Health Impact of Ground Water Sample and its Effect on Flora of Kanker District, Chhattisgarh, India

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Abstract

This study examined the contamination levels of Pb, Cd, Ni, Cr, Cu, and As in ten samples of water and vegetables (Brinjal and Tomatoes) from different sites in Kanker district, Chhattisgarh, India, as well as the health risks of eating these crops and drinking the ground water. Cr, Pb, and Ni averaged 0.745, 1.26, and 0.665 mg/L, respectively, and As, Cu, and Cd were not found in any samples. According to assessments of heavy metal occurrence and concentrations in the research region, Pb > Cr > Ni. Each region had ion translocation quantities within the permissible levels (<1) for Tomatoes and Brinjal. Pd>Cr>Ni was adults' total Ni, Cr, and Pb concentrations in chronic daily intake (CDI). Chronic daily water intake in adults was determined as follows: CDI_{ing} > CDI_{derm}. Complete dermal sorption and ingestion exposure showed that nickel, chromium, and lead had tolerable carcinogenic risks. For non-carcinogenic risk to individuals through all routes of exposure to water, the overall Hazard Quotient and Hazard Index values were less than 1, indicating that there was a non-carcinogenic risk to individuals. This study can be used by residents as well as government officials to protect non-rural water resources against heavy metal toxicity.

Keywords: Ground water, Assessment, Health risk, Heavy metals impact, Dermal and Ingestion pathways

1. Introduction

The term "environment" also means the actual surroundings in which humans live. These are made up of the components of the earth's land, water, and atmosphere; microbes, vegetation, and living creatures; any component or combination of the first two elements of the planet; interactions among as well as between them; and an impact on human health and wellbeing. Several nations experience contamination of the environment for different reasons, most significantly from mining and manufacturing operations, untreated sewage, and disposed waste products. Most contaminants are detrimental to vegetation and animals, but some, when found in significant amounts, can be fatal or toxic. Environmental pollution can also happen naturally when minerals, especially toxic metals, coming from mineral deposits get into the soil, water, and then onto growing plants. Certain indicator plants inhibit the amount of heavy metals they absorb, whereas others store toxins. Some only tolerate a single element, while others may tolerate a number of elements.

For all mankind and every other living thing on the planet, water serves as an essential and fundamental requirement. As a result, drinking water for humans is required to be safe,
convenient, abundant, and uncontaminated in any aspect. The health of humans and the aquatic environment are both seriously threatened by contaminants found in water bodies. There are several different kinds of water contaminants, including infections, thermal pollution, radioactivity pollution, heavy metals, and inorganic, organic, and pathological pollutants. [28] Around 400 million individuals throughout India depend on the Ganga, the longest water system in the nation, which travels 25 kilometres from Gangotri glacier to the Gulf of Bengal. Along the river's course, the water quality has drastically declined over the past few decades. [29]

Because of their prevalence, stability, long-term availability, and toxic effects, metals have attracted attention from all over the world when it comes to water pollution. [29] Toxic metals were anthropogenically and naturally introduced to the biosphere by growing urbanisation and industrialization, with the greatest abundance in water and soil ecosystems and a very small fraction in the atmosphere as particles or vapours. Since so many metals are regarded as necessary for vegetation development, their toxic effects on plants vary with species, particular metals, amounts, elemental composition, soil conditions, and pH. The vegetable is subjected to such ions, and as a result of particles deposited on the leaf surfaces, toxic metals are effectively absorbed by the leaves. [30]

The presence of heavy metals in drinking water has recently become one of scientists' most severe environmental concerns. [10,12-13] Contaminated water has been found in more than 70 countries, threatening innumerable human beings globally. [1,19] Those metalloids have the ability to attain stages in the topsoil and aquifers and are harmful for human beings. [3,5,22] As an issue in India, because of the shortage of confined ingesting water delivery systems, ninety percent of the rural and thirty percent of the urban populace depend on freshwater for consumption and home uses. [23] Groundwater is affected by farming activities; industrial sewage is a major issue; and transition elements are significant toxic metabolites that do not degrade naturally. In freshwater, the primary pathways of absorption are mainly oral and dermal sorption. [11] The previous techniques for assessing the impact of heavy metal contamination in the public can easily be compared with measured amounts and theoretical values, but what they do not do is provide comprehensive risk levels and identify contamination with the most significant toxicants. [14] Assessment of health hazards is a critical technique for measuring the viable impacts on human outcomes in water surroundings due to several toxic elements and pollutants. This technique has been drastically utilized by several experimenters in their studies for the assessment of the unfavourable impact of exposure to infected water. [14] Therefore, the consequences of HMs in human populations ought to be evaluated through calculating elements that include persistent every-day consumption (CDI), Hazard quotient (HQ), and lifelong most cancer hazard (ILCR). [1,14]

