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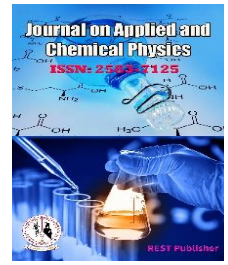

Assessing the Groundwater Quality in Urban Areas Using the DEMATEL Method

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Abstract: *The Dhanbad area in Jharkhand, India, is a significant coal mining region located in the middle of the Damodar River basin. The geological composition of the area ranges in age from to Recent, encompassing, granites, pegmatite, and gneisses. These rocks are accompanied by bands of s and amphibolites. In this particular region, groundwater occurrence and movement are primarily restricted to semi weathered/weathered and fractured rocks. The movement of groundwater depends on various factors, including the thickness, size, extent, and openness of the weathered zone, as well as the interconnections of fractures within the rocks. Due to the dynamic nature of groundwater resources, it is susceptible to various factors that can impact its availability and quality. The expansion of irrigation activities, industrialization, and urbanization in the area can have significant implications for the groundwater resources. These activities can lead to increased water demand, contamination risks, and changes in the hydrological balance. Given the importance of groundwater as a vital resource, it becomes crucial to monitor and conserve it effectively. Monitoring techniques, such as hydrological studies, geophysical surveys, and groundwater level measurements, can provide valuable information about the status and behavior of groundwater resources. Conservation efforts may involve implementing sustainable water management practices, promoting water-use efficiency, and controlling pollution sources. By utilizing GIS and available physic-chemical data, the study seeks to generate a comprehensive water quality index map that can assist in making informed decisions regarding water resource management and protection in the Dhanbad area. This understanding can help in developing sustainable strategies to ensure the availability and quality of groundwater in areas like, where natural resources are intricately linked to human activities and industrial development. The variations in the resistivity of water-bearing weathered/fractured rocks in the Dhanbad area depend on the specific geological characteristics of the rocks and their water content. The resistivity refers to the rock's ability to resist the flow of electric current and can provide insights into the rock's porosity and permeability, which are crucial factors for groundwater movement. The depth to groundwater in the area can vary and is typically measured from below ground level. This depth is influenced by factors such as local topography, rainfall patterns, and geological conditions. The presence of active and abandoned coal mines, waste dumps, coal washeries, coking coal plants, and thermal power plants can introduce pollutants into the environment. These pollutants have the potential to contaminate groundwater, affecting its quality and usability. It is important to address these environmental concerns and prioritize the implementation of effective measures to mitigate the impact of coal mining and related activities on groundwater resources. Alternative parameters taken as Total dissolved solid, total hardness, Nitrate, ammonia nitrogen, Fluoride, Fluoride. the first ranking training is obtained with the lowest quality of compensation.*

