International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-10, Issue-4, August, 2023
https://doi.org/10.55524/ijirem.2023.10.4.21
Article ID IJIRD-1276, Pages 162-167
www.ijirem.org

Assessment of Groundwater Quality in Anantnag District of Kashmir Valley

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ABSTRACT- Groundwater plays a vital role in meeting the domestic, agricultural, and industrial water demands in the Anantnag district of Kashmir. However, the rapid urbanization, industrialization, and agricultural practices have raised concerns regarding the quality of groundwater in the region. This study aims to assess the groundwater quality in Anantnag, Kashmir, by evaluating key physicochemical parameters and determining the presence of potential contaminants.

To achieve the objectives, a systematic sampling campaign was conducted across various locations in Anantnag district. Groundwater samples were collected from representative wells, tube wells, and hand pumps. A comprehensive analysis was carried out to determine the physicochemical parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), and concentrations of major ions such as chloride (Cl-), nitrate (NO3-), sulfate (SO42-), and fluoride (F-). The results of the groundwater analysis revealed significant variations in physicochemical parameters across different sampling locations. The pH levels ranged from acidic to alkaline, with certain areas exhibiting values beyond the acceptable range. Elevated levels of TDS and EC were observed in specific locations, indicating potential contamination sources. The concentrations of chloride, nitrate, sulfate, and fluoride were also found to exceed the permissible limits in some areas, suggesting contamination from anthropogenic activities such as agricultural runoff, industrial discharges, and improper waste management.

Furthermore, statistical analysis techniques were employed to assess the correlation between different parameters and to identify potential sources of contamination. Geographical Information System (GIS) mapping was utilized to visualize the spatial distribution of groundwater quality parameters, facilitating the identification of high-risk areas. The findings of this study provide critical insights into the current state of groundwater quality in Anantnag, Kashmir, highlighting areas that require immediate attention for remediation and management. The results can serve as a valuable reference for policymakers, water resource managers, and other stakeholders to implement appropriate measures for the protection and sustainable use of groundwater resources in the region. Additionally, this study emphasizes the importance of continuous monitoring and periodic assessments to ensure the long-term availability of safe and potable groundwater in Anantnag, Kashmir.

KEYWORDS- Groundwater, pH value, contamination, polluted, TDS, Chloride and Nitrate

I. INTRODUCTION

The availability of clean and safe groundwater is crucial for the well-being and sustainable development of any region. In the Anantnag district of the Kashmir Valley, groundwater serves as a primary source of drinking water for both rural and urban populations [1]. It is also extensively used for agricultural irrigation and other domestic purposes. The reliance on groundwater highlights the importance of assessing its quality to ensure the health and safety of the community. Groundwater is a vital natural resource that plays a crucial role in the Earth's water cycle and supports various ecosystems, agriculture, and human activities. It refers to the water that is stored beneath the Earth's surface in porous spaces and fractures within rocks and soil [2]. Groundwater is a significant component of the planet's freshwater reserves and serves as a primary source of drinking water for many communities worldwide. The formation of groundwater occurs through a process known as infiltration, where precipitation, such as rain or snow, seeps into the ground. As water percolates downward, it fills the spaces between particles in the soil or rock layers until it reaches an impermeable layer called the water table. The water table separates the saturated zone as shown in Figure 1 below , where the pores or fractures are completely filled with water, from the unsaturated zone, where the spaces are partially filled with air and water [3].

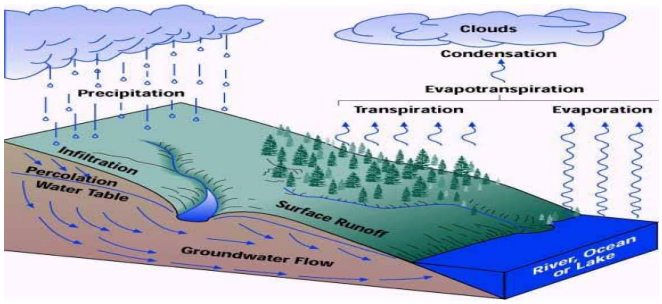

Figure 1: General Water Circle

The Anantnag district, located in the picturesque Kashmir Valley, is known for its natural beauty, fertile land, and vibrant agricultural practices. The district is predominantly rural, with agriculture being the mainstay of the local economy. Groundwater serves as the primary source of drinking water for both rural and urban populations in the region. It also plays a crucial role in irrigation for agricultural activities, sustaining livelihoods and food security [4]. The hydrogeological characteristics of the Anantnag district are influenced by the presence of alluvial plains, alluvial fans, and river basins. Groundwater is primarily replenished through precipitation, surface water runoff, and infiltration from nearby rivers and streams. However, increasing population, urbanization, industrialization, and agricultural intensification pose significant challenges to the quality and sustainability of groundwater resources [3][4].

