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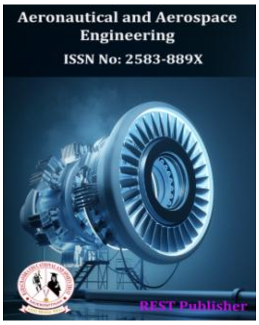

Krishnagiri District, Tamil Nadu, Groundwater Quality Status in relation to MCDM System Pollution

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Abstract. *The essence of life, water, is a fundamental natural resource. The availability and quality of groundwater have been impacted by India's growing urbanisation. The Krishnagiri groundwater has been reduced by 60%, according to the Central Ground Water Board, and additional research could result in salt water intrusion. In order to evaluate the quality of the groundwater in Krishnagiri City, this study was conducted. The appropriateness of groundwater for industrial, household, agricultural, and drinking needs depends in large part on its quality. Evaluation of the suitability of the district of Krishnagiri's northern and eastern groundwater for irrigation and drinking. In the study region, samples of groundwater were taken. By assessing physicochemical factors like pH, TDS, TH, sulphate, chloride, calcium, and magnesium, groundwater quality has been assessed. MCDM is used to evaluate the water quality, and the results show that it is generally suitable for irrigation in most models. The alternative in this method has been used by the Krishnagiri Taluk, Pochampalli Taluk, Uthangarai Taluk, Hosur Taluk, Denkanikottai Taluk, and Bargur Taluk. The evaluation parameters are pH, TDS, TH, Sulphate, Chloride, Calcium, and Magnesium. Six randomly chosen locations were chosen from the six mandals that make up Krishnagiri town, and 18 groundwater samples were taken and their physicochemical characteristics were examined. The algorithm for selecting priorities is created using the well-known ARAS decision-making process. Since Krishnagiri Taluk is ranked top, the district's water quality is the best in the region. Most of the water quality assessment parameters, with the exception of a few, revealed parameters that were within the acceptable standard values of the Bureau of Indian Standards (BIS). None of the metrics exceeded the BIS-recommended allowed levels for water quality assessment, with the exception of pH at one point in Zone 1. These factors determine whether groundwater is acceptable for irrigation and drinking.*

Keywords: *groundwater quality, Total Dissolved Solids, Total Dissolved Solids, MCDM.*

1. INTRODUCTION

The socio-economic well-being of the people of Tamil Nadu is significantly influenced by groundwater, the third-largest supply of freshwater in the world after glaciers and polar ice. Groundwater is used for household, horticultural, agricultural, and hydropower purposes. The inherent quality of groundwater, which takes into account atmospheric inputs, weathering of the soil and rocks, and human activity, determines whether it is suitable for use for various purposes. The degradation of surface and ground water is caused by public ignorance of the environment and related attitudes, growing indiscriminate anthropogenic waste dumping, haphazard pesticide use, and inadequately treated sewage discharges. Groundwater is valuable because of its vast occurrence, availability, and consistently high quality. Once contamination penetrates the subsurface ecosystem, it is predicted to spread over large areas of groundwater and go unnoticed for a long time, making groundwater resources unfit for human consumption and other uses (Nagarajan et al. 2010). The source of the water, how much of it evaporates, the types of rocks and minerals it comes into touch with, and how long it has been in contact with the reactive minerals all affect the hydrochemistry. To determine if water is suitable for different uses, it is crucial to assess its quality. Urban aquifers are the only natural source of drinking water supply, and they are frequently regarded as being less suitable for this purpose. This has caused a crisis based on a lack of drinking water, as well as caused them to become more polluted and less portable. In any place where groundwater is used for irrigation and drinking water needs, understanding hydrochemistry is crucial for determining the quality of the water (Srinivas et al. 2013). Clear information about the surface geologic environments in which water exists can be obtained via water quality assessments (Raju et al. 2011). The majority of water quality investigations have been conducted across India by numerous researchers (Raju et al. 2011; Srinivasamurthy et al. 2011; Subramanian 2011; Gnanachandrasamy et al. 2013; Annapurna and Janarth Hanap 2015; Nagaraju et al. 2015). The study was carried out (Chandrasekhar et al. 2014). In Uttar Pradesh's Pratapgarh district, groundwater chemistry was investigated by Ashwani and Abhay in 2014. Water is a valuable natural resource that supports all life on Earth. Because of its many advantages as well as the issues brought on by its excess, scarcity, and deteriorating quality, water as a resource needs special attention. Because groundwater resources are frequently needed, the study's goal is to evaluate the groundwater's quality as well as the spatial distribution of several hydrogen chemical characteristics for the acceptability of groundwater resources in the study region. The Barkur and Mathur rivers drain the research area. At the southwest corner, where the Bambar river begins and eventually joins the Ponnaiyar, these two rivers merge. The area's topography is steep and consists of enormous rock outcrops with fracture zones. In the research region, a diverse range of litho logy, including alkali syenites, ultramafic complexes, and newer dolerite intrusions, are exposed. The rest of the geology is also concealed by a Proterozoic-aged intrusive volcanic complex, newer dykes, and a recent sedimentary cover in the Barkur and Mettur river tracts. The area experiences a subtropical climate with little seasonal change. From 40 C in the summer to 20 C in the winter, the temperature changes. The main aquifer systems in the research region are formed by weathered and broken Archean crystalline rocks. Less than one metre to more than 15 metres thick is considered weathering zones. In fractured zones at deeper levels, groundwater typically exists in subtropical and semi-confined environments. Groundwater is affected by a number of variables, including physiologic, climatic, geological, and structural characteristics (CGWBoard 2009).

