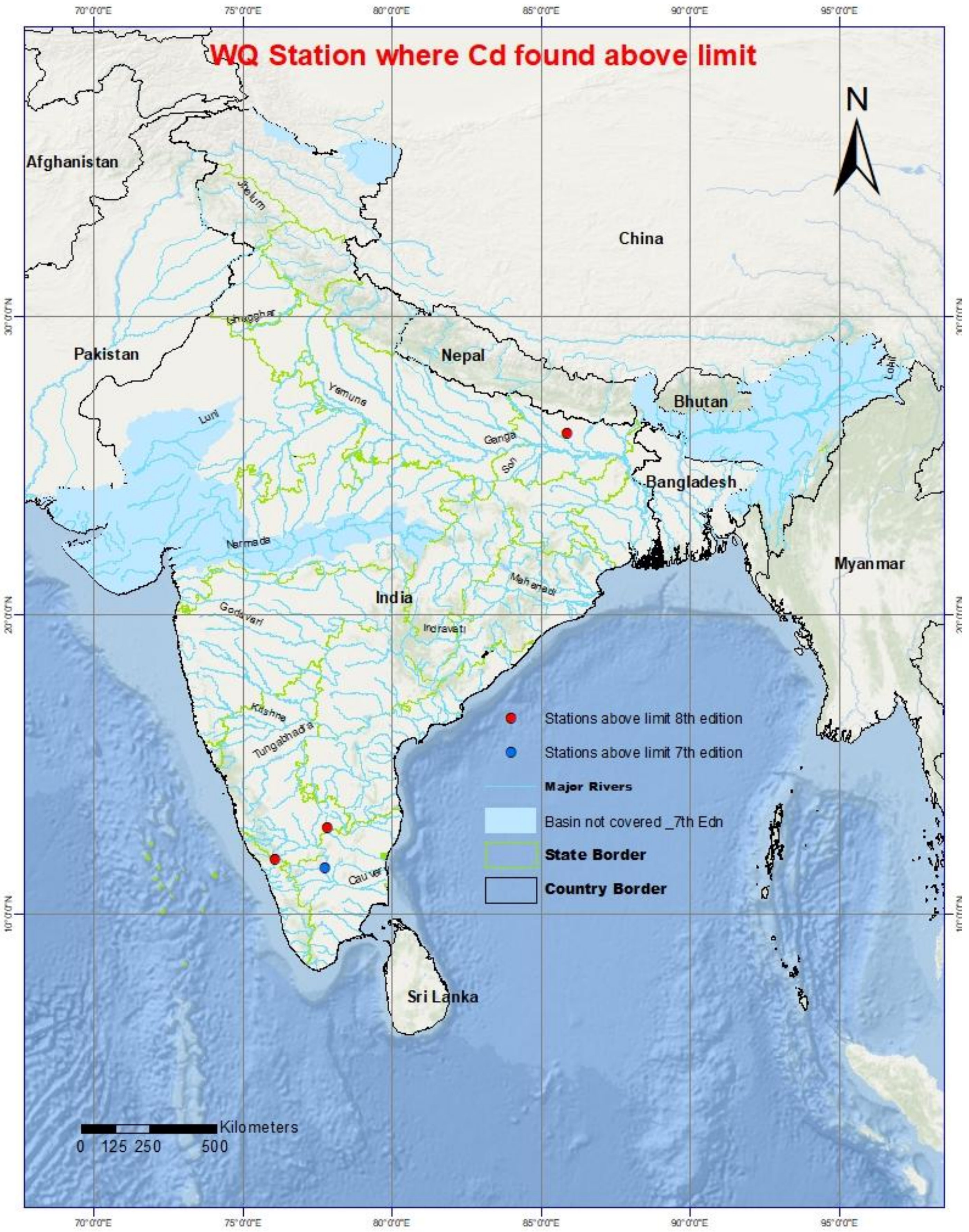

Figure 22: WQ stations where Cadmium found above acceptable limit (both study periods)

7.3 Chromium (Cr)

Bureau of Indian Standards (BIS) 10500:2012 has recommended an acceptable limit of 50 µg/L of chromium in drinking water. Out of total 5039 river water samples analysed, 14 samples from 09 water quality stations were found to have chromium concentrations beyond the acceptable limit. The chromium concentration varies from 0.000 to µg/L. Maximum chromium concentration (248.90 µg/L) was observed at Hogenakkal water quality monitoring station on Chinnar River on 24-10-2024.

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

S. No.	River/ Reser-voir	Water Quality Stations	Date of Sampling	Cr (µg/L)	State	District
1	Arkavathi	Koggedoddi	21.03.2024	54.712	Karnataka	Ramanagara
			12.04.2024	68.744	Karnataka	Ramanagara
			23.09.2024	83.261	Karnataka	Ramanagara
		T Bekuppe	12.04.2024	115.274	Karnataka	Ramanagara
			12.03.2024	51.890	Karnataka	Ramanagara
			01.03.2024	66.905	Karnataka	Ramanagara
2	Cauvery	Chunchanakatte	01.08.2024	52.092	Karnataka	Mysore
		Kudige	22.04.2024	50.608	Karnataka	Kodagu
		Kudlur	22-08-2024	76.360	Karnataka	Chamaraja Nagar
			23-10-2024	99.700	Karnataka	Chamaraja Nagar
3	Chinnar	Hogenakkal	24-10-2024	248.900	Tamil Nadu	Dharmapuri
4	Gataprabha	Gokak	01.08.2024	52.926	Karnataka	Belgaum
5	Yagachi	Thimmanahalli	01.08.2024	53.108	Karnataka	Hassan
6	Yamuna	Okhla Barrage	01.03.2024	64.812	Delhi	South Delhi

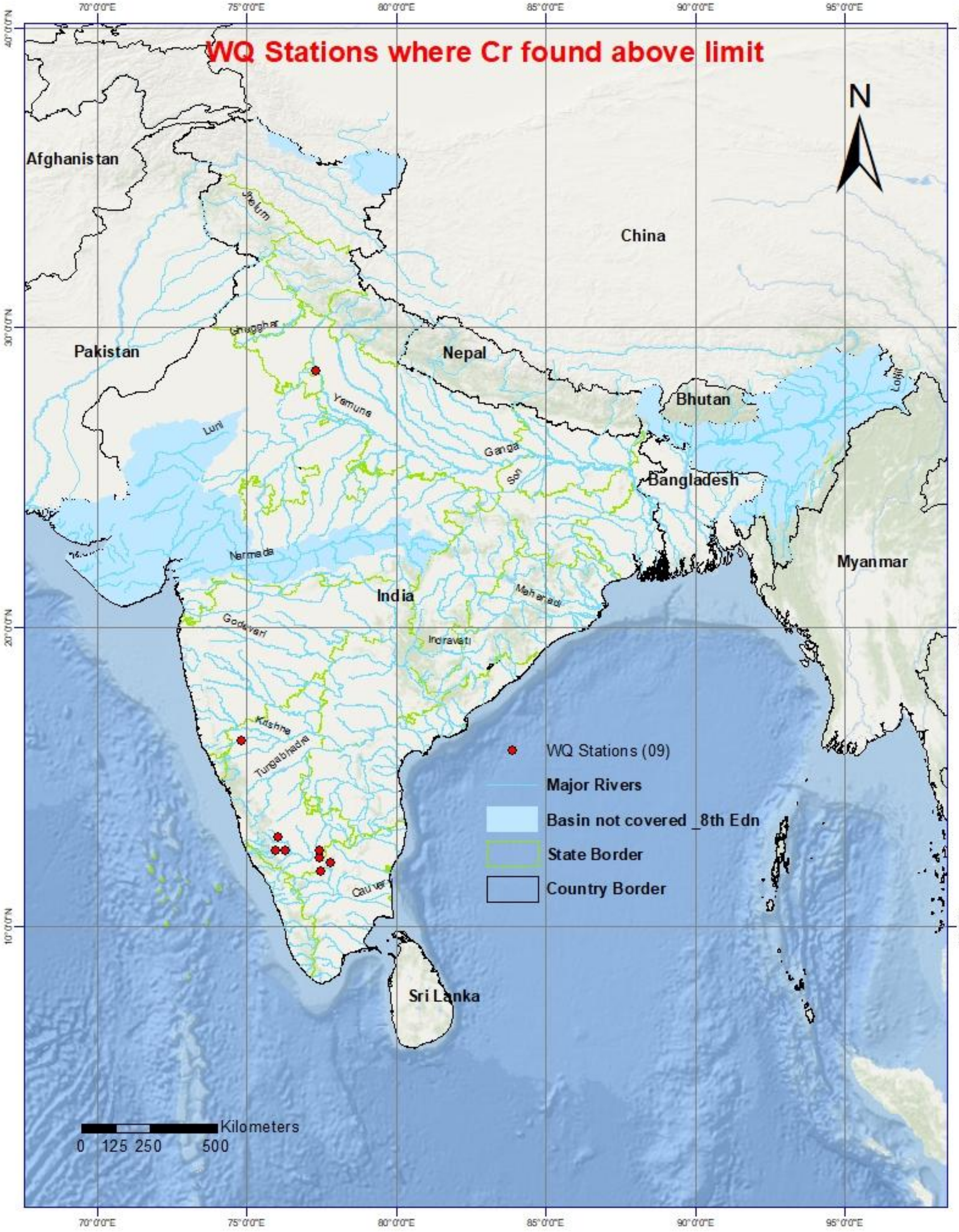

Figure 23: WQ stations where Chromium found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

In 2023, the number of samples exceeding the chromium limit significantly increased to 87 out of 5,730 river water samples analyzed. Chromium concentrations ranged from 0.000 to 84.61 µg/L. The maximum concentration of 84.61 µg/L was observed at the Biligundulu station on the Cauvery River on 12-06-2023. A total of 21 rivers showed chromium levels above the acceptable limit, including: Aliyar, Bhadra, Bhavani, Bhavani/Moyar, Cauvery, Chittar, Gandhayar, Gataprabha, Kallar, Kodaganar, Marudaiyar, Noyyal, Palar, Ponnaiyar, Sarabenga, Suruliyar, Tambraparani, Thoppaiyar, Tungabhadra, Vaigai, and Yamuna.

In 2024, a total of 5,039 river water samples were analyzed, of which 14 samples from 9 water quality stations were found to exceed the acceptable chromium limit. The concentration ranged from 0.000 to 248.90 µg/L, with the highest value of 248.90 µg/L recorded at an unspecified location. Chromium exceedances were reported in 6 rivers: Arkavathi, Chinnar, Cauvery, Gataprabha, Yagachi, and Yamuna.

Notably, three rivers Cauvery, Gataprabha, and Yamuna have reported chromium exceedances in both 2023 and 2024, enabling a direct comparison across years. However, while the number of affected rivers and stations decreased in 2024.

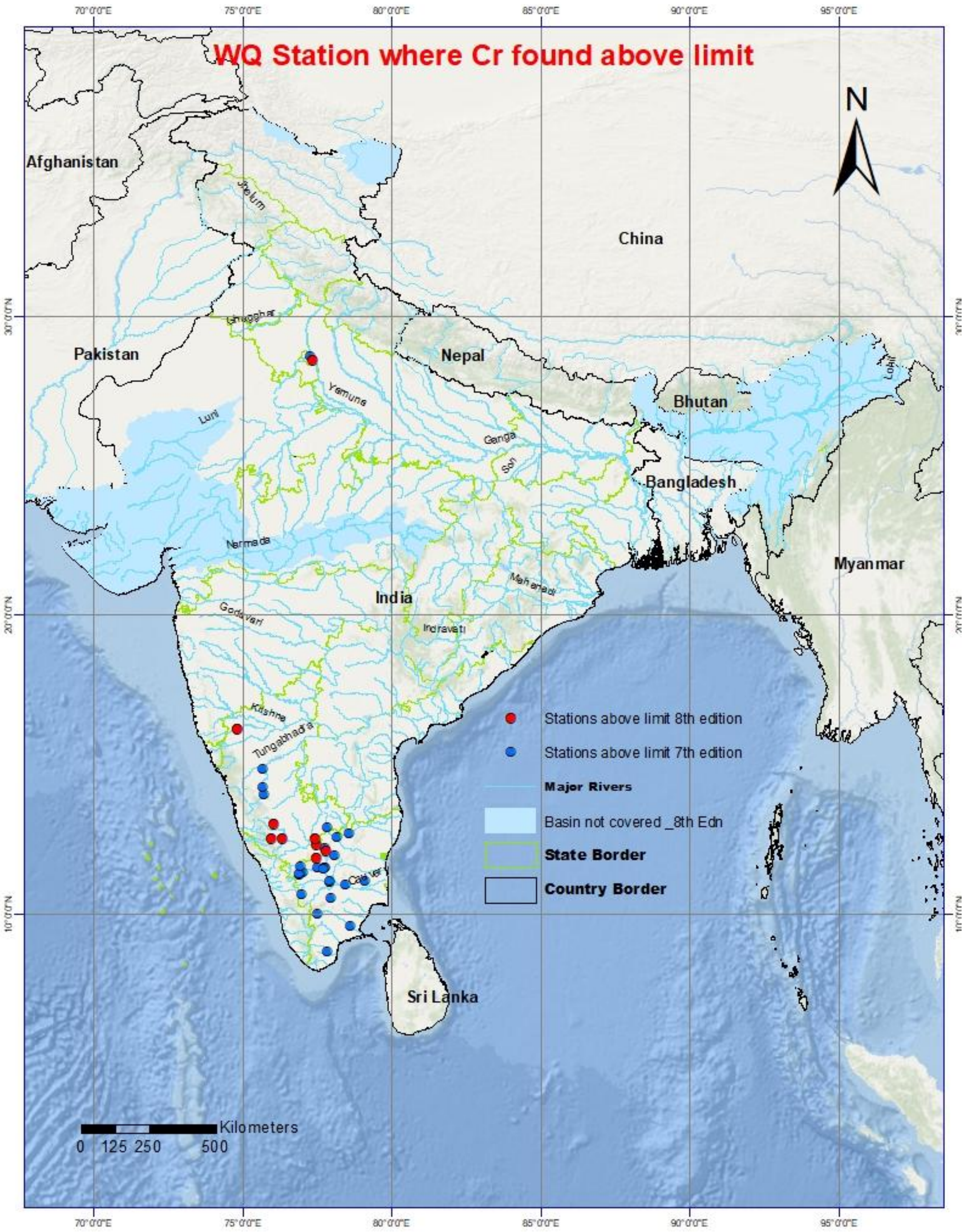

Figure 24: WQ stations where Chromium found above acceptable limit (both study periods)

7.4 Copper (Cu)

Bureau of Indian Standards (BIS) 10500:2012 has recommended an acceptable limit of 50 µg/L of copper in drinking water. Out of total 5457 river water samples analysed, 07 samples from 03 water quality stations were found to have copper concentrations beyond the acceptable limit. The copper concentration varies from 0.000 to 160.41 µg/L. Maximum copper concentration (160.41 µg/L) was observed at Singasadanapalli water quality monitoring station on Ponnaiyar River on 02-09-2024.

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

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Cu (µg/L)	State	District
1	Chinnar	Hogenakkal	03-06-2024	90.055	Tamil Nadu	Dharmapuri
2	Ponnaiyar	Gummanur	06-06-2024	63.831	Tamil Nadu	Dharmapuri
		Singasadanapalli	21-06-2024	98.315	Tamil Nadu	Dharmapuri
			11-07-2024	66.299	Tamil Nadu	Dharmapuri
			02-09-2024	160.410	Tamil Nadu	Dharmapuri
			21-09-2024	156.840	Tamil Nadu	Dharmapuri
			01-10-2024	106.820	Tamil Nadu	Dharmapuri

Figure 25 represents a GIS map of WQ stations where Copper is found above acceptable limit.

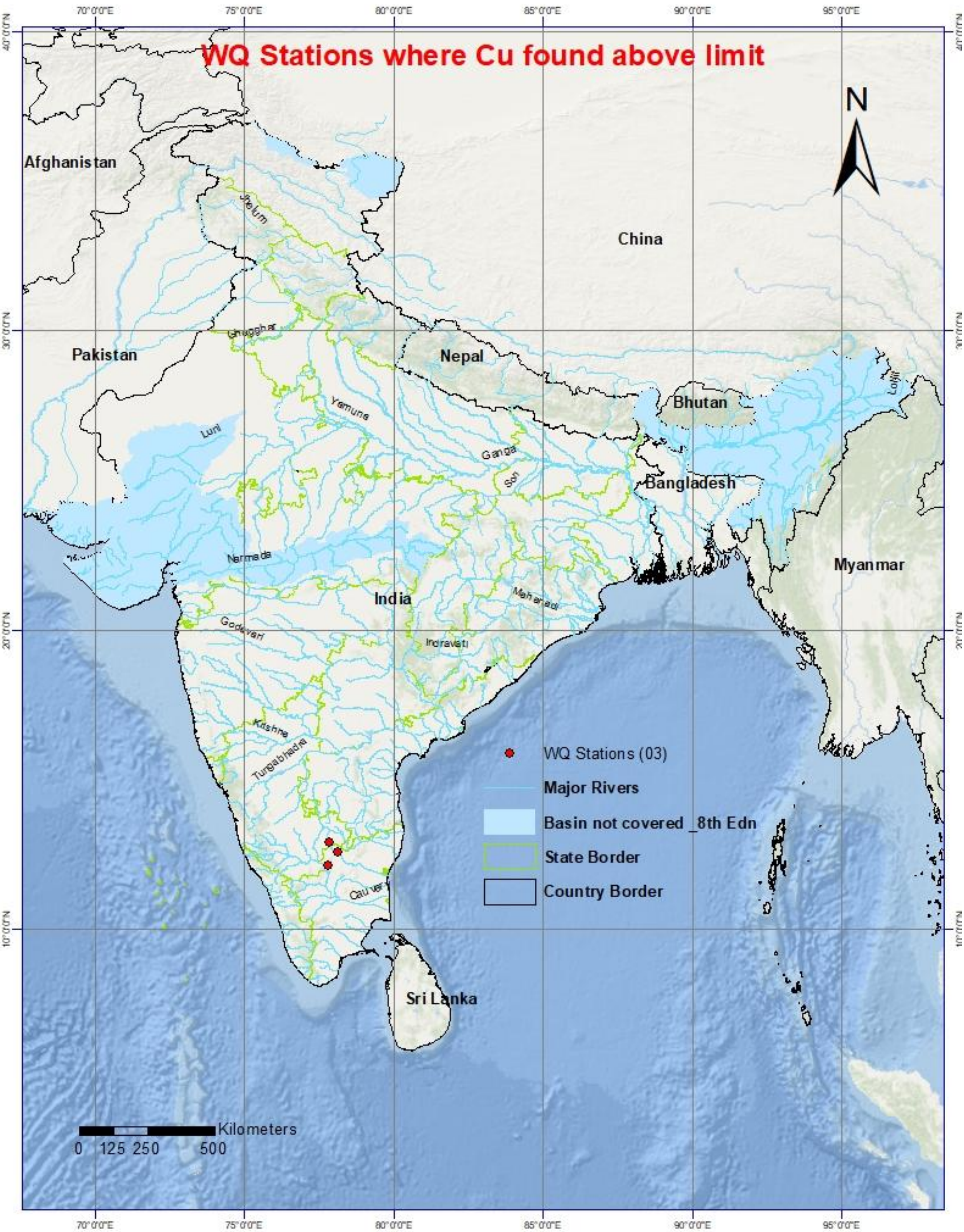

Figure 25: WQ stations where Copper found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

During the period from January to December 2023, a total of 5,940 river water samples were analyzed, with only three samples from three monitoring stations—located on the Aliyar, Bhavani, and Hindon rivers—exceeding the acceptable limit for copper concentration. Although the overall compliance showed improvement, the maximum copper concentration reached 107.01 µg/L at Nellithurai on the Bhavani River. In contrast, during the same period in 2024, a total of 5,457 samples were analyzed, and seven samples from three stations—situated on the Chinnar and Ponnaiyar rivers—were found to exceed the permissible copper levels. The copper concentration in 2024 ranged from 0.000 to 160.41 µg/L, with the highest level recorded at 160.41 µg/L on September 2, 2024, at the Singasadanapalli station on the Ponnaiyar River. Notably, there were no common monitoring stations between the two study periods. While there was a slight decrease in the number of samples analyzed, the increase in exceedances and the rise in maximum copper concentration indicate a potential deterioration in water quality with respect to copper contamination in 2024 compared to 2023.

