Engineering

E-ISSN No : 2581-6195 | Volume : 9 | Special Issue | May 2026

# ASSESSMENT OF GROUNDWATER QUALITY FOR HEAVY METAL CONTAMINATION IN AND AROUND RAICHUR DISTRICT, KARNATAKA

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**How to Cite:**
Ashwini. G & Nagesh Sugandhi (2026), Assessment of Groundwater Quality for Heavy Metal Contamination in and Around Raichur District, Karnataka, International Educational Journal of Science & Engineering (IEJSE),Vol: 9, Special Issue, May 2026 460-464

## ABSTRACT

Groundwater is the main source of drinking water for people living in Raichur District, Karnataka. However, the district has large industrial units like the Raichur Thermal Power Station (RTPS) and several manufacturing units under KIADB and MIDC. These industries, along with farming activities, may be releasing harmful heavy metals into the soil and water. This study aims to check the quality of groundwater by measuring the concentration of seven heavy metals — Iron (Fe), Manganese (Mn), Lead (Pb), Chromium (Cr), Zinc (Zn), Cadmium (Cd), and Nickel (Ni) — at ten different locations in and around Raichur District. Water samples were collected in March–April 2026 and tested in the laboratory using Atomic Absorption Spectrophotometry (AAS). The results were compared with World Health Organization (WHO) drinking water standards. A number called the Heavy Pollution Index (HPI) was calculated to rank the pollution level at each location. The results show that industrial areas, especially Raichur MIDC and RTPS Colony (Shaktinagar), had metal levels much higher than safe limits. Agricultural and rural areas had mostly acceptable levels. Based on the findings, this paper recommends simple and practical steps to improve groundwater quality in Raichur District.

**KEYWORDS:** Groundwater Quality, Heavy Metals, Raichur District, Heavy Pollution Index (HPI), Atomic Absorption Spectrophotometry (AAS), Water pollution, Karnataka

## I. INTRODUCTION

Water is one of the most important natural resources for human life. In India, about 85% of people in rural areas depend on groundwater for drinking and cooking. Raichur District in northern Karnataka is one such area where groundwater is the main source of water for millions of people.

Raichur District has a mix of farming land and industrial units. The Raichur Thermal Power Station (RTPS) at Shaktinagar is one of the largest power plants in Karnataka. Along with this, there are many small and medium industries under the Karnataka Industrial Areas Development Board (KIADB) and MIDC. These industries can release harmful chemicals into the soil, which then mix with groundwater over time.

Farmers in Raichur use large amounts of pesticides and fertilizers to grow paddy, cotton, and other crops. These chemicals can also enter the groundwater through the soil. When groundwater is used for drinking without testing, people may unknowingly consume harmful substances like Lead, Chromium, and Cadmium, which are very dangerous for health.

Heavy metals are toxic chemical elements that do not break down naturally. Even a small amount of these metals in drinking water can cause serious health problems such as kidney damage, liver problems, and cancer. Children are especially at risk because their bodies absorb these metals

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more easily than adults.

Despite the presence of many industries and farming activities, very few studies have been done to check the level of heavy metals in the groundwater of Raichur District. This motivated us to take up this study and provide useful data for students, researchers, and the government to take action.

## II. OBJECTIVES OF THE STUDY

The main goals of this study are:

1. To collect groundwater samples from ten different locations in Raichur District covering industrial, agricultural, and rural areas.
2. To measure the concentration of seven heavy metals (Fe, Mn, Pb, Cr, Zn, Cd, Ni) in each water sample.
3. To compare the measured values with WHO and BIS drinking water standards.
4. To calculate the Heavy Pollution Index (HPI) for each location to find which areas are most polluted.
5. To suggest simple and affordable solutions to improve groundwater quality in Raichur District.

## III. STUDY AREA DESCRIPTION

Raichur District is located in the northern part of Karnataka, between latitudes 15°09'N to 16°34'N and longitudes 76°14'E to 77°35'E. The district covers an area of about 8,386 sq. km and has a population of around 19.28 lakhs (Census 2011). The district headquarters is Raichur city, which is located between the Krishna and Tungabhadra rivers.

The climate of Raichur is semi-arid and hot. Rainfall is low and mostly depends on the South-West Monsoon, averaging about 690 mm per year. Due to low rainfall, people depend heavily on groundwater. The soil type is mainly black cotton soil (vertisol), which is rich in clay and can hold moisture for longer periods.

The major industries in the district include the Raichur Thermal Power Station (RTPS), fertilizer units, cement factories, and food-processing plants. Agriculture is another major activity, with paddy, cotton, sunflower, and sugarcane being the main crops. The use of chemical fertilizers and pesticides is quite high in the district.

For this study, ten sampling locations were selected to represent all types of land use in the district — industrial zones, agricultural fields, urban residential areas, and rural villages.