The prolonged use of effluent water for farming can cause toxic metals to accumulate on agricultural land and vegetation. It is probably one of the most significant ecological issues because of questions about food quality and health hazards. [6] Heavy elements accumulate in both the edible and inedible parts of plants. Vegetable consumption is a main factor in toxic metal contamination. Human beings may suffer several types of long-term diseases as a result of consuming vegetables polluted with toxic metals. [17] With the aim of determining the
potential health hazards associated with it, this research was carried out to determine the levels of heavy metals in water, accompanied by absorption by the vegetables and impending transmission to the ecosystem.

The quantity of aluminium, arsenic, iron, manganese, and nickel in the drinking water of the research area was considerably greater than the acceptable limit, according to a research investigation into the origin and health risk evaluation of heavy metals in the groundwater sources of the central Bastar region. Each of the elements was below the acceptable limit according to the risk estimation framework, with the exception of Arsenic, which reported significant carcinogenic (CR) and non-carcinogenic (NCR) risk values. According to the results, individuals in the region under study might be at higher risk for either cancer or another disease if they are exposed to arsenic over an extended period of time through contaminated drinking water. [37] In earlier studies, different researchers reported higher metal contamination in the groundwater of the Kanker district (CG). They highlighted the fact that industrial clusters and coal mines in different districts of Chhattisgarh, including Kanker, cause severe pollution crises with carcinogenic heavy metals in the air, water, and soils not meeting standards. [35, 36] and this is the reason Chhattisgarh has become one of the most polluted states in the country. [39] Also, the Doodhnadi River in the Kanker region is becoming more polluted due to the growing industrialization and urban expansion that have led to the discharge of massive amounts of untreated sewage and effluent. [38] Since irrigation uses, this water and soil, they act as sinks for the removal of contaminants from industrial wastes, which may comprise many toxic metals like As, Cd, Pb, Cr, Cu, etc.

Using such polluted waters may have cancer-causing effects (IARC, 1990). To better investigate the origins of heavy metal contaminants in groundwater and lower their danger to human health. As a result, this work enhances our understanding of the quality of drinking water assessment and monitoring. The geographic significance of the studied area and the proximity of several types of heavy metal concentration sources suggest the scientific originality of this investigation. A human health risk assessment (HHRA) and further research on these kinds of polluting indices have not yet been computed for this location. The Chronic Daily Dose (CDI) through both routes of exposure (dermal and oral), the Hazard Quotient (HQ), the Hazards Index (HI), and the Transfer Factor (TF) for vegetation were therefore used and tested for the purpose of the research. The novel aspects of this research include, specifically. [19]

- Using signs of risk, guidelines for water quality, and metrics for assessing health risks, an approach has been developed to deal with aleatory and evidential insecurity.
- Examining the types of variables helped to clarify how many challenges water utilities have when responding to such challenging poisoning situations, including the presence of heavy metals in potable water and vegetation.
- The probable outcomes of a health risk limit as a result of long-term exposure to heavy metals and achieving aesthetic goals as a result of heavy metal contents were assessed.
• Water utilities may find it easier to resolve practical problems with heavy metal toxicity in water for consumption using the conventional technique.\[4\]

The primary goals of the prevailing research have been (i) To measure the contamination level of six heavy metals, inclusive of Arsenic (As), Copper (Cu), Lead (Pb), Cadmium (Cd), Chromium (Cr), and Nickel (Ni), in the Ground water and vegetables of Kanker district of Chhattisgarh, India; and (ii) To evaluate the health risks of carcinogenic and non-carcinogenic metals with respect to each day's drinking water and different paths for adults within the populations. \[14\] The predicted outcome will contribute appropriate statistics on the amount of those HMs in the water samples of the research district. The calculations also give sufficient statistics on the extent of contaminants and consequences on human health related to the intake of vegetation and epidermal sorption via water practises.