Keywords: *MCDM (DEMATAL) method, Groundwater quality assessment*

1. INTRODUCTION

Mining operations can potentially affect groundwater through the disruption of geological formations, changes in water flow patterns, and the release of contaminants into the aquifer system. Proper monitoring, regulation, and mitigation measures are necessary to safeguard the groundwater resources in this region. Overall, recognizing the dynamic nature of groundwater resources and the factors that impact them is essential for effective monitoring and conservation. Furthermore, the water infiltration ratio, which refers to the rate at which water can penetrate into the ground, has been impacted by these changes. With urbanization and alterations to the natural landscape, the water infiltration ratio may have decreased, leading to reduced recharge of groundwater. This, in turn, can lower the groundwater levels in the area. The inadequate implementation of environmental protection measures in the coal mining and related industries has contributed to the challenges facing groundwater resources in Dhanbad. Singh and Lawrence conducted a groundwater quality map using GIS for Chennai city, Tamil Nadu. However, assessing groundwater quality in the Dhanbad district presents greater difficulties due to the spatial variability of multiple contaminants and the wide range of indicators that need to be measured. Although numerous publications have focused on identifying groundwater potential zones using resistivity surveys and remote sensing data, there is a lack of systematic and updated publications or databases specifically addressing the creation of a water quality index map for the study region. In light of this, the Department of Applied Geophysics at the Indian School of Mines University undertook a study with the main objective of assessing groundwater quality in the Dhanbad area using GIS. The study utilized available physic-chemical data provided by Singh et al. as a basis for their assessment. The aim was to generate a water quality index map specifically for the Dhanbad district. By employing GIS technology, the researchers integrated various parameters and measurements relevant to groundwater quality assessment. These parameters include indicators such as electrical conductivity, total dissolved solids, concentrations of contaminants, and other pertinent factors. The integration of these data points provides a comprehensive understanding of water quality across different areas of the Dhanbad district. The generation of a water quality index map using GIS can be a valuable tool for visualizing and communicating the spatial distribution of groundwater quality in the study region. This map can assist decision-makers, policymakers, and environmental agencies in identifying areas with water pollution concerns and implementing appropriate measures to mitigate and control contamination issues. Given the lack of a systematic and updated publication or database for a water quality index map in the Dhanbad district, the work carried out by the Department of Applied Geophysics at the Indian School of Mines University will contribute to filling this gap. The study aims to enhance the understanding of groundwater quality in the region and provide valuable insights for effective water resource management and pollution control efforts. The Department of Applied Geophysics at the Indian School of Mines University conducted a study with the primary objective of assessing groundwater quality in the Dhanbad district using GIS (Geographic Information System). The study utilized the available physic-chemical data provided by Singh et al. as a basis for their assessment. Using GIS technology, the researchers integrated and analyzed various physic-chemical parameters related to groundwater quality in the Dhanbad area. These parameters may include pH, electrical conductivity, total dissolved solids, concentrations of contaminant, and other relevant factors.

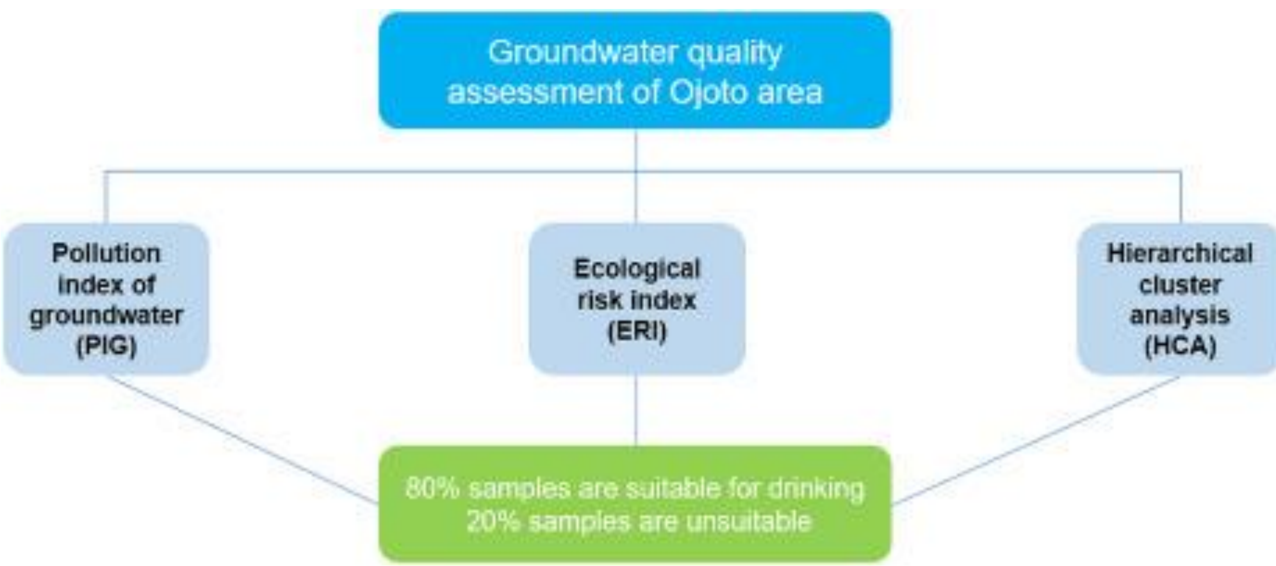

Figure 1. Groundwater quality assessment

2. Materials and methods

Evaluation parameter:

Total dissolved solid: The replenishment of groundwater primarily occurs through the process of recharge. Recharge happens when water from precipitation, surface water bodies (such as rivers and lakes), or irrigation infiltrates into the ground and percolates down to the aquifers. In arid and semi-arid regions, where rainfall is limited and unevenly distributed, recharge may be low, leading to a decline in groundwater levels over time. Over drafting of groundwater resources, which refers to the extraction of groundwater at a rate faster than its replenishment, is a common issue in arid and semi-arid regions.