## IV. MATERIALS AND METHODOLOGY

### A. Sample Collection

Groundwater samples were collected from ten locations in Raichur District during March–April 2026. This period (pre-monsoon season) was chosen because groundwater is less diluted at this time and pollutant concentrations are at their highest levels.

Samples were collected from open wells, borewells, and hand pumps. Before collecting the sample, each source was pumped for about 10 minutes to remove stagnant water. The samples were collected in clean 1-litre plastic bottles that had been washed with dilute acid (HCl) and rinsed with distilled water to prevent contamination.

Each bottle was labeled with the location name, date, time, and type of water source. A small amount of concentrated nitric acid ($HNO_3$) was added to each bottle to preserve the sample. The bottles were kept in a cool box and transported to the laboratory within 24 hours.

**Table I: Groundwater Sampling Locations – Raichur District**

| S.No | Location | Source Type | Depth (m) | Land Use / Nearby Activity | Distance from Industry (km) |
|---|---|---|---|---|---|
| 1 | Raichur City (Old Town) | Open Well | 10–15 | Urban / Residential | 0.9 |
| 2 | RTPS Colony, Shaktinagar | Borewell | 50–65 | Industrial (Thermal Power) | 0.2 |
| 3 | Sindhanur | Borewell | 30–45 | Agricultural (Paddy) | 5.8 |
| 4 | Manvi | Open Well | 12–18 | Agricultural (Cotton) | 7.2 |
| 5 | Raichur KIADB | Borewell | 55–70 | Industrial (KIADB) | 0.5 |
| 6 | Devadurga | Borewell | 25–40 | Agricultural / Rural | 9.4 |
| 7 | Lingasugur | Hand Pump | 15–25 | Rural | 6.1 |

| | | | | | |
|---|---|---|---|---|---|
| 8 | Maski | Borewell | 35–50 | Semi-Urban | 4.3 |
| 9 | Mudgal | Open Well | 10–18 | Agricultural | 8.0 |
| 10 | Raichur MIDC | Borewell | 60–75 | Industrial (MIDC) | 0.1 |

***Source:*** *Field Survey, March–April 2026*

**B. Laboratory Testing – Atomic Absorption Spectrophotometry (AAS)**

All water samples were tested in the Environmental Laboratory. The main method used for heavy metal testing was Atomic Absorption Spectrophotometry (AAS). In this method, the water sample is heated to a very high temperature so that the metal atoms release light. The amount of light released is measured to find the exact concentration of each metal in the water.

Before testing, each sample was prepared (digested) by mixing it with a combination of acids ($HNO_3$ and HCl in 3:1 ratio) and heating it. This breaks down any solid particles and ensures all the metals are dissolved in the liquid. The results were compared with standard reference solutions to ensure accuracy.

The seven metals tested, along with their WHO permissible limits in drinking water, are: Iron (Fe) – 0.30 mg/L, Manganese (Mn) – 0.10 mg/L, Lead (Pb) – 0.010 mg/L, Chromium (Cr) – 0.050 mg/L, Zinc (Zn) – 3.00 mg/L, Cadmium (Cd) – 0.003 mg/L, Nickel (Ni) – 0.070 mg/L. All tests were done as per APHA (2017) standard methods.

**C. Heavy Pollution Index (HPI) – Simple Explanation**

The Heavy Pollution Index (HPI) is a single number that shows how polluted the water is with heavy metals. Instead of looking at seven different metals separately, HPI combines all of them into one score. This makes it easier to compare pollution levels between different locations.

$HPI = \Sigma(W^I \times Q^I) / \Sigma(W^I)$

Where: $W^I$ = weight of each metal (calculated from its safe limit), $Q^I$ = sub-index score for each metal based on how much it exceeds the safe limit. If the HPI value is below 100, the water is considered safe. If it is above 100, the water is too polluted for drinking and needs treatment.

## V. RESULTS AND DISCUSSION

**A. Heavy Metal Concentrations**

Table II shows the measured concentration of each heavy metal at all ten locations. Values shown in red (highlighted) exceed WHO safe limits for drinking water.

**Table II: Heavy Metal Concentrations in Groundwater (mg/L) – Raichur District**

| S. No | Location | HPI Value | Risk Category |
|---|---|---|---|
| 1 | Raichur City (Old Town) | 61.2 | Moderate Risk |
| 2 | RTPS Colony, Shaktinagar | 112.8 | Very High Risk |
| 3 | Sindhanur | 24.3 | Low Risk |
| 4 | Manvi | 19.7 | Low Risk |
| 5 | Raichur KIADB | 134.5 | Very High Risk |
| 6 | Devadurga | 16.2 | Low Risk |
| 7 | Lingasugur | 18.4 | Low Risk |
| 8 | Maski | 44.6 | Low Risk |
| 9 | Mudgal | 21.8 | Low Risk |
| 10 | Raichur MIDC | 184.9 | Very High Risk |

*Risk Levels: Low (<50), Moderate (50–100), High (100–150), Very High (>150)*

From Table III, it is clear that three industrial sites have HPI above 100, meaning the water there is dangerously polluted:

- Raichur MIDC (HPI = 184.9) – Very High Risk: The highest pollution in the district. The water here should not be used for drinking without proper treatment. The MIDC area has many industries that discharge metal-containing wastewater.
- Raichur KIADB (HPI = 134.5) – Very High Risk: Close to MIDC in terms of pollution. KIADB industries include electroplating and chemical units that are known sources of heavy metals.
- RTPS Colony / Shaktinagar (HPI = 112.8) – Very High Risk: The thermal power plant produces fly ash which contains heavy metals. When this ash is stored or disposed improperly, it can leach into the groundwater.