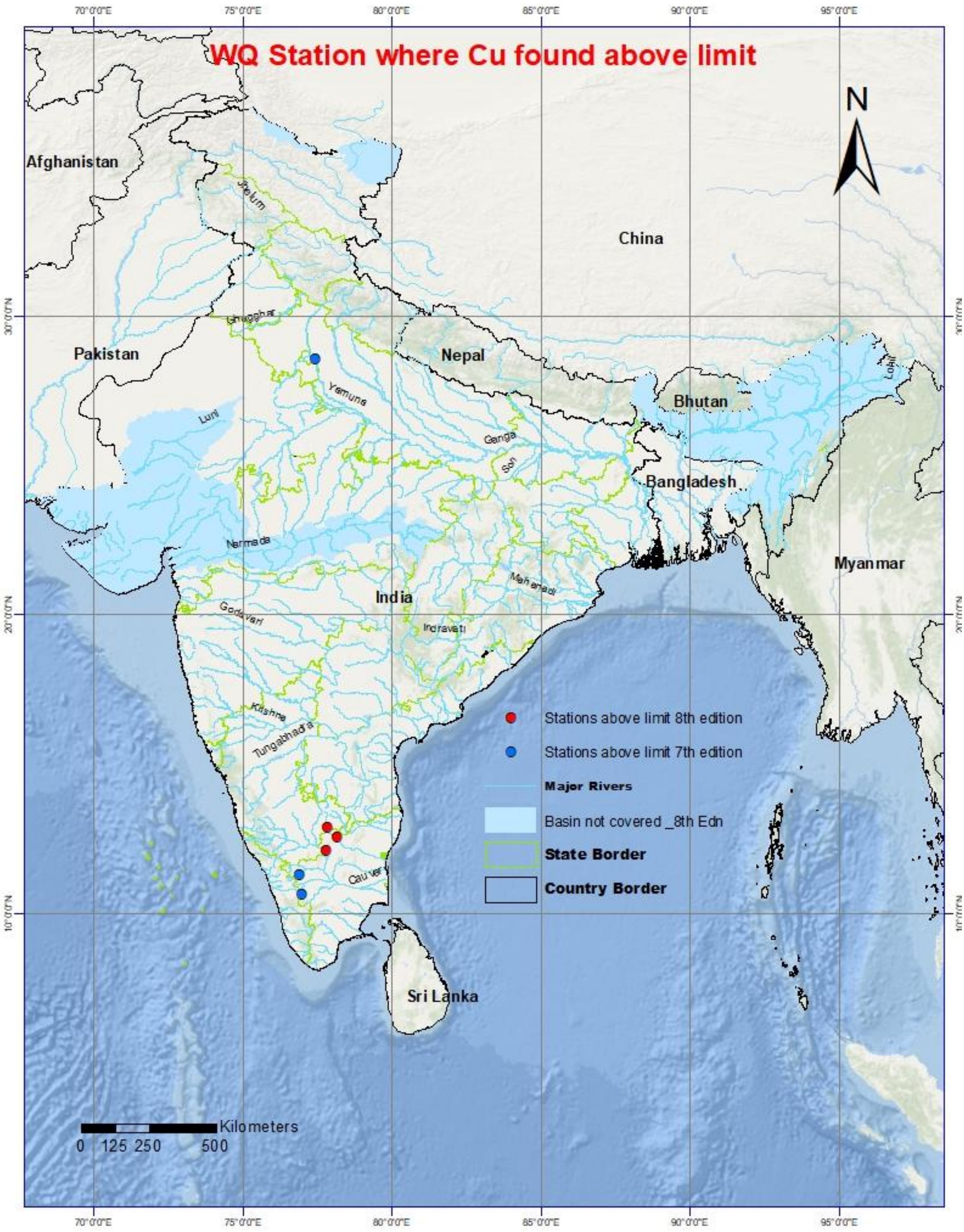

Figure 26: WQ stations where Copper found above acceptable limit (both study periods)

7.5 Iron (Fe)

Bureau of Indian Standards (BIS) 10500:2012 has recommended the acceptable limit of 1.0 mg/L (1000 µg/L) for Iron. Out of total 5417 river water samples analysed, 325 samples from 78 water quality stations were found to have iron concentrations beyond the acceptable limit. The iron concentration varies from 0.000 to 29.216 mg/L. Maximum iron concentration (21.216 mg/L) was observed at Kudlur water quality monitoring station on Cauvery River on 23-10-2024.

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

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
1	Aliyar	Ambarampalayam	11-06-2024	1714.330	Tamil Nadu	Coimbatore
			12-08-2024	1216.700	Tamil Nadu	Coimbatore
			21-08-2024	1706.680	Tamil Nadu	Coimbatore
			01-10-2024	2025.064	Tamil Nadu	Coimbatore
2	Amaravathi	Nallamaranpatti	01-08-2024	1305.711	Tamil Nadu	Karur
			16-08-2024	1830.804	Tamil Nadu	Karur
3	Arkavathi	Koggedoddi	03.06.2024	1281.590	Karnataka	Ramanagara
			11.09.2024	3627.495	Karnataka	Ramanagara
			12.08.2024	2828.142	Karnataka	Ramanagara
		T Bekuppe	02.01.2024	1618.191	Karnataka	Ramanagara
			12.04.2024	1343.794	Karnataka	Ramanagara
4	Ayyar	Thandalaiputhur	02-12-2024	1808.348	Tamil Nadu	Thiruchirapalli
5	Bagamati	Dhengbridge	01.08.2024	1179.578	Bihar	Sitamarhi
			30.09.2024	1105.530	Bihar	Sitamarhi
6	Bagmati	Hayaghat	30.09.2024	1031.492	Bihar	Darbhanga
7	Bata	Ganguwala	21.06.2024	1150.147	Himachal Pradesh	Sirmaur
8	Bhadra	Holehonnur	03.06.2024	1596.748	Karnataka	Shimoga
			02.04.2024	2261.562	Karnataka	Shimoga
			22.10.2024	1420.521	Karnataka	Shimoga
			21.02.2024	3121.290	Karnataka	Shimoga
			01.08.2024	4573.387	Karnataka	Shimoga
			22.07.2024	2688.004	Karnataka	Shimoga
			02.01.2024	1919.124	Karnataka	Shimoga
			11.09.2024	7817.436	Karnataka	Shimoga
			23.01.2024	5127.023	Karnataka	Shimoga
			02.09.2024	2428.008	Karnataka	Shimoga
			23.09.2024	1924.317	Karnataka	Shimoga
			21.08.2024	2206.871	Karnataka	Shimoga
		Lakkavalli	11.09.2024	4026.270	Karnataka	Chikmagalur
			12.04.2024	4733.055	Karnataka	Chikmagalur
			03.06.2024	1169.337	Karnataka	Chikmagalur
			22.04.2024	3802.069	Karnataka	Chikmagalur
			02.09.2024	4446.086	Karnataka	Chikmagalur

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
8	Bhadra	Lakkavalli	01.08.2024	4173.629	Karnataka	Chikmagalur
			02.01.2024	2126.644	Karnataka	Chikmagalur
			23.01.2024	2480.141	Karnataka	Chikmagalur
			02.07.2024	1020.529	Karnataka	Chikmagalur
9	Bhavani	Savandapur	01-08-2024	1048.492	Tamil Nadu	Erode
			12-08-2024	1594.300	Tamil Nadu	Erode
			01-10-2024	1073.551	Tamil Nadu	Erode
10	Bhavani/Moyar	Thengumarahada	11-06-2024	3780.041	Tamil Nadu	Nilgiris
			21-06-2024	3436.773	Tamil Nadu	Nilgiris
			01-07-2024	9686.601	Tamil Nadu	Nilgiris
			11-07-2024	3505.380	Tamil Nadu	Nilgiris
			22-07-2024	6349.590	Tamil Nadu	Nilgiris
			01-08-2024	6118.470	Tamil Nadu	Nilgiris
			12-08-2024	2140.034	Tamil Nadu	Nilgiris
			21-08-2024	11826.100	Tamil Nadu	Nilgiris
			02-09-2024	1807.504	Tamil Nadu	Nilgiris
			11-09-2024	1124.464	Tamil Nadu	Nilgiris
11	Cauvery	Biligundulu	01-07-2024	1160.451	Tamil Nadu	Krishnagiri
			22-07-2024	3346.870	Tamil Nadu	Krishnagiri
			01-08-2024	4526.520	Tamil Nadu	Krishnagiri
			12-08-2024	3222.080	Tamil Nadu	Krishnagiri
			21-08-2024	1107.945	Tamil Nadu	Krishnagiri
			02-09-2024	1659.728	Tamil Nadu	Krishnagiri
			01-10-2024	7937.730	Tamil Nadu	Krishnagiri
		Chunchanakatte	11.06.2024	1559.885	Karnataka	Mysore
			03.06.2024	4718.915	Karnataka	Mysore
			11.09.2024	1322.843	Karnataka	Mysore
			22.07.2024	1368.979	Karnataka	Mysore
			01.08.2024	3091.945	Karnataka	Mysore
			02.09.2024	1803.276	Karnataka	Mysore
			23.09.2024	1098.123	Karnataka	Mysore
		Kodumudi	12-08-2024	1308.165	Tamil Nadu	Erode
		Kollegal	22.07.2024	1907.598	Karnataka	Chamaraja Nagar
			02.09.2024	3151.460	Karnataka	Chamaraja Nagar
			11.09.2024	6031.340	Karnataka	Chamaraja Nagar
		Kudige	21.05.2024	9328.151	Karnataka	Kodagu
			22.07.2024	1469.988	Karnataka	Kodagu
			12.04.2024	1357.648	Karnataka	Kodagu
			01.02.2024	1077.164	Karnataka	Kodagu
			22.10.2024	1749.181	Karnataka	Kodagu
			01.08.2024	2190.362	Karnataka	Kodagu
			11.09.2024	2112.736	Karnataka	Kodagu
			23.09.2024	1122.775	Karnataka	Kodagu
			02.09.2024	1090.124	Karnataka	Kodagu
			02.04.2024	1627.360	Karnataka	Kodagu
		Kudlur	22-08-2024	24212.060	Karnataka	Chamaraja Nagar
			23-10-2024	29216.600	Karnataka	Chamaraja Nagar
		Musiri	01-08-2024	1503.999	Tamil Nadu	Thiruchirapalli
			01-11-2024	1693.881	Tamil Nadu	Thiruchirapalli

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
12	Chambal	Dholpur	12.07.2024	1270.641	Rajasthan	Dholpur
		Udi	12.07.2024	1048.754	Uttar Pradesh	Etawah
13	Chenab	Akhnoor	22.05.2024	1257.475	Jammu & Kashmir	Jammu
		Dhamkund	21.09.2024	3931.298	Jammu & Kashmir	Ramban
		Premnagar	21.06.2024	1046.806	Jammu & Kashmir	Doda
		Tandi	23.09.2024	1043.062	Himachal Pradesh	Lahoul & Spiti
		Udaipur	24.07.2024	2001.857	Himachal Pradesh	Lahoul & Spiti
14	Chinnar	Hogenakkal	03-06-2024	16217.924	Tamil Nadu	Dharmapuri
			24-10-2024	12934.300	Tamil Nadu	Dharmapuri
			02-12-2024	16830.800	Tamil Nadu	Dharmapuri
15	Chittar	AP Puram	13-12-2024	19403.100	Tamil Nadu	Tirunelveli
16	Gad	Belne Bridge	23.09.2024	3387.276	Maharashtra	Sindudurg
			02.01.2024	3063.318	Maharashtra	Sindudurg
			11.07.2024	1189.670	Maharashtra	Sindudurg
			22.07.2024	1302.872	Maharashtra	Sindudurg
			22.01.2024	7382.565	Maharashtra	Sindudurg
			01.03.2024	7857.090	Maharashtra	Sindudurg
			01.08.2024	4078.153	Maharashtra	Sindudurg
			21.08.2024	2965.039	Maharashtra	Sindudurg
17	Gandak	Triveni	30.09.2025	1071.005	Bihar	West Champaran
18	Gandhayar	Gandhavayal	01-06-2024	1082.728	Tamil Nadu	Coimbatore
			21-06-2024	2858.220	Tamil Nadu	Coimbatore
			01-07-2024	1622.354	Tamil Nadu	Coimbatore
			22-07-2024	1171.649	Tamil Nadu	Coimbatore
			01-08-2024	1771.923	Tamil Nadu	Coimbatore
			12-08-2024	1198.693	Tamil Nadu	Coimbatore
			21-08-2024	4296.290	Tamil Nadu	Coimbatore
			02-09-2024	1101.782	Tamil Nadu	Coimbatore
19	Gataprabha	Gokak	03.06.2024	2090.970	Karnataka	Belgaum
			11.07.2024	1697.102	Karnataka	Belgaum
			22.07.2024	1757.802	Karnataka	Belgaum
			01.08.2024	8293.701	Karnataka	Belgaum
			11.09.2024	1602.482	Karnataka	Belgaum
20	Halady	Haladi	01.01.2024	1035.827	KARNATAKA	Udupi
21	Haridra	Byaladahalli	02.09.2024	1469.079	Karnataka	Davanagere
			11.09.2024	1921.589	Karnataka	Davanagere
			23.09.2024	1421.048	Karnataka	Davanagere
			21.08.2024	1399.178	Karnataka	Davanagere
			12.08.2024	1556.155	Karnataka	Davanagere
22	Hemavathi	Akkihebbal	23.09.2024	3553.529	Karnataka	Mandya
			12.03.2024	1049.314	Karnataka	Mandya
			12.04.2024	2154.234	Karnataka	Mandya
			01.08.2024	1231.845	Karnataka	Mandya
		M H Halli	11.09.2024	1237.017	Karnataka	Hassan
			23.09.2024	3113.833	Karnataka	Hassan
			01.08.2024	1228.025	Karnataka	Hassan
		Sakleshpura	11.06.2024	1891.308	Karnataka	Hassan
			22.07.2024	2411.923	Karnataka	Hassan
			02.01.2024	2667.934	Karnataka	Hassan

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
22	Hemavathi	Sakleshpura	21.05.2024	1196.374	Karnataka	Hassan
			03.06.2024	1110.606	Karnataka	Hassan
			11.07.2024	1708.303	Karnataka	Hassan
			12.08.2024	3553.024	Karnataka	Hassan
			23.01.2024	4624.948	Karnataka	Hassan
			23.09.2024	3678.166	Karnataka	Hassan
			11.09.2024	6134.330	Karnataka	Hassan
			01.08.2024	3924.755	Karnataka	Hassan
			11.01.2024	2955.951	Karnataka	Hassan
			02.09.2024	1065.483	Karnataka	Hassan
			13.02.2024	2345.959	Karnataka	Hassan
23	Hindon	Galeta	22.04.2024	1054.548	Uttar Pradesh	Meerut
24	Kabini	Muthankera	22.07.2024	1858.101	Kerala	Wayanad
			21.05.2024	1081.610	Kerala	Wayanad
			02.09.2024	1055.452	Kerala	Wayanad
			22.10.2024	1451.966	Kerala	Wayanad
			01.08.2024	5516.096	Kerala	Wayanad
			23.01.2024	3380.810	Kerala	Wayanad
			03.06.2024	2976.995	Kerala	Wayanad
			11.07.2024	1118.777	Kerala	Wayanad
			23.09.2024	1145.764	Kerala	Wayanad
			11.09.2024	4257.698	Kerala	Wayanad
			22.04.2024	1061.495	Kerala	Wayanad
			01.02.2024	2966.418	Kerala	Wayanad
			12.08.2024	1591.304	Kerala	Wayanad
		T. N. Pura	22.07.2024	1165.955	Karnataka	Mysore
			11.09.2024	6644.244	Karnataka	Mysore
			11.01.2024	1752.558	Karnataka	Mysore
			22.04.2024	1471.737	Karnataka	Mysore
			12.04.2024	1330.620	Karnataka	Mysore
			01.08.2024	1010.094	Karnataka	Mysore
25	Kadalundi	Karathode	01.01.2024	1002.621	Kerala	Malappuram
26	Kaliyar	Kalampur	23.01.2024	1050.808	Kerala	Ernakulam
			21.02.2024	1088.611	Kerala	Ernakulam
27	Kallar	Odenthurai	21-06-2024	1429.456	Tamil Nadu	Coimbatore
			11-07-2024	1313.954	Tamil Nadu	Coimbatore
			22-07-2024	2940.340	Tamil Nadu	Coimbatore
			01-08-2024	1052.543	Tamil Nadu	Coimbatore
			12-08-2024	13719.090	Tamil Nadu	Coimbatore
			21-08-2024	1118.745	Tamil Nadu	Coimbatore
28	Kamalabalan	Jainagar	30.09.2024	1082.867	Bihar	Madhubani
29	Ken	Banda	02.08.2024	1676.195	Uttar Pradesh	Banda
		Madla	23.07.2024	1224.412	Madhya Pradesh	Panna
			02.08.2024	1426.981	Madhya Pradesh	Panna
30	Kinnersani	Sangam	23.04.2024	1079.396	Jammu & Kashmir	Anantnag
31	Kosi	Baltara	30.09.2024	1008.806	Bihar	Khagaria
32	Koyna	Warunji		1038.251	Maharashtra	Satara
33	Kumudvathi	Kuppelur	22.07.2024	7407.729	Karnataka	Haveri
			22.10.2024	1172.664	Karnataka	Haveri
			01.08.2024	6466.449	Karnataka	Haveri

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
33	Kumudvathi	Kuppelur	23.09.2024	1733.448	Karnataka	Haveri
			11.09.2024	1693.302	Karnataka	Haveri
			12.08.2024	1420.995	Karnataka	Haveri
34	Kunwari	Bhind	13.08.2024	1066.241	Madhya Pradesh	Bhind
35	Lalbekia	Baigania	30.09.2024	1262.186	Bihar	Sitamarhi
36	Laxmanathirtha	K M Vadi	11.06.2024	1125.232	Karnataka	Mysore
			22.07.2024	5314.803	Karnataka	Mysore
			12.08.2024	1818.246	Karnataka	Mysore
			11.01.2024	1607.140	Karnataka	Mysore
			01.08.2024	6033.851	Karnataka	Mysore
			11.09.2024	3502.781	Karnataka	Mysore
			23.09.2024	3234.400	Karnataka	Mysore
			02.09.2024	2775.688	Karnataka	Mysore
			23.01.2024	2626.548	Karnataka	Mysore
			11.07.2024	1548.508	Karnataka	Mysore
37	Malaprabha	Cholachagudda	21.11.2024	2230.213	Karnataka	Bagalkot
			22.07.2024	9307.652	Karnataka	Bagalkot
			12.08.2024	7717.623	Karnataka	Bagalkot
			11.07.2024	1708.166	Karnataka	Bagalkot
			21.08.2024	4506.284	Karnataka	Bagalkot
			02.09.2024	1538.317	Karnataka	Bagalkot
38	Noyyal	Alandurai	01-07-2024	3949.041	Tamil Nadu	Coimbatore
			16-07-2024	12610.890	Tamil Nadu	Coimbatore
			25-07-2024	9126.460	Tamil Nadu	Coimbatore
			01-08-2024	4518.480	Tamil Nadu	Coimbatore
			04-09-2024	4754.370	Tamil Nadu	Coimbatore
		Elunuthimangalam	11-06-2024	1049.994	Tamil Nadu	Erode
			01-08-2024	1312.977	Tamil Nadu	Erode
39	Ponnaiyar	Gummanur	06-06-2024	12927.140	Tamil Nadu	Dharmapuri
			11-06-2024	1116.390	Tamil Nadu	Dharmapuri
			02-07-2024	1498.011	Tamil Nadu	Dharmapuri
			12-08-2024	2395.807	Tamil Nadu	Dharmapuri
			21-08-2024	1441.666	Tamil Nadu	Dharmapuri
			02-09-2024	1167.185	Tamil Nadu	Dharmapuri
			01-10-2024	10830.550	Tamil Nadu	Dharmapuri
40	Ponnaiyar	Singasadanapalli	01-06-2024	1861.323	Tamil Nadu	Dharmapuri
			11-06-2024	1639.263	Tamil Nadu	Dharmapuri
			21-06-2024	3806.204	Tamil Nadu	Dharmapuri
			01-07-2024	2313.831	Tamil Nadu	Dharmapuri
			11-07-2024	5268.435	Tamil Nadu	Dharmapuri
			22-07-2024	2927.720	Tamil Nadu	Dharmapuri
			12-08-2024	3556.520	Tamil Nadu	Dharmapuri
			21-08-2024	4290.220	Tamil Nadu	Dharmapuri
			02-09-2024	4533.310	Tamil Nadu	Dharmapuri
			11-09-2024	1145.705	Tamil Nadu	Dharmapuri
			21-09-2024	4070.190	Tamil Nadu	Dharmapuri
			01-10-2024	14615.900	Tamil Nadu	Dharmapuri

