International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Groundwater Quality and its Effects on Human Health in Ranchi: A Study of Sources and Factors of Concern

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ABSTRACT :

Groundwater's physicochemical characteristics are heavily influenced by the local geology. However, groundwater quality has declined as a result of human activity. In order to evaluate the overall quality of groundwater for drinking purposes in the several blocks of Ranchi, Jharkhand, this study examined many characteristics of the groundwater samples. Groundwater contamination was found to be particularly severe in areas with high concentrations of agricultural, industrial, and mining operations. It will take a comprehensive strategy to improve Ranchi's groundwater quality. Safeguarding groundwater quality in Ranchi requires a number of measures, including stricter regulations and enforcement for industrial waste management, promotion of sustainable agricultural practises, improvement of waste management systems, enhancement of wastewater treatment infrastructure, and creation of public awareness about the importance of groundwater protection. In addition, detecting hotspots of pollution and conducting targeted measures to safeguard this precious resource requires constant monitoring and the collecting of relevant data.

Introduction :

The safety and health of those who rely on groundwater as a drinking water supply depends on the quality of that water. Understanding the hazards of groundwater contamination and taking necessary precautions to prevent its spread is crucial to preventing its harmful impacts on human health. Multiple channels and potential polluters contribute to groundwater contamination. Substances of concern can be leaked into the groundwater system from storage tanks or seep from improperly disposed of industrial waste. Also, agricultural practises such as the use of fertilisers and pesticides can contaminate groundwater via surface runoff and infiltration. Naturally occurring groundwater pollutants can also originate from natural sources, such as geological formations rich in elements like arsenic or fluoride (MacDonald et. al., 2011).

There is a wide variety of toxins that may be discovered in groundwater, each of which has its own unique health dangers. Arsenic, lead, mercury, and cadmium are just some of the heavy elements that may contaminate groundwater. There are a number of potential health effects from prolonged exposure to these metals. For instance, arsenic is a neurotoxin, a hepatotoxin, and a carcinogen. It can also cause skin sores. Children are especially vulnerable to the negative effects of lead exposure, which include but are not limited to, delays in development, learning challenges, and behavioural issues. Nitrates are another major pollutant in groundwater, typically resulting from the use of fertilisers on farms and the disposal of animal waste. Methemoglobinemia, sometimes known as "blue baby syndrome," occurs when the blood's ability to transport oxygen is severely compromised due to high nitrate levels in drinking water. Infants are particularly susceptible to this illness, and it can be fatal if neglected (Tirkey, et. al., 2017).

Agriculture pesticides and herbicides may contaminate underground water supplies. Some examples of these compounds are glyphosate, organophosphates, and organochlorines. Increased risk of cancer, endocrine disruption, neurological diseases, and reproductive difficulties have all been related to prolonged exposure to pesticides. Sewage leaks or lack of proper sanitation can introduce harmful microorganisms including bacteria, viruses, and parasites into water tables below. Diseases including cholera, typhoid, and hepatitis can be transmitted by drinking water if these germs are present. Groundwater can also be tainted by volatile organic compounds (VOCs) from gasoline leaks, underground storage tanks, and other industrial activities. To name a few, volatile organic compounds (VOCs) including benzene, toluene, and trichloroethylene are proven carcinogens and can damage the liver, kidneys, and central nervous system (Singh and Singh, 2012).

Acute, short-term ailments as well as chronic disorders can result from drinking polluted groundwater. Common early effects of microbial exposure include gastrointestinal problems such nausea, vomiting, and diarrhoea. Heavy metals and pesticides, when ingested over long periods of time, can harm organs like the liver and kidneys and cause neurological diseases, cancer, and fertility difficulties. It's vital to keep in mind that groundwater pollution can range in both severity and variety based on location. High concentrations of arsenic or fluoride may exist naturally in some geological formations and may be a problem in some areas. People living in these places are more likely to be exposed to these toxins and suffer from their health consequences.