Total hardness: The quality of groundwater is influenced by various factors. The water quality of recharged water, including atmospheric precipitation and inland surface water, plays a role in determining groundwater quality. Additionally, sub-surface geochemical processes, such as mineral dissolution and ion exchange, can affect the composition of groundwater. Human activities, such as industrial discharge, agricultural runoff, and improper waste disposal, can also introduce pollutants into groundwater, leading to water contamination. Temporal changes in groundwater quality can occur due to variations in the origin and constitution of the recharged water, as well as hydrologic and human factors. For example, seasonal fluctuations in rainfall patterns or changes in land use practices can impact the quality of recharged water, subsequently affecting groundwater quality.

Nitrate: Managing groundwater resources in arid and semi-arid regions requires a comprehensive understanding of the local hydrological system, including the occurrence, replenishment, and quality of groundwater. Implementing sustainable water management practices, such as promoting efficient irrigation techniques, monitoring groundwater levels, and enforcing regulations to prevent water pollution, are crucial for preserving groundwater resources and ensuring long-term water security in these regions. Collaboration among stakeholders, including governments, communities, and water management authorities, is essential to address the complex challenges associated with groundwater in arid and semi-arid regions. groundwater for their water needs. The availability of reliable and sustainable groundwater resources is crucial for the development and growth of the region. concepts can aid in the interpretation of complex data sets related to water quality parameters. involves the analysis and modeling of spatially distributed data, considering their spatial dependence and variability.

ammonia nitrogen: Water pollution poses significant challenges to groundwater resources and has far-reaching consequences. Contaminants in groundwater not only degrade water quality but also pose risks to human health when used for drinking or irrigation. Moreover, polluted groundwater can have detrimental effects on ecosystems, agricultural productivity, and economic development in the affected areas. By applying techniques, researchers can better understand the spatial patterns and variations of water quality parameters, such as pollutant concentrations or physicochemical properties, across the study area. This helps in identifying areas of potential contamination or areas with better water quality. Assessing risk is an important aspect of water quality management. It involves identifying potential hazards or sources of contamination and evaluating the probability of those hazards occurring. This risk assessment allows for informed decision-making and prioritization of actions to mitigate or manage the identified risks. analysis can contribute to risk assessment by providing spatial information on the distribution and potential sources of contaminants, enabling authorities to focus their efforts on areas of higher risk.

Fluoride: This overuse can result in the depletion of aquifers, causing a significant drop in water levels and potentially leading to land subsidence or saltwater intrusion in coastal areas. In the specific case of the sub-basin, which is characterized by a hard rock terrain and relies heavily on groundwater, understanding the quantity and quality of groundwater is of paramount importance. With a major portion of rainfall occurring during the northeast monsoon, surface water sources may be unreliable during other seasons. Thus, people in the region depend largely on groundwater to meet their water needs outside of the monsoon period. To ensure sustainable water resource development, it is crucial to establish a comprehensive database of groundwater quantity and quality.

SUM.: This step reflects the importance of each parameter in the overall WQI calculation. Calculate the WQI: Sum up the sub-index values for all parameters to obtain the total WQI. The resulting value represents the overall water quality of the local body. Interpret the WQI: Based on the obtained WQI value, interpret the water quality as excellent, good, fair, poor, or very poor. This interpretation provides an easily understandable classification of the water quality. Establish a continuing record: Maintain a record of the calculated WQI values over time to track any changes or trends in water quality.