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
41	Pravara	Pratappur	02.08.2024	1298.695	Uttar Pradesh	Prayagraj
	Pravara	Pratappur	13.08.2024	1325.038	Uttar Pradesh	Prayagraj
42	Rind	Kora	12.07.2024	2079.783	Uttar Pradesh	Fatehpur
			02.08.2024	5072.692	Uttar Pradesh	Fatehpur
			13.08.2024	1886.102	Uttar Pradesh	Fatehpur
			22.08.2024	2031.919	Uttar Pradesh	Fatehpur
			22.09.2024	1174.332	Uttar Pradesh	Fatehpur
43	Sahibi	Dhansa	11.06.2024	1931.794	Haryana	Jhjjar
44	Sengar	Lalpur	23.07.2024	1180.756	Uttar Pradesh	Kanpur Dehat
			02.08.2024	1350.966	Uttar Pradesh	Kanpur Dehat
			13.08.2024	1706.320	Uttar Pradesh	Kanpur Dehat
45	Suruliyar	Theni	13-06-2024	1110.695	Tamil Nadu	Theni
			01-07-2024	6529.250	Tamil Nadu	Theni
			11-07-2024	6090.488	Tamil Nadu	Theni
			22-07-2024	4489.070	Tamil Nadu	Theni
			01-08-2024	4016.020	Tamil Nadu	Theni
			12-08-2024	5842.120	Tamil Nadu	Theni
			21-08-2024	5628.510	Tamil Nadu	Theni
			02-09-2024	2023.418	Tamil Nadu	Theni
			11-09-2024	1436.883	Tamil Nadu	Theni
			21-09-2024	1430.397	Tamil Nadu	Theni
			01-10-2024	3550.690	Tamil Nadu	Theni
			01-11-2024	7130.430	Tamil Nadu	Theni
			02-12-2024	2495.205	Tamil Nadu	Theni
46	Suvarnavathy	Bendrahalli	22.07.2024	2092.808	Karnataka	Chamaraja Nagar
			11.09.2024	3015.841	Karnataka	Chamaraja Nagar
			02.09.2024	4012.021	Karnataka	Chamaraja Nagar
			12.08.2024	4465.280	Karnataka	Chamaraja Nagar
			01.08.2024	2409.823	Karnataka	Chamaraja Nagar
47	Tambraparani	Murappanadu	01-06-2024	1389.772	Tamil Nadu	Tuticorin
			11-06-2024	1286.126	Tamil Nadu	Tuticorin
			21-06-2024	1405.136	Tamil Nadu	Tuticorin
			01-07-2024	1785.227	Tamil Nadu	Tuticorin
			11-07-2024	1386.115	Tamil Nadu	Tuticorin
			22-07-2024	2481.357	Tamil Nadu	Tuticorin
			01-08-2024	1236.090	Tamil Nadu	Tuticorin
			12-08-2024	1106.127	Tamil Nadu	Tuticorin
			21-08-2024	1198.474	Tamil Nadu	Tuticorin
			02-09-2024	1214.103	Tamil Nadu	Tuticorin
			01-10-2024	1700.285	Tamil Nadu	Tuticorin
48	Thoppaiyar	Thoppur	03-12-2024	1564.873	Tamil Nadu	Salem
49	Tunga	Hariharapura	23.09.2024	1973.940	Karnataka	Chikamagaluru
			11.07.2024	1511.824	Karnataka	Chikamagaluru
			12.04.2024	1426.051	Karnataka	Chikamagaluru
			02.01.2024	2708.570	Karnataka	Chikamagaluru
			03.06.2024	1232.034	Karnataka	Chikamagaluru
			01.08.2024	9072.378	Karnataka	Chikamagaluru
			22.07.2024	1711.198	Karnataka	Chikamagaluru
			11.09.2024	1229.477	Karnataka	Chikamagaluru
			21.08.2024	2381.438	Karnataka	Chikamagaluru

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Fe (µg/L)	State	District
49		Shimoga	22.07.2024	6614.536	Karnataka	Shimoga
			21.05.2024	1572.566	Karnataka	Shimoga
			22.10.2024	1157.619	Karnataka	Shimoga
			02.09.2024	3763.435	Karnataka	Shimoga
			23.09.2024	1726.593	Karnataka	Shimoga
			11.09.2024	1959.378	Karnataka	Shimoga
50	Tungabhadra	Haralahalli	22.07.2024	4873.254	Karnataka	Haveri
			22.10.2024	1270.269	Karnataka	Haveri
			11.09.2024	1869.496	Karnataka	Haveri
			02.09.2024	2851.898	Karnataka	Haveri
			01.08.2024	6831.853	Karnataka	Haveri
			21.08.2024	2053.015	Karnataka	Haveri
			12.08.2024	2189.781	Karnataka	Haveri
			23.09.2024	3188.375	Karnataka	Haveri
		Honnali	22.10.2024	1488.872	Karnataka	Davanagere
			21.08.2024	9313.930	Karnataka	Davanagere
			01.08.2024	5878.442	Karnataka	Davanagere
			22.07.2024	3086.654	Karnataka	Davanagere
			11.09.2024	1539.168	Karnataka	Davanagere
51	Vaigai	Ambasamudram	01-11-2024	1147.152	Tamil Nadu	Theni
52	Varada	Marol	23.09.2024	1140.869	Karnataka	Haveri
			22.10.2024	1071.749	Karnataka	Haveri
			01.08.2024	2409.508	Karnataka	Haveri
			11.07.2024	4257.877	Karnataka	Haveri
			11.09.2024	3594.466	Karnataka	Haveri
			02.09.2024	1224.214	Karnataka	Haveri
			22.07.2024	1881.272	Karnataka	Haveri
53	Vedavathi	Kellodu	21.05.2024	3937.065	Karnataka	Chitradurga
			22.10.2024	1048.966	Karnataka	Chitradurga
			01.08.2024	4162.047	Karnataka	Chitradurga
			02.09.2024	2691.770	Karnataka	Chitradurga
			12.08.2024	2700.520	Karnataka	Chitradurga
			11.09.2024	2715.134	Karnataka	Chitradurga
54	Yagachi	Thimmanahalli	02.04.2024	2239.343	Karnataka	Hassan
			11.06.2024	1118.691	Karnataka	Hassan
			21.03.2024	1268.013	Karnataka	Hassan
			03.06.2024	1451.024	Karnataka	Hassan
			01.03.2024	2041.263	Karnataka	Hassan
			01.08.2024	2142.333	Karnataka	Hassan
			12.08.2024	1060.876	Karnataka	Hassan
			11.09.2024	1434.988	Karnataka	Hassan
55	Yamuna	Gokul Barrage	04.10.2024	3343.751	Uttar Pradesh	Mathura
		Hamirpur	12.07.2024	1901.295	Uttar Pradesh	Hamirpur
			22.08.2024	1373.569	Uttar Pradesh	Hamirpur
		Okhla Barrage	01.03.2024	1002.290	Delhi	South Delhi
		Rajapur	02.08.2024	1436.341	Uttar Pradesh	Chitrakoot
			13.08.2024	1286.807	Uttar Pradesh	Chitrakoot

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. Figure 27 depicts the GIS map of WQ stations where Iron is found to be above limit.

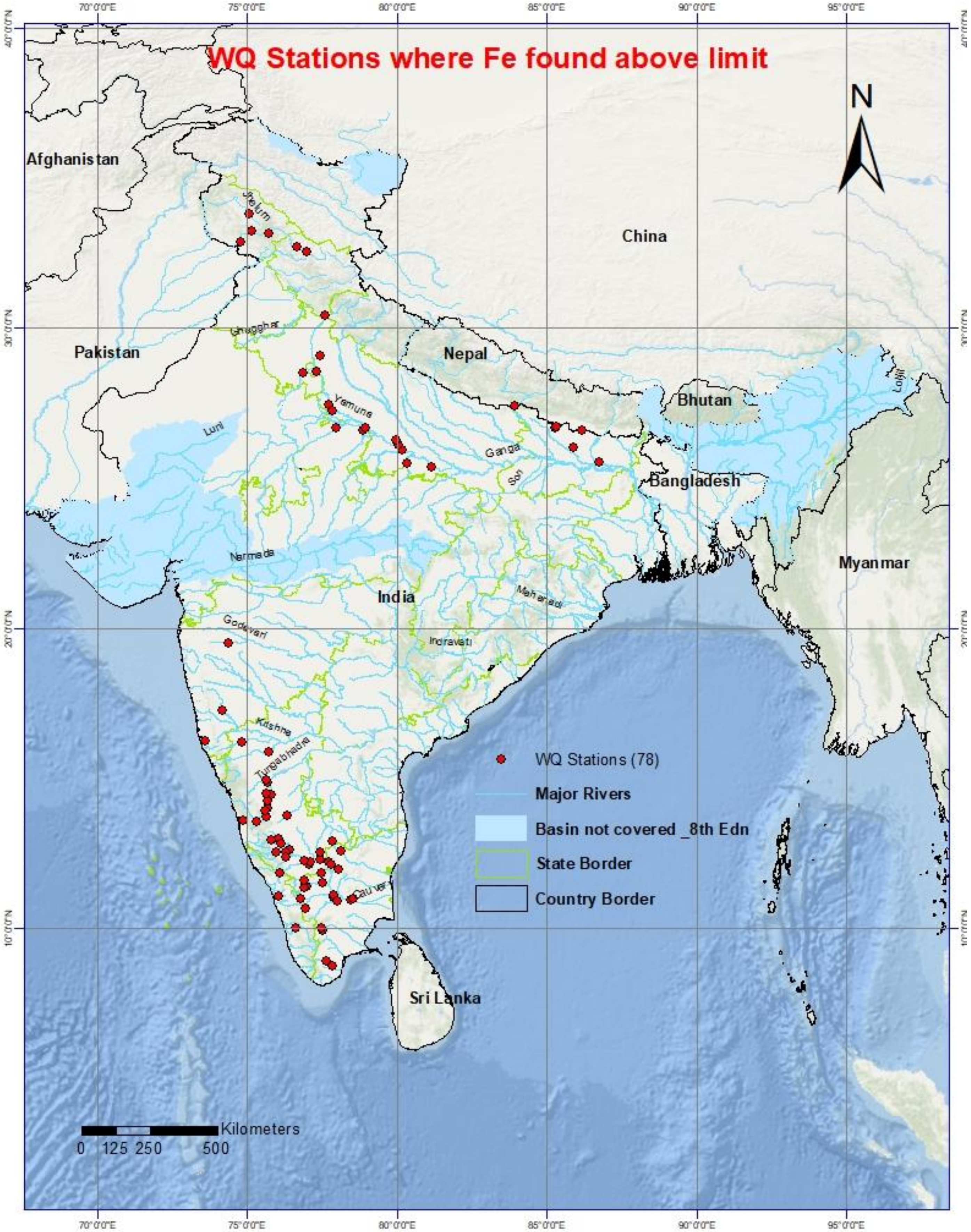

Figure 27: WQ stations where Iron found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

In the 7th edition of the study, during the year 2023, a total of 5,768 river water samples were analyzed to assess iron concentration levels across India. Among these, 292 samples—collected from 63 water quality monitoring stations—were found to contain iron concentrations exceeding the acceptable limit, accounting for approximately 5.06% of the total samples analyzed. These exceedances were reported across 49 different rivers. The iron concentrations ranged from 0.000 mg/L to 5.99 mg/L, with the highest concentration recorded at the Murappanadu monitoring station on the Tambraparani River on November 2, 2023.

In contrast, during 2024, a slightly lower number of samples (5,417) were analyzed; however, there was an increase in the number of samples exceeding the permissible limit. A total of 325 samples from 78 monitoring stations were found to have iron levels above the acceptable limit. The iron concentration range in 2024 varied from 0.000 mg/L to 21.216 mg/L, with the highest concentration recorded at the Kudlur monitoring station on the Cauvery River on October 23, 2024.

Compared to 2023, the data from 2024 show an increase in the number of non-compliant samples, the number of affected stations, and the maximum recorded iron concentration. This indicates a rising trend in iron contamination levels in river water..

A graphical representation of the above-limit values at the common stations is given as Figure 28.

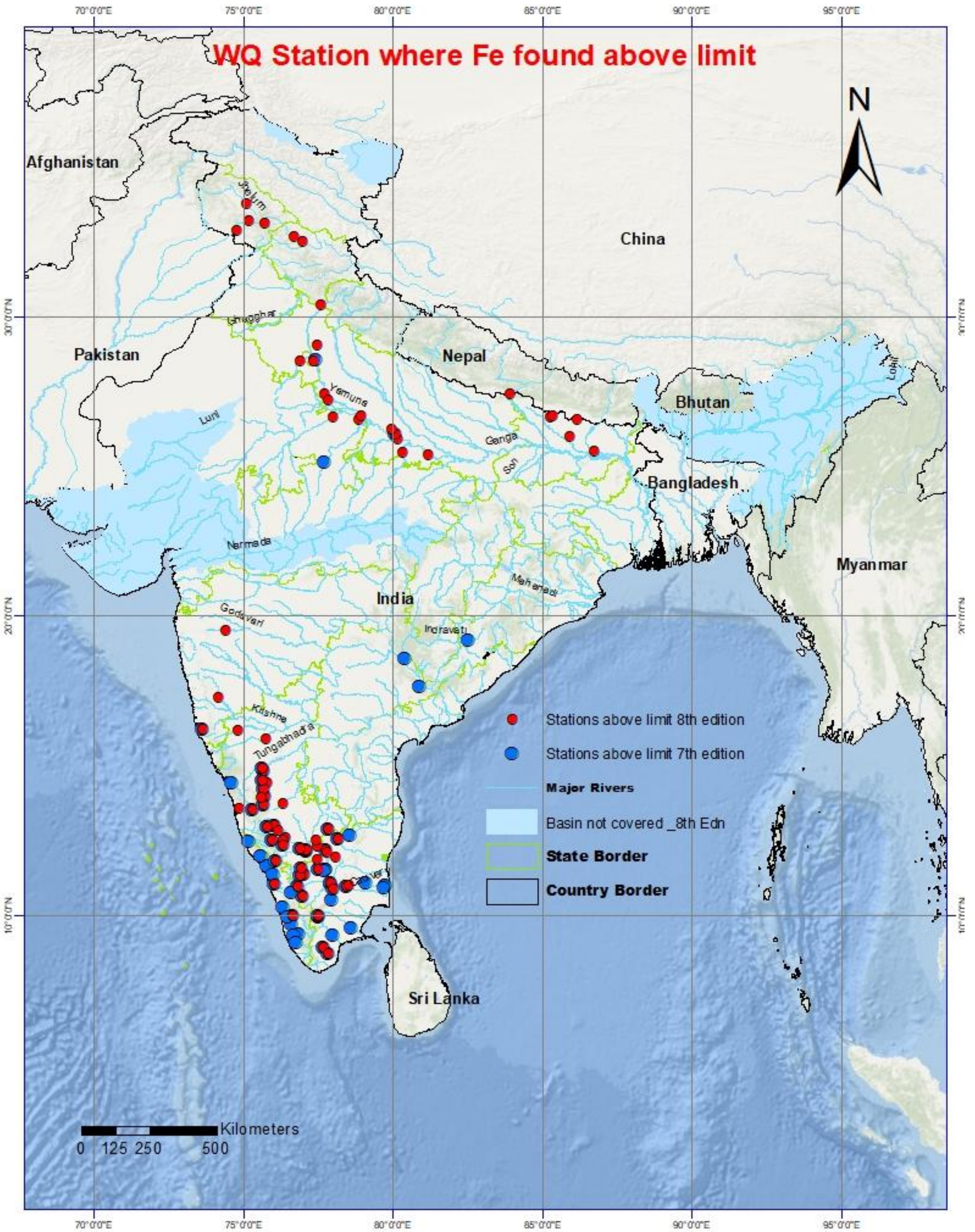

Figure 28: WQ stations where Iron found above acceptable limit (both study periods)

7.6 Lead (Pb)

Bureau of Indian Standards (BIS) 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 5265 river water samples analysed, 80 samples from 45 water quality stations were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 117.90 µg/L. Maximum lead concentration (117.90 µg/L) was observed at Hogenakkal water quality monitoring station on Chinnar River on 24-10-2024.

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

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Pb (µg/L)	State	District
1	Arkavathi	Koggedoddi	11.06.2024	27.274	Karnataka	Ramanagara
			01.03.2024	19.057	Karnataka	Ramanagara
			02.09.2024	13.002	Karnataka	Ramanagara
			11.07.2024	11.407	Karnataka	Ramanagara
			12.04.2024	11.982	Karnataka	Ramanagara
			12.03.2024	34.116	Karnataka	Ramanagara
		T Bekuppe	02.04.2024	21.469	Karnataka	Ramanagara
			21.08.2024	16.589	Karnataka	Ramanagara
			13.05.2024	13.071	Karnataka	Ramanagara
2	Bagamati	Dhengbridge	30.09.2024	10.133	Bihar	Sitamarhi
3	Bhadra	Holehonnur	01.03.2024	16.819	Karnataka	Shimoga
			02.09.2024	16.377	Karnataka	Shimoga
		Lakkavalli	01.03.2024	10.451	Karnataka	Chikmagalur
			12.03.2024	17.036	Karnataka	Chikmagalur
			02.01.2024	12.448	Karnataka	Chikmagalur
4	Bhavani/Moyar	Thengumarahada	21-08-2024	16.000	Tamil Nadu	Nilgiris
5	Burhi Gandak	Sakra	30.09.2024	10.736	Bihar	Muzaffarpur
6	Cauvery	Kollegal	02.01.2024	12.947	Karnataka	Chamaraja Nagar
			23.09.2024	14.012	Karnataka	Chamaraja Nagar
		Kudlur	22-08-2024	22.050	Karnataka	Chamaraja Nagar
			23-10-2024	81.500	Karnataka	Chamaraja Nagar
7	Chinnar	Hogenakkal	03-06-2024	18.694	Tamil Nadu	Dharmapuri
			24-10-2024	117.900	Tamil Nadu	Dharmapuri
			02-12-2024	12.920	Tamil Nadu	Dharmapuri
8	Chittar	AP Puram	13-12-2024	10.460	Tamil Nadu	Tirunelveli
9	Gad	Belne Bridge	11.07.2024	14.422	Maharashtra	Sindudurg
			12.03.2024	16.316	Maharashtra	Sindudurg
10	Ganga	Azamabad	01.05.2024	10.605	Bihar	Bhagalpur
11	Gataprabha	Gokak	22.07.2024	15.449	Karnataka	Belgaum
12	Haridra	Byaladahalli	22.07.2024	18.832	Karnataka	Davanagere
			23.12.2024	14.298	Karnataka	Davanagere

