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Hydrogeochemical Assessment of Trace Elements in Groundwater

by **Radha Kumari**, Assistant Professor,
Department of Chemistry,
J.K. College, Biraul- 847203, India
(L.N. Mithila University, Darbhanga, India)
radha8015@gmail.com

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Abstract:

Groundwater serves as a crucial source of drinking water in numerous parts of the world. Yet, the presence of trace elements and heavy metals in groundwater has turned into a major environmental and health concern. Toxic elements like arsenic (As), lead (Pb), cadmium (Cd), iron (Fe), manganese (Mn), and chromium (Cr) can appear in groundwater due to both natural factors, such as geological conditions, and human actions, including agricultural practices, industrial waste, and poor disposal methods. This study examines the hydrogeochemical aspects of trace elements in groundwater and their effects on water quality and human health. Groundwater samples were tested using standard lab techniques to measure the levels of these elements. The findings reveal that certain trace elements are found in concentrations that go beyond the safe limits set by the World Health Organization (WHO) for drinking water.

The chemical properties of the groundwater suggest that mineral breakdown, oxidation and reduction processes, and human activities contribute to the presence of these elements. As a result, consistent monitoring of groundwater quality and the use of suitable water management practices are essential to guarantee safe drinking water.

Keywords: Groundwater quality, Trace elements, Hydrogeochemistry, Heavy metals, Water pollution.

1. Introduction:

Groundwater is very important for meeting the water needs of people, farms, and industries. In many developing countries, it is the main source of drinking water because it is more easily available and generally has better quality than surface water. However, the quality of groundwater can be affected by both natural and human activities. Some elements are present in groundwater in very small amounts, but some of them can be harmful even at low levels.

Elements like arsenic, lead, cadmium, chromium, and mercury are dangerous to human health when their levels go above safe limits. According to the World Health Organization (WHO), long-term exposure to these harmful elements can cause serious health issues such as organ damage, neurological disorders, and cancer.

Hydrogeochemical studies help us understand the chemical makeup of groundwater and the processes that influence how trace elements are distributed. These processes include the weathering of rocks, the dissolution of minerals, ion exchange, and human activities such as the use of fertilizers and industrial waste discharge.

The purpose of this study is to measure the levels of trace elements in groundwater and to identify the hydrogeochemical processes responsible for their presence. The study also aims to evaluate the suitability of groundwater for drinking purposes.

2. Study Area:

The study area is a region that depends on groundwater for drinking water, with tube wells and hand pumps being commonly used. The geology of the area is mostly alluvial deposits, including sand, clay, and silt, which significantly influence the chemical composition of the groundwater. The climate is subtropical, with moderate to heavy rainfall during the monsoon season. Groundwater is mainly filled by rainwater soaking into the ground and mixing with surface water. Due to a growing population and more farming, the amount of groundwater being taken out has increased a lot in recent years. These conditions cause changes in the groundwater's chemical makeup and can affect the levels of certain trace elements in the water.

3. Materials and Methods:

3.1 Sample Collection:

Groundwater samples were gathered from various places using clean polyethylene bottles. The samples were collected from hand pumps and tube wells after letting the water run for a few minutes to prevent contamination.

3.2 Laboratory Analysis:

The samples were tested for trace elements such as arsenic (As), iron (Fe), lead (Pb), cadmium (Cd), manganese (Mn), and chromium (Cr). The chemical analysis followed standard methods recommended by the American Public Health Association (APHA).

The levels of these trace elements were measured using atomic absorption spectrophotometry (AAS). The results were then compared to the permissible limits set by WHO and BIS for safe drinking water.

3.3 Data Analysis:

A hydrogeochemical study was conducted to understand the chemical make-up of the groundwater. Statistical approaches and visual tools were used to analyze the data and figure out where the trace elements might be coming from.

Table 1: Groundwater Analysis

Sample	pH	Fe	Mn	Cr	Cd	Pb	As
S1	7.3	0.45	0.12	0.05	0.01	0.02	0.01
S2	7.5	0.60	0.16	0.04	0.02	0.03	0.02
S3	7.2	0.30	0.11	0.03	0.01	0.01	0.01
S4	7.6	0.70	0.20	0.06	0.03	0.04	0.03
S5	7.3	0.50	0.14	0.05	0.02	0.02	0.02
S6	7.4	0.55	0.13	0.05	0.02	0.02	0.01
S7	7.5	0.65	0.17	0.06	0.03	0.03	0.02
S8	7.3	0.40	0.11	0.04	0.01	0.01	0.01
S9	7.6	0.67	0.18	0.05	0.02	0.03	0.02
S10	7.3	0.53	0.14	0.05	0.02	0.02	0.02

4. Results and Discussion:

The study of groundwater samples shows that various trace elements are present in different amounts. Iron and manganese were found in higher levels in many samples, which might be because of natural rock formations and the breakdown of minerals.

In some areas, arsenic and lead levels were close to or exceeded the safe limits for drinking water. This could be because of natural chemical processes in the ground and human activities like farming runoff and poor waste management. The chemical makeup of groundwater shows that rock breakdown, changes in oxygen levels, and exchanges between ions help control the amount of trace elements.

The way groundwater interacts with the rock layers also helps increase certain elements. Having harmful trace elements in groundwater can be dangerous for people who mainly drink from this water source.

To make sure the water is safe, it's important to keep checking the quality and treat the water as needed.

5. Conclusion:

The analysis of groundwater's chemical makeup shows that there are several trace elements present, which can affect the quality of the water. While most of the samples are within acceptable levels, certain areas have higher amounts of harmful elements like arsenic and lead.

The study emphasizes the need for ongoing checks of groundwater quality to avoid possible health risks. Effective ways to manage groundwater, such as controlling pollution and using water treatment methods, should be put in place to ensure safe drinking water.

More studies are needed to better understand how trace element levels change over time and what effects they may have on both the environment and people's health.

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