Interconnected hydrological systems that play a crucial role in They are often formed by geological processes that result in the accumulation of water in underground rock formations, such as fractured rocks, porous sediments, or formations. This database serves as a valuable resource for planning future water resource strategies, including identifying areas with potential groundwater reserves, determining suitable locations for groundwater extraction wells, and implementing appropriate water treatment and management practices. Overall, the evaluation of groundwater quantity and quality through analysis and risk assessment is essential for effective water resource management, sustainable development, and the well-being of communities in the study area and beyond The proposed characterization of hydro chemical processes in the study area is crucial for understanding the behavior of the aquifer and assessing the groundwater quality. Given the dominance of local human activities, agricultural practices, and industries in the region, there is a significant potential for contamination and the need to protect the groundwater environment. One approach to characterizing hydro chemical processes is to evaluate various water quality parameters and classify water based on specific indices. Sodium percentage (Na%), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), total hardness (TH), and water quality index (WQI) are commonly used indicators for assessing groundwater quality. The sodium percentage (Na%) indicates the proportion of sodium ions in relation to other s present in the water. High sodium levels can lead to soil degradation and reduce water suitability for irrigation. The sodium adsorption ratio (SAR) assesses the potential of water to cause sodium adsorption on soil particles. High SAR values indicate a higher risk of soil degradation due to increased sodium content. Residual sodium carbonate (RSC) measures the concentration of carbonate and bicarbonate ions, which can contribute to the alkalinity of water. High RSC values may affect the suitability of water for irrigation purposes. Total hardness (TH) quantifies the concentration of divalent such as calcium and magnesium, in the water. High levels of hardness can lead to scaling issues in water supply systems and affect the suitability of water for various purposes. Water quality index (WQI) is a composite parameter that integrates multiple water quality parameters into a single value. It provides an overall assessment of water quality and helps in comparing the quality of water from different sources or over time. By analyzing these parameters and calculating the respective indices, researchers can gain insights into the hydro chemical processes in the study area. This information helps in identifying potential sources of contamination, understanding the impact of natural and man-made activities on groundwater quality, and establishing a basis for water quality management and protection measures.

3. DEMATEL METHOD

The DEMATEL method is a particular problem, pin-up binding work through problems and structural modelling techniques contribute to identifying solutions that a hierarchical system can work on, relationships between dependencies and the fundamental idea of situational relationships that identify system components for a reason can influence the impact of factors. Management and emergency response are connected with the DEMATEL system. It is not necessary to decompose the fuzzy numbers in the suggested way before using the DEMATEL algorithm [12]. It use visualisation method analysis to analyse and resolve issues and is based on the fundamental DEMATEL principle. In this organised approach, modelling takes the shape of a motivating diagram, which shows the causal relationship and its importance in illustrating how various components interact. All elements are a causal group and are split into effect groups by looking at the visual relationship of conditions between systematic factors. It offers structure between computer components, a clearer knowledge of the relationship, and the ability to come up with sophisticated solutions to computer issues [13]. The DEMATEL method changes the appropriate method for selecting a management device among many configurations, effectively calculates inter-criteria impacts, divides a set of complex components into a sender organization and a receiver organization. The zogp model enables firms to plan the adoption of ideal management systems while making the most of their limited resources [14]. To reduce the impact or affect the constraints, decision-makers must ascertain the limitations of the legal framework and guarantee that it is controlled. As a result, there is considerable consistency between the outcomes of the DEMATEL and ism techniques. The structure of these constraints' interconnections is determined by integrated ism DEMATEL results for e-waste management constraints [15]. The relative weights of decision-makers in the DEMATEL approach, which currently do not take into consideration the incorporation of group decision-making, formed one of the preliminary flaw clusters as a result. Methods based on unstructured comparisons, such DEMATEL [16], are thought to be a substantial factor in the aforementioned disparities. It is common practise to utilise DEMATEL to classify elements into cause and effect categories and examine the overall relationship between components. As a result, each source is taken into account while making decisions in this essay. Based on DEMATEL, it is possible to combine the DEMATEL method with source theory to better manage the importance and level of importance of each source. In this article, corresponding propositions between bodies of evidence are modified in place of the comparison criteria provided by experts in DEMATEL [17]. The DEMATEL technique and integrated multidimensional decision making (MCDM) were used to establish causal links between the evaluation criteria for the outreach workforce initiative.

