Abstract

Groundwater plays a pivotal role in providing stream flow during arid times and is an absolute necessity for several lakes and wetlands, as well as offering significant resources for people, plants, and aquatic wildlife. However, as populations grow and the demand for water increases, pressures on our groundwater resources also increase, leading to contamination from poor sanitation systems and pollution. To assess and analyse these vulnerable areas, geographic information systems (GIS) techniques were used for the study area selected in Kumbalgodu village of Bengaluru city (Karnataka, India).

Keywords

Groundwater, Geographic information systems, Water quality index, Sanitation

Introduction

Desalinated water and groundwater make up 63% (2.14 billion cubic meter) and 37% (1.26 billion cubic meter) of the annual water distribution, respectively [1]. Groundwater serves various purposes including domestic, drinking, industrial, and agricultural uses, with approximately 97% of irrigation water sourced from groundwater reservoirs [2, 3]. Despite being preferred for drinking due to its safety and quality compared to surface water, groundwater quality is increasingly impacted by human activities, leading to the introduction of physical, chemical, and microbial pollutants [4-6]. This contamination poses a significant global challenge affecting both human health and environmental stability [7]. The quality of groundwater is influenced by factors such as geological composition, weathering processes, recharge rates, and interactions between rock formations and water [8, 9]. Sources of aquifer degradation include both natural (lithogenic) and human-induced (anthropogenic) factors, as well as seawater intrusion [10, 11]. Anthropogenic sources of pollution stem from industrial discharge, agricultural runoff, wastewater, and waste disposal, while geological sources contribute to pollutants like sulfate from carbonate sedimentary rocks enriched with gypsum minerals [12]. Magnesium contamination may arise from natural sources like ferromagnesium minerals or anthropogenic activities such as industrial processes and mining. Calcium presence in groundwater can result from carbon dioxide in the soil and ion exchange processes [13]. Sodium contamination is attributed to evaporation, cation exchange, silicate weathering, and reactions of cation exchange, while chlorine can originate from anthropogenic sources or natural processes like mineral weathering and leaching [14, 15].

Waste management in the ecosystem is greatly influenced by nanoscience. Due to their extremely small sizes, nanomaterials have highly elevated surface-to-volume ratios compared to their bulk counterparts. A wide range of science and technology fields use nanomaterials as catalysts. Water purification with...
nanomaterials is of particular interest. As nano-adsorbents derived from waste materials are highly efficient (due to their high surface-to-volume ratio) and more effective against both cationic and anionic inorganic pollutants, they can be applied to one-step water treatment. In agriculture and water quality management, nanomaterials are used in different types and shapes according to the needs.

Experimentation

Details of study area

Kumbalgodu a quaint village in Bengaluru district of Karnataka, India (Figure 1). It falls under Bengaluru South Taluk. lies between Lat Long: 12°52’22"N 77°26’54"E covering over an area of approximately 4.92 sq.km The Kumbalgodu town has population of 10178, as per the Census data.

Sample collection and testing

The current investigation is attempting to examine the existing condition of the groundwater around the Vrishabha vathi river (Figure 2) and industrial area of Kumbalgodu village. We analyzed the quality properties of the groundwater to evaluate the contamination's effects. To collect groundwater samples, grab sampling was utilized and the samples were analyzed according to the Bureau of Indian Standards (BIS 2016. Samples are collated in cleaned, polyethylene containers of 2 L were cleaned twice by rinsing with collected water sample and stored in a cooler at 4 °C in the laboratory. Premonsoon samples (February to June) were collected from 19 bore wells at 19 sampling points on a monthly basis, labeled as S1 to S19 for identification. Figure 3 show the sampling locations and the Google Image of the study area.

In order to conduct a statistical analysis, a correlation matrix was adopted and the water quality parameters that were analyzed included physical water quality parameters include eight principle indicators: electrical conductivity, salinity, total dissolved solids, turbidity, temperature, color, and taste and odor. Chemical water parameters include pH, acidity, alkalinity, hardness, chlorine, fluoride, nitrate, sulfate, and iron.

Results and Discussion

The parameters of water testing results gave the information of health of water and their characteristics were represented in figure 4 to figure 13 and were evaluated to ensure the BIS standards prescribed in IS: 10500:2016.