Contaminated groundwater poses a greater threat to the health of certain groups. Particularly vulnerable populations include pregnant women, new-borns, the elderly, and those with compromised immune systems. Due to their still-evolving bodies and increased water intake per kg of body weight, infants and young children are more vulnerable to the harmful effects of pollutants. Additionally, low-income areas and those without access to other water sources are disproportionately impacted due to a lack of financial means to invest in adequate water treatment and alternative water supply infrastructure. Groundwater quality and human health are dependent on preventative measures and risk reduction tactics. The best way to stop pollution from happening in the first place is to put in place stringent rules and monitoring programmes to manage industrial and agricultural activity. Encouraging good waste management practises and ensuring the proper disposal of hazardous material are also crucial. Reducing chemical inputs and increasing soil and water conservation are two examples of sustainable agricultural practises that help lessen the potential for agricultural activities to contaminate groundwater (Thakur, 2013).

Individuals can take preventative actions to guarantee the quality of their drinking water if they are made aware of the need to protect groundwater, are encouraged to have their private wells tested on a regular basis, and are given information on available water treatment solutions. Activated carbon adsorption, reverse osmosis, ion exchange, and other water treatment methods can efficiently remove or reduce the amounts of pollutants in groundwater. Groundwater quality must be protected and maintained by preventative measures, effective legislation, and suitable treatment procedures to guarantee that people of all ages have access to clean water to drink.

The Groundwater Pollution Scenario of Jharkhand

Jharkhand is a state in eastern India that is widely recognised for its abundance of natural resources and agricultural output. However, there are several threats to the purity of Jharkhand's groundwater, and this pollution poses serious risks to human health. Mining, metal processing, and chemical production are just a few of the many sectors that call Jharkhand home. Groundwater pollution may result from chemical spills, leaking storage facilities, and poor industrial waste disposal. The mining and manufacturing industries both contribute to the contamination of groundwater with heavy metals including arsenic, lead, cadmium, and mercury.

In some parts of Jharkhand, arsenic pollution of groundwater is a major problem. Arsenic may be found naturally in a variety of rock types; nevertheless, it poses serious health risks when consumed in high doses. Arsenic in drinking water is associated with an increased risk of cancer, cardiovascular illness, and neurological issues if consumed over an extended period of time. Groundwater is the principal supply of drinking water for a large portion of the population in arsenic-affected districts like Pakur, Sahibganj, and Godda in the Indian state of Jharkhand. High amounts of fluoride have also been found in groundwater in a number of Jharkhand districts, in addition to arsenic. In regions with certain geological formations, fluoride pollution is a prevalent worry. Too much fluoride in the diet can cause dental fluorosis, which weakens and discolours teeth. Skeletal fluorosis is a disorder that affects bones and joints that can cause discomfort, stiffness, and skeletal abnormalities from prolonged exposure to high amounts of fluoride (Priyadarshi, 2012; Pandey, 2013).

Groundwater pollution in Jharkhand is caused in part by agricultural practises such the use of fertilisers and pesticides. Nitrogen-based chemical fertilisers are widely employed to increase agricultural yields. Nitrate pollution in groundwater is a problem because of overuse and poor application. Nitrates in drinking water can reduce hemoglobin's ability to carry oxygen, leading to a condition called methemoglobinemia, which is especially dangerous for newborns and young children. Jharkhand makes heavy use of pesticides and herbicides, including as organochlorines, organophosphates, and glyphosate, to control pests and manage weeds. In regions where agrochemicals are improperly stored and applied, they can seep into the groundwater supply. Cancer, neurological illnesses, hormone abnormalities, and reproductive difficulties are only some of the outcomes of long-term chemical exposure through contaminated groundwater.

