Evaluation Of Groundwater Quality Using Remote Sensing And Gis: A Case Study

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Abstract: One of the main issues facing the world today is water quality, which primarily affects poor nations. One of the essential ingredients for the survival of life in any form is water. Nearly 70% of the surface of the earth is covered by water. Since it is directly related to daily life activity, maintaining water quality is crucial. Color, EC, pH, BOD, COD, TDS, iron, nitrates, and other parameters were examined from a physiochemical and biological perspective. The groundwater in the Kolar district is suitable for household and agricultural use. Groundwater's pH ranges from 7 to 8.67, indicating that it has an alkaline pH by nature. The specific conductance values are mostly within at 2000 us/cm 25 °C, us/cm. more than 1.5 mg/l of fluoride is present. However, fluoride concentrations of 2 mg/l and more have also been found in some of the exploratory borewells. It has been reported that nitrate concentrations exceed 100 ppm. In the study region, this has led to numerous health complications. It is possible to determine the quality of water using GIS and remote sensing technology. Thematic maps with characteristics indicating the water quality were produced using the ArcGIS software. GIS maps can be used to evaluate changes in groundwater quality over time and space. Understanding water quality and creating appropriate management strategies to safeguard groundwater resources are both aided by the study.
Keywords: Water quality parameters, Remote sensing, GIS, Arc GIS software

1. Introduction

Water quality is one of the biggest global challenges, the impact of which is mostly felt in developing countries. Water is one of the most important requirements for the survival of life in any form. Almost 70% of the earth's surface was covered by water. Water is one of the basic tools of existing life. Almost 70% of the earth's surface is covered by water. Maintaining water quality is the most important because it is directly related to daily life and also one of the most important substances on Earth because it is needed for most human activities such as agriculture, domestic, drinking, shipping, industry, leisure and fishing . The main source of water is rain, which can be available as surface water or groundwater. Groundwater is considered one of the most valuable natural resources. About 50 percent of drinking water in urban centers is groundwater. Groundwater is considered safer than surface water because it contains little suspended solids and many dissolved substances. All groundwater contains dissolved minerals, the type and concentration of which depend on the surface and underground environment, the velocity of the groundwater, and the source of the groundwater. Groundwater characterization is a geochemical process that is an integral part of the scientific management of groundwater resources to monitor groundwater quality. Groundwater geochemical processes involve the interaction of bedrock with water, causing the development of secondary mineral phases. Because water is considered a universal solvent, it contains a wide variety of substances. The substances are in the form of both suspension and solution. Therefore, all foreign bodies pollute water; it can be both natural and artificial. This pollution leads to health risks and reduced water availability, which can be called water pollution. Groundwater contamination is a very complex and slow process. Groundwater pollution can be caused by on-site sewage systems, landfills, waste water from sewage treatment plants, leaking sewers, mining operations, gas stations, the use of fertilizers in agriculture, and also various mechanisms affecting the transport of pollutants, such as diffusion. . , adsorption, precipitation. , degradation in groundwater. Once groundwater is contaminated, it is very difficult to restore its quality, so groundwater quality must be investigated. Thus, this study covers part of the study area of Kolar Hobl. The city's water needs are partially covered by the Lakshmisagara reservoir. However, the delivery did not meet the requirements. Groundwater was used as a free and healthy resource to meet the unstable pressure of the city. The existing groundwater is now used by mining, which leads to drying up of boreholes. They were increasingly used in boreholes.

2. Literature Studies

Pandian M et al., (2014)

In this study, the authors conducted a detailed survey using Indian Topographic Model No. (57 O/4) to 1: 50,000 scale remote sensing image data and IRS ID (LISS III) (False color combination (FCC)).321 (RGB) and Landsat 7 ETM (Enhanced Thematic Mapping) bands (color combination (FCC) of 457 (RGB) bands) visually interpreted in terms of color, texture, size, shape , reliefs, drainage patterns, plant relationships and other elements. Field surveys were also carried out and corrections were made based on geology, contour lines and geomorphological maps. During the field investigation, well performance, water level, and groundwater samples were collected. Finally, ArcGIS tools are used to analyze and visualize spatial data for research. data on groundwater quality.The study concluded that important parameters overlap for mobile and non-mobile areas in the study area, with the final groundwater quality map showing only a small area in the northwest and north. south of the study area where groundwater can be found. Therefore, the study area also has high groundwater potential in the Northwest and South.This proves the fact that the quality of groundwater depends on the amount of natural impurities.