2. MATERIALS AND METHODS

In 18 tiny watersheds spread across 25 wells in Krishnagiri district, groundwater samples were taken. Most of the 25 well sites are near or close to the Barkur, Mettur, and mini-tributaries of the Ponnaiyar and Mettur rivers. In a grid design, water samples were taken at regular intervals. The samples were kept in polypropylene containers that had been washed with 1 N hydrochloric acid beforehand and rinsed three to four times with distilled water. Standard techniques for the study of water and wastewater were used to analyse the water (APHA 1999). A calibrated thermometer with 0.1 resolution was used to detect EC in the field, and an Eliko portable water quality tester was used to evaluate pH. Electrical conductivity (EC) was multiplied by a factor to create a total dissolved solid (TDS) (0.64). Utilizing standard EDTA, total hardness (TH), calcium (Ca), and CaCO3 were titrimetrically measured. Total hardness (TH) and calcium (Ca) concentration differences were used to determine magnesium (Mg). By using a conventional AgNO3 titration, chloride (Cl)) was determined titrimetrically. Using an EEL flame photometer with a suitable air-LPG flame and sodium and potassium sulphate standards with the appropriate concentrations, the amount of sodium (Na) and potassium (K) in groundwater was calculated. All metrics are reported in milligrammes per litre (mg/l), with the exception of pH (no units) and electrical conductivity (EC). At 25 degrees Celsius, electrical conductivity (EC) is measured in micrositemens/cm (lS/cm).

Hydrogen ion concentration (pH): The source water's pH level water's hydrogen ion concentration can be measured to determine its acidity or alkalinity. The pH of the water system has an impact on the majority of biological and chemical processes. The pH range for all groundwater samples used in this investigation was between 7.5 and 8.9. BIS for drinking water the pH scale, according to the WHO, go from 7.0 to 8.5. Samples S1 and S10 had pH values that are higher than allowed. The mucous membrane of the cells is harmed if the pH is outside the acceptable range.

Total Dissolved Solids (TDS): owing to the total dissolved solids (TDS) in water, which include both inorganic and organic materials. Iron, manganese, magnesium, potassium, sodium, calcium, carbonates, bicarbonates, chlorides, phosphates, and maybe other minerals are among the elements that make up solids. TDS values for humans are higher. They irritate the stomach, although long-term use of water with a high TDS Kidney stones and cardiac issues may result from it. TDS values in the current investigation ranged from 627 to 2336 mg/l. TDS has a maximum allowed value of 1500 mg/l and a preferred level of 500 mg/l. The TDS value for each groundwater sample was under the allowed limit of 1500 mg/l.