4. RESULT AND DISCUSSION

TABLE 1. Groundwater quality assessment data set

	Total dissolved solid	Total hardness	Nitrate	ammonia nitrogen	Fluoride	Sum
Total dissolved solid	0	3	3	4	5	15
Total hardness	3	0	4	2	1	10
Nitrate,	2	5	0	3	3	13
ammonia nitrogen	4	3	2	0	3	12
Fluoride	1	3	2	5	0	11

Table 1 shows Groundwater quality assessment **"**Alternative: Analog & Digital Electronics, Power Systems, Electric Circuits, Electric Machines, Digital Controllers, Sum**" "** Evaluation preference: Total dissolved solid, Total hardness, Nitrate, ammonia nitrogen, Fluoride, Fluoride Groundwater quality assessment**."** the total of all the parameters with high values. The highest value is seen in table 2, where 15.

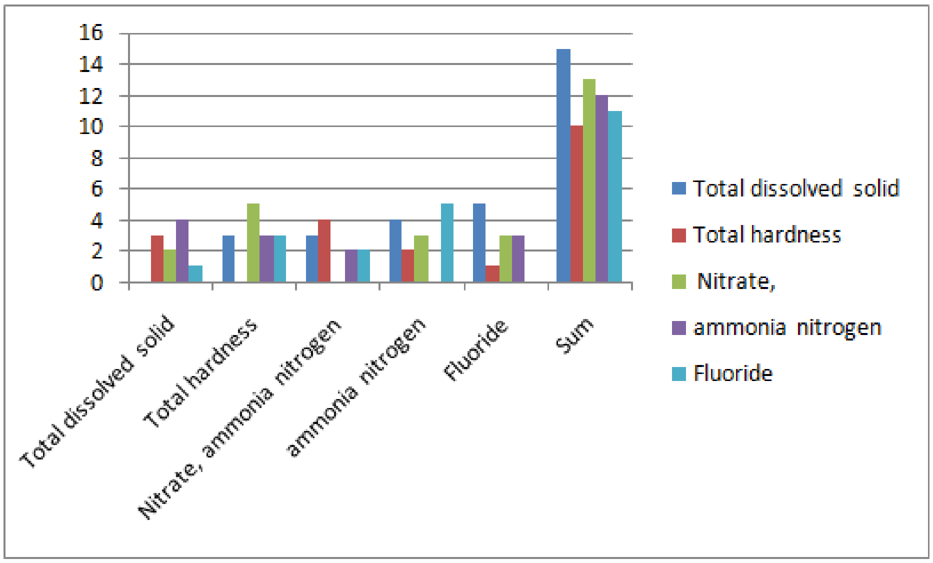

FIGURE 2. Groundwater quality assessment

Figure1 Shows the in use Groundwater quality assessment "Alternative preference for Analog & Digital Electronics, Power Systems, Electric Circuits, Electric Machines, Digital Controllers" Evaluation preference for Total dissolved solid, Total hardness, Nitrate, ammonia nitrogen, Fluoride, Fluoride Groundwater quality assessment." It is an assessment and comparison of any two facilities.

TABLE 2 Groundwater quality assessment Normalization of direct relation matrix

	Total dissolved solid	Total hardness	Nitrate	ammonia nitrogen	Fluoride
Total dissolved solid	0	0.2	0.2	0.266666667	0.333333333
Total hardness	0.2	0	0.266666667	0.133333333	0.066666667
Nitrate,	0.133333333	0.333333333	0	0.2	0.2
ammonia nitrogen	0.266666667	0.2	0.133333333	0	0.2
Fluoride	0.066666667	0.2	0.133333333	0.333333333	0

Table 3 displays the normalised direct relation matrix for the Groundwater quality assessment Total dissolved solid, Total hardness, Nitrate, ammonia nitrogen, Fluoride, Fluoride Groundwater quality assessment." Figure 2 shows that all of the data's diagonal values are zero. Consider the Y Value in Table 3.