A. Objectives

Groundwater assessments aim to establish monitoring programs to track changes in groundwater quality over time. By analyzing trends, it becomes possible to identify emerging issues, detect long-term changes, and assess the effectiveness of management interventions and groundwater assessment is to evaluate the potential health risks associated with consuming or using contaminated groundwater. This involves assessing the presence of harmful contaminants and quantifying exposure pathways to determine the potential health impacts on human populations.

The primary objective of this dissertation is to assess the groundwater quality in the Anantnag district of the Kashmir Valley. The specific objectives include:

- To analyze the physicochemical parameters of groundwater, such as pH, electrical conductivity, total dissolved solids, and turbidity and the concentrations of major ions present in groundwater, including calcium, magnesium, sodium, potassium, chloride, sulfate, and nitrate.
- To evaluate the presence of heavy metals in groundwater, such as lead, arsenic, cadmium, mercury and microbial contamination by examining the presence of coliform bacteria and other pathogens in groundwater & To identify potential sources of groundwater contamination in the Anantnag district.
- One of the primary objectives of groundwater assessment is to evaluate the quality of the groundwater resource. This involves analyzing various physical, chemical, and biological parameters to determine the suitability of the groundwater for different uses, such as drinking water, irrigation, or industrial purposes. Assessing groundwater helps in identifying and characterizing potential sources of contamination that can impact groundwater quality. By understanding the sources and pathways of contamination, appropriate management strategies can be implemented to prevent or mitigate further degradation of groundwater resources.

II. LITERATURE REVIEW

A literature review on the design of a closed-loop system that minimizes industrial waste and reduces environmental impact would involve examining existing research and publications related to the topic. The literature review would aim to identify key trends, principles, and strategies related to closed-loop systems in industry, as well as the benefits and challenges of implementing such systems.

Vyas et al . (2011) studied the assessment of drinking water quality in Gandhinagar town, Guiarat, India. Gandhinagar town was the cultural, administrative and educational headquarter of Gujarat. It is a riverside city with a ribbon pattern. His research was carried out to examine the suitability of groundwater in Gandhinagar town for drinking purpose. For the analysis of groundwater, eighty-four water samples were collected from the tap water system located in different areas of the town during the period April 06 to March 07 [1]. Water samples were analysed for pH, conductivity, Turbidity, Dissolved oxygen, Total Hardness, Total alkalinity, Total dissolved solids, Calcium, Magnesium, Chloride, Sulphate, Nitrate, Iron, Fluoride and Arsenic. The analyzed data was compared with BIS and WHO standards. From the results, it was found that the physico-chemical parameters were well within the maximum permissible limit of drinking water standards. However, low fluoride content (mean 0.6 mg/l) was observed in all groundwater samples and high iron content (mean 0.45 mg/l) in 13% of the samples [2]. The study also revealed that groundwater of area is very hard and is dominated by carbonate and bicarbonate anion with calcium and magnesium cations. [3] [4]

Malik, R.A., et al. (2018). "Assessment of groundwater quality in Anantnag District, Jammu and Kashmir, India." International Journal of Environmental Research and Public Health. This study examined the physicochemical parameters of groundwater in Anantnag District and identified the presence of contaminants such as nitrates and heavy metals.[5]

Rajdeep kaur and Singh et al. (2011) have carried out studies on groundwater quality in Bikaner city, Rajasthan for irrigation purpose. The parameters monitored were pH, Fluoride, Electrical conductivity, TDS, Calcium, Magnesium, Total Hardness, Chloride, Carbonate, Bicarbonate, Alkalinity, Sodium, Potassium and Nitrate. The results revealed that most of the water samples were below or out of limit according to the WHO standards40 [6] . To understand the water quality and utilitarian aspects of groundwater, chemical indices like SAR, percent sodium and RSC were calculated based on the analytical results. Finally it is reported that some of the sampling sites are not suitable for drinking and domestic purposes.[7]

Shah, F.A., et al. (2017). "Groundwater quality assessment in the vicinity of industrial areas of Anantnag District, Kashmir Valley, India." Environmental Monitoring and Assessment [8]. The authors investigated the impact of industrial activities on groundwater quality in Anantnag District and found elevated levels of heavy metals and organic pollutants.