S. Venkateswaran et al., (2015)

The objective of the study was to assess groundwater quality in the Vaniyar Watershed of the Ponnaiyar River in Tamil Nadu using GIS techniques. Sixty groundwater samples were systematically collected before and after the monsoon season from Vaniyar watershed in Dharmapuri district of Tamil Nadu. Understand the geochemistry of groundwater and evaluate the general physicochemical surfaces of the study area. The Vaniyar watershed is located between latitudes 11°46'N and 12°09'39''N and longitudes 78°12'27''E and 78°36'65''E and covers an area of 982.25 km2. The area is 591.43 km2 . Archean crystalline rocks are surrounded by mountains below the study area. The physical and chemical parameters of groundwater analysis results were compared with the Bureau of Indian Standards (BIS) and World Health Organization (WHO) recommended standard guidelines for suitability for irrigation and domestic use standards. Other hydrogeochemical data are plotted on a standard chart, such as the United States Salinity Laboratory (USSL) and Wilcox charts. According to United States Salinity Laboratory (USSL) results, category C3-S1 (452.75 Km2) is good and can be used for all types of crops. The interpretation of Piper's three-line diagram shows that most of the water samples belong to the Ca-Mg-Cl mixed types, CaHCO3 and CaCl types in order of their dominance. The graph shows that 65% of the samples are categorized under alkaline earth metals (Ca2 and Mg2 and Cl– outnumber other anions). Organized in the chemical evolution of groundwater, where the interaction between water and rocks is considered important in determining their type of calcium bicarbonate, as shown in the Piper diagram, where the dispersion of cations (calcium and magnesium) and Cl content of groundwater samples. is shown This can be related either to lithological heterogeneity or to some human activity in both seasons. Gibb's plots show that all samples from both seasons fall within the stone-dominated field. It has been suggested that chemical weathering of rock-forming minerals is the main process that adds ions to water. Groundwater samples during the pre-monsoon period were class I according to Donen permeability index classification at almost all locations except two samples. During the post-monsoon period, most of the samples belonged to class I (except four samples) and it is good for irrigation.

Piyush Gupta et al., (2012)

In the present study, the authors attempted to assess the quality and suitability of groundwater for drinking. Detailed mapping was done within 10 km of KGF and 12 domestic wells were identified for groundwater sampling. Each well was sampled in each season and analyzed for various water quality parameters. It was found that the groundwater pH, solid content, nitrate, arsenic, fluoride, cyanide, sulfate, alkalinity and sodium content were within normal limits, while other parameters exceeded the standards. Water Quality Index (WQI) was evaluated to know the overall quality of groundwater in each well during different seasons. A multiple regression model was developed to predict WQI and the performance of the model was evaluated. This article also proposes methods for treating groundwater. Based on the results and analyzes of water samples, the study concluded that water is only used for drinking after boiling and filtration or reverse osmosis treatment. For large-scale water purification, it is recommended to install KGF electrodialysis treatment. However, water from various wells can also be used for other domestic purposes if the WQI indicates that the water quality is good or excellent.

P. Balakrishnan et al., (2011)

In this study, water samples were collected from 76 boreholes and open pits representing the entire company area. The physico-chemical parameters of the water samples such as TDS, TH, Cl and NO3 were analyzed in the laboratory using standard techniques and compared with the standards. Groundwater quality data maps of the entire study area were compiled using the GIS spatial interpolation technique for all the above-mentioned parameters. The results obtained in this work and the spatial database created by the spatial information system are helpful in the monitoring and management of groundwater pollution under investigation. The mapping was coded for drinking zones because there were no better alternative source and drinking zones in the study area in terms of water quality. The regional distribution analysis of soil quality in the study area showed that many collected samples do not meet the drinking water quality requirements established by WHO and ISI, as almost half of the city has non-potable groundwater. The obtained results made it necessary to inform citizens, local authorities and the government about the crisis of poor soil quality in the region.