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Pb (μg/L)	State	District
13	Hemavathi	M H Halli	12.08.2024	18.809	Karnataka	Hassan
			21.08.2024	12.385	Karnataka	Hassan
		Sakleshpura	02.09.2024	11.441	Karnataka	Hassan
			12.03.2024	13.285	Karnataka	Hassan
14	Kabini	Muthankera	02.09.2024	12.971	Kerala	Wayanad
			11.09.2024	14.973	Kerala	Wayanad
15	Kal	Mangaon		12.191	Maharashtra	Raigad
16	Kallar	Odenthurai	12-08-2024	20.460	Tamil Nadu	Coimbatore
17	Kamalabalan	Jainagar	30.09.2024	11.437	Bihar	Madhubani
		Jhanjharpur	01.08.2024	11.116	Bihar	Madhubani
18	Krishna	Kurundwad		11.874	Maharashtra	Kolhapur
19	Kumudvathi	Kuppelur	22.07.2024	20.064	Karnataka	Haveri
			12.08.2024	10.426	Karnataka	Haveri
20	Lalbekia	Baigania	30.09.2024	11.828	Bihar	Sitamarhi
21	Laxmanathirtha	K M Vadi	02.09.2024	11.715	Karnataka	Mysore
22	North Koel	Garhwa	02.09.2024	10.395	Jharkhand	Palamu
23	Noyyal	Alandurai	16-07-2024	17.290	Tamil Nadu	Coimbatore
			04-09-2024	10.090	Tamil Nadu	Coimbatore
24	Ponnaiyar	Gummanur	06-06-2024	19.776	Tamil Nadu	Dharmapuri
			01-10-2024	19.850	Tamil Nadu	Dharmapuri
		Singasadanapalli	21-06-2024	17.190	Tamil Nadu	Dharmapuri
			01-07-2024	10.317	Tamil Nadu	Dharmapuri
			11-07-2024	14.524	Tamil Nadu	Dharmapuri
			21-08-2024	18.030	Tamil Nadu	Dharmapuri
			02-09-2024	26.430	Tamil Nadu	Dharmapuri
			21-09-2024	21.110	Tamil Nadu	Dharmapuri
			01-10-2024	29.210	Tamil Nadu	Dharmapuri
25	Sina	Wadakbal		11.635	Maharashtra	Solapur
26	Sone	Banjari	01.07.2024	11.997	Bihar	Rohtas
		Koelwar	01.05.2024	10.439	Bihar	Bhojpur
27	Suruliyar	Theni	01-10-2024	10.590	Tamil Nadu	Theni
28	Tunga	Hariharapura	11.07.2024	12.303	Karnataka	Chikamagaluru
			12.04.2024	12.185	Karnataka	Chikamagaluru
			21.08.2024	13.923	Karnataka	Chikamagaluru
			02.04.2024	16.930	Karnataka	Chikamagaluru
		Shimoga	22.07.2024	10.968	Karnataka	Shimoga
			02.01.2024	12.894	Karnataka	Shimoga
29	Tungabhadra	Haralahalli	22.07.2024	17.515	Karnataka	Haveri
			02.09.2024	10.776	Karnataka	Haveri
		Honnali	03.06.2024	11.173	Karnataka	Davanagere
30	Varada	Marol	23.09.2024	14.112	Karnataka	Haveri
31	Vedavathi	Kellodu	02.09.2024	14.250	Karnataka	Chitradurga
32	Yagachi	Thimmanahalli	22.07.2024	11.704	Karnataka	Hassan
			01.03.2024	13.655	Karnataka	Hassan
			02.09.2024	17.248	Karnataka	Hassan

S.No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Pb (µg/L)	State	District
33	Yamuna	Baghpat	04.10.2024	98.251	Uttar Pradesh	Baghpat
	Yamuna	Karnal	21.03.2024	13.000	Haryana	Karnal
	Yamuna	Okhla Barrage	01.03.2024	12.352	Delhi	South Delhi
	Yamuna	Rajapur	12.01.2024	14.804	Uttar Pradesh	Chitrakoot

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

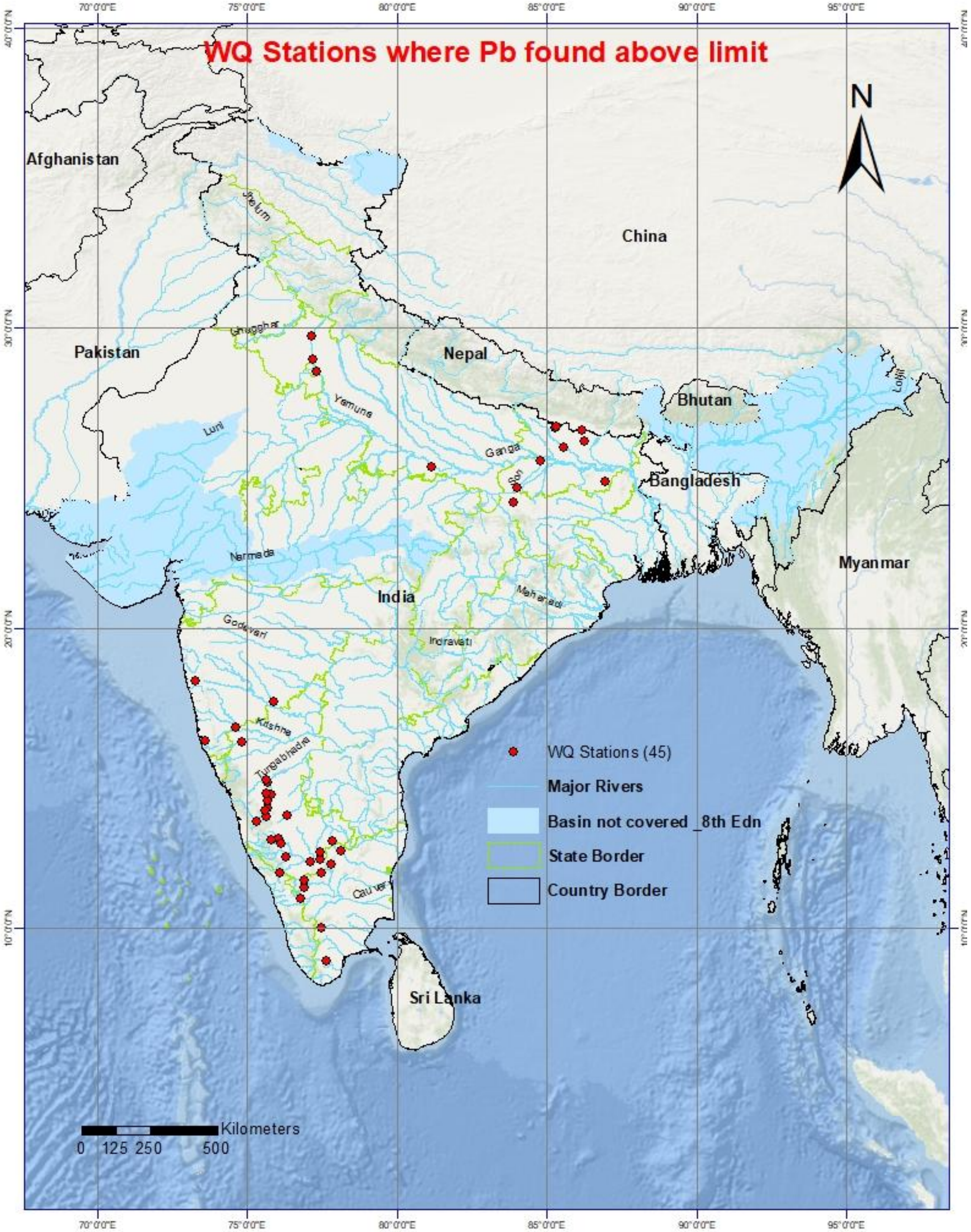

Figure 29: WQ stations where Lead found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

During the period from January-December, 2023 a total 5890 river water samples analysed, 76 samples from 23 water quality stations were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 75.51 µg/L. Maximum lead concentration (75.51 µg/L) was observed at Kudige water quality monitoring station on Cauvery River on 14-11-2023.

In 2024, total 5265 river water samples analysed, 80 samples from 45 water quality stations were found to have lead concentrations beyond the acceptable limit. The lead concentration varies from 0.000 to 117.90 µg/L. Maximum lead concentration (117.90 µg/L) was observed at Hogenakkal water quality monitoring station on Chinnar River on 24-10-2024.

These findings indicate an increase in both the number of samples exceeding the limit and the peak contamination level in 2024 compared to 2023. In 2023, 76 samples from 23 water quality stations across 20 rivers surpassed the acceptable limit, while in 2024, 80 samples exceeded the limit, but they were recorded at fewer stations—45 stations across 34 rivers.

A graphical representation of the above-limit values at the common stations is given as Figure 30.

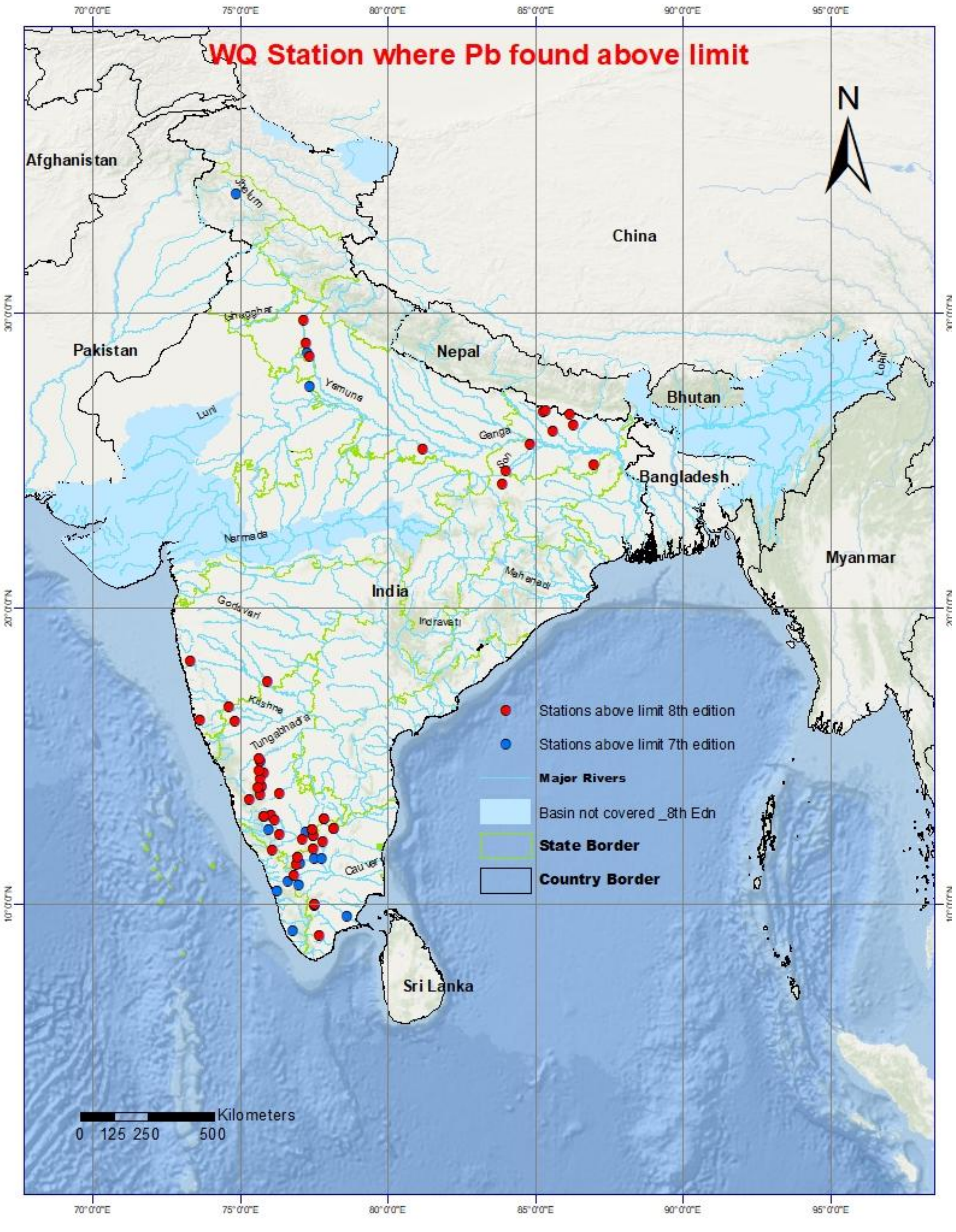

Figure 30: WQ stations where Lead found above acceptable limit (both study periods)

7.7 Mercury (Hg)

Bureau of Indian Standards (BIS) 10500:2012 has recommended an acceptable limit of 1 μg/L of mercury in drinking water. Out of total 5361 river water samples analysed, 35 samples from 16 water quality stations were found to have mercury concentrations beyond the acceptable limit. The mercury concentration varies from 0.000 to 3.834 μg/L. Maximum mercury concentration (3.834 μg/L) was observed at Koggedoddi water quality monitoring station on Arkavathi River on 02-09-2024.

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

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Hg (μg/L)	State	District
1	Arkavathi	Koggedoddi	02.09.2024	3.834	Karnataka	Ramanagara
		T Bekuppe	02.09.2024	2.623	Karnataka	Ramanagara
			21.08.2024	1.843	Karnataka	Ramanagara
2	Baghmati	Ekmighat	03.06.2024	1.432	Bihar	Darbhanga
3	Bagmati	Hayaghat	03.06.2024	1.544	Bihar	Darbhanga
4	Gandak	Lalganj	01.05.2024	1.222	Bihar	Vaishali
5	Ganga	Azamabad	01.05.2024	1.654	Bihar	Bhagalpur
6	Godavari	Bhadrachalam	11.06.2024	1.057	Telangana	Khammam
			21.06.2024	1.284	Telangana	Khammam
		Polavaram	13.05.2024	1.324	Andhra Pradesh	West Godavari
			21.05.2024	1.030	Andhra Pradesh	West Godavari
			01.07.2024	1.095	Andhra Pradesh	West Godavari
			22.07.2024	1.079	Andhra Pradesh	West Godavari
		Rajahmundry	13.05.2024	1.430	Andhra Pradesh	East Godavari
			21.06.2024	1.027	Andhra Pradesh	East Godavari
			11.07.2024	2.237	Andhra Pradesh	East Godavari
		Yelli	13.05.2024	1.564	Maharashtra	Nanded
			21.05.2024	1.502	Maharashtra	Nanded
			01.07.2024	2.213	Maharashtra	Nanded
7	Indravathi	Nowrangpur	13.05.2024	1.093	Odisha	Nowrangpur
			11.07.2024	1.371	Odisha	Nowrangpur
8	Kinnersani	Sangam	13.05.2024	1.463	Telangana	Bhadradri-Kothagudem
			21.05.2024	1.213	Telangana	Bhadradri-Kothagudem
			03.06.2024	1.071	Telangana	Bhadradri-Kothagudem
			11.06.2024	1.909	Telangana	Bhadradri-Kothagudem
			21.06.2024	1.242	Telangana	Bhadradri-Kothagudem
			11.07.2024	2.324	Telangana	Bhadradri-Kothagudem
9	Krishna	Kurundwad		1.373	Maharashtra	Kolhapur
				1.351	Maharashtra	Kolhapur
10	Laxmanathirtha	K M Vadi	02.09.2024	1.304	Karnataka	Mysore
			21.08.2024	1.635	Karnataka	Mysore

S. No.	River/ Reservoir	Water Quality Stations	Date of Sampling	Hg (µg/L)	State	District
11	Musi	Deosugur	13.05.2024	2.017	Karnataka	Raichur
			21.05.2024	2.254	Karnataka	Raichur
			11.06.2024	1.176	Karnataka	Raichur
12	Yamuna	Naugaon	04.11.2024	1.398	Uttrakhand	Uttarkashi

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

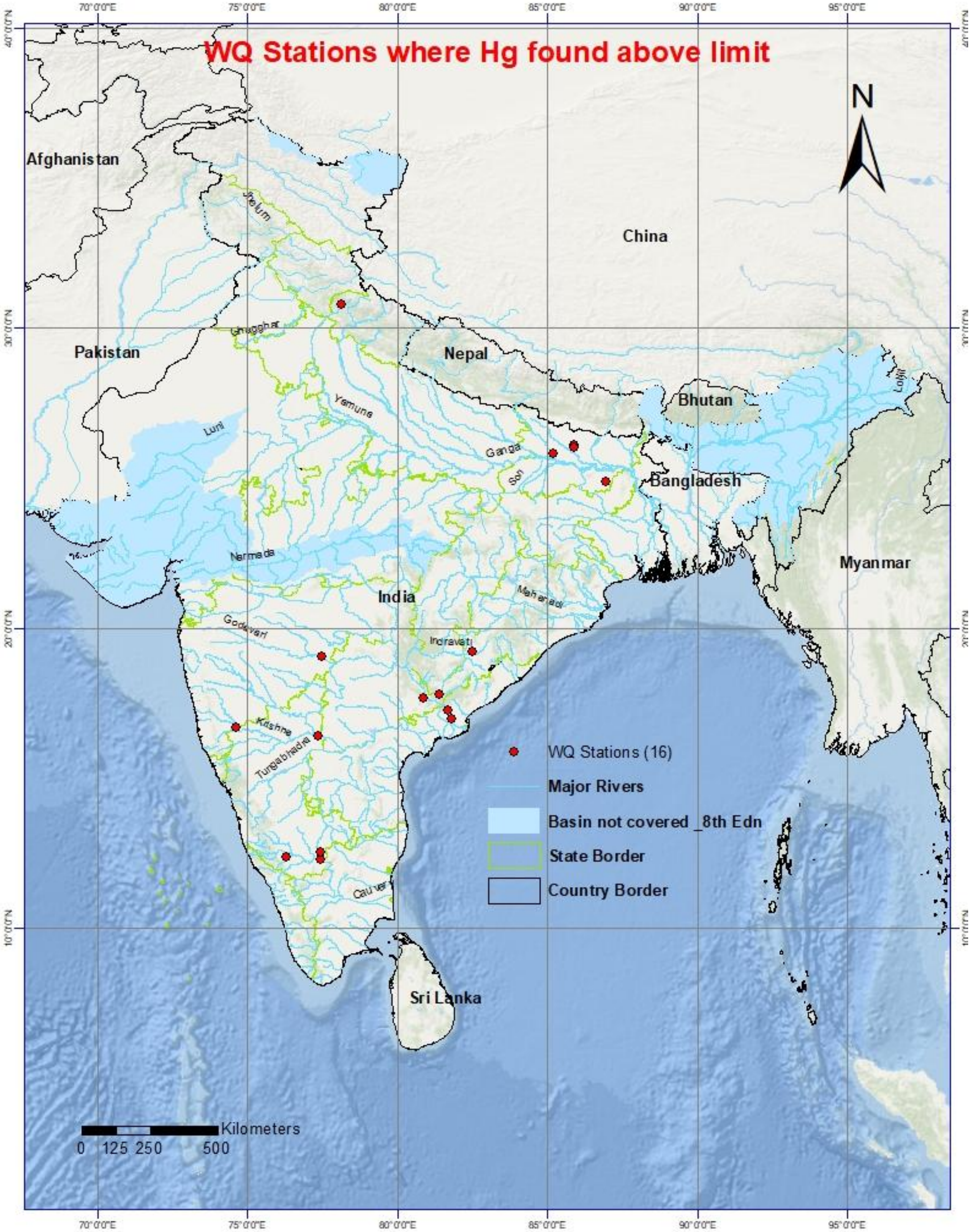

Figure 31: WQ stations where Mercury found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

In 2023, out of 5897 analyzed samples, 28 samples from 14 water quality stations were found to exceed the acceptable limit. The mercury concentration ranged from 0.000 to 4.79 µg/L, with the maximum concentration of 4.79 µg/L observed at the Rajahmundry station on the Godavari River on 20.10.2023.

In 2024, total 5361 river water samples analysed, 35 samples from 16 water quality stations were found to have mercury concentrations beyond the acceptable limit. The mercury concentration varies from 0.000 to 3.834 µg/L. Maximum mercury concentration (3.834 µg/L) was observed at Koggedoddi water quality monitoring station on Arkavathi River on 02-09-2024.

The data reveals an increase in the number of samples and stations with mercury levels beyond the acceptable limit in 2024 compared to 2023. However, the maximum mercury concentration observed in 2023 (4.79 µg/L) was significantly higher than in 2024 (3.834 µg/L).

A graphical representation of the above-limit values at the common stations is given as Figure 32.