Total Hardness (TH): Sulfates, carbonates, and bicarbonates are the main components of water hardness. relates to calcium's aesthetic value and is brought on by magnesium chlorides. As a result, soap won't foam as much, and water will boil more quickly. completely unpalatable for drinking The highest allowed level is 300 mg/l (BIS). Hardness is categorised as soft up to 75 mg/l, moderate up to 150 mg/l, severe up to 300 mg/l, and more severe over 300 mg/l. Hardness above 300 mg/l might affect the heart and lead to renal issues (Bhattacharya et al., 2012). Groundwater samples taken from the Study area have a total hardness ranging from 156 to 546 mg/l. Since 58% of the groundwater samples in the research area were extremely hard, adequate treatments must be performed before usage.

Chloride (Cl): Chloride can occur naturally in groundwater or be brought on by household trash. The amount of chloride in wastewater serves as a contaminant indicator. In forming chloride concentration and penetrability, soil porosity is crucial. Metal pipes and agricultural products with high chloride concentration in water bodies can be harmful. due to kidney and cardiac conditions affected individuals (Chapolikar et al. 2010). The range of chloride content is 45-660 mg/l. Most groundwater tests were within the WHO-approved limit of 250 mg/l for chloride concentration; any less chloride indicates pollution. Groundwater samples S3 and S5 have slightly greater chloride concentrations, which results in certain physical abnormalities.

Calcium (Ca): limestone, rocks, and industrial waste Calcium from abundant sources seeps into the groundwater. Calcium is crucial for healthy bone formation. The WHO says that calcium is OK. The cap is set at 100 mg/l. The

calcium concentration in the area ranges from 46 to 210 mg/l. The groundwater samples' various physicochemical properties were examined, and descriptive statistics of the determined parameters are shown in Table 1. The outcomes are contrasted with BIS standards and the maximum permitted limits advised by the World Health Organization.
Zavadskas&Turskis created the new Additive Ratio Assessment (ARAS) methodology (2010). The ARAS approach is a successful and simple MCDM method, despite being a recently proposed method. The effectiveness and utility of the aforementioned approach are supported by its extensions, such as the method's usage of grey numbers ARAS-G and interval-valued triangular fuzzy numbers (Turskis & Zavadskas, 2010) extensions (Stanujkic, 2015). The ARAS technique is founded on the claim that straightforward relative comparisons can be used to comprehend complicated world phenomena. It describes an alternative to the total values of the normalised and weighted criterion that is being considered. These standards outline the ideal alternative and the level of excellence attained by the alternative in contrast. [20], [7], [21]. The values (xij) and weights (j) of the investigated criteria and their respective influence on the outcome are directly and proportionally related to the optimal function (Table 1), taking the calculation method into consideration. As a result, it is easy to assess and rank choice alternatives when utilising this method [13].

3. RESULTS AND DISCUSSION

TABLE 1. Data set

	PH	TDS	TH	SULPHATE	CHLORIDE	CALCIUM	MAGNESIUM
Krishnagiri Taluk	8.1	1850	535	145	248	63	346
Pochampalli Taluk	6.9	735	495	93	402	147	378
Uthangarai Taluk	7.6	1050	455	134	442	154	249
Hosur Taluk	7.3	1754	376	64	384	88	432
Denkanikottai Taluk	6.1	1522	549	119	267	163	102
Bargur Taluk	6.8	1171	324	104	368	93	137

Table 1 demonstrates the data set used in this procedure, which includes the taluks of Krishnagiri, Pochampalli, Uthangarai, Hosur, Denkanikottai, and Bargur. The parameters used for evaluation are pH, TDS, TH, Sulphate, Chloride, Calcium, and Magnesium. The pH value for Krishnagiri Taluk is high and the TDS value for Denkanikottai Taluk is low. The pH of Pochampalli Taluk is low and the TDS of Krishnagiri Taluk is high. The data set graph displays Figure 1.