3. Motivation

- Exploring the quality of Groundwater in based on the chemical parameters to check the permissible limits.
- Demarcation of chemical parameters of the groundwater in the study area and its possible impact through Remote Sensing and GIS techniques.
- Controlling of groundwater over-exploitation, pollution, and management and utilisation of groundwater resources effectively and efficiently.
- Exploring the possibilities of artificial recharge of groundwater.

4. Problem Domain

Remote Sensing and GIS Technique in Groundwater Study.

Problem Definition

Avoiding groundwater is cheaper than restoring contaminated groundwater. Contaminated groundwater is less visible but more difficult to clean up. Groundwater pollution is mostly caused by improper waste disposal. the most important sources are industrial and domestic chemicals and landfills, excess fertilizers and pesticides used in agriculture, industrial waste lagoons, mine tailings and process wastewater, industrial fracking, brine mines in oil fields, leaking underground tanks and pipelines, sewage and septic tanks. . The unrestrained use of borehole technology has led to groundwater extraction to such an extent that recharge is often insufficient. Groundwater pollution has become a major problem today. Pollution of air, water and land affects contamination and contamination of groundwater. The resulting solid, liquid and gaseous waste pollutes the environment if not properly treated. it also affects underground water due to hydraulic coupling of the hydrological cycle. It is known from previous studies that groundwater quality is deteriorating mainly due to increasing domestic and mining activities in Kolar. Table 1 shows the water quality parameters according to Bureau of Indian Standards (BIS) and WHO.

Table 1: Water quality parameters as per the BIS and WHO.

PARAMETERS	BIS	WHO
Physical		
Colour	10 Hazen	10 Hazen
Odour	Unobjectionable	Unobjectionable
Temperature	20^0C	20^0C
Turbidity	5-10 NTU	510 NTU
Chemical		
Chloride	250 mg/lit	250mg/lit
pH	6.5-8.5	6.5-8.5
Hardness	<600 mg/lit	350-600 mg/lit
Sulphate	<100 mg/lit	100mg/lit
Nitrate	45 mg/lit	45 mg/lit
Iron	0.3 mg/lit	0.3mg/lit
Manganese	0.5 mg/lit	0.5mg/lit
Magnesium	50mg/lit	50 mg/lit
Biological		
DO	4 mg/lit	4 mg/lit
BOD	20 mg/lit	20 mg/lit
Pathogens	1 MPN	1MPN

The main objective of this study is to bridge this knowledge by using modern remote sensing and GIS tools to assess groundwater quality. The purpose of these studies is to assess the feasibility and effectiveness of soil quality assessment, and the results suggest initiatives to limit deterioration in the study area. Kolar Hobli is a subdivision of Kolar taluk in Kolar district in the Indian state of Karnataka. Located 33 km from KGF (Kolar Gold Fields). Kolar Hobli, Kolar taluk, Kolar district, Karnataka state, India is located in the southern plateau (semi-arid agro-climatic zone). Kolar district covers an area of 8238 km2 between 77021′ - 78035′ east and 12046′ - 13058′ north latitude. It rains in this area 743 mm per year. The temperature varies from 14.40 C to 35.70 C. The topography of the land varies between 595 meters and 1474 meters. The geographical area of the farm is 793 square kilometers. According to a recent survey, the current population is 183462. Granites, gneisses, slates and laterites are the most important rocks in the study area, which have been penetrated by many dikes. Granites and gneisses form the bulk of the land. Groundwater intake occurs through wells. Boreholes dominate among abstract structures. The productivity of hard rock wells usually varies from 15-200 m3/day. The depth of the irrigation wells varies between 100-300 mbgl and the productivity of the wells varies from 0.5-20 m3/h. A semi-confined aquifer forms as a result of fracturing of hard formations. This groundwater system is developed from boreholes up to 300 meters deep. Its performance varies up to 1200 m3/day and a specific performance between 2-173 lpm/m. Overdraft in the region is 56,260 hectares per year. Taluk-wise resources and classification are shown in Figure 1.