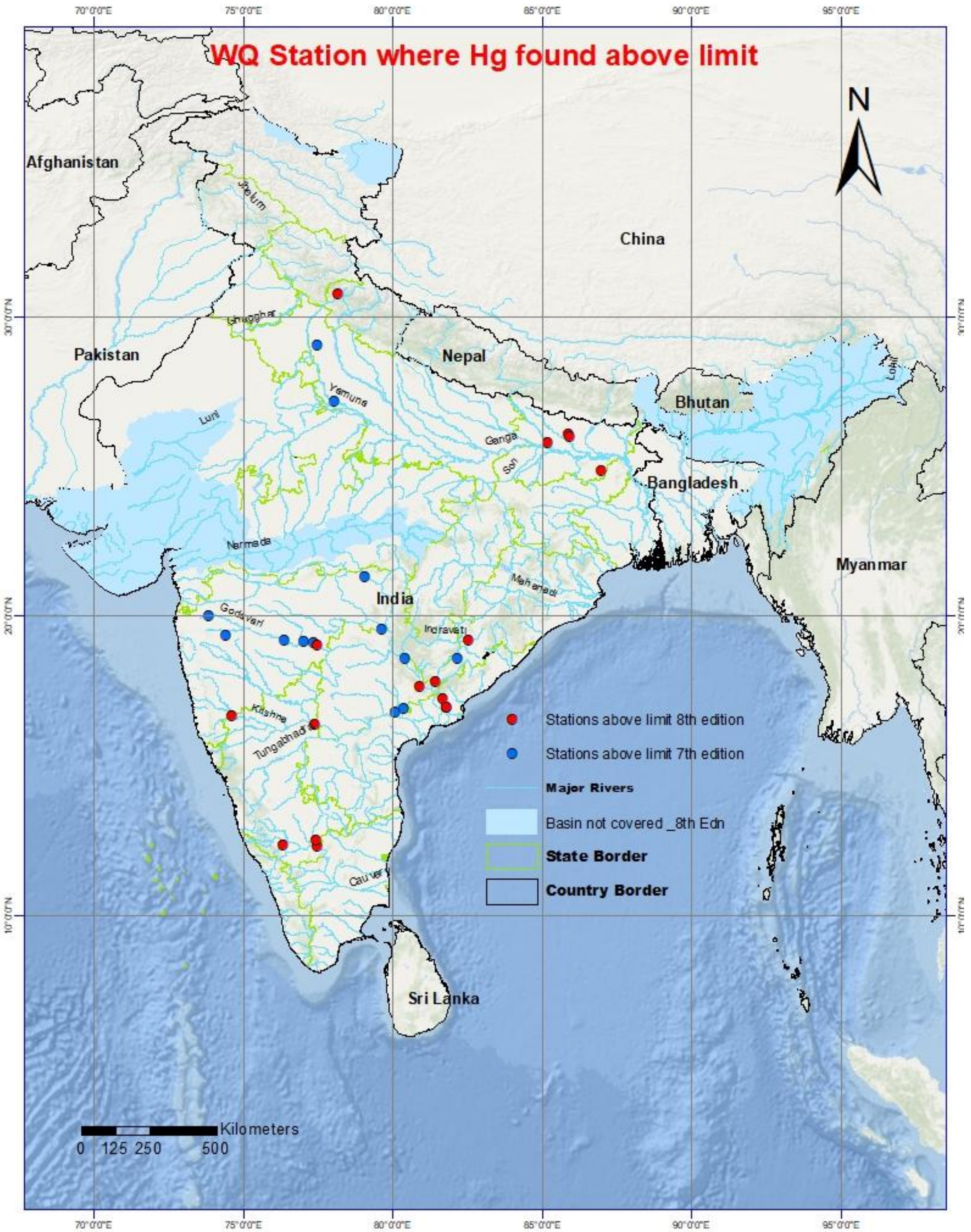

Figure 32: WQ stations where Mercury found above acceptable limit (both study periods)

7.8 Nickel (Ni)

Bureau of Indian Standards (BIS) 10500:2012 has recommended an acceptable limit of 20 µg/L of nickel in drinking water. Out of total 5014 river water samples analysed, 33 samples from 22 water quality stations were found to have nickel concentrations beyond the acceptable limit.The nickel concentration varies from 0.000 to 72.11 µg/L. Maximum nickel concentration (72.11 µg/L) was observed at Kudlur water quality monitoring station on Cauvery River on 22-08-2024. 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

S.No.	River/ Reser-voir	Water Quality Stations	Date of Sampling	Ni (µg/L)	State	District
1	Arkavathi	Koggedoddi	12.03.2024	23.416	Karnataka	Ramanagara
2	Bhavani/Moyar	Thengumarahada	21-08-2024	21.990	Tamil Nadu	Nilgiris
3	Cauvery	Biligundulu	01-10-2024	21.360	Tamil Nadu	Krishnagiri
		Kudige	21.05.2024	27.023	Karnataka	Kodagu
		Kudlur	22-08-2024	72.110	Karnataka	Chamaraja Nagar
4	Chinnar	Hogenakkal	03-06-2024	56.888	Tamil Nadu	Dharmapuri
			24-10-2024	20.080	Tamil Nadu	Dharmapuri
			02-12-2024	26.170	Tamil Nadu	Dharmapuri
5	Chittar	AP Puram	13-12-2024	27.440	Tamil Nadu	Tirunelveli
6	Ganga/Yamuna	Kalindi Kunj	01.03.2024	23.210	Delhi	East Delhi
			01.04.2024	22.172	Delhi	East Delhi
			21.06.2024	28.886	Delhi	East Delhi
7	Hindon	Galeta	22.04.2024	39.098	Uttar Pradesh	Meerut
		Noida	11.04.2024	21.965	Uttar Pradesh	Gautam Budh Nagar
			21.06.2024	21.121	Uttar Pradesh	Gautam Budh Nagar
8	Hindon Cut	Chilla Village	01.04.2024	20.846	Delhi	East Delhi
			21.06.2024	24.341	Delhi	East Delhi
9	Kallar	Odenthurai	12-08-2024	25.630	Tamil Nadu	Coimbatore
10	Kamalabalan	Jainagar	01.08.2024	20.171	Bihar	Madhubani
11	Malaprabha	Cholachagudda	01.08.2024	22.391	Karnataka	Bagalkot
			11.09.2024	30.215	Karnataka	Bagalkot
12	Noyyal	Alandurai	16-07-2024	28.100	Tamil Nadu	Coimbatore
13	Ponnaiyar	Gummanur	01-10-2024	33.820	Tamil Nadu	Dharmapuri
		Singasadanapalli	01-10-2024	24.260	Tamil Nadu	Dharmapuri
14	Yamuna	Delhi Railway Bridge	01.03.2024	23.839	Delhi	North Delhi
			21.05.2024	20.869	Delhi	North Delhi
			21.06.2024	25.442	Delhi	North Delhi
		Karnal	21.03.2024	25.400	Haryana	Karnal
		Mawi	21.06.2024	24.871	Uttar Pradesh	Muzaffar Nagar
		Mohna	01.07.2024	32.873	Haryana	Faridabad
		Okhla Barrage	01.03.2024	34.748	Delhi	South Delhi
		Okhla Barrage	01.04.2024	20.889	Delhi	South Delhi
		Okhla Barrage	21.06.2024	29.919	Delhi	South Delhi

One state, namely Tamil Nadu is found to be affected by the issue of Nickel contamination. Figure 33 represents the GIS map of WQ stations with nickel values above limit.

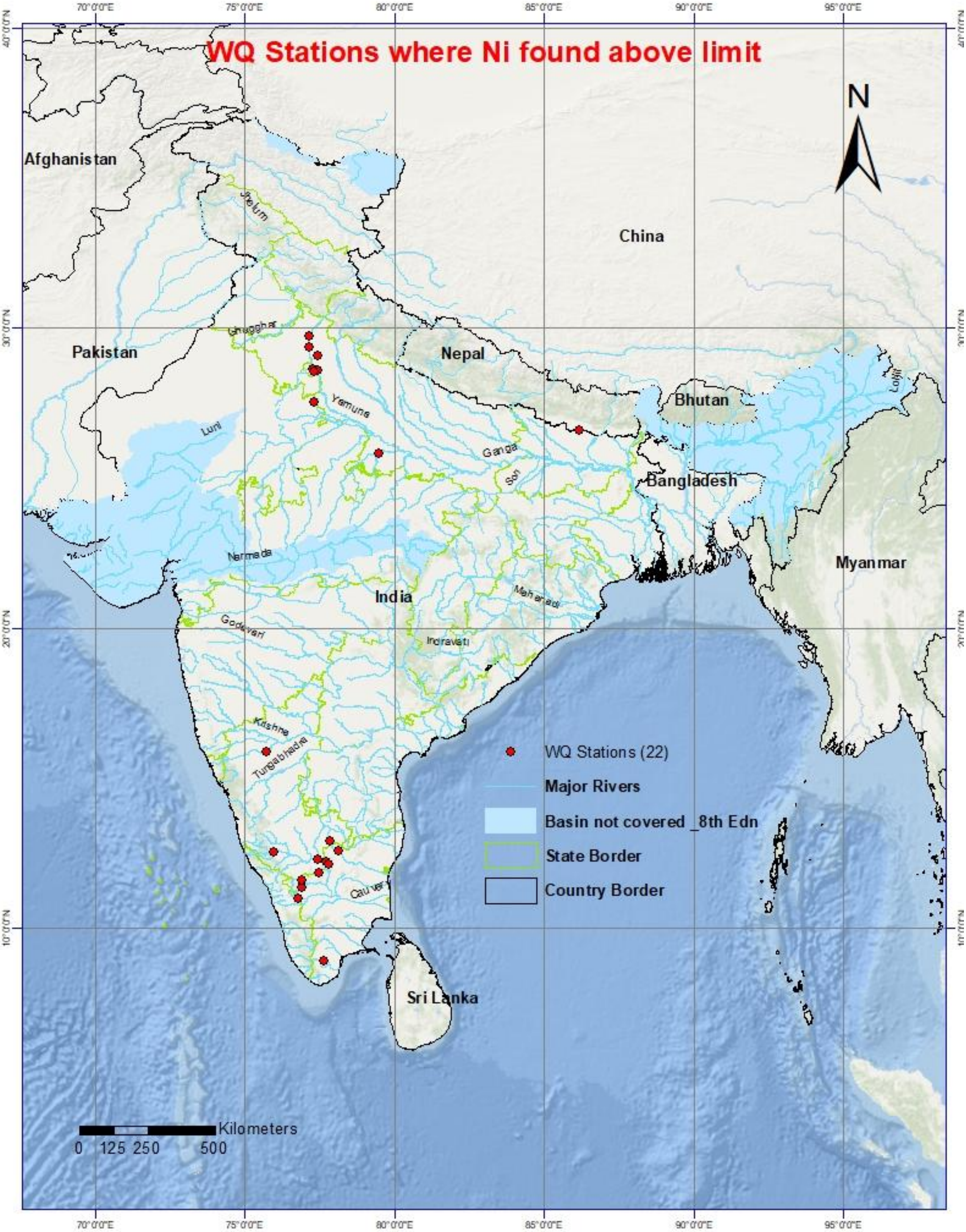

Figure 33: WQ stations where Nickel found above acceptable limit

Comparison with 7th edition (period: January-December, 2023)

The comprehensive analysis of water quality during two distinct periods: January-December, 2023 and subsequently January-December,2024 has provided valuable insights into nickel concentrations in Indian rivers. The comparison between 2023 and 2024 data from the 7th edition of the report reveals notable changes in nickel contamination levels in river water samples.

In 2023, 17 out of 5898 samples exceeding the limit, identified at only 6 stations across 4 rivers. The maximum concentration in 2023 was lower, at 66.64 µg/L, observed at the Musiri station on the Cauvery River. In 2024, 5014 river water samples analysed, 33 samples from 22 water quality stations were found to have nickel concentrations beyond the acceptable limit. The nickel concentration varies from 0.000 to 72.11 µg/L. Maximum nickel concentration (72.11 µg/L) was observed at Kudlur water quality monitoring station on Cauvery River on 22-08-2024.

These findings indicate a increasing in the number of stations and rivers affected and a slight increase in the peak nickel concentration.

The GIS map in Figure 34 illustrates the stations which have exceeded the Ni limit in both the current and previous reports.

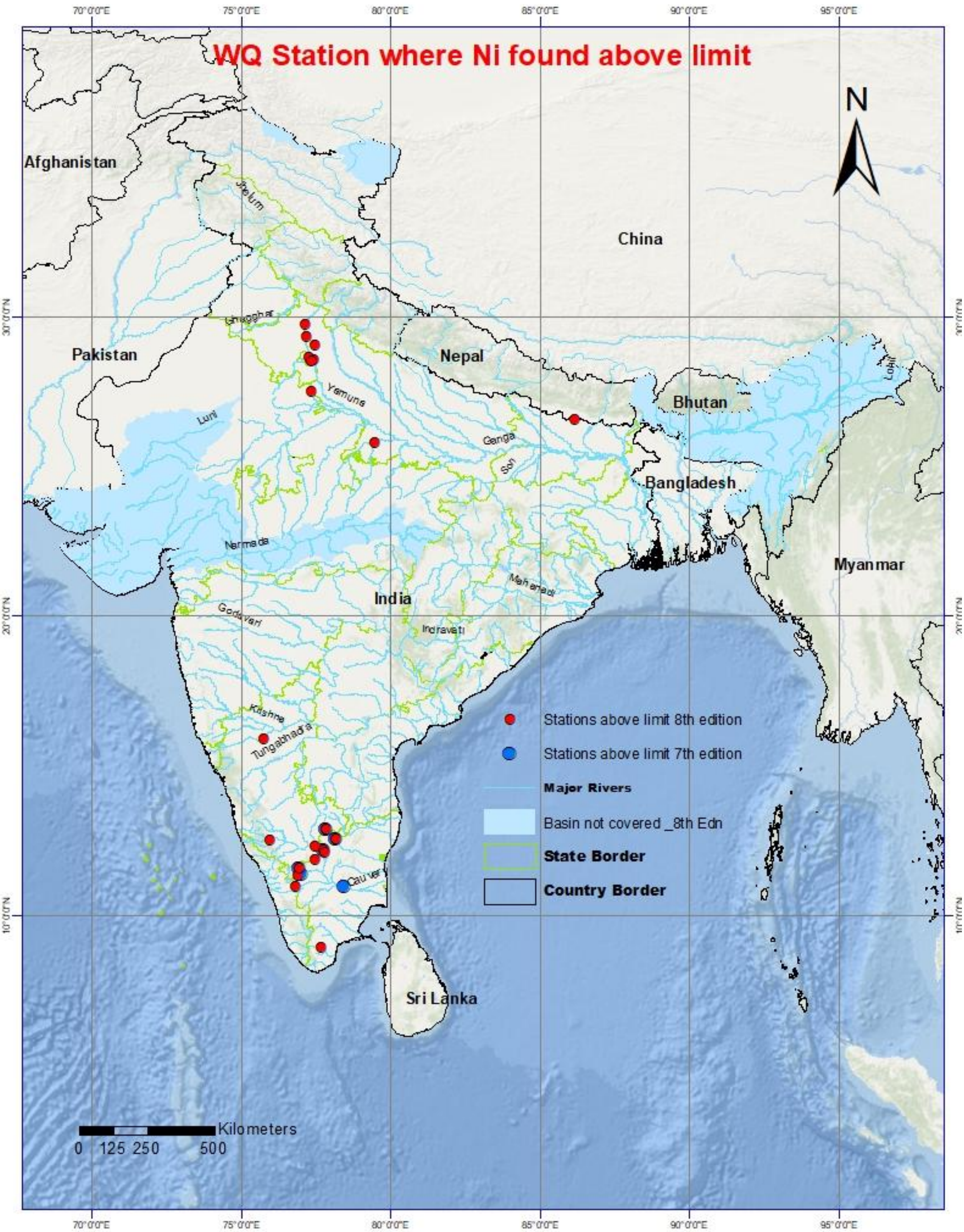

Figure 34: WQ stations where Nickel found above acceptable limit (both study periods)

7.9 Zinc (Zn)

Bureau of Indian Standards (BIS) 10500:2012 has recommended acceptable limit of 5 mg/L (5000 µg/L) of Zinc in drinking water. Out of total 5456 river water samples analysed, no sample is found to have zinc concentration beyond the acceptable limit. The zinc concentration varies from 0.000 to 4636.728 µg/L. Maximum zinc concentration (4636.728 µg/L) was observed at Kora water quality monitoring station on Rind River on 03-12-2024.

Out of total 5456 river water samples analysed; no sample is found to have zinc concentration beyond the acceptable limit. Maximum zinc concentration (4636.728 µg/L) was observed at at Kora water quality monitoring station on Rind River on 03-12-2024. The data indicates that while zinc concentrations remained within acceptable limits in both years, the maximum recorded concentration was significantly higher in 2024 compared to 2023.

8. CONCLUSION

The analysis results of 9 metals analysed in samples collected from 434 water quality monitoring stations spread over 13 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 322 monitored stations while at 64 stations, at only 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 41 samples from 13 stations among the 5456 samples analysed.
- Similarly, cadmium surpassed the acceptable limit of 3 µg/L in 07 samples from 03 stations.
- Chromium, copper, and nickel also presented challenges, exceeding their acceptable limits in 09, 03, and 22 stations across various rivers.
- The significant concern arises with iron, where 325 samples from 78 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 80 samples from 45 stations.
- Mercury breached the acceptable limit of 1 µg/L in 35 samples from 16 stations, emphasizing the widespread presence of this toxic element.
- Hogenakkal (Chinnar River) and Singasadanapalli (Ponnaiyar River) are water quality monitoring stations where 5 metals were observed, while Gummanur (Ponnaiyar River), Koggedoddi and T Bekuppe (Arkavathi River), Kudlur (Cauvery River), and Okhla Barrage (Yamuna River) are water quality monitoring stations where 4 metals were observed to breach the acceptable limits prescribed by BIS

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 analysis of 434 water quality (WQ) stations revealed that a total of 112 stations exhibited one or more metals exceeding the acceptable limits. The overall summary of the results of metal contamination across the 434 stations is as follows:

Table 20: Overall Statistics of Analysis

Sl. No	Parameters	No. of Stations where metal found above acceptable limit
1	Arsenic only	**08**
2	Cadmium only	**00**
3	Chromium only	**00**
4	Copper only	**00**
5	Iron only	**35**
6	Lead only	**07**
7	Mercury only	**08**
8	Nickel only	**06**
9	Zinc only	**00**
10	Two or More metals	**48**
Total WQ stations where one or more metals found above acceptable limits		**112**
Total WQ Stations where all toxic metals found within acceptable limits		**322**
Total WQ Stations under study		**434**

Table 21: Overall Status of 112 stations where one or more metals found above acceptable limits

No. of stations where 5 metals found to be above limit	2
No. of stations where 4 metals found to be above limit	**5**
No. of stations where 3 metals found to be above limit	**10**
No. of stations where 2 metals found to be above limit	**31**
No. of stations where only 1 metal found to be above limit	**64**

The analysis of the 112 water quality stations where one or more metals were found above the acceptable limits reveals the following distribution:

- Table 21 above show that there is two (02) stations where five metals were found to exceed the limit, five (05) stations where four (04) metals were above the limit, ten (10) stations where three (03) and thirty one (31) stations where two (02) metals were above the limit metals exceeded the limit.
- It is evident from the tables that, out of 112 stations where one or more metals are found above acceptable limits, 64 stations have only 1 metal which exceeds the limit. Among these 112 stations, 35 stations have only Iron exceeding the limit. This means that, only Iron metal is found to breach the limit at 31% of the 112 stations affected.
- However, it is important to note that there are 322 WQ stations (74.19%) where all the toxic metals are found within acceptable limits.

The analysis of water quality (WQ) stations across various basins reveals significant variations in the presence of metals above the acceptable limits. Out of the total 434 WQ stations studied across the basins, a substantial proportion of these stations showed metal concentrations exceeding the permissible 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	Brahmani & Baitrani	23	0
2	Cauvery	40	27
3	East Flowing Rivers between Mahanadi & Godawari	07	0
4 & 5	East Flowing Rivers between Pennar and Cauvery Basin and East Flowing Rivers South of Cauvery	16	06
6	Ganga & Yamuna	146	46
7	Godavari	52	05
8	Indus	11	06
9	Krishna	44	16
10	Mahanadi	36	00
11	Pennar	05	00
12	Subernarekha	14	00
13	West Flowing rivers south of Tapi	40	06

Table 22 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. Out of 434 water quality (WQ) monitoring stations studied across 13 major river basins in India, 112 stations (25.8%) were found to have one or more heavy metals exceeding acceptable limits. The highest number of exceedances was observed in the Ganga & Yamuna basin (46 out of 146 stations), followed by the Cauvery basin (27 out of 40 stations), Krishna (16 out of 44), and the Indus basin (6 out of 11). Moderate exceedances were also noted in the Godavari basin, East Flowing Rivers between Pennar and Cauvery and South of Cauvery, and the West Flowing Rivers south of Tapi.

In contrast, no metal exceedances were reported in the Brahmani & Baitarani, East Flowing Rivers between Mahanadi & Godavari, Mahanadi, Pennar, and Subernarekha basins. These findings highlight significant regional disparities, with basins such as Ganga, Yamuna, and Cauvery facing considerable pollution pressure likely due to urbanization, industrial discharge, and agricultural runoff, underscoring the need for targeted mitigation and stricter pollution control strategies.