Carbonates, bicarbonates, and hydroxides caused alkalinity levels in natural waters to vary from 152 (S11) to 488 (S10) mg/L as CaCO₃. In this study, 90% of the collected groundwater exceeded the 200 mg/L as CaCO₃, the sample S12 having the highest recorded pH at 8.85. The pH value of the few samples ranged between 6.4 and 8.85. The electrical conductivity in the Kumbalagodu area scaled from 0.3 to 1.9 mS/cm, with the exception of sample S8, all samples surpassing with value limit in the range of 0.5 mS/cm. The main cations responsible for causing hard water were ferrous, manganese, calcium, and magnesium ions. Analysis carried out for groundwater in selected area revealed that bicarbonates, sulfates, chlorides, nitrates, and silicates were all important contributing anions. Total hardness ranged from 32 mg/L to 840 mg/L as CaCO₃, with 60% of the samples exceeding the permissible limit. The chloride anion was the one primary inorganic ion contained in water as well as in the wastewater. Salinity in the water is greatly depending on the chemical composition, such as chloride, sodium, calcium, and magnesium ions. For example, 250 mg/L of chloride can produce a taste like salt, if the cations are sodium, while a 1000 mg/L of chloride may be undetectable when the preponderant cations of magnesium and calcium [4]. According to the study, the concentration of chloride in water samples ranges from 42 to 401 mg/L, 21% samples exceeding BIS required limit of 250 mg/L. The iron concentration in sample water is high could be attributed to various problems like, rusting in the casing pipes, iron contaminants are perco-
lated through the gap of bore hole and the casing pipe, scrap waste iron disposed in open dumped areas, and contamination of water caused by industrial processes, as indicated in reference [5], are some of the common sources of iron contaminatio-
tion. High content of iron concentration was found in sample S10, and the lowest was found in S5. Nine samples exceeded 0.3 mg/L. Sulfate levels of the study area ranged from 138 to 661 mg/L, and ten water samples did not exceed the limit of 200 mg/L. Nine samples crossed the range with higher values, which indicates an abundance of sulfate in industrial waste.

The exceeded nitrate values in selected groundwater samples, which ranged from 38 to 159 mg/L, may have been due to the seepage of contaminated liquids from industrial effluents, agricultural chemicals, sewage waste, soak pit and septic tanks.
This suggests and the results groundwater has been significantly impacted by nitrate pollution.

The water quality index (WQI), a potent and effective operative tool for monitoring both surface and groundwater pollution. It is extremely useful in improving water quality programs, as it provides information on a rating scale from 0 - 100. Ten quality characteristics of water tested and are used in the calculation of this index. We calculated the WQI according to the for drinking water standards set by the World Health Organization, BIS, and Indian Council for Medical Research, using the Weighted Arithmetic Index Method. Additionally, the water quality rating, or sub index (qn), calculated equation 1.

\[
qn = 100\frac{(Vn - Vio)}{Sn - Vio}
\]  

(1)

To determine the rate of quality for all the selected water parameter, we compare the parameter’s value at point of collection to its consummate value in clear water (except for pH and dissolved oxygen with ideal values of 7.0 and 14.6 mg/L, respectively) and the standard permissible value.

The unit weight was determined by comparing the suggested standard value for the congruous parameters to the actual value, with the result being inversely proportional.

\[
Wn = \frac{K}{Sn}
\]  

(2)

Where, Wn n\textsuperscript{th} parameters for unit weight and Sn are n\textsuperscript{th} parameters for standard value, and K being proportionality constant.

By averaging the quality rating with the unit weight linearly, the overall WQI was calculated.

\[
WQI = \frac{\sum qn Wn}{\sum Wn}
\]  

(3)

According to table 1, water samples tested are shows that there is no sample fall under ‘Excellent’, and sample no. S19 being marginal and the rest being unsuitable for drinking. The spatial map of the WQI shows most of the water collected points have poor water quality (Figure 14).

### Conclusion

The results obtained from the study found that 19 groundwater samples had physicochemical characteristics that exceeded the BIS limits in certain sampling stations. The groundwater quality in the Kumbalgodu industrial area and Virsibhavathi River is not safe for human consumption without proper treatment. Stringent rules, awareness, attention, and monitoring are immediately required to prevent further pollution. Proper treatment must be employed for any effluent or industrial waste being disposed of in order to prevent groundwater contamination.

### Acknowledgements

None.

### Conflict of Interest

None.

### References


