Physico-chemical analysis of groundwater of the Budhi Gandak in East Champaran district, Bihar

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***Abstract*—The current investigation aimed to analyze water samples from bored tube wells at various locations along the Budhi Gandak river, spanning from Lalmetia to Mehsi in the East Champaran district of Bihar state. The study was conducted during the winter season (January and February) of 204. Several parameters including pH, conductivity, TDS, DO, total hardness, alkalinity, sodium, potassium, calcium, magnesium, chloride, as well as heavy metals such as Cu, Zn, Fe, and As were examined. It was observed that the TDS levels in some samples exceeded the maximum permissible limit set by the World Health Organization (WHO). Additionally, the concentration of iron in almost all samples was found to be significantly higher than the WHO's maximum permissible limit. Furthermore, certain water samples along the Budhi Gandak river exhibited arsenic contamination, surpassing the WHO's maximum permissible limit. The presence of arsenic contamination in the groundwater of this area poses a serious concern for human health.**

***Index Terms*—Groundwater quality, physico-chemical and heavy metal parameters, Budhi Gandak River, East Champaran.**

I. INTRODUCTION

Water has always played a vital role in sustaining human life and is crucial for the survival of all living organisms. With the exception of fat, water constitutes approximately 70% of the human body's mass. It is an essential component in metabolic processes and acts as a solvent for various substances within the body. Groundwater, an unseen natural resource, exists beneath our feet within the dark pores and crevices of the earth's upper crust composed of sand and rocks. Groundwater, which is accessed to provide drinking water for households, is often contaminated by activities taking place directly above it. The pollution of groundwater is not easily detectable until after individuals fall ill. Human activities are the primary cause of groundwater pollution, posing a significant global problem.

Water becomes classified as contaminated when it is affected by human-made pollutants and can no longer be used for human consumption, like drinking water, or when there is a significant alteration in its ability to sustain its natural living communities, such as fish. Natural events like volcanic eruptions, algal blooms, storms, and earthquakes also have a significant impact on water quality and the overall ecological health of water bodies. Studies have shown that water pollution is a major global issue, leading to numerous deaths and illnesses, with over 14,000 fatalities occurring daily worldwide, and 1,000 children in India succumbing to diarrheal diseases each day. Therefore, regular testing of water samples is crucial to ensure that groundwater remains uncontaminated.

The purpose of this study was to assess the water quality of samples collected from bored tube wells along the Budhi Gandak river in the East Champaran district of Bihar state. The study was conducted during the winter season of 2024, specifically in the months of January and February. In order to analyze the water quality, we focused on several key parameters including Na, K, Ca, Mg, Cu, Zn, Fe, and As. These parameters were chosen as they are known to have significant impacts on human health and the environment. Additionally, we also measured various physico-chemical parameters such as pH, TDS, EC, TH, DO, alkalinity, and chloride. These parameters provide valuable insights into the overall quality and suitability of the water for drinking purposes. To ensure the accuracy and reliability of our findings, we followed standardized sampling and testing procedures. Samples were collected from multiple stations along the Budhi Gandak river, covering a wide geographical area. The samples were then analyzed in a laboratory using state-of-the-art equipment and techniques. Once the data was collected and analyzed, we compared our findings with a range of national and international standards for drinking water. This allowed us to determine the level of contamination and the potential risks associated with consuming water from the bored tube wells in this region. By comparing our results with established standards, we were able to identify any deviations and assess the overall quality of the water.

II. MATERIAL AND METHODS

Water samples were obtained from bored tube wells at two different locations along the Budhi Gandak river, spanning from Lalmetia to Mehsi in the East Champaran district. This collection took place during the winter season of 2024, specifically in the months of January and February. To ensure accuracy, the samples were collected in polythene bottles that had been thoroughly cleaned beforehand. At the sampling sites, the pH and dissolved oxygen (DO) levels were measured. Additionally, various other parameters such as total hardness (TH), calcium, magnesium, sodium, potassium, iron, copper, zinc, and arsenic were determined using established methods.

For a detailed understanding of the techniques employed to assess the physico-chemical and metal parameters, please refer to Table 1. Furthermore, Table 2 provides information on the physico-chemical parameters and heavy metal concentrations found in the groundwater samples obtained from the Budhi Gandak River.

Table-1 Methods used for physico-chemical analysis of water samples

Parameters used	Methods employed
pH	pH meter
Electrical Conductivity (EC)	Conductivity/ TDS meter
Total Dissolved Solids (TDS)	Conductivity/ TDS meter
Dissolved Oxygen (DO)	DO meter
Total hardness(TH)	EDTA Titration.
Total Alkalinity (TA)	Neutralising with standard HCl (Titration)
Calcium	EDTA Titration
Magnesium	By Calculation.
Sodium	Flame photometer
Potassium	Flame photometer
Chloride	Titration by $AgNO_3$
Copper	UV-Visible Spectrophotometer
Zinc	UV-Visible Spectrophotometer
Iron	UV-Visible Spectrophotometer
Arsenic	UV-Visible Spectrophotometer

Table - 2
Physico-chemical parameters and heavy metals of ground water samples

Sample	pH	EC	TDS	TH	DO	TA	Ca	Mg	Na	K	Cl^-	Cu	Zn	Fe	As
Site-1	7.40	671	435	165	4.7	170	46	25.5	11.02	6.89	135.2	0.025	0.26	1.15	Nil
Site-2	7.35	540	355	142	4.1	155	55	21.2	8.60	6.76	67.5	0.022	0.33	1.00	Nil
US EPA	6.5-8.2	-	500	-	4-6	-	100	30	<60	10(EU)	250	1	5	-	-
WHO	6.5-9.2	300	500	500	-	200	75	50	200	-	250	1	5	0.30	10
BIS	6.5-8.5	-	500-1000	300-600	3	200-600	75-200	30-100	250	-	250-1000	0.05-1.5	5-15	0.3-1.0	50
ICMR	6.5-9.2	-	500-1500	300	-	-	75	50	-	-	200	0.05	0.1	0.1	-