2. Method and Materials

2.1 Study area

Kanker District is in the latitudes 80.48 to 81.48 and longitudes 20.6 to 20.24. This district is situated in the southern vicinity of Chhattisgarh, India (Fig. 1) 5285.01 square kilometres is the total area of the district. 748,941 is the total population of Kanker District. The groundwater especially takes place in phreatic (water desk) situations and at places below semi-limited situations. Weathered formation thickness varies from 10 to 30 m. The groundwater sources for Kanker district have been expected primarily based on the Groundwater Estimation methodology 1997.

2.2 Water Sample Analysis

For comprehensive quantitative analysis, the water samples collected from all borewells were kept in a transparent 1-litre plastic bottle. Before collecting the water samples, all bottles were properly cleansed with distilled water and air-dried. For pump wells, they were taken out shortly after the well was operated by pumping for 5–10 minutes. To assure that there was no accumulation of residual content before keeping it in sterilized containers, samples of water were filtered in the field through 0.45 mm diameter filtration. The collected samples were sent to the testing facility and stored in the refrigerator. \[33\]

Ten groundwater samples were taken from bore wells in Kanker district, Chhattisgarh, India. All samples were accrued in sterilized acid-washed polyethylene terephthalate (PET) bottles and immediately transported to the laboratory. Before sampling, all the bottles were soaked in a 10% solution of Nitric acid and cleaned by rinsing in a metal-free soap. Metalloids consisting of As, Cr, Cu, Cd, Ni, and Pb were analysed through AAS (Electronic Cooperation of India Limited) for water samples \[34\], as shown in Table 2 and Fig 2.

2.3 Plant Samples Analysis

At the sampling areas, edible vegetable parts were taken from Brinjal (Solanum melongena L.), and Tomato (Lycopersicon esculentum L.). They are the main vegetables that are cultivated in the study area for personal consumption as well as to serve the commercial and retail markets. Eatable parts of the sample vegetables were taken. Samples were heated in a microwave at 80°C to a consistent weight after being washed with potable tap water to get rid of the dirt. Before testing, the dehydrated material was grinded, placed over a 2 mm sieve, and kept at room temperature. 1 mL of hydrogen peroxide was mixed and heated to 200 °C after cooling. This process was continued until the brown-coloured vapours appeared. After cooling, 0.5 ml of concentrated nitric acid and 10 mL of distilled water were mixed, and the mixture was heated to 200 °C until white vapours were released. 10 mL of distilled
water and 1 mL of ethanol were added after cooling, and the mixture was again heated to 240 °C until white vapours once again appeared. A 50-mL volumetric flask was then filled to the mark with distilled water once the digest had been cooled and filtered via a Millipore filter (45µm pore size). AAS was also used to evaluate the concentration levels of Cd, Cr, Pb, Ni, Cu, and As in the Tomato and Brinjal edible parts of the samples. [19]

3. Health Hazard Evaluation

The method of evaluating the probability of occurrence of any specified probable amount of unfavourable effects on health over a predicated period of time is known as risk assessment. Each element's risk for health can frequently be assessed based only on the assessment of its level of risk and categorised into non-carcinogenetic and carcinogenetic categories. [14]

(i) Evaluation of exposure: According to the integrated risk information and computation system, it estimates the risk connected with heavy metals as chronic daily intake (mgkg⁻¹ day⁻¹) transformed into calculated risk for children and adults (USEPA 2010). Chronic daily intake by oral ingestion and chronic daily dermal ingestion have been calculated using Equations (1) and (2) for adults. [14, 24]

\[
\text{Chronic daily intake}_{\text{ingestion}} = \frac{C \times \text{ABS} \times \text{EF} \times \text{IR} \times \text{EP}}{\text{BW} \times \text{AT}}
\]

\[
\text{Chronic daily intake}_{\text{dermal}} = \frac{C \times \text{EF} \times \text{SA} \times \text{ABS} \times \text{Kp} \times \text{ET} \times \text{EP} \times \text{CF}}{\text{BW} \times \text{AT}}
\]

Where, \(C\) = Heavy metal concentrations; \(\text{ABS}\) = Dermal absorption factor (Unitless); \(\text{EF}\) = Exposure frequency (in days/year); \(\text{IR}\) = Ingestion rate; \(\text{EP}\) = Exposure duration (in years); \(\text{BW}\) = Body weight (in kg/person); \(\text{AT}\) = Average time (in days); \(\text{SA}\) = skin area available for contact (cm²); \(\text{Kp}\) = Permeability coefficient (in cm/hour); \(\text{CF}\) = Unit conversion factor (in L = cm³). [45]