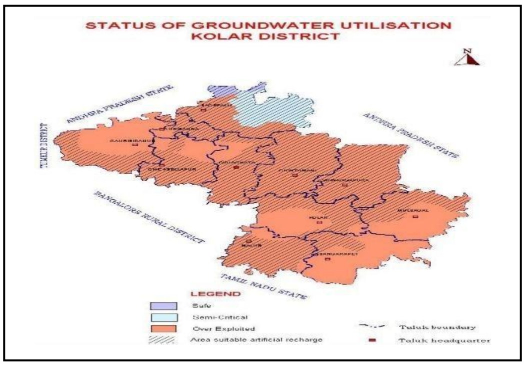


Fig. 1: Status of Groundwater Utilisation in Kolar district.

Problem Statement

Assessing groundwater quality using remote sensing and GIS: A case study

Innovative Content

Using ArcGIS software, thematic maps were created to indicate water quality parameters. Spatial and temporal changes in groundwater quality can be assessed using GIS maps. This research helps better understand water quality as well as develop appropriate management measures to protect groundwater resources.

5. Solution Methodologies

The methodology followed in this study includes - Data collection from topographic panels and satellite images, georeferencing, image processing, preparation of various maps using GIS.

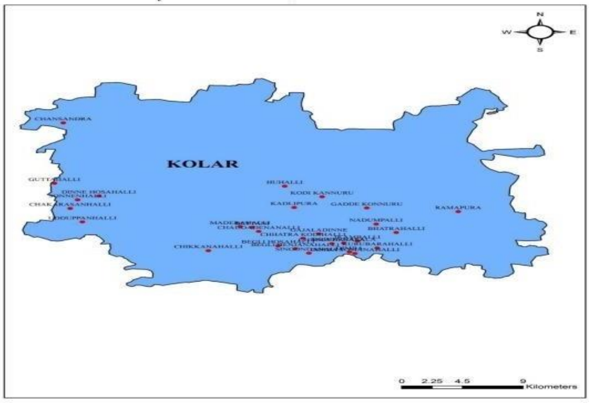
Groundwater samples are systematically collected to test water quality parameters for domestic and agricultural use. When collecting water samples, care should be taken to collect representatives from the entire study area (Figure 1). The collected samples are analyzed in the laboratory for chemical analysis to determine pH, total dissolved solids, total hardness, alkalinity, calcium, magnesium and sulfate. The important water chemical parameters of the analyzed samples are presented in Table 2. With the chemical analysis data, many different maps were created using GIS techniques to localize different locations of the water. Study shows high concentrations of chemical constituents in groundwater (Figure 2 to 9).

Table 2: Showing the water quality data of the study area

Sl No	TDS (mg/lit)	Total Alkalinity (mg/lit)	Ca (mg/lit)	Mg (mg/lit)	TH (mg/lit)	SO4 (mg/lit)
1	1287	114.2	216.6	49.1	746	19.2
2	409.5	48	40	30	225	28.8
3	370.5	52	50	19.2	205	26.4
4	11.18	136	138	82.8	690	25.6
5	162.5	20	26.6	5.4	88.8	9.5
6	117	108.1	18.7	5.6	70.2	4
7	1131	112	186.4	50.1	674.8	67.2
8	652.6	92	111.8	36.3	430.6	58.4
9	136.5	32	21.3	9.6	93.2	6.5
10	123.5	24	18.1	10.3	88.3	6.5
11	143	14	18	14.4	497	3.2
12	292.5	72	60.3	10.7	195.3	17.6
13	1137.5	42.2	236.1	71.9	890	20
14	1111.5	49.2	243.9	63.9	876	19.2
15	1008.5	45.7	243.86	62	896	21
16	877.5	84	114	69.6	575	28.8

6. Result Analysis

The water chemistry data of the analyzed samples have been presented in Table 2. Along with the chemical analysis data, various maps were prepared using GIS techniques to delineate different locations in the area.The study area has high concentrations of chemical components in groundwater (Figures 2 to 2). Remote sensing and GIS tools have helped mark areas where the concentrations of different chemical parameters exceed allowable limits, and the results are shown in drawings 2 to 9.