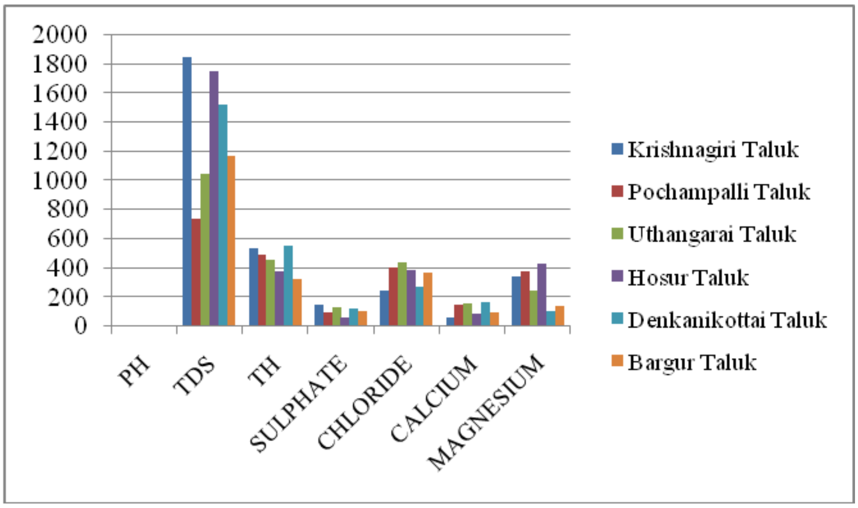

FIGURE 1. Graph for data set

TABLE 2. calculated the maximum value

	PH	TDS	TH	SULPHATE	CHLORIDE	CALCIUM	MAGNESIUM
Max	**8.1**	**1850**	**549**	**145**	**442**	**163**	**432**
Krishnagiri Taluk	8.1	1850	535	145	248	63	346
Pochampalli Taluk	6.9	735	495	93	402	147	378
Uthangarai Taluk	7.6	1050	455	134	442	154	249
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Denkanikottai Taluk	6.1	1522	549	119	267	163	102
Bargur Taluk	6.8	1171	324	104	368	93	137

Table 4 calculated for maximum value for data set.

TABLE 3. Normalized for Data Set

	PH	TDS	TH	SULPHATE	CHLORIDE	CALCIUM	MAGNESIUM
Max	0.1591356	0.1862666	0.1672251	0.1803483	0.1731297	0.0638465	0.1692127
Krishnagiri Taluk	0.1591356	0.1862666	0.1629607	0.1803483	0.0971406	0.0246769	0.1355268
Pochampalli Taluk	0.1355599	0.0740032	0.1507767	0.1156716	0.1574618	0.0575793	0.1480611
Uthangarai Taluk	0.1493124	0.1057189	0.1385928	0.1666667	0.1731297	0.0603212	0.0975323
Hosur Taluk	0.1434185	0.1766009	0.1145294	0.079602	0.1504113	0.0344693	0.1692127
Denkanikottai Taluk	0.1198428	0.153242	0.1672251	0.14801	0.1045828	0.0638465	0.039953
Bargur Taluk	0.1335953	0.1179017	0.0986902	0.1293532	0.1441441	0.0364277	0.0536624

Table 5 Data for analysis are transformed into normalized data. In which all values are less than 1. This makes the analysis easier. A weight age value of 0.14286 is taken for all the data to get the weighted normalized matrix.