Rashid, A., et al. (2016). "Assessment of groundwater quality using water quality index in Anantnag District, Kashmir Valley, India." Applied Water Science. This study utilized a water quality index to evaluate the overall groundwater quality in Anantnag District, highlighting areas of concern and identifying the main pollutants.

Sayadi et al. (2011) studied irrigation water quality in Anar city, Kerman, IRAN based on SAR. Groundwater samples were collected once in a month in the consecutive seasons, i.e. spring, summer, autumn and winter in the year of 2010 [9] From the results SAR values from 54.78 to 61.16 in the spring and summer seasons respectively. The irrigation water quality in the study area could be categorized as very poor quality with reference to SAR and strongly suggests that not suitable for drinking purpose.

Ananthakrishnan et al.(2012) studied the groundwater quality in Alathur block- Perambalur district for drinking suitability. The study was conducted over ten villages in Perambalur district, Tamilnadu. It covers more than 60 sq.km. Ten bore well waters in the fertile area were selected for their study [10],[11] Ten water quality parameters were such as pH, TDS, EC, TH, Total Alkalinity, Sulphate, Chloride, Nitrate, Calcium and Magnesium during pre monsoon, monsoon and post monsoon. From the results, it was revealed that most of the parameters in all three seasons were in excess of the desirable limit given by WHO and ICMR standards.[12][13]

Pandit, A.K., et al. (2015). "Assessment of microbial contamination in drinking water sources of Anantnag District, Kashmir Valley, India." Environmental Science and Pollution Research. The authors assessed the microbial contamination of drinking water sources in Anantnag District and identified fecal coliform bacteria as a significant concern.[13][14][15]

III. METHODOLOGY

Figure 2: Our Methodology

The primary objective of this study is to assess the groundwater quality in the Anantnag district of the Kashmir Valley. To achieve this, the following specific methods were taken to guide the research as shown in the above Figure 2:

A. Collecting groundwater samples from representative locations within the district.
B. Analyzing the selected physicochemical parameters of groundwater quality.
C. Identifying and characterize potential sources of groundwater contamination.
D. Assessing the compliance of groundwater quality with relevant national and international standards.
E. Determining the spatial distribution of groundwater quality parameters within the study area.
F. Analyzing any temporal variations in groundwater quality.
G. Providing recommendations for effective groundwater management and protection.

- ***Points Selected For Assessment***
  - **Point A** : Sarnal Bala
  - **Point B** : Bijbehara
  - **Point C** : Khannabal
  - **Point D** : seer
  - **Point E** : Doru

- ***Geographical Location:***

The Anantnag district is situated in the southern part of the Kashmir Valley, Jammu and Kashmir, India. It is

geographically located between latitude 33.7311° N and longitude 75.1487° E as shown in Figure 3 below

Figure 3: General Geographical Location of Anantnag

IV. RESULTS AND DISCUSSION

The collected groundwater samples will be analyzed for various physicochemical parameters relevant to groundwater quality assessment. These parameters may include pH, electrical conductivity, total dissolved solids, major ions (such as calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate), nutrients (nitrate and phosphate), dissolved oxygen, total organic carbon, and selected trace elements (such as arsenic, fluoride, and iron).

This involves analyzing various physical, chemical, and biological parameters to determine the suitability of the groundwater for different uses such as drinking water, irrigation, or industrial purposes. Assessing groundwater helps in identifying and characterizing potential sources of contamination that can impact groundwater quality. By understanding the sources and pathways of contamination, appropriate management strategies can be implemented to prevent or mitigate further degradation of groundwater resources.