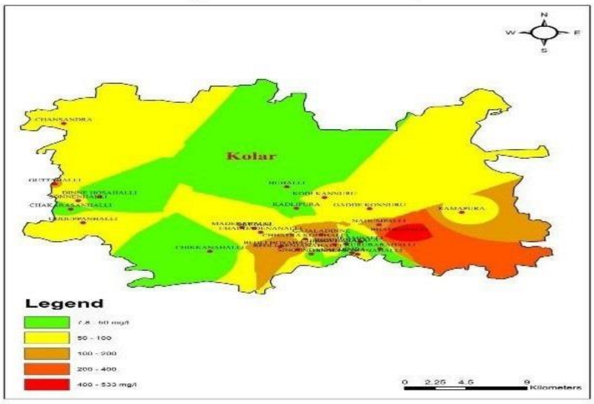
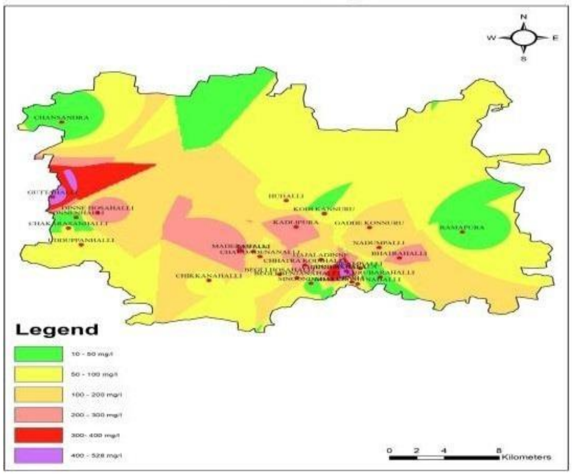


Fig. 2: Map showing location of water samples. **Fig. 3:** Map showing alkalinity levels.

Figure 3 indicates that the water sample analyzed at Bhatrahalli exceeds the permissible limits. It has a value of 534 mg/ltr of alkalinity present in the water and it has been indicated by red color in the figure. Figure 4 shows that chlorides in the study area within the permissible limits.



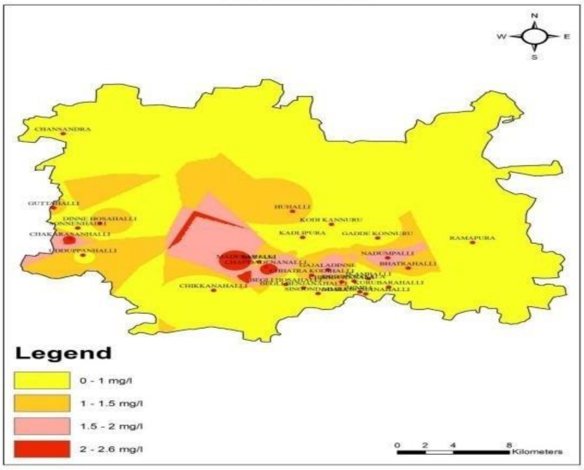
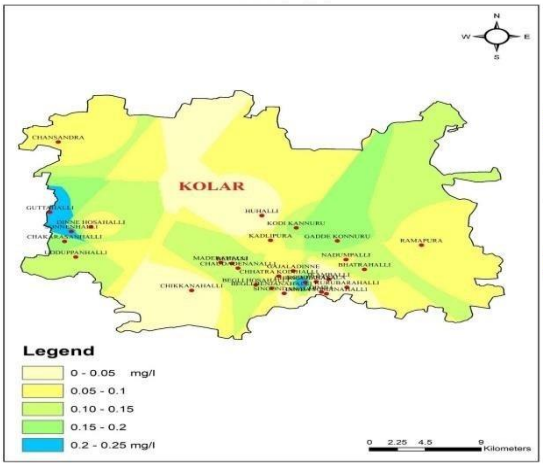


Fig. 4: Map showing chlorides of the samples area. **Fig. 5:** Map showing fluorides in the study analyzed.

