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ANALYSIS OF QUALITY PARAMETERS OF GROUNDWATER USING ION CHROMATOGRAPHY TECHNIQUES NEAR INDUSTRIAL AREAS IN UTTARAKHAND

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ABSTRACT

Water is one of the most important natural resources to survive on the earth. It is required for almost every purpose whether industrial, commercial or residential as well as forestry, fishing, agriculture and hydropower production. More than 70% of the earth's surface is covered by water but availability and quality of water is a major concern. The safety of drinking water is influenced by its physio-chemical and microbiological properties, which can lead to severe health issues if it exceeds permissible limits. The present study has been carried out with the objective to examine the suitability of ground water in near areas of industrial zone of Bhagwanpur Block in Uttarakhand. Ion Chromatography (IC) technique has been used for the analysis of samples. During the study, it was found that most of the physical and chemical parameters of ground water were within the acceptable and permissible limits as prescribed for drinking water (BIS, 2012). However, continuous discharge of domestic wastes and industrial effluents from various industries may contaminate the ground water in future and cause serious health problems. Groundwater quality degradation is common in populated, industrialized areas with shallow levels, requiring regular monitoring to ascertain the suitability for drinking and domestic needs.

Key words: Physio-chemical, Microbiology, Health problem, Permissible, Industrial effect.

INTRODUCTION

Water is one of the most important resource among all natural resources on earth. We depend on water for drinking, irrigation and industrial needs as well as for disposal of wastes. The Terai region in Uttarakhand is facing a significant water quality issue due to population growth, urbanization, deforestation, and industrialization (Tyagi et al., 2013). Therefore, the level of water resources is getting polluted and depleted and also unfavourably affecting the quantity and quality of ground water (Sharma et. al., 2012). Groundwater pollution is a critical global issue that requires urgent attention and action. Groundwater contamination has surged due to illogical and reckless disposal methods of industrial, agricultural, and household waste (Lacorte, 2005). Monitoring the physical, chemical, and biological characteristics of water or water supply is possible (Fernandez-Luqueno et al., 2013). Recently, supply chain of drinking water contaminated with metals including copper, iron, aluminium, calcium, lead, mercury, and manganese as a result of geological activities or anthropogenic activities has increased that raise human health issues (Gupta et.al., 2012).

Today, we must make every effort to ensure the safety of drinking water as reasonably possible. Safe drinking water doesn't pose significant health risks over a lifetime, despite potential differences in sensitivity between life stages, especially for vulnerable groups like the elderly, disabled, and newborns and small children (WHO, 2011).

In the Haridwar district of Bhagwanpur, Uttarakhand, an industrial estate has been constructed. Bhagwanpur belongs to the Terai region of Uttarakhand state. Studying how industrial expansion has impacted natural resources, especially groundwater supplies, is therefore essential. In the present work we have studied the quality of ground water in the industrial area of Bhagwanpur. For the present study on ground water quality monitoring, three different sites are selected near the industrial area of Bhagwanpur. The present research provides an interpretation of the monitored data. The researchers are trying to use the recent analytical techniques for better determination of the parameters under study. Researchers and decision-makers now need routine monitoring to understand the current status of the water quality and the level of probable pollutants in the water (Saini et.al, 2024).

MATERIALS AND METHODS

Sampling sites

Ground water which is used for drinking purpose is collected 2 times from each site in the months of October to April 2022-2023 considering the guideline of BIS (Bureau of Indian Standard) in clean plastic bottles from hand pumps / bore wells and from different locations of industrial area of Bhagwanpur. The water samples were collected after flushing out the hand pump for about 10 minutes to get the fresh ground water. Bottles were also rinsed thoroughly 5 to 6 times with the same water before filling the water sample. The bottles were sealed and labelled and the samples were protected from direct sunlight during transportation.

The samples were kept fresh by adding 5 ml of ultra-pure nitric acid to one-litre sample to reduce adsorption and precipitation by bringing the pH down below 2. Turbidity and pH of the samples were determined at the time of sample collection on the site, among other significant water quality indicators. The collected water samples were transported in sample boxes at a temperature of 4°C to the Water Quality Analysis Laboratory National Institute of Hydrology (NIH), Roorkee for further examination.

Table 1: Ground Water Samples Collected from sites near Bhagwanpur Industrial Area

S. No.	Sample No.	Sample collection sites
1.	Sample 1	Hand Pump Makkhanpur village, Bhagwanpur.
2.	Sample 2	Hand Pump Sisona Village, Bhagwanpur.
3.	Sample 3	Hand Pump Sikanderpur Bhainswal Village, Bhagwanpur.

Water Sample Analysis

The water samples were analysed in the laboratory at NIH, Roorkee. Total 18 water quality parameters were analysed in the laboratory as given in Table-2.

