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INVESTIGATING THE KEY FACTORS INFLUENCING GROUNDWATER QUALITY IN SUPAUL DISTRICT, BIHAR: A DETAILED ASSESSMENT OF DRINKING WATER

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Abstract

Life depends on water, and the aim of this study is to evaluate the drinking water quality in Supaul district of Bihar. Water samples were collected from ten tubewells and ten wells across five villages in the district. The research focused on examining various physicochemical properties, such as pH, electrical conductivity, free carbon dioxide, total alkalinity, total hardness, dissolved oxygen, biological oxygen demand, and chemical oxygen demand. The findings indicated that all the parameters met the permissible standards set by the Bureau of Indian Standards, except for chemical oxygen demand, which necessitates further research.

Introduction

Groundwater is an essential resource for the sustenance of human life and agricultural activities, providing about 50% of the world's drinking water supply (Foster and Chilton, 2003). The quality of groundwater is significantly influenced by various factors such as geological, hydrological, and anthropogenic aspects (Selvam et al., 2014). In recent years, groundwater quality has emerged as a significant concern worldwide, particularly in developing countries like India. High levels of contaminants, such as fluoride, nitrate, and arsenic, have been reported in several regions across India, posing severe health risks to the population (Suthar et al., 2009). Bihar is one such region, with Supaul district displaying a wide range of groundwater quality issues. Therefore, understanding the factors affecting groundwater quality in Supaul district is crucial for devising appropriate strategies for sustainable groundwater management and ensuring the health and well-being of the local population.

Supaul district in Bihar is predominantly an agrarian area, with more than 90% of the population dependent on agriculture (Census of India, 2011). The region is characterized by a tropical monsoon climate, with more than 80% of the annual rainfall occurring during the monsoon season (June-September) (Kumar et al., 2018). Groundwater is the primary source of drinking water and irrigation in the district, with over 65% of the population relying on it for their daily needs (Census of India, 2011). However, the quality of groundwater in the district has been deteriorating in recent years, with several instances of contamination reported (Kumar et al., 2018).

Several factors contribute to the contamination of groundwater in Supaul district. Geologically, the region is mainly composed of alluvium, which is highly permeable and allows easy infiltration of rainwater and surface water into the aquifers (Mukherjee et al., 2007). This makes the groundwater more susceptible to contamination

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from anthropogenic activities such as agriculture, domestic waste disposal, and industrial effluents (Selvam et al., 2014). Additionally, the high water table and flat topography of the region facilitate the mixing of shallow groundwater with deeper aquifers, increasing the risk of contamination (Mukherjee et al., 2007).

Agricultural activities are known to have a significant impact on groundwater quality, particularly in regions where agriculture is the primary occupation (Ravikumar et al., 2011). In Supaul district, the intensive use of chemical fertilizers, pesticides, and herbicides has led to the leaching of these chemicals into the groundwater, causing elevated levels of nitrate, phosphate, and other contaminants (Kumar et al., 2018). Furthermore, improper irrigation practices and over-extraction of groundwater for agriculture have led to a decline in the groundwater levels, increasing the concentration of contaminants in the remaining water (Selvam et al., 2014).

Besides agricultural activities, domestic waste disposal and industrial effluents also contribute to the contamination of groundwater in the district. Inadequate waste management practices, such as open dumping of solid waste and discharge of untreated sewage into water bodies, can lead to the leaching of harmful chemicals and pathogens into the groundwater (Suthar et al., 2009). Moreover, industrial activities, such as food processing, tanneries, and textile dyeing, generate a large amount of effluents containing heavy metals, organic compounds, and other pollutants that can contaminate the groundwater (Ravikumar et al., 2011).

In conclusion, understanding the factors affecting groundwater quality in Supaul district, Bihar, is crucial for devising appropriate strategies for sustainable groundwater management and ensuring the health and well-being of the local population. This study aims to investigate the geological, hydrological, and anthropogenic factors influencing groundwater quality in the district and provide insights into potential mitigation measures to improve the groundwater quality for the benefit of the local population and the environment.

Study Area

The Supaul district is located at the north eastern parts of Bihar state, which is situated in the middle parts of Ganga Basin. The district falls in the Kosi Sub-basin.

In the district shallow tube wells are suitable up to a depth of 50 m with discharge of 20 to 40 m^3/hr. The deep tube well of more than 100 m depth can also be constructed with estimated discharge of 100-200 m^3/hr. Whereas Bamboo Boring of 20 to 25 m depth tapping water table aquifer can yield 10 to 20 m^3/hr with a safe draw down. Depth to water level in the Supaul district remains shallow during pre- as well as postmonsoon periods, going maximum up to 5.0 m at few patches.

Sample collection site

District	**Block**	**Village**	**No. of samples**	
			Bore well	**Well**
Supaul	Chhatapur	Amha	2 (BW1& BW2)	2 (OW1& OW2)
	Kishanpur	Andauli	2 (BW3& BW4)	2(OW3& OW4)
	Marauna	Barahara	2(BW5 & BW6)	2(OW5& OW6)
	Nirmali	Bela	2(BW7 & BW8)	2(OW7& OW8)
	Pipra	Basaha	2 (BW9 & BW10)	2(OW9& OW10)

Materials and Methods

A total of 20 water samples of tube wells and wells were collected directly into 2.0 Ltr acid cleaned polythene bottles. These water samples were kept in the darkness in an ice box at 4^0C till the samples reached the laboratory for analysis.The samples were analyzed for physicochemical using standard procedures (USEPA, 1990; APHA, 1992).