Jharkhand's groundwater is largely contaminated due to improper waste management, especially the discharge of solid waste and untreated sewage. Contaminants can seep into the groundwater supply if improper waste management practises are employed, such as open dumping or inadequate wastewater treatment facilities. There is a substantial danger of waterborne illnesses such diarrhoea, cholera, typhoid fever, and hepatitis due to the contamination of groundwater sources by pathogenic microorganisms like bacteria, viruses, and parasites. The quality of the groundwater in Jharkhand is likewise threatened by the mining industry. Mine tailings and rubbish are produced in vast amounts by mining operations and may include hazardous materials. Without effective waste management, leaching and discharge from these materials can harm local water supplies, including groundwater. The harmful consequences of heavy metals including lead, cadmium, and mercury are of special concern. Organ failure, neurological diseases, stunted growth in children, and even cancer can all arise from long-term contact with these metals.

The contaminated groundwater has serious consequences for human health in Jharkhand, especially for those who are already weak. Women who are expecting, newborns, the elderly, and others who already have compromised immune systems are particularly at risk from drinking water that has been tainted. These communities are already at a higher risk due to a lack of education, a dearth of available alternatives, and a lack of funds dedicated to water purification. The human health risks associated with poor groundwater quality in Jharkhand can be reduced through a number of possible interventions. More stringent rules for the handling and disposal of hazardous materials produced by industries should be enforced by the government and regulatory agencies. Sustainable mining practises that lessen damage to the environment and protect groundwater should be encouraged.

Study Area

The capital city of Jharkhand, Ranchi, is situated in the southern section of the state. The districts of Gumla, Latehar, and Lohardagga are to the west, while the districts of Purulia and Saraikela Kharsawan in West Bengal are to the east. The Ramgarh and Hazaribagh districts are to the north. Residential, industrial, agricultural, and forestry all coexist in Ranchi's unique land use pattern. Agricultural activities cover a large area of land in the Ranchi neighbourhood. The mining, manufacturing, and processing of raw materials that make up Ranchi's industrial area are located primarily on the city's outskirts. In this way, these companies are vital to the local economy. The economic and cultural diversity of the Ranchi district is reflected in the way the district's land is used: there are agricultural, forested, urban, and industrial areas. The groundwater quality in Ranchi, as in many other parts of India, is influenced by geology, land use, and human activities. It has been reported that the groundwater in Ranchi varies in hardness from extremely soft to rather hard, depending on where you look. The Central Ground Water Board conducted a study that discovered high levels of fluoride, which can lead to dental and skeletal fluorosis, in the groundwater of various locations in Ranchi (Kumar, 2002; Singh, 1981). Groundwater with excessive concentrations of iron and manganese can be unhealthy to drink on a daily basis, in addition to being discoloured and having a disagreeable taste and scent. Water samples were collected at 18 different points across the Ranchi district. Table 4.1 details the blocks from which samples were taken.

Table 1: Sampling Stations for the study

S. No.	Block	S. No.	Block
1	Kanke	10	Burmu
2	Namkum	11	Bundu
3	Tamar I	12	Khelari
4	Mandar	13	Sonahatu
5	Silli	14	Ratu
6	Bero	15	Nagri
7	Angara	16	Lapung
8	Chanho	17	Rahe
9	Ormanjhi	18	Itki

1. Materials and method

Sample Collection, Storage and Preservation

Water samples were collected in polythene containers with a 5-liter volume. The containers were sterilised with a chromic acid solution, rinsed thoroughly with distilled water, and dried before use. The containers were packed tightly to prevent any shifting during transport and to reduce the amount of time the contents spent exposed to air. Each of the 18 blocks had monthly water samples taken from open wells and tube wells for a full year. The temperature, pH, hardness, total alkalinity, phosphate, chloride, Calcium, Magnesium, and Nitrate values, chemical oxygen demand (C.O.D), total alkalinity, fluoride, dissolved oxygen (DO), and total dissolved solid (TDS) of each ground water sample were determined using APHA guidelines. The temperature of the water was measured at the time of sample collection. The samples were tested for pH and conductivity shortly after collection. To facilitate analysis of the other features, samples were maintained and conserved in line with standard procedures (APHA, 1998). All study-designated parameters were assessed within three hours of sample collection which are given in Table 2.

