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The spatial distribution of various groundwater quality parameters and perform hydro chemical studies to understand the groundwater quality status in the Bhiwani and Hisar district area

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Abstract
Overuse of groundwater in the districts of Bhiwani and Hisar over time may have an impact on the quantity and quality of groundwater. Groundwater in the unconfined aquifer has been significantly impacted in some areas, although deep confined aquifers that are typically protected are not as affected. Particularly in coastal regions where seawater intrusion is frequent and variations in water salinity take place within a certain time frame, the wide-ranging impact—particularly on groundwater quality—is extremely noteworthy. In light of these circumstances, studies were conducted on variations in the temporal and spatial distribution patterns of groundwater quality, as well as on the salinity-related physical and chemical characteristics of constrained aquifer conditions in coastal regions. Groundwater depth and physico-chemical parameters were connected. There was a negative correlation between groundwater depth and all the indicators.

Keywords: Groundwater, quality parameters, hydro chemical, Bhiwani, Hisar

Introductions
One of the most crucial sources of water for a variety of human endeavors is groundwater. Both urban and rural communities are depending more and more on groundwater supplies as a result of declining surface water quality. As a result of resource misuse, groundwater quality and quantity are constantly under danger. Deteriorating groundwater quality and a declining groundwater table are now widespread issues worldwide. India is one of the biggest users of groundwater resources, which are not uniformly distributed throughout the nation. There is a dearth of scientific data in India since the recharging and discharge mechanisms of subterranean water are not fully understood and are primarily estimated. Rapid growth in the number of groundwater withdrawal structures has resulted in overuse and resource depletion. The Indian capital is experiencing a severe water crisis as a result of the constant and significant population growth, with groundwater providing around 50% of the water needed. The aquifers of the groundwater are very useful for the agricultural, industrial and domestic purpose in the regions of Hisar and Bhiwani in Haryana, India particularly in the arid and semi-arid zones. This is due to these areas being in a greater reliance with the groundwater because they have limited water from the surface. For this reason, they are liable to be contaminated and overused. Population pressure on these areas due to agricultural growth, urbanization and increased population is creating more pressure on the available groundwater. It is equally important to have accurate information of the quality and availability of groundwater at the right time. Remote Sensing and Geographic Information Systems are effective geospatial tools for evaluating the groundwater; vulnerability zone mapping and land use and land cover changes.
It is widely used as a source of drinking, irrigation and industrial water where there is little or no surface water. Due to high population growth rate, increased urbanization and agricultural activities, the demand of water has increased tremendously which put lot of pressure on ground water resources and most of the areas are over exploited and deteriorated. Hisar and Bhiwani, situated in the arid and semi-arid region of Haryana, are the most affected areas of Haryana due to groundwater pollution and depletion, especially with the help of improper rainfall distribution and excessive irrigation.

When the quality of groundwater degrades due to salinity, nitrate content, and industrial waste water on account of various reasons, its spatial distribution and its susceptibility should be identified for better water management. Remote sensing and geographic information systems, therefore, have been identified as useful tools in groundwater potential and quality assessment through integration of several environmental factors.

All life on Earth, including human life, has long depended on water to survive. Despite the fact that water makes up the majority of the Earth's makeup, not all forms of water are suitable for direct human consumption. Only groundwater, which makes up 0.625% of all water on Earth, is ideal for meeting needs because it is up to 96% freshwater. It is because it is easily accessible and has a wide range of applications that might impact the social and economic circumstances of a region. Based on data from 2010, the expected global groundwater extraction rate is 982 km^3 per year, with the United States, China, and India using the most groundwater. Aquifers, which are rocks beneath the surface that have the capacity to store and release water, are the source of groundwater. The aquifer is separated into two types: confined aquifers, which are enclosed by two impermeable layers, and free aquifers, which are situated directly below the ground surface and in direct contact with the air. Some people prefer to dig private or group wells to draw groundwater from a deep constrained aquifer, but most communities, especially those near water sources, use shallow groundwater by digging wells and springs. Particularly in emerging nations, the number of wells being constructed has expanded dramatically, necessitating a high level of fresh and clean water supply. The number of wells that do not supply information to local authorities or policymakers to enable monitoring of the amount and quality of wells and water has not been taken into account in this condition. The quantity and quality of groundwater have changed significantly throughout time. It has decreased in this instance. Excessive and unregulated pumping is the primary cause of a number of situations, including the decline in mean groundwater level, saltwater or seawater intrusion, draining of river flows, and 1& subsidence. These effects will not be felt immediately, but they will gradually become more noticeable and cause adverse effects, particularly in coastal regions where groundwater fluctuations are more dynamic.