Table 2: Parameters, Methods and Instrumentation

S.No.	Parameters	Methods	Apparatus /Instrumentation
1.	Temperature	Electrical	Mercury thermometer
2.	Colour	Visual	-
3.	Taste and Odour	-	-
4.	Ph	Electrical	pH meter
5.	Electrical Conductivity	Electrical	EC meter
6.	Total Dissolved Solids	Filtration and evaporation	Volumetric glassware
7.	Alkalinity	Titration	Volumetric glassware
8.	Hardness	Titration	Volumetric glassware
9.	Sodium	Flame emission	Flame Photometer
10.	Potassium	Flame emission	Flame Photometer
11.	Calcium	Titration	Volumetric glassware
12.	Magnesium	Titration	Volumetric glassware
13.	Chloride	Titration	Volumetric glassware
14.	Sulphate	Turbidimetric	Turbidimeter
15.	Nitrate	Colour development with absorption measurement	UV-VIS Spectrophotometer
16.	Fluoride	Colour development with absorption measurement	UV-VIS Spectrophotometer

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RESULTS AND DISCUSSION

The colours of the ground water samples from sites 1 and 2 are below the desirable limit of BIS whereas the colour of sample from site 3 is within the desirable limit (DL) and permissible limit (PL). The pH values of all the samples during all the months were also found within the DL and PL of BIS specification. The water quality and its acceptability has been evaluated on the basis of physiological parameters, that are generally affected by pollution, thermal pollution, acidification, salinization, ion toxicity etc. (Rosly, et al., 2015). Many water resources lack basic protection. Therefore, these resources are vulnerable to pollution from factory, farms and industrial plants. Hence, water quality evaluation becomes necessary and important to ensure the quality of the water. The water quality can be defined as the chemical, physical and biological characteristics of water, usually in respect to its suitability for a designated use (Jain and Bhatia, 1988; Roy, 2019). Temperature is one of the most crucial elements for both the terrestrial and aquatic environments because it controls a variety of physio-chemical as well as biological activities (Sharma et. al., 2015; Saini et.al., 2024). In present study the temperature of the ground water in industrial area was found to be 19.4-20.5 ºC. Water is colourless, tasteless and odourless in nature but the Colour, taste and odour of the water may be from various contaminants such as suspended matter, natural metallic ions, humus, plankton, industrial wastes, colloidal or suspended material (Srivastava, 2018). In this study we found the colourless water which is free from colour changing contaminant. The pH scale identifies the amount of acidic or alkaline substances contained in water. In this study the maximum pH value (8.3) is found at the hand pump water of site 3, Sikanderpur Village, and the minimum (7.1) is found at the hand pump water of site 1, Makkhanpur Village.

The level of dissolved oxygen (D.O.) in a water body is a key indicator of water quality, since it reflects the physical and biological processes that occurs in the water sample. The value of D.O. indicate the degree of pollution in the water bodies (Omer, 2019; Vasistha and Ganguly, 2020). In this study the valve of dissolved oxygen of the ground water was found to be 3.2-3.6 (mg/l). Biochemical oxygen demand is the amount of oxygen utilized by micro-organism in stabilizing the organic matter (Eaton et. al., 2005; Saini et.al, 2024). BOD in general gives a qualitative index of organic substances which are degraded quickly in a short time period (Omer, 2019). In the present study the BOD of groundwater was found to be 0.59-0.63 (mg/l).

Dissolved solids and particulate organic and inorganic matter in any water sample are represented by TDS (Total Dissolved Solids). Kidney stones and heart problems may develop in humans who consume water with high TDS value for an extended period of time. Water with higher TDS levels promotes gastro-intestinal irritation in humans (WHO, 2004). People who drink water with a high TDS value over time are at high risk of having cardiac issues. The high level of TDS may be caused by anthropogenic sources such home sewage and solid waste dumping (WHO, 2011). Maximum TDS was observed at site- 1 (780 mg/l) and minimum at site- 3 (540 mg/l). The electrical conductivity of water is typically used to calculate the salt concentration. Oversalting can cause physiological dry conditions by raising the osmotic pressure of soil fluids (Gupta et. al., 2012). In this study the maximum electrical conductivity was found at the site -1 (1217 µS/cm) and minimum found at site -3 (841 µS/cm).

Alkalinity of water is the degree to which a strong acid can be neutralised. Water becomes alkaline due to the presence of hydroxyl ions, bicarbonates, and carbonates, water may also contain phosphates, silicates and borates (Islam and Majumder, 2020). In this study the maximum alkalinity was found at site- 1 (277 mg/l), and minimum is found at site-3 (228 mg/l).