TABLE 3. I= Identity matrix

1	0	0	0	0
0	1	0	0	0
0	0	1	0	0
0	0	0	1	0
0	0	0	0	1

Table 4 given that the Identity matrix the matrix diagonal line got values one other values is zero.

TABLE 4 shows in (I-Y)-1value

1.718296193	1.0941183	0.9292338	1.1433493	1.0602232
0.695631081	1.6887479	0.7820782	0.7864739	0.6581706
0.751260077	1.0718472	1.6776611	0.9620544	0.8498196
0.823152863	0.9462302	0.767475	1.7815931	0.8472799
0.628231594	0.8690138	0.6978777	0.9556563	1.5980516

Table 7 calculated the (I-Y)-1 value. All values are negative but diagonal line values are positive values.

TABLE 5. Total Relation matrix (T)

Total dissolved solid	0.718296193	1.0941183	0.9292338	1.1433493	1.0602232
Total hardness	0.695631081	0.6887479	0.7820782	0.7864739	0.6581706
Nitrate,	0.751260077	1.0718472	0.6776611	0.9620544	0.8498196
ammonia nitrogen	0.823152863	0.9462302	0.767475	0.7815931	0.8472799
Fluoride	0.628231594	0.8690138	0.6978777	0.9556563	0.5980516

Table 5 shows the total correlation matrix, the direct correlation matrix, Multiplied by the inverse of the direct correlation matrix value subtracted from the identity matrix.

TABLE 6 positive value (Ri) and negative values (Ci)

	Ri	Ci
Total dissolved solid	4.9452208	3.6165718
Total hardness	3.6111017	4.6699574
Nitrate,	4.3126425	3.8543259
ammonia nitrogen	4.1657311	4.629127
Fluoride	3.7488311	4.013545

Table 10 shows the positive values and negative values.

TABLE 7 Calculation of Ri+Ci, Ri-Ci and ranking

	Ri+Ci	Ri-Ci	Rank	Identity
Total dissolved solid	8.5617926	1.328649	2	cause
Total hardness	8.2810591	-1.0588557	3	effect
Nitrate,	8.1669684	0.4583165	4	cause
ammonia nitrogen	8.7948581	-0.4633959	1	effect
Fluoride	7.7623761	-0.2647139	5	effect

Table 7 shows Groundwater quality assessment Ri+Ci, Ri-Ci and given ranking ammonia nitrogen for a first rank , Total dissolved solid for a second rank, Total hardness for a third rank, Nitrate for a fourth rank and Fluoride for a fifth rank, seen in figure 5.