Raichur City (Old Town) has an HPI of 61.2, which is in the 'Moderate Risk' range. This is likely due to old water supply pipes, urban waste, and vehicle workshops releasing metals into the soil. The agricultural and rural locations (Sindhanur, Manvi, Devadurga, Lingasugur, Mudgal, Maski) all have HPI below 50, meaning the water quality in these areas is comparatively better.

**C. Why Industrial Areas are More Polluted**

The results clearly show that areas near industries have much higher levels of heavy metals. This is mainly because:

1. Industrial wastewater from electroplating, chemical, and textile units is sometimes discharged without proper treatment, and metals seep into the ground.
2. Fly ash from RTPS contains metals like Iron, Chromium, and Lead. If fly ash ponds are not properly lined, metals can leach into groundwater.
3. Old and leaking pipes in industrial areas and urban zones can also add metals like Lead and Iron to the water.

In agricultural areas, the metal levels are lower mainly because industries are farther away. However, the use of pesticides containing Cadmium and Zinc can still cause a small amount of contamination over a long period.

## VI. SUGGESTIONS TO IMPROVE GROUNDWATER QUALITY

Based on our study results, we suggest the following simple and practical steps to improve groundwater quality in Raichur District:

- Install Water Purification Units: The government should install Reverse Osmosis (RO) water purification systems in areas near Raichur MIDC, KIADB, and RTPS Colony. These systems can remove heavy metals from water and provide safe drinking water to local communities.
- Treat Industrial Wastewater Properly: All industries in MIDC and KIADB must be required to treat their wastewater before releasing it into the environment. The Karnataka State Pollution Control Board (KSPCB) should regularly inspect industrial units for compliance.
- Use Plants to Clean the Soil (Phytoremediation): Certain plants like Sunflower and Vetiver grass can absorb heavy metals from the soil. These plants can be grown in contaminated areas around industries to slowly clean the soil and prevent further pollution of groundwater.
- Proper Fly Ash Management: RTPS should ensure that fly ash disposal ponds are properly lined with impermeable material to prevent metal leaching into groundwater. Fly ash should also be reused in construction wherever possible.
- Regular Water Quality Testing: The district administration should set up a routine water quality monitoring program. Water from wells and borewells near industrial areas should be tested at least twice a year for heavy metals.
- Awareness Among Villagers: Local people should be made aware about the dangers of using contaminated water. Simple field test kits can be given to gram panchayats to test water quality at the village level before use.
- Stop Use of Harmful Pesticides: Farmers should be encouraged to use organic farming methods and reduce the use of chemical fertilizers and pesticides that contain cadmium and zinc, to prevent future contamination of groundwater.

## VII. CONCLUSION

This study investigated the heavy metal contamination in groundwater at ten locations in and around Raichur District, Karnataka. Based on the results, the following conclusions can be drawn:

1. Groundwater near industrial areas (Raichur MIDC, KIADB, and RTPS Colony) is heavily contaminated with heavy metals like Iron, Lead, Chromium, and Cadmium, which are well above WHO permissible limits.
2. The Heavy Pollution Index (HPI) clearly identified three locations (Raichur MIDC, KIADB, RTPS Colony) as 'Very High Risk', meaning the water there is not safe for drinking without treatment.
3. Groundwater in agricultural and rural areas like Sindhanur, Manvi, Devadurga, Lingasugur, and Mudgal is comparatively better in quality, with HPI values below 50.
4. The main cause of heavy metal pollution in Raichur District is industrial discharge, particularly from the thermal power station and MIDC/KIADB units. Farming activities also contribute to a smaller extent.
5. Simple solutions like RO purification units, proper industrial wastewater treatment, phytoremediation, and regular monitoring can go a long way in improving groundwater quality in Raichur District.

We hope that this study will be useful for the local government, environmental engineers, and future researchers to take action and ensure that people in Raichur District have access to clean and safe drinking water.

## ACKNOWLEDGEMENTS

The authors would like to thank the teaching staff and laboratory technicians of the Civil Engineering Department for their guidance and support during sample collection and testing. We are also grateful to the local communities in Raichur District who allowed us to collect water samples from their wells and borewells. We thank Guru Nanak Dev Engineering College, Bidar for providing the platform of NCETETM-2026 to present this work.

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