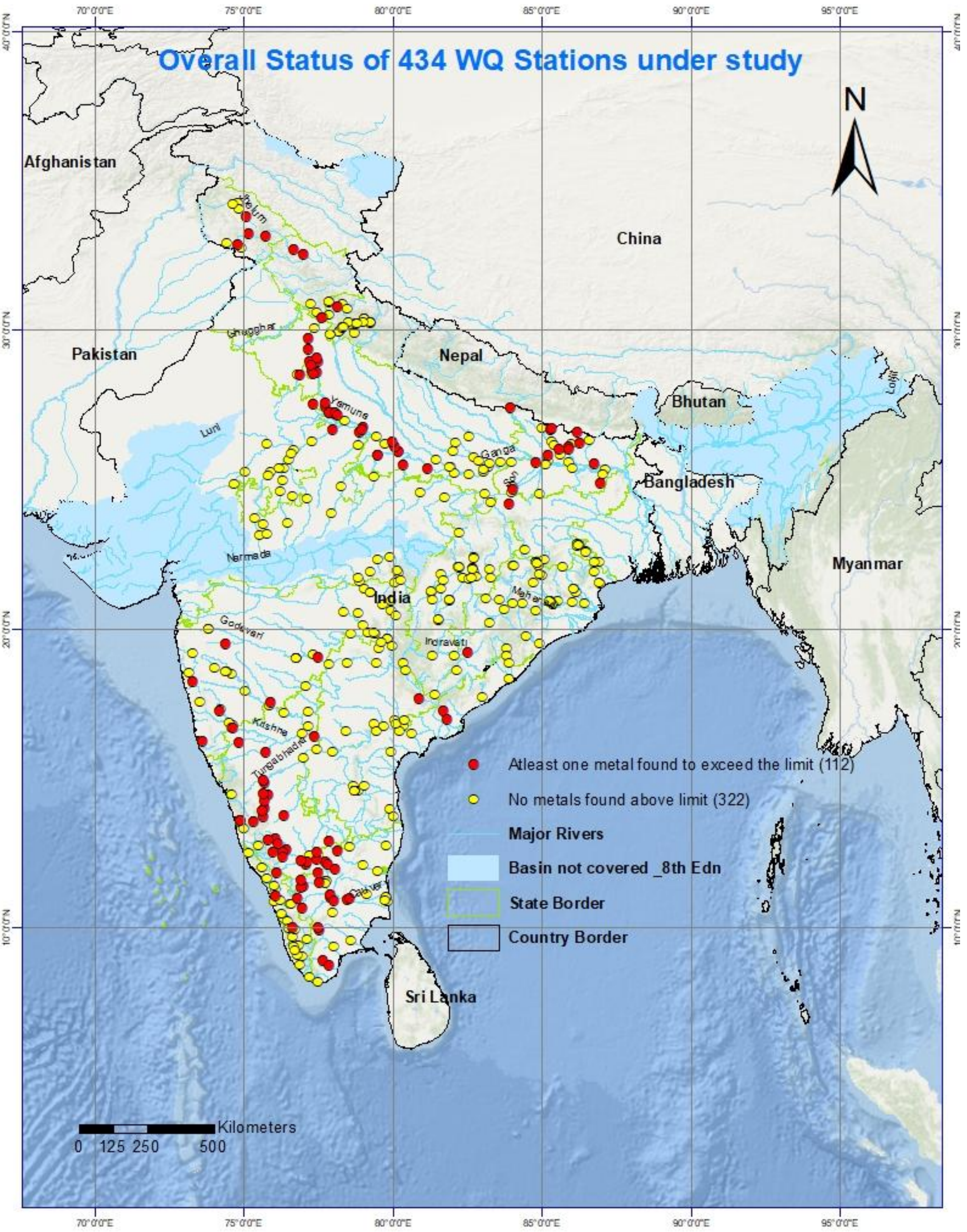

Figure 35: Overall status of 434 stations under study

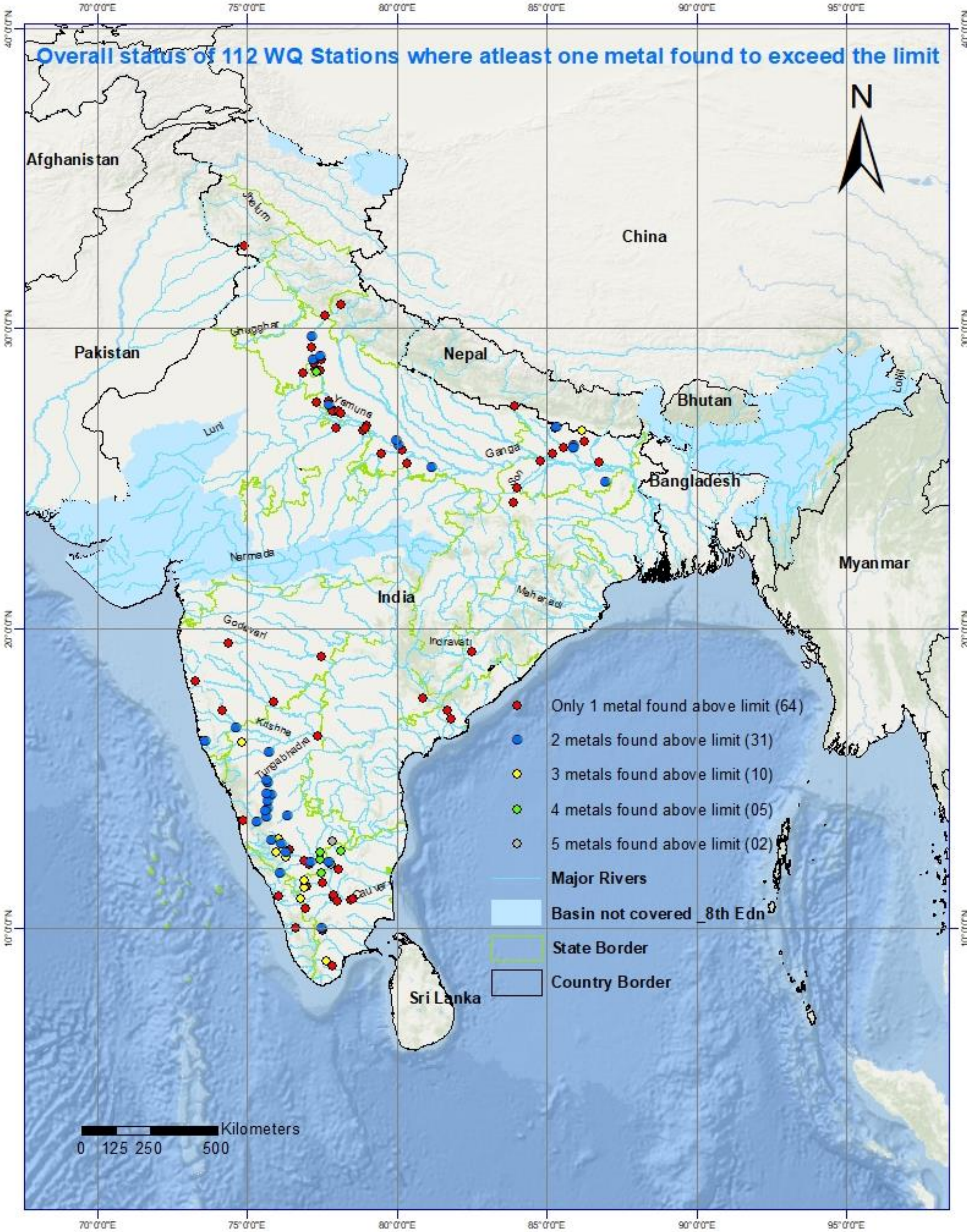

Figure 36: Overall status of 112 stations where at least one metal is found above the limit

Comparison with 7th edition

The analysis results of trace and toxic metal concentrations in river water samples for the years 2023 and 2024 have been compared to assess compliance with the acceptable limits specified by BIS: 10500, 2012.

Table 23: Comparison of Metal-wise Analysis Result

			Analysis result (2023)				Analysis result (2024)			
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**	5911	5901	10	0.16	5456	5415	41	0.75
2	Cadmium (Cd)	**3**	5940	5939	1	0.02	5459	5452	07	0.13
3	Chromium (Cr)	**50**	5730	5643	87	1.52	5039	5025	14	0.28
4	Copper (Cu)	**50**	5940	5937	3	0.05	5457	5450	07	0.13
5	Iron (Fe)	**1000**	5768	5476	292	5.06	5417	5092	325	6.00
6	Lead (Pb)	**10**	5890	5814	76	1.29	5265	5185	80	1.52
7	Mercury (Hg)	**1**	5897	5869	28	0.47	5361	5326	35	0.65
8	Nickel (Ni)	**20**	5898	5881	17	0.29	5014	4981	33	0.66
9	Zinc (Zn)	**5000**	5946	5946	0	0.00	5456	5456	00	0.00

Table 24: Overall comparison of 2 reports

WQ stations	Year 2024	Year 2023	WQ Samples	Year 2024	Year 2023
No of stations where no metal found above acceptable limit	322	212	No of samples where no metal found above acceptable limit	5005	5495
No of stations where at least one metal found above acceptable limit	112	88	No of samples where at least one metal found above acceptable limit	455	451
Total Stations under study	434	300	Total Samples under study	5460	5946

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 434 Water Quality Monitoring Stations

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
1	Akkihebbal	Fe	Karnataka	Mandya	Cauvery	HEMAVATHY	12.5986	76.4004
2	Bendrahalli	Fe	Karnataka	Chamaraja Nagar	Cauvery	SUVARNAVATHY	12.1288	77.0830
3	Holehonnur	Pb, Fe	Karnataka	Shimoga	Krishna	BHADRA	13.9761	75.6852
4	Thimmanahalli	Pb, Cr, Fe	Karnataka	Hassan	Cauvery	YAGACHI	12.9853	76.0379
5	A.B. Road Xing	No metals found above limit	Madhya Pradesh	Guna	Yamuna Basin	Parwati	24.366	77.099
6	A.P.M.(ASHTI)	No metals found above limit	Maharashtra	Gadchiroli	Godavari	Wainganga	19.668	79.789
7	Addoor	No metals found above limit	Karnataka	Dakshina Kannada	WFR South of Tapi	Gurupur	12.929	74.954
8	Adityapur	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Kharkai	22.791	86.174
9	Akbarpur	No metals found above limit	Uttar Pradesh	Ambedkar Nagar	Ganga	Chhoti Sarju	26.433	82.533
10	Akhnoor	Fe	"Jammu & Kashmir "	Jammu	Indus	Chenab	32.763	74.884
11	Aklera	No metals found above limit	Rajasthan	Jhalawar	Yamuna Basin	Parwan	24.430	76.604
12	Alandurai	Pb, Fe, Ni	Tamil Nadu	Coimbatore	Cauvery	Noyyal	10.9543	76.7857
13	Alladupalli	No metals found above limit	Andhra Pradesh	Kadapa	Pennar	Kunderu	14.717	78.669
14	Allahabad	No metals found above limit	Uttar Pradesh	Allahabad	Ganga	Ganga	25.403	81.911
15	Altuma	No metals found above limit	Odisha	Dhenkanal	Brahmani and Baitarni Basin	Ramial	20.931	85.519
16	Ambarampalayam	Fe	Tamil Nadu	Coimbatore	WFR South of Tapi	Aliyar	10.6303	76.9461
17	Ambasamudram	Fe	Tamil Nadu	Theni	EFR South of Cauvery	Vaigai	9.9256	77.5117
18	Anakapali	No metals found above limit	Andhra Pradesh	Visakhapatnam	EFR between Mahanadi and Godavari	Sarada	17.689	82.996
19	Anandapur	No metals found above limit	Odisha	Keonjhar	Brahmani and Baitarni Basin	Baitarani	21.211	86.121

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
20	Andhiyarkhore	No metals found above limit	Chhattisgarh	Bemetara	Mahanadi	Hamp	21.834	81.598
21	Annavasal	No metals found above limit	Pondicherry	Karaikal	Cauvery	Cauvery/Nattar	10.975	79.754
22	AP Puram	Pb, Fe, Ni	Tamil Nadu	Tirunelveli	EFR South of Cauvery	Chittar	8.9014	77.6486
23	Aradei	No metals found above limit	Odisha	Keonjhar	Brahmani and Baitarni Basin	Aradei	20.859	86.402
24	Arangaly	No metals found above limit	Kerala	Trichur	WFR South of Tapi	Chalakkudy	10.281	76.315
25	Arcot	No metals found above limit	Tamil Nadu	Vellore	EFR between Pennar-Cauvery	Palar	12.914	79.333
26	Arjunwad	No metals found above limit	Maharashtra	Kolhapur	Krishna	Krishna	16.781	74.633
27	Arnota	No metals found above limit	Uttar Pradesh	Agra	Ganga	uttgan	26.962	78.367
28	Ashramam	No metals found above limit	Tamil Nadu	Kanyakumari	WFR South of Tapi	Pazhayar	8.159	77.460
29	Augustmuni D/S	No metals found above limit	Uttrakhand	Rudraprayag	Ganga	Mandakani	30.392	79.022
30	Augustmuni U/S	No metals found above limit	Uttrakhand	Rudraprayag	Ganga	Mandakani	30.400	79.042
31	Auraiya	No metals found above limit	Uttar Pradesh	Auraiya	Ganga	Yamuna	26.427	79.418
32	Avarankuppam	No metals found above limit	Tamil Nadu	Vellore	EFR between Pennar-Cauvery	Palar	12.6842	78.5394
33	Avershe	No metals found above limit	KARNATAKA	Udupi	WFR South of Tapi	Seetha	13.521	74.880
34	Ayilam	No metals found above limit	Kerala	Thiruvananthapuram	WFR South of Tapi	Vamanapuram	8.715	76.850
35	Azamabad	Pb, Hg	Bihar	Bhagalpur	Ganga	Ganga	24.886	86.942
36	B.P.M. (BAMNI)	No metals found above limit	Maharashtra	Chandrapur	Godavari	Wardha	19.840	79.360
37	Bachhawara	No metals found above limit	Bihar	Begusarai	Ganga	Baya	25.574	85.889
38	Badalapur	No metals found above limit	Maharashtra	Thane	WFR South of Tapi	Ulhas	19.162	73.254
39	Baghpat	As, Pb	Uttar Pradesh	Baghpat	Yamuna Basin	Yamuna	28.988	77.203
40	Baigania	As, Pb, Fe	Bihar	Sitamarhi	Ganga	Lalbekia	26.673	85.249
41	Bakhari	No metals found above limit	Madhya Pradesh	Seoni	Godavari	Wainganga	22.325	79.468
42	Baleni	As	Uttar Pradesh	Baghpat	Yamuna Basin	Hindon	28.959	77.470
43	Balighat	No metals found above limit	Odisha	Balasore	Subernarekha basin	Burhabalanga	21.494	86.952

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
44	Baltara	Fe	Bihar	Khagaria	Ganga	Kosi	25.540	86.725
45	Baluaghat	No metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.421	83.184
46	Bamni	No metals found above limit	Maharashtra	Chandrapur	Godavari	Wardha	19.814	79.379
47	Bamnidih	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Hasdeo	21.909	82.714
48	Banda	Fe	Uttar Pradesh	Banda	Ganga	Ken	25.483	80.313
49	Banjari	Pb	Bihar	Rohtas	Ganga	Sone	24.665	83.998
50	Banka	No metals found above limit	Bihar	Banka	Ganga	Chandan	25.579	83.977
51	Bantwal	No metals found above limit	Karnataka	Dakshina Kannada	WFR South of Tapi	Nethravathi	12.881	75.041
52	Baranwada	No metals found above limit	Rajasthan	Sawai-Madhopur	Yamuna Basin	Banas	26.000	76.667
53	Baridhi	No metals found above limit	Jharkhand	Paschim Singhbhum	Subernarekha basin	Subarnarekha	22.804	86.260
54	Baripada	No metals found above limit	Odisha	Mayurbhanj	Subernarekha basin	Burhabalanga	21.924	86.718
55	Barod	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Kalisindh	25.383	76.334
56	Baronda	No metals found above limit	Chhattisgarh	Gariaband	Mahanadi	Pairi	20.910	81.888
57	Basantpur	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Mahanadi	21.728	82.788
58	Basoda	No metals found above limit	Uttar Pradesh	Vidisha	Ganga	Betwa	23.887	77.920
59	Bawapuram	No metals found above limit	Andhra Pradesh	Kurnool	Krishna	Tungabhadra	15.883	77.957
60	Belne Bridge	Pb, Fe	Maharashtra	Sindudurg	WFR South of Tapi	GAD	16.2208	73.5947
61	Belodi	No metals found above limit	Chhattisgarh	Durg	Mahanadi	Seonath	21.233	81.270
62	Bhadana	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Chambal	25.240	75.880
63	Bhadrachalam	Hg	Telangana	Khammam	Godavari	Godavari	17.668	80.877
64	Bhatpalli	No metals found above limit	Telangana	Adilabad	Godavari	Peddavagu	19.332	79.503
65	Bhind	Fe	Madhya Pradesh	Bhind	Ganga	Kunwari	26.608	78.857
66	Bido	No metals found above limit	Odisha	Dhenkanal	Brahmani and Baitarni Basin	Brahamani	20.810	85.345
67	Bigod	No metals found above limit	Rajasthan	Bhilwara	Yamuna Basin	Banas	25.251	75.035
68	Biligundulu	Fe, Ni	Tamil Nadu	Krishnagiri	Cauvery	Cauvery	12.1822	77.7239

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
69	Bolani	No metals found above limit	Odisha	Sundargarh	Brahmani and Baitarni Basin	Brahamani	22.105	84.851
70	Bonaigarh	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	21.807	84.967
71	Boudh	No metals found above limit	Odisha	Angul	Mahanadi	Mahanadi	20.866	84.313
72	Buxar	No metals found above limit	Bihar	Buxar	Ganga	Ganga	25.337	87.099
73	Byaladahalli	Pb, Fe	Karnataka	Davanagere	Krishna	HARIDRA	14.4340	75.7797
74	Champa Road Bridge	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Hasdeo	22.024	82.642
75	champua	No metals found above limit	Odisha	Keonjhar	Brahmani and Baitarni Basin	Baitarani	22.066	85.673
76	Chengalpet	No metals found above limit	Tamil Nadu	Kancheepuram	EFR between Pennar-Cauvery	Palar	12.650	79.947
77	Chennur	No metals found above limit	Andhra Pradesh	Kadapa	Pennar	Pennar	14.572	78.800
78	Chhapriyal (Bar-doh)	No metals found above limit	"Jammu & Kashmir "	Jammu	Indus	Manawar Tawi	32.763	74.884
79	Chilla Village	Ni	Delhi	East Delhi	Yamuna Basin	Hindon Cut	28.588	77.299
80	Chindnar	No metals found above limit	Chhattisgarh	Dantewara	Godavari	Indravathi	19.079	81.301
81	Chittorgarh	No metals found above limit	Rajasthan	Chittorgarh	Yamuna Basin	Gambhiri	24.867	74.636
82	Cholachagudda	Fe, Ni	Karnataka	Bagalkot	Krishna	MALAPRABHA	15.8792	75.7213
83	Chopan	No metals found above limit	Uttar Pradesh	Sonebhadra	Ganga	Sone	24.533	83.050
84	Chunchanakatte	Cr, Fe	Karnataka	Mysore	Cauvery	CAUVERY	12.5111	76.3031
85	D/S (ASHTI)	No metals found above limit	Maharashtra	Gadchiroli	Godavari	Wainganga	19.668	79.786
86	Dadri	No metals found above limit	Haryana	Dadri	Yamuna Basin	Sahibi	28.505	76.790
87	Dameracherla	No metals found above limit	Telangana	Nalgonda	Krishna	Musi	16.739	79.670
88	Daund	No metals found above limit	Maharashtra	Pune	Krishna	Bhima	18.474	74.576
89	Delhi Railway Bridge	Ni	Delhi	North Delhi	Yamuna Basin	Yamuna	28.663	77.249

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
90	Deongaon Bridge	No metals found above limit	Karnataka	Bijapur	Krishna	Bhima	17.1703	76.3283
91	Deosugur	Hg	Karnataka	Raichur	Krishna	Musi	16.382	77.357
92	Devprayag	No metals found above limit	Uttrakhand	Pauri	Ganga	Ganga	30.141	78.647
93	Dhalegaon	No metals found above limit	Maharashtra	Parbhani	Godavari	Godavari	19.220	76.363
94	Dhamkund	Fe	"Jammu & Kashmir "	Ramban	Indus	Chenab	32.763	74.884
95	Dhansa	Fe	Haryana	Jhjjar	Yamuna Basin	Sahibi	28.534	76.871
96	Dhareri	No metals found above limit	Madhya Pradesh	Ujjain	Yamuna Basin	Chambal	23.133	75.515
97	Dhengbridge	Pb, Fe	Bihar	Sitamarhi	Ganga	Bagamati	26.724	85.324
98	Dholpur	Fe	Rajasthan	Dholpur	Ganga	Chambal	26.666	77.967
99	Dobhi	No metals found above limit	Bihar	Gaya	Ganga	Phalgu	24.530	84.918
100	Domuhani	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Subarnarekha	22.836	86.161
101	Duddhi	No metals found above limit	Uttar Pradesh	Sonebhadra	Ganga	Kanhar	24.227	83.275
102	Ekmighat	Hg, Cd	Bihar	Darbhanga	Ganga	Aadhwara Group	26.119	85.876
103	Elunuthimangalam	Fe	Tamil Nadu	Erode	Cauvery	Noyyal	11.0317	77.8875
104	Erinjipuzha	No metals found above limit	kerala	Kasargod	WFR South of Tapi	Payaswani	12.479	75.147
105	Etawah	As	Uttar Pradesh	Etawah	Ganga	Yamuna	26.750	78.983
106	Fatehpora(Prang)	No metals found above limit	"Jammu & Kashmir "	Gandarbal	Indus	Sindh Nallah	32.763	74.884
107	Gaisabad	No metals found above limit	Madhya Pradesh	Damoh	Ganga	Bearma	24.243	79.844
108	Galeta	Fe, Ni	Uttar Pradesh	Meerut	Yamuna Basin	Hindon	29.082	77.437