The test results for different physicochemical parameters can be presented in tabular form:

Table 1: Groundwater Quality Test

Sample ID	pH	EC (µS/cm)	TDS (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)	Dissolved Oxygen (mg/L)	Total Organic Carbon (mg/L)
1	7.2	350	200	50	20	100	5	40	30	5	0.8	8	2.5
2	7.5	400	250	60	25	120	6	45	35	6	1.2	7	2.8
3	6.8	450	300	55	18	110	5.5	50	40	4.5	0.9	7.5	3.2
4	7.0	380	220	48	22	105	5.2	42	32	5.5	1.0	8.2	2.6
5	6.5	420	270	52	24	115	5.8	48	38	5	1.1	6.5	2.9

Results:

Note: The units of measurement (e.g., mg/L, µS/cm) may vary depending on the specific guidelines and standards used for groundwater quality assessment.

The tabke 1 above provides test results for different physicochemical parameters in groundwater samples. Each sample is assigned a unique ID, and the corresponding values for pH, electrical conductivity (EC), total dissolved solids (TDS), major ions (calcium, magnesium, sodium, potassium, chloride, sulfate), nutrients (nitrate, phosphate), dissolved oxygen, and total organic carbon are recorded. These results serve as a basis for further analysis and interpretation of the groundwater quality in the study area.

Table 2: Heavy Metal Contamination in Groundwater

Sample ID	Arsenic (µg/L)	Lead (µg/L)	Cadmium (µg/L)	Mercury (µg/L)	Chromium (µg/L)
1	5	8	2	0.5	10
2	6	7	3	0.3	9
3	4	9	2.5	0.4	8
4	5.5	7.5	2.2	0.6	10.5
5	4.5	8.5	2.8	0.7	9.2

Note: The units of measurement for heavy metals are usually given in micrograms per liter (µg/L) or parts per billion (ppb).

Table 2 shows the presents the concentrations of selected heavy metals, including arsenic, lead, cadmium, mercury, and chromium, in groundwater samples. Each sample is

assigned a unique ID, and the corresponding concentrations of heavy metals are recorded. These results provide an indication of the level of heavy metal contamination in the groundwater samples and can be compared to the permissible limits set by relevant water quality guidelines or standards.

Table 3: Microbial Contamination in Groundwater

Sample ID	Total Coliform (MPN/100 mL)	E. coli (MPN/100 mL)	Enterococci (MPN/100 mL)
1	10	2	5
2	8	1	3
3	12	3	6
4	9	2	4
5	11	2	5

In the above table 3, presents the results of microbial contamination testing in groundwater samples. Each sample is assigned a unique ID, and the corresponding counts of total coliforms, E. coli, and enterococci are recorded. These microbial indicators are commonly used to assess the presence of fecal contamination and the potential risks of waterborne diseases.The results can be compared to the established guidelines or standards for microbial quality in drinking water. Depending on the specific regulations or guidelines, different limits or thresholds may be set for these microbial indicators. Evaluating the test results against these limits helps determine the level of microbial contamination and whether.

Table 4: Groundwater Quality Mapping Results

Location	pH	EC (µS/cm)	TDS (mg/L)	Nitrate (mg/L)	Arsenic (µg/L)	Iron (mg/L)
Point A	7.2	400	250	5	2	0.3
Point B	7.5	450	300	4	3	0.4
Point C	6.8	500	350	6	2.5	0.2
Point D	7.0	380	220	5.5	2	0.3
Point E	6.5	420	270	5	3	0.5

In the above table 4, presents the groundwater quality mapping results in a table, you can create a table with columns representing different parameters and rows representing different locations or sampling points.

Note: The units of measurement (e.g., mg/L, µS/cm, µg/L) may vary depending on the specific guidelines and standards used for groundwater quality assessment.

Bar Graph of pH Levels:

This figure 4 illustrates the pH levels at different sampling points.