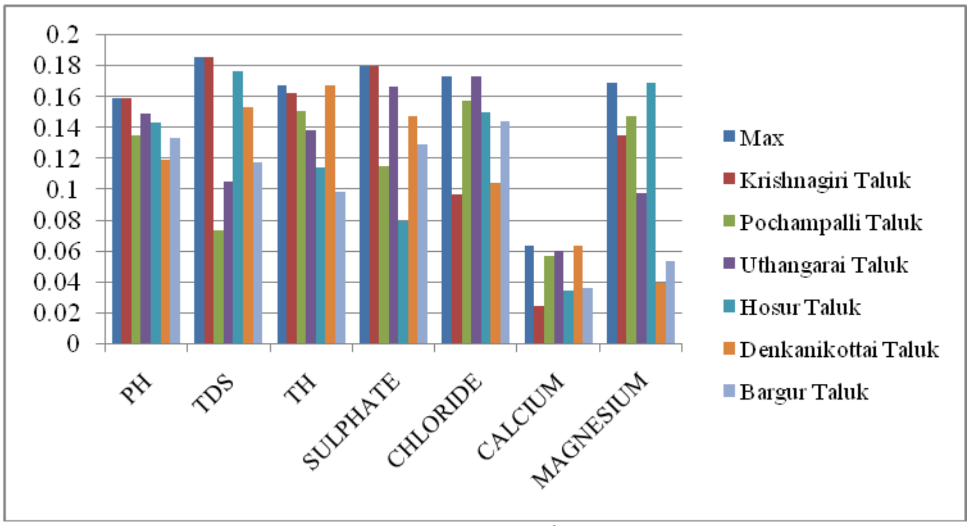

FIGURE 2. Normalized for Data Set

TABLE 4. Weighted Normalized Matrix

	PH	TDS	TH	SULPHATE	CHLORIDE	CALCIUM	MAGNESIUM
Max	0.0227341	0.02661	0.0238898	0.0257646	0.0247333	0.0091211	0.0241737
Krishnagiri Taluk	0.0227341	0.02661	0.0232806	0.0257646	0.0138775	0.0035253	0.0193614
Pochampalli Taluk	0.0193661	0.0105721	0.02154	0.0165249	0.022495	0.0082258	0.021152
Uthangarai Taluk	0.0213308	0.015103	0.0197994	0.02381	0.0247333	0.0086175	0.0139335
Hosur Taluk	0.0204888	0.0252292	0.0163617	0.0113719	0.0214878	0.0049243	0.0241737
Denkanikottai Taluk	0.0171207	0.0218922	0.0238898	0.0211447	0.0149407	0.0091211	0.0057077
Bargur Taluk	0.0190854	0.0168434	0.0140989	0.0184794	0.0205924	0.0052041	0.0076662

Weighted Normalized Matrix is obtained in Table 6. With this we can get sum of value.

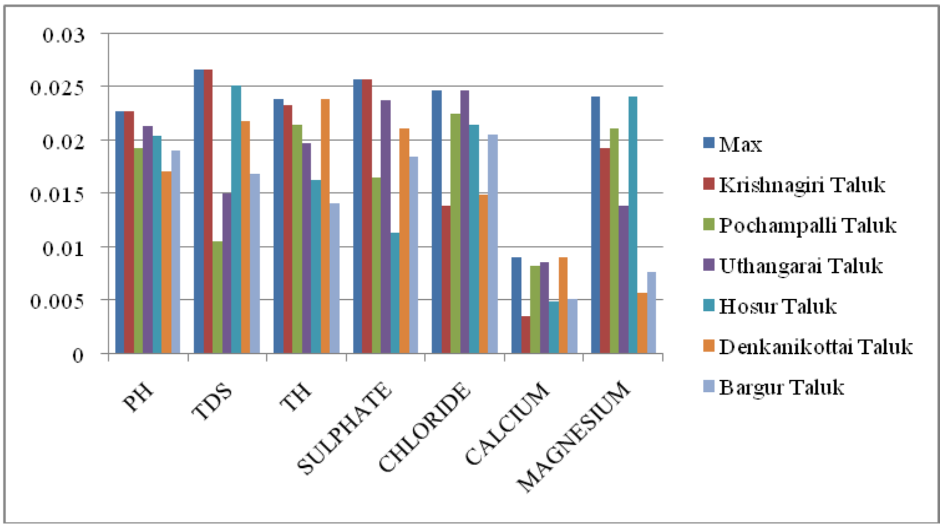

FIGURE 3. Weighted Normalized Matrix

TABLE 5. Si and Ki value

	Si	Ki
Max	**0.1570266**	**1**
Krishnagiri Taluk	0.1351535	0.8607043
Pochampalli Taluk	0.1198758	0.7634106
Uthangarai Taluk	0.1273274	0.810865
Hosur Taluk	0.1240373	0.7899128
Denkanikottai Taluk	0.113817	0.724825
Bargur Taluk	0.10197	0.649379

From table 7 sum of value is obtained and Ki value is obtained. Ki value is obtained by dividing Si Max value. This can be seen in Figure 4.