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
109	Gandhavayal	Fe	Tamil Nadu	Coimbatore	Cauvery	Gandhayar	11.3742	76.9922
110	Gandhighat	No metals found above limit	Bihar	Patna	Ganga	Ganga	25.623	85.171
111	Gandlapet	No metals found above limit	Telangana	Nizamabad	Godavari	Peddavagu	18.829	78.437
112	Ganguwala	Fe	Himachal Pradesh	Sirmaur	Yamuna Basin	Bata	30.436	77.578
113	Garhakota	No metals found above limit	Madhya Pradesh	Sagar	Ganga	Sonar	23.829	79.167
114	Garhwa	Pb	Jharkhand	Palamu	Ganga	North Koel	24.214	83.878
115	Garrauli	No metals found above limit	Madhya Pradesh	Chhatarpur	Ganga	Dhasan	25.081	79.344
116	Gatora	No metals found above limit	Chhattisgarh	Bilaspur	Mahanadi	Arpa	22.049	82.222
117	Gatora-1	No metals found above limit	Chhattisgarh	Bilaspur	Mahanadi	Arpa	22.090	82.150
118	Gatora-2	No metals found above limit	Chhattisgarh	Bilaspur	Mahanadi	Arpa	22.071	82.189
119	Gaya	No metals found above limit	Bihar	Gaya	Ganga	Phalgu	24.771	84.012
120	GH.Rd.Bridge	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Subarnarekha	22.594	86.448
121	Ghatshila	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Subarnarekha	22.581	86.468
122	Ghazipur	No metals found above limit	Uttar Pradesh	Ghazipur	Ganga	Ganga	25.586	83.607
123	Gokak	Cr, Pb, Fe	Karnataka	Belgaum	Krishna	GATAPRABHA	16.1814	74.8011
124	Gokul Barrage	As, Fe	Uttar Pradesh	Mathura	Yamuna Basin	Yamuna	27.443	77.714

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
125	Gomlai	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	21.834	84.913
126	Gopiballavpur	No metals found above limit	West Bengal	Paschim Midnapur	Subernarekha basin	Subarnarekha	22.220	86.905
127	Gopurajapuram	No metals found above limit	Tamil Nadu	Nagapattinam	Cauvery	Puravidlayar	10.850	79.790
128	Govindpur(NH-5)	No metals found above limit	Odisha	Balasore	Subernarekha basin	Burhabalanga	21.548	86.918
129	GR Bridge	No metals found above limit	Maharashtra	Parbhani	Godavari	Godavari	19.022	76.729
130	Gudam Bridge	No metals found above limit	Maharashtra	Gadchiroli	Godavari	Pranhita	19.417	79.972
131	Gudari	No metals found above limit	Odisha	Rayagada	EFR between Mahanadi and Godavari	Vamsadhara	19.347	83.782
132	Gummanur	Pb, Fe, Cu, Ni	Tamil Nadu	Dharmapuri	EFR between Pennar-Cauvery	Ponnaiyar	12.5550	78.1383
133	Gunderdehi	No metals found above limit	Chhattisgarh	Balod	Mahanadi	Tandula	20.954	81.294
134	Gunupur	No metals found above limit	Odisha	Rayagada	EFR between Mahanadi and Godavari	Vamsadhara	19.083	83.806
135	Haladi	Fe	KARNATAKA	Udupi	WFR South of Tapi	Halady	13.582	74.858
136	Halia	No metals found above limit	Telangana	Nalgonda	Krishna	Halia	16.790	79.339
137	Hamirpur	Fe	Uttar Pradesh	Hamirpur	Ganga	Yamuna	25.960	80.154
138	Haralahalli	Pb, Fe	Karnataka	Haveri	Krishna	TUNGABHADRA	14.8306	75.6746
139	Haridwar	No metals found above limit	Uttrakhand	Haridwar	Ganga	Ganga	29.976	78.188
140	Haridwar D/S	No metals found above limit	Uttrakhand	Haridwar	Ganga	Ganga	29.963	78.173
141	Haridwar U/S	No metals found above limit	Uttrakhand	Haridwar	Ganga	Ganga	29.968	78.176

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
142	Hariharapura	Pb, Fe	Karnataka	Chikamagaluru	Krishna	TUNGA	13.5224	75.3037
143	Haripur	No metals found above limit	Uttrakhand	Dehradun	Yamuna Basin	Tons	30.537	77.826
144	Hathidah	No metals found above limit	Bihar	Patna	Ganga	Ganga	25.385	85.988
145	Hayaghat	Hg, Fe	Bihar	Darbhanga	Ganga	Bagmati	26.036	85.887
146	Hivra	No metals found above limit	Maharashtra	Wardha	Godavari	Wardha	20.547	78.325
147	Hogenakkal	Cr, Cu, Pb, Fe, Ni	Tamil Nadu	Dharmapuri	Cauvery	Chinnar	12.1208	77.7856
148	Honnali	Pb, Fe	Karnataka	Davanagere	Krishna	TUNGABHADRA	14.2372	75.6625
149	Huvinhedgi	No metals found above limit	Karnataka	Raichur	Krishna	Krishna	16.491	76.923
150	Irrukkankudi	No metals found above limit	Tamil Nadu	Virudhunagar	EFR South of Cauvery	Vaippar	9.3242	77.9906
151	Jagdalpur	No metals found above limit	Chhattisgarh	Bastar	Godavari	Indravathi	19.108	82.023
152	Jainagar	Pb, Fe, Ni	Bihar	Madhubani	Ganga	Kamalabalan	26.590	86.147
153	Jamshedpur	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Subarnarekha	22.816	86.216
154	Jamsolaghat	No metals found above limit	Odisha	Mayurbhanj	Subernarekha basin	Subarnarekha	22.220	86.717
155	Japla	No metals found above limit	Jharkhand	Palamu	Ganga	Sone	24.569	83.976
156	Jaraikela	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Koel	22.327	85.080
157	Jaunpur	No metals found above limit	Uttar Pradesh	Jaunpur	Ganga	Gomti	25.744	82.690
158	Jawahar Bridge, Agra	As	Uttar Pradesh	Agra	Ganga	Yamuna	27.204	78.035
159	Jenapur	No metals found above limit	Odisha	Jajpur	Brahmani and Baitarni Basin	Brahamani	20.888	86.011
160	Jhalawar	No metals found above limit	Rajasthan	Jhalawar	Yamuna Basin	Kalisindh	24.591	76.188
161	Jhanjharpur	Pb	Bihar	Madhubani	Ganga	Kamalabalan	26.227	86.256
162	Jhansi Mirjapur Highway Road Bridge	No metals found above limit	Uttar Pradesh	Hamirpur	Ganga	Betwa	25.944	80.155
163	Jondhra	No metals found above limit	Chhattisgarh	Bilaspur	Mahanadi	Seonath	21.717	82.338
164	K M Vadi	Pb, Hg, Fe	Karnataka	Mysore	Cauvery	LAXMANATHIRTHA	12.3472	76.2923
165	K.T.(SATRAPUR)	No metals found above limit	Maharashtra	Nagpur	Godavari	Kanhan	21.217	79.233

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
166	Kailash Mandir (Agra U/S)	As	Uttar Pradesh	Agra	Ganga	Yamuna	27.236	77.931
167	Kakarghatti	No metals found above limit	Bihar	Darbhanga	Ganga	Jivach	26.189	85.951
168	Kalampur	Fe	Kerala	Ernakulam	WFR South of Tapi	Kaliyar	9.991	76.632
169	Kalanaur	No metals found above limit	Uttar Pradesh	Saharanpur	Yamuna Basin	Yamuna	30.068	77.354
170	Kalindi Kunj	Ni	Delhi	East Delhi	Yamuna Basin	Ganga/Yamuna	27.543	77.309
171	kallooppara	No metals found above limit	Kerala	pathanamthitta	WFR South of Tapi	Manimala	9.404	76.650
172	Kalma	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Mahanadi	21.695	83.278
173	Kalpi	No metals found above limit	Uttar Pradesh	Jalaun	Ganga	Yamuna	26.200	79.700
174	Kamalanga	No metals found above limit	Odisha	Angual	Brahmani and Baitarni Basin	Brahamani	20.917	85.264
175	Kamalapuram	No metals found above limit	Andhra Pradesh	Kadapa	Pennar	Papagani	14.581	78.678
176	Kanker	No metals found above limit	Chhattisgarh	Kanker	Mahanadi	Dhudh	20.282	81.516
177	Kantamal	No metals found above limit	Odisha	Baudh	Mahanadi	Tel	20.658	83.732
178	Kanti	No metals found above limit	Bihar	Muzaffarpur	Ganga	Burhi Gandak	26.274	85.300
179	Karad	No metals found above limit	Maharashtra	Satara	Krishna	Krishna	17.294	74.190
180	Karathode	Fe	Kerala	Malappuram	WFR South of Tapi	Kadalundi	11.057	76.039
181	Karnal	Pb, Ni	Haryana	Karnal	Yamuna Basin	Yamuna	29.762	77.132
182	Karnprayag	No metals found above limit	Uttrakhand	Chamoli	Ganga	Pinder	30.255	79.221
183	Karnprayag Con-fluence D/S	No metals found above limit	Uttrakhand	Chamoli	Ganga	Alkalnanda	30.265	79.214
184	Karnprayag Con-fluence U/S	No metals found above limit	Uttrakhand	Chamoli	Ganga	Alkalnanda	30.264	79.218
185	Kashinagar	No metals found above limit	Odisha	Gajapati	EFR between Mahanadi and Godavari	Vamsadhara	18.848	83.873
186	Keesara	No metals found above limit	Andhra Pradesh	Krishna	Krishna	Munneru	16.716	80.316
187	Kellodu	Pb, Fe	Karnataka	Chitradurga	Krishna	VEDAVATHI	13.7542	76.3197
188	Keolari	No metals found above limit	Madhya Pradesh	Seoni	Godavari	Wainganga	22.381	79.900
189	Kesinga	No metals found above limit	Odisha	Kalahandi	Mahanadi	Tel	20.198	83.225
190	Khairmal	No metals found above limit	Odisha	Baudh	Mahanadi	Mahanadi	20.831	84.000

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
191	Khatoli	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Parwati	25.683	76.483
192	Kidangoor	No metals found above limit	Kerala	Kottayam	WFR South of Tapi	Meenachil	9.676	76.606
193	Kirtinagar D/S	No metals found above limit	Uttrakhand	Pauri	Ganga	Alkalnanda	30.229	78.730
194	Kirtinagar U/S	No metals found above limit	Uttrakhand	Pauri	Ganga	Alkalnanda	30.230	78.767
195	Kodumudi	Fe	Tamil Nadu	Erode	Cauvery	Cauvery	11.0811	77.8903
196	Koelwar	Pb	Bihar	Bhojpur	Ganga	Sone	25.571	84.798
197	Koggedoddi	Cr, Pb, Hg, Ni	Karnataka	Ramanagara	Cauvery	ARKAVATHI	12.2962	77.4409
198	Kokiwada	No metals found above limit	Madhya Pradesh	Chhindwara	Godavari	Pench	21.898	79.234
199	Kollegal	Pb, Fe	Karnataka	Chamaraja Nagar	Cauvery	CAUVERY	12.1893	77.1019
200	Konta	No metals found above limit	Chhattisgarh	Dantewara	Godavari	Sabri	17.799	81.393
201	Kopergaon	No metals found above limit	Maharashtra	Ahmednagar	Godavari	Godavari	19.878	74.481
202	Kora	As, Fe	Uttar Pradesh	Fatehpur	Ganga	Rind	26.106	80.051
203	Korba	No metals found above limit	Chhattisgarh	Korba	Mahanadi	Hasdeo	22.394	82.703
204	Korba-1	No metals found above limit	Chhattisgarh	Korba	Mahanadi	Hasdeo	22.342	82.689
205	Kota Hanging Bridge U/S	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Chambal	25.140	75.795
206	Koteshwar	No metals found above limit	Uttrakhand	Tehri	Ganga	Bhagirathi	30.263	78.501
207	Kotni	No metals found above limit	Chhattisgarh	Durg	Mahanadi	Seonath	21.238	81.250
208	Kudige	Cr, Fe, Ni	Karnataka	Kodagu	Cauvery	CAUVERY	12.5024	75.9610
209	Kudlur	Pb, Cr, Fe, Ni	Karnataka	Chamaraja Nagar	Cauvery	Cauvery	11.8406	77.4628
210	Kuldahbridge	No metals found above limit	Madhya Pradesh	Sidhi	Ganga	Sone	24.410	81.704
211	Kulpatanga	No metals found above limit	Jharkhand	Purba Singhbhum	Subernarekha basin	Kharkai	22.766	86.159
212	Kumbidi	No metals found above limit	Kerala	Palakkad	WFR South of Tapi	Bharatapuzha	10.854	76.020
213	Kumhari	No metals found above limit	Madhya Pradesh	Balaghat	Godavari	Wainganga	21.884	80.175
214	Kuniyil	No metals found above limit	Kerala	Malappuram	WFR South of Tapi	Chaliyar	11.239	76.023
215	Kuppelur	Pb, Fe	Karnataka	Haveri	Krishna	KUMUDVATHI	14.5000	75.6339
216	Kurubhata	No metals found above limit	Chhattisgarh	Raigarh	Mahanadi	Mand	21.981	83.211
217	Kurundwad	Pb, Hg	Maharashtra	Kolhapur	Krishna	Krishna	16.684	74.603

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
218	Kusei	No metals found above limit	Odisha	Keonjhar	Brahmani and Baitarni Basin	Baitarani	21.350	86.055
219	Kuthnaur	No metals found above limit	Uttrakhand	Uttarkashi	Yamuna Basin	Yamuna	30.874	78.303
220	Kuttiyadi	No metals found above limit	Kerala	Kozhikode	WFR South of Tapi	Kutiyadi	11.638	75.776
221	Kuzhithurai	No metals found above limit	Tamil Nadu	Kanyakumari	WFR South of Tapi	Thamarabarani	8.305	77.186
222	Lakhisarai	No metals found above limit	Bihar	Lakhisarai	Ganga	Kiul	25.185	87.020
223	Lakhoura	No metals found above limit	Bihar	East Champaran	Ganga	Tiyar	26.721	84.972
224	Lakkavalli	Pb, Fe	Karnataka	Chikmagalur	Krishna	BHADRA	13.707	75.645
225	Lakshmanapatti	No metals found above limit	Tamil Nadu	Dindigul	Cauvery	Kodaganar	10.4981	77.9458
226	Lalganj	Hg	Bihar	Vaishali	Ganga	Gandak	25.831	85.168
227	Lalpur	As, Fe	Uttar Pradesh	Kanpur Dehat	Ganga	Sengar	26.271	79.950
228	Lodhikheda	No metals found above limit	Madhya Pradesh	Chhindwara	Godavari	Jam	21.579	78.866
229	Lupungdhi	No metals found above limit	Jharkhand	Saraikela kharsawan	Subernarekha basin	Subarnarekha	22..788	86.302
230	M H Halli	Fe, Pb	Karnataka	Hassan	Cauvery	HEMAVATHY	12.8199	76.1410
231	Madamon	No metals found above limit	Kerala	Pathanamthitta	WFR South of Tapi	Pampa	9.364	76.838
232	Madhira	No metals found above limit	Telangana	Khammam	Krishna	Wyra	16.918	80.356
233	Madhya Bharat Paper Ltd	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Hasdeo	22.013	82.648
234	Madla	Fe	Madhya Pradesh	Panna	Ganga	Ken	24.733	80.007
235	Magaral	No metals found above limit	Tamil Nadu	Kancheepuram	EFR between Pennar-Cauvery	Cheyyar	12.708	79.750
236	Magardhara	No metals found above limit	Maharashtra	Balaghat	Godavari	Wainganga	21.956	80.109
237	MAHALGAON	No metals found above limit	Maharashtra	GONDIA	Godavari	WAINGANGA	21.551	80.027
238	Mahidpur	No metals found above limit	Madhya Pradesh	Ujjain	Yamuna Basin	Shipra	23.481	75.636
239	Maighat	No metals found above limit	Uttar Pradesh	Jaunpur	Ganga	Gomti	25.644	82.847
240	Malakkara	No metals found above limit	Kerala	Pathanamthitta	WFR South of Tapi	Pampa	9.333	76.663
241	Malkhed	No metals found above limit	Karnataka	Gulbarga	Krishna	Bhima	17.203	77.157

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
242	Manakkad	No metals found above limit	Kerala	Idukki	WFR South of Tapi	Thodupuzha	9.910	76.687
243	Mancherial	No metals found above limit	Telangana	Adilabad	Godavari	Godavari	18.836	79.445
244	Mandawara	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Chambal	25.385	76.152
245	Manderial	No metals found above limit	Rajasthan	Karauli	Yamuna Basin	Chambal	26.273	77.275
246	Manendragarh	No metals found above limit	Chhattisgarh	Koriya	Mahanadi	Hasdeo	23.201	82.214
247	Mangaon	Pb	Maharashtra	Raigad	WFR South of Tapi	Kal	18.232	73.283
248	Manjhi	No metals found above limit	Bihar	Saran	Ganga	Ghaghra	25.827	85.584
249	Mankara	No metals found above limit	Kerala	Palakkad	WFR South of Tapi	Bharatapuzha	10.781	76.513
250	Mantralayam	No metals found above limit	Andhra Pradesh	Kurnool	Krishna	Tungabhadra	15.948	77.426
251	Marella	No metals found above limit	Andhra Pradesh	Prakasam	Krishna	Gundakamma	15.883	79.910
252	Marol	Pb, Fe	Karnataka	Haveri	Krishna	VARADA	14.9388	75.6181
253	Mawi	Ni	Uttar Pradesh	Muzaffar Nagar	Yamuna Basin	Yamuna	29.383	77.155
254	Meja Road	No metals found above limit	Uttar Pradesh	Allahabad	Ganga	Tons	25.233	82.038
255	Menangudi	No metals found above limit	Tamil Nadu	Tiruvarur	Cauvery	Noolar	10.949	79.704
256	Mirzapur	No metals found above limit	Uttar Pradesh	Mirzapur	Ganga	Ganga	25.157	82.530
257	Mohana	No metals found above limit	Uttar Pradesh	Jalaun	Ganga	Betwa	25.824	79.462
258	Mohna	Ni	Haryana	Faridabad	Yamuna Basin	Yamuna	28.224	77.456
259	Mungoli	No metals found above limit	Maharashtra	Yavatmal	Godavari	Penganga	19.864	79.125