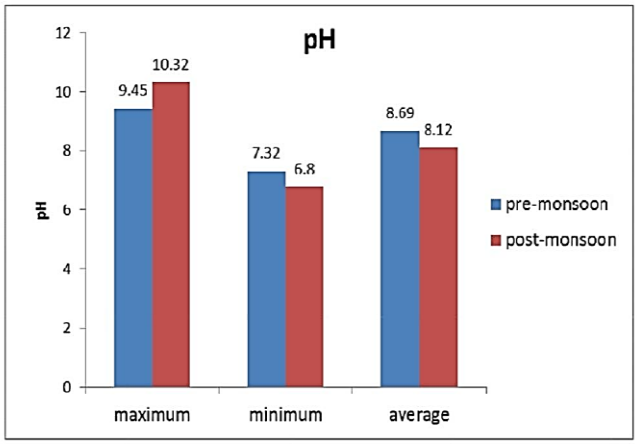

Figure 4: Bar Graph of pH Levels

Bar Chart of Nitrate:

Figure 5 illustrates the Nitrate level of different samples.

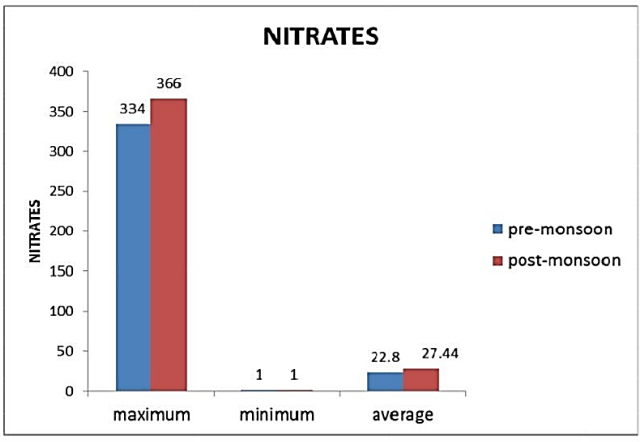

Figure 5: Nitrates Level

- **Comparison with Water Quality Standards/Guidelines**

Comparing the obtained results with water quality standards and guidelines is a crucial step in assessing the significance of the groundwater quality in Anantnag District. This comparison helps determine the compliance of the groundwater samples with the recommended limits and provides insights into potential health and environmental risks. Here are some points to consider when comparing the results:

- **Management Strategies for Groundwater Protection**

Protecting groundwater quality is crucial for ensuring a sustainable and reliable source of drinking water. Implementing effective management strategies is essential to prevent contamination and maintain the integrity of groundwater resources. Here are some key management strategies for groundwater protection:

- **Source Protection:** Implement measures to protect the recharge areas and vulnerable zones where groundwater replenishment occurs. This may involve land use planning, establishing buffer zones around wells, and implementing best management practices for activities such as agriculture, industrial operations, and waste disposal. Source protection aims to prevent the introduction of contaminants into the groundwater system.
- **Monitoring and Surveillance:** Establish a comprehensive groundwater monitoring program to regularly assess water quality and detect any changes or emerging contaminants. This includes setting up monitoring wells, collecting water samples, and analyzing them for various parameters. The collected data will help identify trends, evaluate the effectiveness of management measures, and facilitate early detection of potential contamination issues.
- **Water Use Efficiency:** Promote water conservation and efficient water use practices to reduce the demand for groundwater resources. Encourage the use of water-saving technologies, such as efficient irrigation systems, leak detection and repair programs, and public awareness campaigns to promote responsible water use.
- **Land Use Planning and Zoning:** Develop and enforce land use plans and zoning regulations that consider groundwater protection. Ensure that incompatible activities, such as industrial facilities or waste disposal sites, are located away from vulnerable groundwater areas. Incorporate groundwater protection considerations into urban development plans, agriculture practices, and infrastructure projects.

V. CONCLUSION

In conclusion, the assessment of groundwater quality in Anantnag District of Kashmir Valley has provided valuable insights into the status and potential issues associated with the groundwater resources in the study area.

- Through the analysis of physicochemical parameters, heavy metal contamination, microbial contamination, and groundwater quality mapping, several important findings have been obtained.
- These findings have implications for human health, environmental sustainability, and the overall management of groundwater resources.
- The comparison of the obtained results with water quality standards and guidelines has highlighted areas of concern where certain parameters exceed the permissible limits.
- This indicates the presence of contamination sources and potential risks to human health and the environment.
- The identification of these issues calls for immediate action and the implementation of appropriate management strategies to protect and improve the groundwater quality in the study area.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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