Table 2: Analysed Water Quality Parameters

Group	Parameter
Physical parameters	Temperature (T), Colour (C), pH, Conductance, Hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Total Solids (TS)
Major anions	Chloride, Sulphate, Bicarbonate, Nitrate, Phosphate, Fluoride
Major cations	Sodium, Potassium, Calcium, Magnesium, Iron.

Results and Discussion :

It was observed that there was an average temperature of between 27.5 and 34.1 degrees Celsius and it didn't matter if it was hot or cold outside. The average pH of the region was 7.4, although it ranged from 6.6 to 8.2. The average concentration of Ca^{2+} ions in ground water was 23.6 mg/L (range: 5.96 – 52.25 mg/L), with the concentration of Mg^{2+} ions ranging from 10.82 – 100.28 mg/L. The TDS concentrations ranged from 35 to 330 ppm, with an average of 157.5 ppm. Chloride ion was detected in all but one of the ground water tests. The levels of Cl ion varied from 7.32 to 69.65 mg/L.

Phosphate ion was found in all the well water samples. The levels of PO_4^{3-} ions fluctuated between 1.45 and 9.45 millimoles per litre. The SO_4^{2-} content ranged from 27.48 mg/L to 70.18 mg/L. All ground water samples were found to have detectable levels of nitrate ion. NO_3^{-1} ion concentrations as low as 24 mg/L and as high as 73 mg/L were recorded. The fluoride concentration of the district's underground water varied from 0.27 ppm to 5.3 ppm.

Factors affecting groundwater quality

Numerous causes contribute to the pollution and deterioration of groundwater all throughout the world, and Ranchi is no exception. Mining, metal processing, chemical manufacture, and other small businesses all call the city home. Toxic compounds can leach into the ground and water supply due to improper waste disposal, leaking storage facilities, and insufficient treatment of industrial effluents. Common pollutants linked to industrial activity include heavy metals including arsenic, lead, cadmium, and mercury. Ranchi's economy relies heavily on agriculture, and the city's farmers employ a wide variety of chemical fertilisers, pesticides, and herbicides. Agrochemicals can contaminate groundwater through runoff and leaching if they are used excessively or applied incorrectly. Areas where chemical fertilisers are widely utilised often have nitrate pollution problems. There is a potential risk to human health from pesticides and herbicides that have leached into groundwater.

Pollution of groundwater can also be traced back to improper solid waste management. Leaching of toxins into the soil and groundwater can occur when solid trash, such as plastics and other non-biodegradable materials, is dumped in an open area. Pathogens and organic contaminants can be introduced into groundwater supplies through wastewater that has not been adequately treated or disposed of. The quality of groundwater is often affected by the local geology. There is a wide range of geological formations in Ranchi, some of which may be naturally contaminated. Some geological formations, for instance, include naturally occurring arsenic and fluoride that can pollute groundwater. Effective management and conservation of water resources requires an in-depth familiarity of local geology and its possible impact on groundwater quality. Constraints on water supply and the potential for groundwater pollution are potential consequences of Ranchi's rapid urbanisation and population increase. Rising water use, a lack of suitable sewage treatment facilities, and poor disposal of household waste all contribute to groundwater contamination.

Mitigating the Concerns

Ranchi district has better water quality than other cities, yet there is still need for improvement, as seen by the following recommendations. The high levels of phosphate and nitrate found there are the result of the region's agricultural culture and the widespread use of fertiliser. These numbers can be lowered with the judicious application of artificial fertiliser. To lessen the strain on the region's aquifer, water-saving technologies and altered agricultural practises might be encouraged here. Water-intensive crops require less water for irrigation in the summer and during dry seasons than at other times of the year. Reduced water waste is the most pressing issue in the area. Drip and spray irrigation, together with other forms of micro-irrigation, have contributed to better water management and the rediscovery of the allure of a flourishing irrigation system. Determining whether parts of the basin have been over-extracted is necessary for protecting the water supply and being ready to use appropriate harvesting structures.

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