*All parameters are expressed in mg/L except pH, EC (in µScm-1) and Arsenic (in ppb)

III. RESULTS AND DISCUSSION

Water quality is often determined by its pH level, which plays a crucial role in geochemical equilibrium solubility calculations. In the research area, the pH of groundwater ranged from 7.33 to 7.40. The pH values of the samples analyzed fall within the recommended limits set by BIS and WHO for different water applications, such as drinking and household use.

The electrical conductivity (EC) ranged from 540 to 671 µScm-1, with all samples exceeding the permissible limit set by the World Health Organization (WHO). Similarly, the total dissolved solids (TDS) in the groundwater of the study area varied from 355 to 435 mg/L, all of which were found to be above the maximum permissible limit established by WHO. As water passes through soil and rock, it gradually dissolves trace amounts of minerals, retaining them in solution. Calcium and magnesium, along with their carbonates, sulphates, and chlorides, are the most prevalent minerals that contribute to water hardness in groundwater. The total hardness in the study area ranged from 142 to 165 mg/L in the groundwater.

Dissolved oxygen (DO) is a crucial factor in determining water purity. The levels of DO ranged from 4.1 to 4.7 mg/L. Alkalinity in natural water is primarily caused by the presence of carbonates, bicarbonates, and hydroxides. Groundwater alkalinity levels ranged from 155 to 170 mg/L. Calcium content in the water samples fluctuated between 46 and 55 mg/L. Approximately 25% of the samples exceeded the WHO limit. Magnesium concentrations varied from 21.2 to 25.5 mg/L, all falling within WHO's permissible limits. Sodium concentrations in the study area ranged from 8.60 to 11.02 mg/L, all within WHO's acceptable range.

The primary origins of potassium in groundwater consist of rainwater, the breakdown of potash silicate minerals, the application of potash fertilizers, and the utilization of surface water for irrigation. It is predominantly found in sedimentary rocks and is typically found in feldspar, mica, and other clay minerals. The potassium levels in the groundwater samples ranged from 6.76 to 6.89 mg/L. Upon comparison with the standards set by the European Union (EU), the potassium concentration did not exceed the limit at the sampling site. The low concentration of potassium in water is attributed to the high stability of potassium-bearing minerals.

The chloride concentration in the study area varied between 67.5 and 135.2, indicating that all the samples analyzed in this study are within the recommended limit of 250 mg/L set by the World Health Organization (WHO). The limits for chloride levels are primarily established based on taste preferences. It is worth noting that no negative health impacts on humans have been documented from the consumption of water with even higher chloride content.

Copper contamination in drinking water is a result of the corrosive nature of water, which causes the leaching of copper from pipes. The concentration of copper in the water samples analyzed ranged from 0.022 to 0.025 mg/L. Excessive copper intake can lead to sporadic fever, coma, and potentially fatal consequences. However, the water samples examined in this study do not pose a copper hazard.

Zinc is introduced into drinking water through the degradation of galvanized iron. The accumulation of zinc in the human body can lead to symptoms such as vomiting, renal damage, and cramps. The concentration of zinc in the water samples ranged from 0.26 to 0.33 mg/L, indicating that the water samples are not contaminated with zinc.

The limits for iron in water supplies for potable use are not established based on health concerns, but rather due to the potential of iron in water supplies to cause discoloration of clothing, plumbing fixtures, and porcelain items, as well as imparting a bitter taste. Iron in drinking water can exist in various forms such as $Fe2+$, $Fe3+$, and Fe (OH)3, either suspended or filterable. However, excessive concentrations can lead to issues like a rapid increase in respiration, hypertension, and drowsiness. The iron levels in the water samples analyzed ranged from 1.00 to 1.15 mg/L. All samples in the study area exceeded the WHO's permissible limit, indicating a high iron content in the groundwater of the research area.

In typical groundwater environments, both the As(III) and As(V) states can contain arsenic. As(III) is generally more mobile in water and has higher toxicity compared to As(V). Excessive withdrawal of groundwater has led to increased contamination of iron, fluoride, and arsenic in various parts of India. Out of the nine groundwater samples analyzed in the study area, two (S3 and S6) were found to have arsenic contamination exceeding the maximum permissible limit of 10 ppb set by the WHO. The results obtained from our analysis of various water quality parameters have been included in Table 2.

IV. CONCLUSION

The analysis of physico-chemical properties conducted indicated that the groundwater in the Lalmetia to Mehsi region of East Champaran district exhibits elevated electrical conductivity levels, suggesting the presence of high ionic concentrations. Additionally, certain samples displayed high total dissolved solids (TDS) content, which could lead to aesthetic issues and disturbances. Nevertheless, the other physico-chemical parameters remained within the respective maximum permissible thresholds. In terms of heavy metals, iron levels exceeded the WHO's maximum permissible limit in nearly all samples. Alarmingly, arsenic levels surpassed the

WHO's permissible limit in a few samples, posing a significant health risk to the local population.

Therefore, there is a pressing requirement for a well-organized strategy and execution of water resource assessment, enhancement, control, and restoration initiatives, along with regular supervision to prevent any escalation in the levels of heavy metals, particularly arsenic, in the designated region.

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