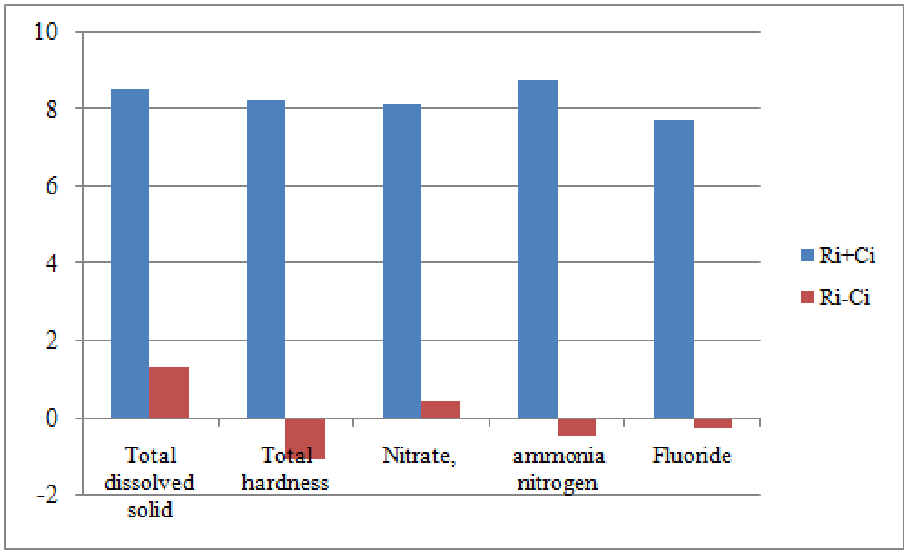

FIGURE 3. Ri+Ci and Ri-Ci

Figure 3 shows Groundwater quality assessment Ri+Ci and Ri-Ci

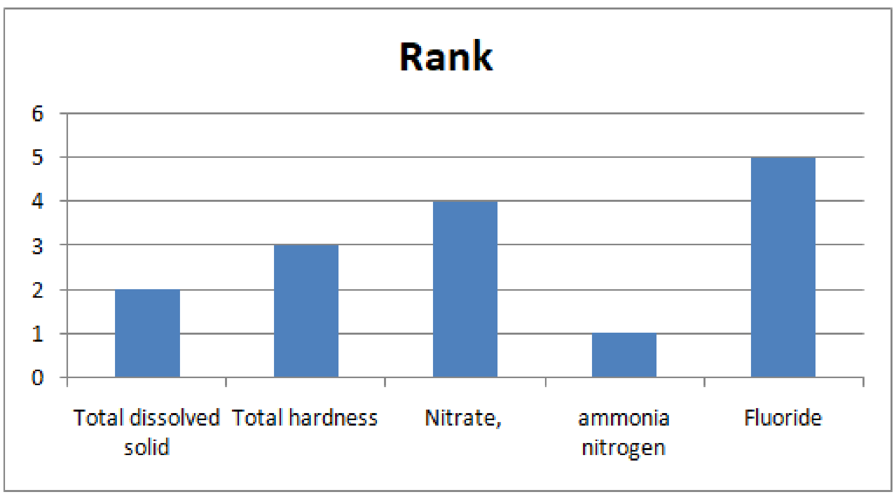

FIGURE 4. Ranking

Figure 4 shows Groundwater quality assessment Total dissolved solid for a 2rd rank, Total hardness for a 3th rank, Nitrate for a 5th rank, ammonia nitrogen for a 1st rank, Fluoride for a 5th rank Groundwater quality assessment

5. CONCLUSION

The characterization of hydro chemical processes and the classification of water based on these parameters provide a comprehensive understanding of the groundwater quality in the study area. This knowledge is vital for making informed decisions regarding the use of groundwater resources and implementing appropriate mitigation measures to protect the environment and ensure the sustainable use of water for domestic, agricultural, and industrial purposes. To determine the Water Quality Index (WQI) of a local water body, a comprehensive testing process involving multiple water quality parameters is typically carried out. This process helps establish a baseline understanding of the water quality and provides a basis for ongoing monitoring and potential remediation efforts. While the specific parameters included in the test can vary depending on local regulations and priorities, here is a general outline of the steps involved: Identify relevant water quality parameters: Determine the key parameters that are essential for assessing the water quality of the local body. These parameters may include physical, chemical, and biological indicators. Collect water samples: Take representative water samples from different locations within the local body, considering any known sources of pollution or areas of concern. Laboratory analysis: Conduct laboratory tests to measure the various water quality parameters. The specific tests will depend on the selected parameters, but common analyses include pH, temperature, dissolved oxygen, turbidity, total suspended solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total nitrogen, total phosphorus, and specific ions such as nitrates, phosphates, and heavy metals. Quantify parameter values: Record the measured values for each parameter from the laboratory analysis. Assign weightings and ratings: Assign weightings to each parameter based on their relative importance in determining water quality. This step involves assessing the significance of each parameter and its impact on overall water quality. Weightings can be assigned based on expert opinion, local regulations, or environmental guidelines. Normalize parameter values: Normalize the measured values of each parameter to This step ensures that parameters with different measurement units and scales are comparable. Calculate sub-index values for each parameter by multiplying the normalized value by the assigned weighting. Regular monitoring and recording of WQI values help identify potential issues, assess the effectiveness of remediation efforts, and guide future water management strategies. By following these steps and regularly conducting WQI tests, a continuing record can be established to monitor the water quality of the local body. This record serves as a valuable resource for identifying areas of concern, implementing targeted remediation measures, and evaluating the success of water quality improvement initiatives.

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