(ii) Assessment of Risk: On the basis of the United States Environmental Protection Agency, human danger assessment model for Heavy metals, the accumulation exceeds the Bureau of Indian Standards (BIS) permissible limit. Carcinogenetic and non-carcinogenetic dangers have been primarily predicted. By comparing the exposure levels of heavy metals to the Reference Dose for each exposure route (oral intake of water and dermal sorption), both dangers associated with metalloids were identified. [17, 32]

3.1 Hazard Quotient

Non-carcinogenic risks have been calculated for the samples for analysis using the risk quotient (HQ) values from Equations 3 and 4 below. [14, 25] The USEPA formula was used to determine the Hazard Quotient for non-carcinogenic hazards (1999)

\[
\text{HQ}_{\text{oral}} = \frac{\text{CDI}_{\text{oral}}}{\text{RFD}_{\text{oral}}}
\]

\[
\text{HQ}_{\text{dermal}} = \frac{\text{CDI}_{\text{dermal}}}{\text{RFD}_{\text{dermal}}}
\]

Where, \(\text{HQ}\) = Hazard Quotient; \(\text{CDI}\) = Chronic Daily Intake (mg/kg/day); and \(\text{RFD}\) = Reference Dose (mg/kg/day).

Reference Dose (oral Ingestion and Dermal) values for both groups are calculated through the USEPA 2010 (Integrated Risk Information System model). Reference Dose Dermal values of 0.14, 96 × 10⁻⁵, 0.06, 0.015, 0.42, and 0.00042 Reference Dose Ingestion values of 0.7, 0.024, 0.3, 3, 1.4 and 20 for Fe, Mn, Zn, Cr, Pb, and Ni. [14]
On the condition that the values of HQ are higher than 1, it means detrimental non-carcinogenetic outcomes of the issue; when the values of HQ are not greater than 1, it means its tolerable level. [14]

3.2 Hazard Index

The Hazard index for non-carcinogenetic hazards is determined by the total of all HQ values. HI is the proportion of the various harmful metals to only one subjection path. The risk Index of all of the metalloids has been calculated via Equations (5) and (6). [14, 25]

\[
\text{Hazard Index} = \sum_{i=1}^{n} \text{Hazard Quotient} \quad \text{(5)}
\]

\[
\text{Hazard Index} = \text{Hazard Quotient Lead} + \text{Hazard Quotient Chromium} + \text{Hazard Quotient Nickel} \quad \text{(6)}
\]

Where the Hazard index is the risk indication for the total poisonous threat and n is the total concentration of metals under attention. If HI is less than one, the non-carcinogenetic unfavourable effect due to this subjection pathway is assumed to be insignificant. [2]

Different parameter values for exposure assessment are shown in Table 1.

3.4 Carcinogenetic Risk Analysis:

The ILCR can be used to calculate the heavy metals' potential cancer risk due to exposure to a specific dose in drinkable water. The ILCR described the incremental likelihood that a person will develop any type of cancer over the course of a lifetime due to a twenty-hour exposure. [8, 14]

The subsequent formula (Equation 7) was normally used for the determination of the ILCR (mg/kg/day)

\[
\text{ILCR} = \text{CDI} \times \text{CSF} \quad \text{(7)}
\]

\[
\text{CSF} = \text{Cancer slope factor (mg/kg/day)}.
\]

3.5 Transfer factor (TF)

According to Cui et al. (2004), a transfer factor (TF) was developed to determine the risk level and induced toxicity resulting from water irrigation and the subsequent metal ion absorption in the edible parts of sample vegetables (Equation 8). [6, 40]

\[
\text{TF} = \frac{\text{Concentration of metal in edible part}}{\text{Concentration of metal in soil}} \quad \text{(8)}
\]

4. Results and Discussion

4.1 Concentrations of Heavy Metals

In all 10 water samples, this research evaluates both the presence and amounts of toxic metals like chromium (Cr), arsenic (As), copper (Cu), cadmium (Cd), nickel (Ni), and lead (Pb). Table 2 illustrates the significant amount of metalloid contamination that was detectable in the water, with Pb having the highest average value of 3.6 mg/L and Cr having the lowest average concentration of 0.11 mg/L, respectively. Arsenic, Cadmium, and Copper were not present in any of the samples, and lead, zinc, and chromium amounts in the collected samples were within acceptable ranges. The order of heavy metals in the study was Pb > Ni > Cr, based on analyses of their occurrence and concentrations within the research zone. Arsenic exposure in organisms comes primarily via water consumption, which has become a major issue on a global scale. Long-term exposure to arsenic can cause immediate health problems, such as infections of the skin, damage to the kidneys, failure of the liver, and damage to the nervous system. [41]
Cd (non-degradable) ions are challenging to eliminate and can cause adverse biological effects because they are mainly extremely hazardous and consumed by species via diet. Because of all of these problems, the World Health Organization (WHO) has stated that the highest permissible level of Cadmium in the bloodstream must not reach above 0.005 mg/L. [41] Severe problems with health in humans, including osteoporosis, neurological dysfunction, and disorders of the immune system, are caused by a high level of copper. [42]