Results and Discussion

The water quality analysis of 20 water samples has been carried out for 8 physico- chemical parameters, pH, Electrical conductivity, free carbon dioxide, total alkalinity, total hardness, dissolved oxygen, Biological oxygen demand and chemical oxygen demand.

pH

The pH varied from 6.5-6.8 in tubewell water and 6.8-7.0 in open well water. pH is one of the importance on determining the corrosivity of water because generally the lower the pH, the higher the level of corrosion (WHO, 1996). Cautious attention to pH is necessary at all stages of water treatment before distribution to ensure satisfactory clarification and disinfection to minimize the corrosion of water. Exposure to extreme ($pH > 11$) results in irritation in eyes, skin and mucous membrane and also cause hair fibers to swell in human. Similarly, low pH also results in same effects with the severity of which increases with decreasing pH (WHO Working Group, 1986). According to the WHO guidelines, the taste of drinking water should be non-objectionable or acceptable to consumers. The taste also depends on the pH of water. The BIS of drinking water pH is 6.8 – 8. The pH of water sample of tube well and well is within range of BIS (BIS 2012)

Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts. EC values were observed in the range of 430.0 micromhos/cm to 490.0 micromhos/cm.in borewell water and 415.0 micromhos/cm to 450.0 micromhos/cm.in well water. EC values were found within WHO limit.

Free Carbon dioxide

The main source of free carbon dioxide is respiration of the plant and animals and also the decomposition of the organic matter. It has been reported that minimum free carbon dixide in water is good for health. In the present study the free carbon dioxide is ranged 6.0-6.4 ppm in tube well and 4.8-8.0 ppm in well water. There is no guide line of BIS for free carbon dioxide so it should be minimum in drinking water.

Total Alkalinity

Total alkalinity of water may be due to the presence of one or more number of ions. These include hydroxides, carbonates and bicarbonates. Hydroxide ions are always present in water, even if the concentration is extremely low. However, significant concentrations of hydroxides are unusual in natural water supplies, but may be present after certain types of treatment. The total alkalinity ranged from 152-190ppm in tube well water and 178-190ppm in well water. as per BIS it is 200-600 ppm. so the sample water is within range of BIS.

Total Hardness

Total hardness observed for streams and rivers throughout the world range between 1-1000 ppm as $CaCO3$. Hardness reflects the composite measure of polyvalent cations whereas calcium and magnesium are the primary constituent of hardness (Larry, 1996). The measure value of total hardness for studies samples was 140172 ppm in tube well and 140180ppm in well water. The BIS recommendation is 200-600ppm. The sampled water the total hardness was found within the permissible limit of BIS.

Dissolved oxygen

A high DO level in a community water supply is good because it makes drinking water taste better. However, high DO levels speed up corrosion in water pipes. The amount of dissolved oxygen often determines the number and types of organisms living in that body of water. the dissolved oxygen was 1.2-1.8ppm in tube well water and 2.4-4.2 ppm in well water. one the reason of high dissolved oxygen in well may the open well and direct contact with the air.

Biological oxygen demand (BOD)

There is no specific limit prescribed for BOD in drinking water by BIS. The presence of BOD in drinking water indicates that the water contains biodegradable organic substances. The bacterial growth will start in such water very easily. The BOD should be Zero in drinking water, but it's almost impossible to maintain Zero BOD in open water source. The BOD level found 1.2-2.8 ppm in tube well and 4.2-4.6ppm in well water. BOD <5ppm will not cause any harmful impacts on human body, since the bacteria present in our digestive system will degrade all the organic contents.

Chemical Oxygen demand (COD)

The COD in tube well water ranged 60-68 ppm and in well water 38.00-44.00 as per BIS standard for drinking water (IS 10500:1991), there is no mention of COD limit. These parameters are meant for Effluent samples not for drinking water. It means there should not be any trace of COD values for drinking water. The presence of COD in the water in area needs further detailed study about the reasons and remedies.

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Table 1: Physico Chemical status of Bore well and well of the project area

parameters	Village	Amha		Andauli		Barahara		Bela		Basaha		Amha		Andauli		Barahara		Bela		Basaha	
	Unit	BW1	BW2	BW3	BW4	BW5	BW6	BW7	BW8	BW9	BW10	OW1	OW2	OW3	OW4	OW5	OW6	OW7	OW8	OW9	OW10
Temperature	^0C	24.5	24.5	25.0	25.3	25.2	25.6	25.4	25.6	25.0	25.2	24.6	26.0	25.6	25.8	26.0	26.2	26.2	25.0	25.4	25.2
pH		6.5	6.6	6.8	6.8	6.4	6.8	6.7	6.8	6.8	6.8	7.0	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.6	6.8
Electrical conductivity	mhos/cm	480	490	430	480	445	430	450	458	452	452	435	430	432	430	428	425	424	420	415	416
Free CO_2	ppm	6.0	6.0	6.2	6.4	6.2	6.0	6.0	6.0	6.2	4.8	4.8	5.8	6.8	7.2	7.2	7.2	6.8	7.6	7.8	7.8
Total Alkalinity	ppm	156	152	158	180	182	189	190	190	168	176	184	190	182	178	182	184	186	182	182	180
Total Hardness		140	152	154	146	142	146	148	158	170	172	142	158	172	175	174	180	182	140	146	144
Dissolved Oxygen	ppm	1.46	1.80	1.2	1.8	1.2	1.2	1.2	1.4	1.2	1.2	2.4	2.6	4.0	4.0	4.2	2.8	4.2	4.0	4.0	4.0
BOD	ppm	1.2	2.8	2.6	2.4	2.2	2.4	2.2	2.8	2.6	2.4	4.2	4.4	4.4	4.2	4.6	4.8	4.2	4.6	4.2	4.4
COD	ppm	68	64	66	64	62	62	60	62	67	68	42	44	40	42	40.0	38.0	40.0	42	42.0	42

BW: Bore well, OW: Open well