The presence of anions i.e., carbonates, bicarbonates, and chloride and cations i.e, calcium and magnesium, in the water causes the hardness. There are no known negative impacts of hard water (Islam and Majumder, 2020). Nonetheless, some research points its connection to cardiac conditions (WHO, 2010). Hardness levels of the water 150–300 mg/l and more may result in kidney issues and the development of stones (WHO, 2010). In this study the maximum hardness is found at the site -1 (215 mg/l) and minimum found at site -3 (162 mg/l).

Calcium is more prevalent in the earth's crust. Magnesium is typically found in lower concentrations than calcium (Folk, 1974). Magnesium-rich minerals dissolve in water at a slower rate than calcium. For healthy bone development, calcium is essential. Because calcium is more soluble and abundant in most rocks, and it is frequently found in groundwater. An excess of allowable magnesium concentration in groundwater results cause bad taste in the water (Omema et. al., 2019). Deficiency of magnesium in human body may lead to structural and functional changes. Magnesium ion is necessary for enzyme activation and cell functioning, at higher concentrations it is regarded as a laxative agent (Ismail and Ismail, 2016). In this study the maximum amount of calcium is found at site- 1 (57.22 mg/l), and

Table-3 Physico-chemical Data of Ground Water Samples of Industrial Area Bhagwanpur

Parameter	Desirable Limit (DL)	Permissible Limit (PL)	**Sample 1** Vill-Makkhanpur	**Sample 2** Vill-Sisona	**Sample 3** Vill- Sikanderpur, Bhainswal
Colour	5	15	Colourless	Colourless	Colourless
Taste and Odour	Agreeable	Agreeable	Normal	Normal	Normal
Ph	6.5	8.5	7.8	7.9	8.3
Temperature (°C)			19.2	19.39	19.6
Electrical Conductivity, µS/cm	781-3125		1217	911	841
Total Dissolved Solids, mg/L	500	2000	780	583	540
Alkalinity, mg/L			277	244	228
Hardness, mg/L	200	600	215	188	162
Calcium, mg/L	75	200	57.22	45.93	31.54
Sodium, mg/L			14.25	12.46	24.96
Potassium, mg/L			3.51	2.49	3.83
Magnesium, mg/L	30	100	17.23	17.74	20.15
Chloride, mg/L	250	1000	10.33	1.89	1.72
Sulphate, mg/L	200	400	11.81	6.22	0.52
Nitrate, mg/L	45	No relaxation	Nil	Nil	Nil
Fluoride, mg/L	1.0	1.5	0.21	0.22	0.38

Sample 1: Hand Pump, Vill- Makkhanpur, Bhagwanpur
Sample 2: Hand Pump, Vill- Sisona, Bhagwanpur
Sample 3: Hand Pump, Vill- Sikanderpur, Bhainswal, Bhagwanpur

magnesium found at site-3 (20.15 mg/l) whereas minimum amount of calcium is found at site -3 (31.54 mg/l) and magnesium found at site- 1 (17.23 mg/l).

Chloride is a widely distributed element in all types of rocks in one or another form. In addition of providing food a salty taste, chloride can increase the risk of developing essential hypertension, stroke, kidney stones, and asthma in people (WHO, 2010; Kumar and Puri, 2012). Even though chloride is crucial for maintaining the proper electrolyte balance in blood plasma, excessive concentrations of the salt might lead to certain conditions (Bandak and Kashan, 2017). In this study the maximum amount of chloride and sulphur ions was found at site- 1 (10.33 mg/l & 11.81 mg/l), and minimum was found at site-3 (1.72 mg/l & 0.52 mg/l). During the monitoring periods, the values of the sulphate, nitrate, and fluoride concentrations in the samples were found to be below the acceptable ranges.

Conclusion

The groundwater quality near industrial areas of Bhagwanpur block has been studied for the 16 drinking water quality parameters as per the BIS

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(2012). It varies from place to place and with the depth of the water table. The study reveals that most water quality constituents are within acceptable limits for drinking water, with no sample exceeding the maximum permissible limits. The study concluded that all parameters were within the prescribed limits of IS: 10500–12 and WHO (2004). Thus, the present study reveals that all parameters of sites 1, 2, and 3 of the near industrial zone of Bhagwanpur, Uttarakhand, are within the permissible limits. So, the groundwater in the Bhagwanpur region satisfies the water quality for drinking purposes and other uses. Groundwater, a clean drinking water source, is polluted by industrial effluent, domestic sewage, and solid waste dumps, leading to health issues. Groundwater quality issues are more severe in densely populated, industrialised areas with shallow tables. Rapid urban growth and overexploitation of resources further impact groundwater quality. This study analysed the physio-chemical parameters of groundwater samples in the Bhagwanpur Industrial Area using standard methods, including TDS, EC, pH, alkalinity, total hardness, free CO2, DO, and BOD.

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