Literature Review

Omolaye and Sanuade (2020) [2] used remote sensing, GIS and 2D resistivity technique to assess the groundwater resources in Obafemi Owode LGA Ogun State Nigeria. The surface water potential was also checked with the existing well and it was observed that there is a good match for the future irrigation and water development. Saha and Chowdhuri (2023) [4] assessed flood hazard susceptibility of the Kangsabati river basin, West Bengal, with machine learning (SVM, RF, and ANN) applied to a GIS platform. They solved the nonlinear issues involved in causative factor relationships, making the analysis complex. Their results can be utilized in the formulation of flood mitigation strategies and inform future studies on flood susceptibility mapping. Thakur and Jakariya (2022) selected 41 articles on the application of geospatial technology in groundwater hydrology for sustainable water resources. It also discussed water quality parameters, pollution and salinity threats, with a focus on the application of geographic information systems in groundwater pollution and its effects on the health of the people as per UNSDGs 3 and 6. Wenlong and Qiaomin (2020) have associated the increase in flash floods to geographical factors and climate change. They proposed a flood sensitivity mapping approach using the Analytical Hierarchy Process (AHP) that incorporates elevation, slope, and land use and drainage density data coupled with remote sensing data. The study pointed out that weak infrastructure and lack of preparedness were the causes of flood disasters and recommended the use of this model in other such regions for better flood handling and development. Shelar and Nandgude (2023) [7] examined groundwater potential in the Urmodi River Basin, where decreasing levels have long plagued the area. The results indicate potential for sustainable groundwater utilization and serve as a model for subsequent analyses. Pal *et al.* (2020) [4] evaluated the Purba Bardhaman district groundwater potential through GIS and remote sensing. They considered several geo-environmental parameters such as land use, soil, litho logy, rainfall, and distance from rivers, using the multi-criteria decision analysis (MCDA) technique. Panda and Sabarathinam (2023) stressed on the importance of groundwater for social, agricultural, and environmental needs and also emphasized the significance of the remote sensing, geophysical information, and GIS applications for efficient utilization. The research on the groundwater potential categorized them into five zones that include the topsoil thickness, pediments, litho logy, slope, and rainfall that defined the availability of the water. Ranjan and Borah (2021) [11] used RS, GIS and AHP model to identify FVZ in Kanya Kumari district. The study established the southern, southeastern, southwestern, and parts of the northeastern areas as high-vulnerability areas. Lee *et al.* (2020) [1] noted the importance of groundwater in the rural areas and used GIS coupled with machine learning models for the evaluation of the groundwater yield index in Yangpyeong-gun, South Korea. The study has provided evidence on the applicability of machine learning in data-scarce areas to model groundwater and support sustainable use. Mansour and El-Baz (2022) noted that RS and GIS techniques are effective in identifying the GWPZs in the arid regions like the Sahara. The NDVI data validation also justified the GWPZs map prepared in the study confirming the applicability of GIS based multi-criteria approach in the management of groundwater resources in arid zones. Shirazi and Kazmi (2020) [6] have established the relationship between population growth, natural resource, and urbanization with reference to Lahore, the second-largest city of Pakistan having a population of 6,318,745 in 1998. The authors provided evidence that RS and GIS were effective in analyzing the growth of urban areas, the use of land and to identify the suitable areas for expansion in Lahore. Singh and Agrawal (2023) studied the use of geospatial techniques for assessment of groundwater in hard rock aquifers with the help of Jakham river basin. The method based on the groundwater level data can be used as a reference for the planning of the groundwater recharge and the artificial recharge structure in arid regions.

Tiwari and Chaudhary (2021) explained the need to apply sustainable management and presented RS, GIS and geo statistical as important techniques for assessment and management of the groundwater resources. Yassine and Mohammed (2021) applied GIS and remote sensing in

mapping groundwater potential in the fractured conditions of lower Chaouia. The study indicated that the area consisted mainly of Very Weak and Weak groundwater zones (51%), followed by Medium (31%) and Strong (18%) zones. Sikakwe (2020) [8] identified the groundwater potential zones in Oban Massif through geospatial analysis of satellite data and GIS software for the area of 677,298 km² based on the parameters such as geology, geomorphology, lineament density, and land use. The results of multi-criteria analysis of the groundwater potential map included four classes: very good, moderate, fair, and poor. Tolche (2021) [9] employed weighted index overlay analysis on the basis of remote sensing and GIS to evaluate groundwater potential in the Dhungeta-Ramis sub-basin, Ethiopia. The research concluded that the map that was produced would be a helpful guide for finding appropriate locations to exploit groundwater. Zhu and Abdelkareem (2021) [12] adopted the knowledge-based method to assess the groundwater potential of Sahara using geologic, geomorphic, seismic, hydrologic and remote sensing data. Established in the study area of Egypt's Kom Ombo, their model used other criterion such as satellite data including ALOS/PALSAR, SRTM and Sentinel-1 in identifying the GPZs. The study highlighted the effectiveness of GIS and remote sensing in mapping of groundwater resource in arid zones.

Scope of the study

This analysis will be done on Nitrate, Magnesium, Fluoride, pH, Sulphate, and Electrical Conductivity of the groundwater as well as the identification of areas of high potential for groundwater and areas of groundwater vulnerability to pollution. Based on the Random Forest classification, IDW interpolation, SMA and other techniques in groundwater vulnerability mapping used in the current study, the research aims at explaining the temporal and spatial changes in the quality of groundwater and impacts of land use changes on these resources. These will help in developing sound polices on management of groundwater and some of the recommendations include combating groundwater loss and pollution in these major areas.