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
260	Munugodu	No metals found above limit	Andhra Pradesh	Guntur	Krishna	Edduvagu	16.555	80.206
261	Muradpur	No metals found above limit	Maharashtra	Ratnagiri	WFR South of Tapi	Vashishti	17.539	73.522
262	Murappanadu	Fe	Tamil Nadu	Tuticorin	EFR South of Cauvery	Tambraparani	8.7144	77.8350
263	Muri	No metals found above limit	Jharkhand	Ranchi	Subernarekha basin	Subarnarekha	22.817	86.213
264	Mushal	No metals found above limit	Odisha	Keonjhar	Brahmani and Baitarni Basin	Baitarani	21.326	86.040
265	Musiri	Fe	Tamil Nadu	Thiruchirapalli	Cauvery	Cauvery	10.9433	78.4350
266	Muthankera	Pb, Fe	Kerala	Wayanad	Cauvery	KABINI	11.8082	76.0841
267	Nagothane	No metals found above limit	Maharashtra	Raigad	WFR South of Tapi	Amba	18.519	73.156
268	Naidupet	No metals found above limit	Andhra Pradesh	Nellore	EFR between Pennar-Cauvery	Swarnamukhi	13.947	79.897
269	Nallamaranpatti	Fe	Tamil Nadu	Karur	Cauvery	Amaravathi	10.881	77.985
270	Nallathur	No metals found above limit	Pondicherry	Karaikal	Cauvery	Nandalar	11.002	79.752
271	Nanded	No metals found above limit	Maharashtra	Nanded	Godavari	Godavari	19.142	77.320
272	Nandgaon	No metals found above limit	Maharashtra	Wardha	Godavari	Wunna	20.526	78.810
273	Nandipalli	No metals found above limit	Andhra Pradesh	Kadapa	Pennar	Sagileru	14.721	79.019
274	Nandira	No metals found above limit	Odisha	Angual	Brahmani and Baitarni Basin	Brahamani	20.890	85.259
275	Nashik	No metals found above limit	Maharashtra	Nasik	Godavari	Godavari	20.002	73.803
276	Naugaon	Hg	Uttrakhand	Uttarkashi	Yamuna Basin	Yamuna	30.792	78.138
277	Nawapara	No metals found above limit	Chhattisgarh	Raipur	Mahanadi	Mahanadi	20.967	81.871
278	Neeleswaram	No metals found above limit	Kerala	Ernakulam	WFR South of Tapi	Periyar	10.181	76.469
279	Nellipally	No metals found above limit	Kerala	Kollam	WFR South of Tapi	Kallada	9.028	76.925
280	Nirmali	No metals found above limit	Bihar	Supaul	Ganga	Tiljuga	26.304	86.578
281	Noida	Ni	Uttar Pradesh	Gautam Budh Nagar	Yamuna Basin	Hindon	28.602	77.424
282	Nowrangpur	Hg	Odisha	Nowrangpur	Godavari	Indravathi	19.198	82.512
283	Odenthurai	Pb, Fe, Ni	Tamil Nadu	Coimbatore	Cauvery	Kallar	11.3217	76.8928
284	Okhla Barrage	Pb, Cr, Fe, Ni	Delhi	South Delhi	Yamuna Basin	Yamuna	28.545	77.312

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
285	Orai Rath marg Road Bride, Chikasi	No metals found above limit	Uttar Pradesh	Jalaun	Ganga	Betwa	25.811	79.461
286	P.G.BRIDGE	No metals found above limit	Maharashtra	Yavatmal	Godavari	Penganga	19.821	78.561
287	Pachawali	No metals found above limit	Madhya Pradesh	Shivpuri	Ganga	Sindh	27.247	77.830
288	Pachegaon	No metals found above limit	Maharashtra	Ahmednagar	Godavari	Pravara	19.534	74.834
289	Padampur	No metals found above limit	Odisha	Bargarh	Mahanadi	Ong	21.016	83.103
290	Palakkadavu	No metals found above limit	Kerala	Thrissur	WFR South of Tapi	Karuvannur	10.425	76.238
291	Paleru Bridge	No metals found above limit	Andhra Pradesh	Krishna	Krishna	Krishna	16.949	80.048
292	Pali	No metals found above limit	Rajasthan	Sawai-Madhopur	Yamuna Basin	Chambal	25.863	76.577
293	Palla	As	Delhi	North West Delhi	Yamuna Basin	Yamuna	28.845	77.213
294	Panposh	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	22.237	84.797
295	Panposh-I	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Sankh	22.248	84.787
296	Panposh-II	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Koel	22.249	84.797
297	Paramakudi	No metals found above limit	Tamil Nadu	Ramanathapuram	EFR South of Cauvery	Vaigai	9.5533	78.5864
298	Pargaon	No metals found above limit	Maharashtra	Pune	Krishna	Bhima	18.572	74.392
299	Patala	No metals found above limit	Maharashtra	Chandrapur	Godavari	Wardha	20.127	79.001
300	Patansaongi	No metals found above limit	Maharashtra	Nagpur	Godavari	Chandrabhaga	21.321	79.024
301	Pathagudem	No metals found above limit	Chhattisgarh	Dantewara	Godavari	Indravathi	18.853	80.349
302	Pathardih	No metals found above limit	Chhattisgarh	Raipur	Mahanadi	Kharun	21.341	81.594
303	Pattazhy	No metals found above limit	Kerala	Kollam	WFR South of Tapi	Kallada	9.073	76.761
304	Pauni	No metals found above limit	Maharashtra	Bhandara	Godavari	Wainganga	20.795	79.649
305	Peralam	No metals found above limit	Tamil Nadu	Tiruvarur	Cauvery	Vanjiyar	10.969	79.662

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
306	Perumannu	No metals found above limit	Kerala	Cannanore	WFR South of Tapi	Valapatnam	11.982	75.584
307	Perur	No metals found above limit	Telangana	Khammam	Godavari	Godavari	18.587	80.396
308	Phulgaon	No metals found above limit	Maharashtra	Pune	Krishna	Bhima	18.667	74.002
309	Poanta	No metals found above limit	Himachal Pradesh	Simaur	Yamuna Basin	Yamuna	30.434	77.623
310	Poiyaghat, Agra	As	Uttar Pradesh	Agra	Ganga	Yamuna	27.254	78.023
311	Polavaram	Hg	Andhra Pradesh	West Godavari	Godavari	Godavari	17.252	81.656
312	Porakudi	No metals found above limit	Tamil Nadu	Nagapattinam	Cauvery	Arasalar	10.904	79.707
313	Prakash Industries Ltd	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Hasdeo	21.988	82.670
314	Pratapgarh	No metals found above limit	Uttar Pradesh	Pratapgarh	Ganga	Sai	25.935	82.002
315	Pratappur	Fe	Uttar Pradesh	Prayagraj	Ganga	Pravara	19.519	74.384
316	Premnagar	Fe	"Jammu & Kashmir "	Doda	Indus	Chenab	32.763	74.884
317	Pudur	No metals found above limit	Kerala	Palakkad	WFR South of Tapi	Kannadipuzha	10.775	76.583
318	Pulamanthole	No metals found above limit	Kerala	Palakkad	WFR South of Tapi	Pulanthodu	10.899	76.197
319	Pulikukku	No metals found above limit	KARNATAKA	Dakshina Kannada	WFR South of Tapi	Kumaradhara	12.711	75.469
320	Purashottampur	No metals found above limit	Odisha	Ganjam	EFR between Mahanadi and Godavari	Rushikulya	19.517	84.883
321	Purna	No metals found above limit	Maharashtra	Parbhani	Godavari	Purna	19.176	77.014
322	Purunagarh	No metals found above limit	Odisha	Deogarh	Brahmani and Baitarni Basin	Brahamani	21.526	84.713
323	R.S.P	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	22.207	84.830
324	R.S.P-I	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	22.208	84.828
325	R.S.P-II	No metals found above limit	Odisha	Sundergarh	Brahmani and Baitarni Basin	Brahamani	22.204	84.828
326	Rahu	No metals found above limit	Maharashtra	Pune	Krishna	Mula-Mutha	18.568	74.381

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
327	Rajahmundry	Hg	Andhra Pradesh	East Godavari	Godavari	Godavari	16.966	81.783
328	Rajapur	Pb, Fe	Uttar Pradesh	Chitrakoot	Ganga	Yamuna	25.390	81.154
329	Rajegaon	No metals found above limit	Madhya Pradesh	Balaghat	Godavari	Bagh	21.624	80.253
330	Rajghat	No metals found above limit	Uttar Pradesh	Lalitpur	Ganga	Betwa	24.768	78.236
331	Rajim	No metals found above limit	Chhattisgarh	Gariaband	Mahanadi	Mahanadi	20.975	81.881
332	Ram Munshi Bagh	No metals found above limit	"Jammu & Kashmir "	Srinagar	Indus	Jhelum	32.763	74.884
333	Ramakona	No metals found above limit	Madhya Pradesh	Chhindwara	Godavari	Kanhan	21.719	78.824
334	Ramamangalam	No metals found above limit	Kerala	Ernakulam	WFR South of Tapi	Muvattupuzha	9.944	76.478
335	Rampur	No metals found above limit	Chhattisgarh	Baloda Bazar	Mahanadi	Jonk	21.647	82.516
336	Renuka ji	No metals found above limit	Uttrakhand	Sirmaur	Yamuna Basin	Giri	30.604	77.441
337	Rishikesh	No metals found above limit	Uttrakhand	Dehradun	Ganga	Ganga	30.103	78.304
338	Rishikesh D/S	No metals found above limit	Uttrakhand	Dehradun	Ganga	Ganga	30.076	78.287
339	Rishikesh U/S	No metals found above limit	Uttrakhand	Dehradun	Ganga	Ganga	30.126	78.329
340	Roorkee D/S	No metals found above limit	Uttrakhand	Haridwar	Ganga	Solani	29.880	77.898
341	Roorkee U/S	No metals found above limit	Uttrakhand	Haridwar	Ganga	Solani	29.886	77.891
342	Rudraprayag	No metals found above limit	Uttrakhand	Rudraprayag	Ganga	Alkalnanda	30.288	78.984
343	Safapora	No metals found above limit	"Jammu & Kashmir "	Baramula	Indus	Jhelum	32.763	74.884
344	Sahijana	No metals found above limit	Uttar Pradesh	Hamirpur	Ganga	Betwa	25.950	80.148
345	Saidpur	No metals found above limit	Uttar Pradesh	Ghazipur	Ganga	Ganga	25.534	83.221
346	Saigaon	No metals found above limit	Karnataka	Bidar	Godavari	Manjera	18.076	77.053
347	Sakhara	No metals found above limit	Maharashtra	Gadchiroli	Godavari	Wainganga	20.621	79.937
348	Sakleshpura	Pb, Fe	Karnataka	Hassan	Cauvery	HEMAVATHI	12.9435	75.7938
349	Sakmur	No metals found above limit	Maharashtra	Chandrapur	Godavari	Wardha	19.559	79.612
350	Sakra	Pb	Bihar	Muzaffarpur	Ganga	Burhi Gandak	26.041	85.555
351	Salebardi	No metals found above limit	Maharashtra	Bhandara	Godavari	Chulband	20.913	79.927
352	Salebhata	No metals found above limit	Odisha	Balangir	Mahanadi	Ong	20.983	83.539

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
353	Saloora	No metals found above limit	Telangana	Nizamabad	Godavari	Godavari	18.792	77.834
354	Samdoli	No metals found above limit	Maharashtra	Sangali	Krishna	Warana	16.856	74.496
355	Sangam	Hg, Fe	"Jammu & Kashmir	Anantnag	Indus	Kinnersani	32.763	74.884
356	Sangod	No metals found above limit	Rajasthan	Kota	Yamuna Basin	Parwan	24.960	76.301
357	Santegulli	No metals found above limit	Karnataka	Uthara Kannada	WFR South of Tapi	Aghnanashni	14.435	74.587
358	Saradaput	No metals found above limit	Odisha	Malkangiri	Godavari	Sabri	18.613	82.143
359	Sarangpal	No metals found above limit	Chhattisgarh	Kanker	Mahanadi	Mahanadi	20.313	81.532
360	Sarangpur	No metals found above limit	Madhya Pradesh	Rajgarh	Yamuna Basin	Kalisindh	23.550	76.467
361	Sarati	No metals found above limit	Maharashtra	Pune	Krishna	Nira	17.91139	75.0075
362	Satna	No metals found above limit	Madhya Pradesh	Satna	Ganga	Tons	24.562	80.908
363	Satpuli D/S	No metals found above limit	Uttrakhand	Pauri	Ganga	Nayar	29.938	78.702
364	Satpuli U/S	No metals found above limit	Uttrakhand	Pauri	Ganga	Nayar	29.919	78.707
365	Satrapur	No metals found above limit	Maharashtra	Nagpur	Godavari	Kanhan	21.217	79.233
366	Savandapur	Fe	Tamil Nadu	Erode	Cauvery	Bhavani	11.5214	77.5100
367	Seondha	No metals found above limit	Madhya Pradesh	Datia	Ganga	Sindh	26.172	78.804
368	Seorinarayan	No metals found above limit	Chhattisgarh	Janjgir-Champa	Mahanadi	Mahanadi	21.718	82.598
369	Sevanur	No metals found above limit	Tamil Nadu	Erode	Cauvery	Chittar	11.5519	77.7319
370	Shahzadpur	No metals found above limit	Uttar Pradesh	Kaushambi	Ganga	Ganga	25.667	81.430
371	Shastri bridge	No metals found above limit	Uttar Pradesh	Allahabad	Ganga	Ganga	25.437	81.889
372	Shimoga	Pb, Fe	Karnataka	Shimoga	Krishna	TUNGA	13.9269	75.5850
373	Sidhra, Jammu	No metals found above limit	"Jammu & Kashmir	Jammu	Indus	Tawi	32.763	74.884
374	Sikandarpur	No metals found above limit	Bihar	Muzaffarpur	Ganga	Burhi Gandak	26.143	85.376
375	Simga	No metals found above limit	Chhattisgarh	Baloda Bazar	Mahanadi	Seonath	21.633	81.685
376	Singasadanapalli	Pb, Cd, Fe, Cu, Ni	Tamil Nadu	Dharmapuri	EFR between Pennar-Cauvery	Ponnaiyar	12.8700	77.8359
377	Sorada	No metals found above limit	Odisha	Ganjam	EFR between Mahanadi and Godavari	Rushikulya	19.759	84.450

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
378	Srikakulam	No metals found above limit	Andhra Pradesh	Srikakulam	EFR between Mahanadi and Godavari	Nagavali	18.313	83.884
379	Srinagar	No metals found above limit	Uttrakhand	Pauri	Ganga	Alkalnanda	30.228	78.786
380	Sripalpur	No metals found above limit	Bihar	Patna	Ganga	Punpun	25.501	85.121
381	Suddakallu	No metals found above limit	Telangana	Mahaboob Nagar	Krishna	Dindi	16.567	78.417
382	Sultanpur	No metals found above limit	Uttar Pradesh	Sultanpur	Ganga	Gomti	26.226	82.068
383	Sulurpet	No metals found above limit	Andhra Pradesh	Nellore	EFR between Pennar-Cauvery	Kalingi	13.708	80.010
384	Sundargarh	No metals found above limit	Odisha	Sundargarh	Mahanadi	Ib	22.115	84.011
385	Sundargarh(Town)	No metals found above limit	Odisha	Sundargarh	Mahanadi	Ib	22.130	84.024
386	T Bekuppe	Cr, Fe, Pb, Hg	Karnataka	Ramanagara	Cauvery	ARKAVATHI	12.5071	77.4282
387	T. N. Pura	Fe	Karnataka	Mysore	Cauvery	KABINI	12.2302	76.8943
388	T.K Halli	No metals found above limit	Karnataka	Mandya	Cauvery	SHIMSHA	12.4121	77.1929
389	T.Ramapuram	No metals found above limit	Karnataka	Bellary	Krishna	Hagari	15.661	76.963
390	Tadipatri	No metals found above limit	Andhra Pradesh	Anantapur	Pennar	Pennar	14.922	78.016
391	Takali	No metals found above limit	Maharashtra	Solapur	Krishna	Bhima	17.41306	75.84778
392	Tal	No metals found above limit	Madhya Pradesh	Ratlam	Yamuna Basin	Chambal	23.723	75.347
393	Talcher	No metals found above limit	Odisha	Angual	Brahmani and Baitarni Basin	Brahamani	20.919	85.236
394	Tandi	Fe	Himachal Pradesh	Lahoul & Spiti	Indus	Chenab	32.763	74.884
395	Terwad	No metals found above limit	Maharashtra	Kolhapur	Krishna	Panchganga	16.674	74.574
396	Thandalaiputhur	Fe	Tamil Nadu	Thiruchirapalli	Cauvery	Ayyar	10.9912	78.5133
397	Thengudi	No metals found above limit	Tamil Nadu	Tiruvarur	Cauvery	Thirumalairajanar	10.916	79.639
398	Thengumarahada	Pb, Fe, Ni	Tamil Nadu	Nilgiris	Cauvery	Bhavani/Moyar	11.5722	76.9192
399	Theni	Pb, Fe	Tamil Nadu	Theni	EFR South of Cauvery	Suruliyar	10.0011	77.4850
400	Thevur	No metals found above limit	Tamil Nadu	Salem	Cauvery	Sarabenga	11.5272	77.7508
401	Thoppur	Fe	Tamil Nadu	Salem	Cauvery	Thoppaiyar	11.9383	78.0572
402	Thotathinkadavu	No metals found above limit	Kerala	Kozhikode	WFR South of Tapi	Iruvazhinjipuzha	11.362	76.002
403	Thumpamon	No metals found above limit	Kerala	Pathanamthitta	WFR South of Tapi	Achankovil	9.225	76.715

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
404	Tikarpada	No metals found above limit	Odisha	Angul	Mahanadi	Mahanadi	20.589	84.783
405	Tilga	No metals found above limit	Jharkhand	Simdega	Brahmani and Baitarni Basin	Sankh	22.624	84.418
406	Tonk	No metals found above limit	Rajasthan	Tonk	Yamuna Basin	Banas	26.206	75.776
407	Triveni	Fe	Bihar	West Champaran	Ganga	Gandak	27.436	83.907
408	Tuini	No metals found above limit	Uttrakhand	Dehradun	Yamuna Basin	Tons	30.940	77.847
409	Tuini (P)	No metals found above limit	Himachal Pradesh	Dehradun	Yamuna Basin	Pabar	30.955	77.853
410	U/S (BAMNI)	No metals found above limit	Maharashtra	Chandrapur	Godavari	Wardha	19.850	79.340
411	U/S (SATRAPUR)	No metals found above limit	Maharashtra	Nagpur	Godavari	Kanhan	21.226	79.231
412	Udaipur	Fe	Himachal Pradesh	Lahoul & Spiti	Indus	Chenab	32.763	74.884
413	Udi	Fe	Uttar Pradesh	Etawah	Ganga	Chambal	26.696	78.938
414	Ujjain	No metals found above limit	Madhya Pradesh	Ujjain	Yamuna Basin	Shipra	23.168	75.771
415	Urachikottai	No metals found above limit	Tamil Nadu	Erode	Cauvery	Cauvery	11.4778	77.7000
416	Uttarkashi	No metals found above limit	Uttrakhand	Uttarkashi	Ganga	Bhagirathi	30.729	78.447
417	V S Bridge	No metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.255	83.025
418	Valigonda	No metals found above limit	Telangana	Nalgonda	Krishna	Musi	16.571	79.421
419	Vandiperiyar	No metals found above limit	Kerala	Idukki	WFR South of Tapi	Periyar	9.573	77.091
420	Varanasi	No metals found above limit	Uttar Pradesh	Varanasi	Ganga	Ganga	25.324	83.038
421	Varanavasi	No metals found above limit	Tamil Nadu	Perambalur	Cauvery	Marudaiyar	11.0925	79.0850
422	Vazhavachanur	No metals found above limit	Tamil Nadu	Thiruvannamalai	EFR between Pennar-Cauvery	Ponnaiyar	12.066	78.978
423	Vijayawada	No metals found above limit	Andhra Pradesh	Krishna	Krishna	Krishna	16.501	80.625
424	Villupuram	No metals found above limit	Tamil Nadu	Villupuram	EFR between Pennar-Cauvery	Ponnaiyar	11.871	79.459
425	Vrindawan Bridge	As	Uttar Pradesh	Mathura	Yamuna Basin	Yamuna	27.566	77.708
426	Wadakbal	Pb	Maharashtra	Solapur	Krishna	Sina	17.533	75.885
427	Wadenapalli	No metals found above limit	Telangana	Nalgonda	Krishna	Krishna	16.794	80.069
428	Wairagarh	No metals found above limit	Maharashtra	Gadchiroli	Godavari	Wainganga	20.422	80.092
429	Warunji	Fe	Maharashtra	Satara	Krishna	Koyna	17.272	74.165

S.No.	Water Quality Stations(data as received)	Metal Found Above Limit	State	District	Basin	River/ Reservoir	Latitude	Longitude
430	Yadgir	No metals found above limit	Karnataka	Gulbarga	Krishna	Bhima	16.738	77.125
431	Yamuna Expess-way Road Bridge, Etamadpur	As	Uttar Pradesh	Agra	Ganga	Yamuna	27.179	78.119
432	Yashwant Nagar	No metals found above limit	Himachal Pradesh	Simaur	Yamuna Basin	Giri	30.882	77.209
433	Yelli	Hg	Maharashtra	Nanded	Godavari	Godavari	19.044	77.456
434	Yennehole	No metals found above limit	Karnataka	Udupi	WFR South of Tapi	Swarna	13.294	74.981

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