In this analysis, lead was also not seen as a concern because all results were within the permissible range. The lead concentrations ranged from 0.8 mg/L to 3.6 mg/L. Human beings can readily absorb the poisonous element Pb. In human beings, it leads to renal diseases, tumours, brain damage, and harm to the nervous system. Both plants and animals are more at risk when lead is present. [41] All reported Chromium values come within permitted limits. The levels of chromium varied from 0.11 mg/L to 2.63 mg/L. Chromium is an essential part of the diet of humans and, when present in water for consumption within the permissible level, contributes to maintaining a healthy metabolic process.

According to Lajçi et al. (2017), Cr can harm organs such as the liver, kidneys, circulatory system, and nerve cells when exposed for an extended period of time. It may trigger allergies and wounds on the skin at levels across the permitted range. [43] The World Health Organization's (2011) water for consumption criteria were fulfilled by the Nickel concentrations in all samples. The nickel concentrations ranged from 0.33 mg/L to 1.07 mg/L. Despite being abundant and essential for many animals' survival, nickel poisoning of living things may be caused by anthropogenic emissions and geogenic levels that vary in some places. Lung function and our immune systems are also impacted by the toxin. Food and water are the main oral routes to Ni absorption for everyone else. [43] The order of the heavy metals was Pb > Ni > Cr, based on observations of their occurrence and quantity in the Kanker district of Chhattisgarh.

4.2 Non-Carcinogenetic Risk Analysis

In Table 3, the minimal, maximum, and average chronic daily intakes, as well as the general chronic daily intake for adults via dermal and oral exposure paths in Kanker district, are shown. Table 4 represents the minimal, mean, and maximum ranges of HQ and also the overall HQ via dermal and oral ingestion exposure routes for adults. In Table 5, an evaluation of the carcinogenic danger for adults is given. Water contaminated due to the presence of heavy metals can increase human health hazards due to constant exposure via different routes. In this research, both types of health risks (non-carcinogenetic and carcinogenetic) that occur due to dermal and oral ingestion contact were discussed.

Food, inhaled aerosol particles, dust, and pathways of drinking water are the main sources of human exposure to heavy metals. The toxicity level of HMs in humans depends on their direct intake. In this research, dermal sorption and oral ingestion through drinking water are mentioned. Firstly, the analysis of non-carcinogenetic risk is estimated as a determination of CDI values. The average values of Total chronic daily intake shown in Table 3 in mg kg⁻¹day⁻¹ are 2.4 × 10⁻⁵ for Cr, 3.96 × 10⁻⁵ for Pb, and 2.09 × 10⁻⁵ for Ni. Accordingly, the average value of the total chronic daily intake of analysed metalloids in adults was in the sequence Pb>Cr>Ni.

All the studied heavy metals had a total Hazard quotient less than 1, as shown in Table 4. Therefore, assessment of the health risk of Pb, Cr, and Ni gives about the average Hazard quotient, showing the non-carcinogenic risk is within an acceptable limit in all samples of the Kanker district of Chhattisgarh. By evaluating the total hazard quotient, it was found that the value of Lead is greater than that of Chromium and Nickel (Pb>Cr>Ni). In addition to determining the total capability of non-carcinogenetic effects because of the number of metals, the Hazard Index calculated for every toxic metal is added and denoted as the hazard index. The average values of the Hazard Index via oral
ingestion and dermal sorption and the Overall Hazard Index are $3.86 \times 10^{-5}$, $3.86 \times 10^{-5}$, and $7.49 \times 10^{-6}$, respectively. In Table 4 the values of the Hazard Index of the analyzed Metals in the research area are shown, and from the values, it can be concluded that the non-carcinogenetic risk in the population of the study area is negligible because the value of the Hazard Index is less than one.