Objective

To find the Spatial Distribution of Various Groundwater Quality Parameters and Perform Hydro Chemical Studies to Understand The Groundwater Quality Status in The Bhiwani and Hisar District Area

Research Methodology

The study area covers Hisar and Bhiwani districts in the arid and semi-arid regions of Haryana state of India, where favorable ground water situation has been a major issue due to over exploitation, seasonal variation and unavailability of surface water. The districts have seen development in the sector of agriculture, industrialization and growth of population and all these factors have put lots of pressure on the available ground water in the area. Hisar and Bhiwani districts are the two important areas of assessment of the quality and availability of groundwater since the two districts rely on the ground water for irrigation, drinking and other uses. This study area has been selected for the purpose of evaluating the spatial and temporal fluctuations of the factors that affect groundwater quality like Nitrate, Magnesium, TDS, Sulphate, pH, Fluoride, Calcium, Chloride and Electrical. Furthermore, the current quality of the groundwater resources of the area and the possibilities of water pollution due to human activities are also going to be analyzed in the laboratory and by using spatial data. As the groundwater behavior in the region is highly complex and since there exist both the satellite imagery and other geospatial data Hisar and Bhiwani is suitable for this entire geospatial analysis to aid in the planning and the development of sustainable groundwater resource.

Results and Discussion

When groundwater quality data is processed, electrical conductivity is the first outcome. An overview of the pattern and amplitude of the regional and temporal changes in the electrical conductivity value in the research area is given by the data in Table 1. According to the statistics, the pattern of change from 2019 to 2023 differs. The area of EC value, which is represented as brackish water, grew between 2019 and 2020 before sharply declining between 2012 and 2023, particularly in the northern and central regions. Nonetheless, over that period, regions with varying electrical conductivity values emerged, suggesting the introduction of new distributions in the western portion of the research area in 2022 and 2023.

Table 1: Data on groundwater quality and EC value area (km²) in relation to salinity parameters for the years 2019-2023

Groundwater Quality Type according to EC	Distribution of Area in Year				
	2019	2020	2021	2022	2023
Fresh Water	130.02	130.05	99.55	110.22	105.11
Brackish Water	14.09	14.21	40.12	25.44	35.12
Saltwater	-	-	-	-	-

Total dissolved solids (TDS) are the second outcome of processing the groundwater quality data that was acquired. An overview of the pattern and amplitude of the temporal and spatial changes in the TDS value in the research region is given by the data in Table 2. According to the data provided, the pattern of change from 2019 to 2023 varied. The region with the TDS value indicated as brackish water, which had grown from 2019 to 2020, saw a notable increase until 2020, when areas with saltwater type appeared, after which the area saw a decrease, particularly in the north. While the center region is expanding in the northern part of the process, it appears to be locally tied to changes in the kind of groundwater salinity in the central and northeastern regions.

Table 2: Details on groundwater quality and TDS value area (km²) in relation to salinity factors for the years 2019-2023

Groundwater Quality Type according to TDS	Distribution of Area (km²) in Year				
	2019	2020	2021	2022	2023
Fresh Water	139.55	139.55	132.55	139.55	139.55
Brackish Water	0.50	0.96	5.25	7.02	6.56
Saltwater	-	-	0.74	0.20	0.15

The third result of processing the collected groundwater quality data is the degree of acidity (pH). The information in Table 3 provides a summary of the pattern and magnitude of the regional and temporal fluctuations in pH values within the study area. The data indicates that between 2019 and 2023, the pattern of change changed. Between 2019 and 2020, the area of the pH value that was identified as

brackish water expanded significantly. From 2019 to 2020, it increased once again, and in 2023, areas with typical saltwater appeared. While the west and south exhibit localized changes linked to differences in groundwater salinity types, the north, east, northeast, southeast, and middle are the main areas that grow during the process of change. According to the classification, there are three categories of groundwater salinity based on the range of TDS values obtained: freshwater, which has a value range of roughly 7 to 8, brackish water, which has a value range of 8 to 9, and saltwater, which has a value range of greater than 9.

Table 3: Details on the area's size (km^2), pH, and groundwater quality with reference to salinity factors from 2019 to 2023

Groundwater Quality Type according to pH	Distribution of Area (km^2) in Year				
	2019	2020	2021	2022	2023
Fresh Water	110.22	87.05	81.05	75.77	69.40
Brackish Water	29.08	55.05	59.20	70.30	69.90
Saltwater	-	-	-	-	0.01

Conclusion

Significant oscillations occurred in the spatial and temporal distribution of groundwater quality categories based on salinity parameters in restricted aquifers in Semarang City's Alluvial Plain between 2019 and 2023. A number of factors saw both a sharp decline and expansion, as well as a gradual increase. Some parameters resulted in two types of salinity—freshwater and brackish water while the remaining parameters produced three types that were supplemented with saltwater, according to the reference grouping based on the type of salinity.

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