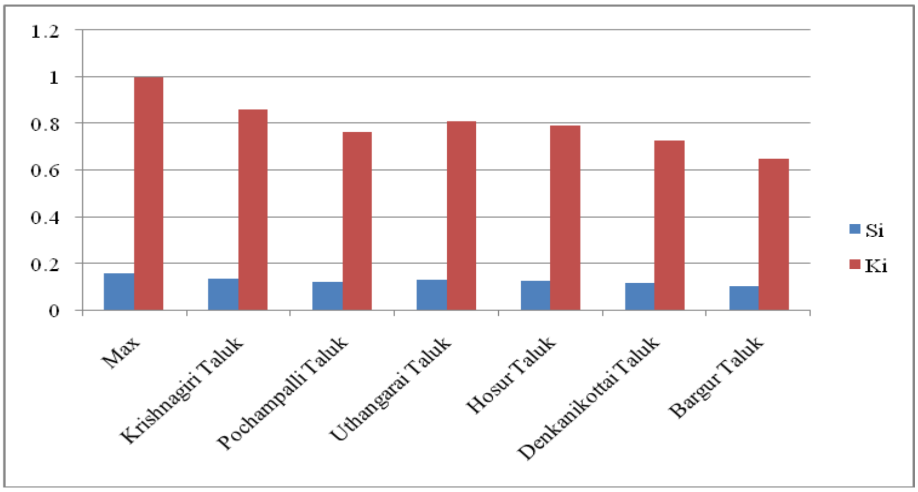

Figure 4 graph for Si and Ki value

TABLE 6. Ranking

	Rank
Krishnagiri Taluk	1
Pochampalli Taluk	4
Uthangarai Taluk	2
Hosur Taluk	3
Denkanikottai Taluk	5
Bargur Taluk	6

Table 5 shown that the values about the rank, Krishnagiri Taluk is first ranking , Uthangarai Taluk is second ranking, Hosur Taluk is third ranking, Pochampalli Taluk is fourth ranking, Denkanikottai Taluk is fifth ranking and Bargur Taluk is sixth ranking. Figure 4 shown in ranking.

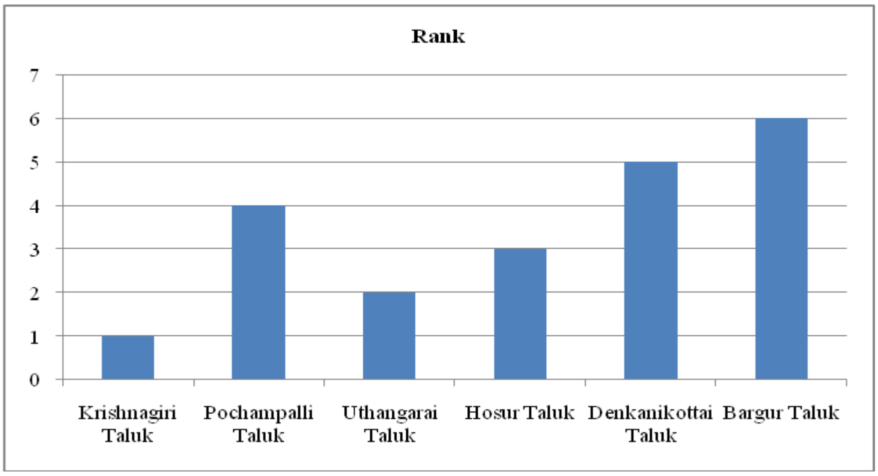

FIGURE 5. Ranking

Figure 5 shown that the values about the rank, Krishnagiri Taluk is first ranking , Uthangarai Taluk is second ranking, Hosur Taluk is third ranking, Pochampalli Taluk is fourth ranking, Denkanikottai Taluk is fifth ranking and Bargur Taluk is sixth ranking. Figure 4 shown in ranking.

4. CONCLUSION

Except in a few places, the groundwater's caveat chemistry indicates an excess of Na. Na+, Mg2+, Ca2+, and K+ are the most abundant elements. Except for a few samples, the groundwater's ion composition indicates an overabundance of chloride. The abundance is arranged as follows: Cl->SO2<4CO2 3. The type of water with CaMgCl and NaCl mixed together can be identified by the hydrochemical facies results. Statistical study reveals a substantial link between Na and Cl. The research area's industrial, household, and agricultural effluents, as well as rock disintegration, all contribute to the rise in Cl and Na. It is clear from the Wilcox plot that 58% of the samples are irrigation-ready. When compared to WHO allowed limits and BIS requirements, the analytical results revealed that 40% of the sample did not contain potable water. In the research area, lithology, which is parent control and human, influences such discharge from neighbouring tanneries, which regulate the hydrogeochemistry of groundwater and render it unsafe for drinking, are the main sources of all hydrogeochemical processes. Managers of water resources can use this presumption to help society's environmental challenges. As can be observed from the results, Bargur Taluk has the lowest rank whereas Krishnagiri Taluk is ranked first. This study demonstrates the superior water quality in Tamil Nadu's Krishnagiri Taluk

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