4.3 Carcinogenic Risk Analysis

Pb, Cr, Cd, and Ni are examples of heavy metals that may increase an individual’s risk of acquiring cancer. Thus, several different kinds of cancer may develop after prolonged exposure to very small amounts of hazardous metals. On the basis of the average Chronic Daily Intake values shown in Table 3 utilizing Lead, Chromium, Cadmium, Copper, Arsenic, and Nickel as carcinogens, the overall consumption of the people who lived there was calculated. Table 5 shows the carcinogenic risk assessment for adults. An Incremental Lifetime cancer risk of less than $1 \times 10^{-6}$ for any heavy metal is considered inconsequential, and the possibility of cancer can be disregarded, whereas an ILCR of more than $1 \times 10^{-4}$ is seen as detrimental, and the cancer risk is problematic. The permissible limit for all heavy metals through all exposure pathways is $1 \times 10^{-5}$. Nickel has the highest cancer risk value of all the examined heavy metals (mean ILCR $1.75 \times 10^{-5}$), whereas lead has the lowest cancer risk value (mean ILCR $3.37 \times 10^{-6}$).

4.4 Plant uptake of Heavy Metals

In Tables 6 and 7 and Figs. 6 and 7, the transfer factor values of Brinjal and Tomato are given. In Brinjal and Tomatoes, respectively, the transfer factor values for Cd ranged from 0.286 to 0.808 mg kg$^{-1}$ and from 0.51 to 0.98 mg kg$^{-1}$. The concentrations of Cr in Brinjal varied from 0.51 to 0.98 mg kg$^{-1}$ and from 0.663 to 0.875 mg kg$^{-1}$, respectively. Pb levels in Brinjal and Tomatoes ranged from 0.42 to 0.95 mg kg$^{-1}$ and 0.37 to 0.917 mg kg$^{-1}$, respectively. Ni concentrations in Brinjal and Tomatoes, respectively, ranged from 0.26 to 0.6 mg kg$^{-1}$ and from 0.221 to 0.856 mg kg$^{-1}$. The concentrations of As in the Brinjal and Tomatoes ranged from 0.36 to 0.93 mg kg$^{-1}$ and from 0.545 to 0.917 mg kg$^{-1}$, respectively. Collectively, the transfer factor for vegetables (Tomatoes and Brinjal) at every location was well below what are regarded as tolerable levels for agricultural cultivation (FAO/WHO 2001 and 2004; EU 2002). This includes concentrations of Cd, Cr, Pb, Ni, Cu, and As.

5. Conclusion

In the present research, the overall quality of the ground water in the Chhattisgarh district of Kanker as well as the adverse impacts of heavy metals on the health of humans and plants are evaluated. Pb (3.6 mg L$^{-1}$) and Cr (0.11 mg L$^{-1}$) had the greatest and lowest amounts of the tested metalloids, respectively. These three metals (Cu, As, and Cd) are no longer detected out of the six heavy metals whose concentrations are being examined. The order of heavy metals in the study was Pb > Cr > Ni, based on analyses of their occurrence and concentrations within the research area. The amounts of the toxic elements Cd, Cr, As, Ni, Cu, and Pb did not exceed the permissible limits for vegetables (Tomatoes and Brinjal) at each location (FAO/WHO, 1984; EU, 2001). Consequently, the transfer factor of toxic metals in Brinjal and Tomatoes is in this order: Cr > Pb > As > Cu > Cd > Ni. The average values of the chronic daily intake total of heavy metals in adults were found to be $22.4 \times 10^{-5}$ for Cr, $3.96 \times 10^{-5}$ for Pb and a pair of $9 \times 10^{-7}$ for Ni. The average of the Hazard Index via oral ingestion and dermal sorption along with the Hazard Index were found to be $3.86 \times 10^{-5}$, and $7.49 \times 10^{-6}$, respectively. Out of all six toxic metals, the sequence of ILCR values is Ni>Cr>Pb. Thus, it can be concluded that almost all available groundwater in the study region is suitable for drinking, with concentrations of all six metals within the permissible limit. Regarding the quality of groundwater, not much study has been done in this Kanker district of Chhattisgarh. Therefore, this research would provide in-depth information so that decision-makers could act appropriately to
enhance the overall quality of the groundwater in this region. It is essential to increase the general public's awareness of the negative effects on wellbeing caused by potentially dangerous chemicals in groundwater. The current study may be very useful for both the general public in taking protective precautions and for regulatory agencies in decreasing contamination in non-rural groundwater sources.

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