Excess of flouoride in the water leads dental fluorosis and skeletal fluorosis. The permissible limit fluoride in the drinking water as per Bureau of Indian Standards (BIS) and World Health Organisation (WHO) is 1.5mg/litre. In the present investigation Gajaladinne (2.67), Chatrakodihalli (1.89), Hoohalli (2.19), Cholaghatta (2.46) and Bhatrahalli (1.61)exceeds the permissible value and it has been shown in the figure.4. The iron, nitrates, sulphates and pH content in the study area is within in the permissible limit (Fig.6,7,8).



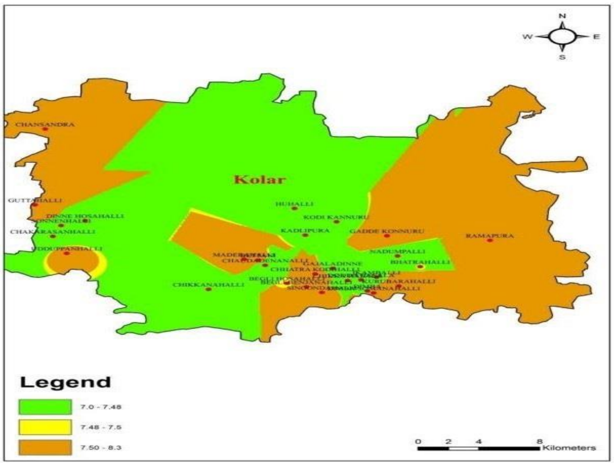
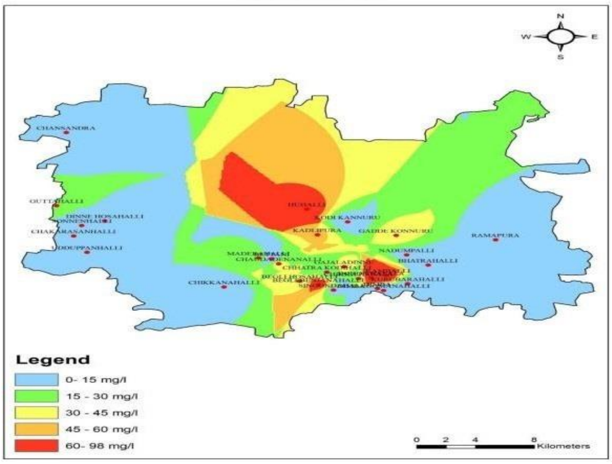


Fig. 6: Map showing level of iron. **Fig. 7:** Map showing pH in the study area.

Total hardness is one of the important components of the water quality. In the present study Nadupalli (746),Gajaladinne (674.8), Kallipura (890), Kodiramasandra (876), Dinnehosahalli (896) exceeds the permissible limits of total hardness and affected area has been indicated by red color in the figure 9.



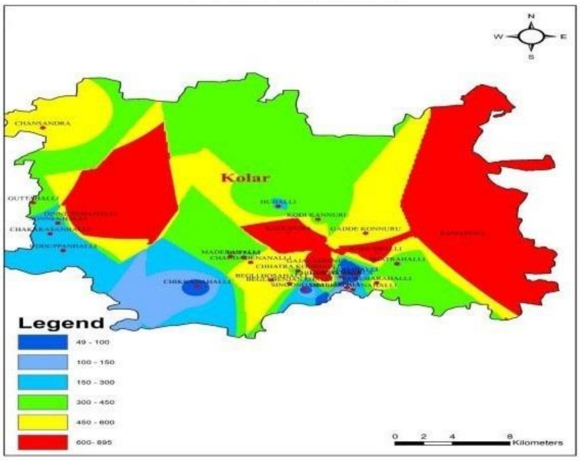


Fig. 8: Map showing Nitrates in the study area. **Fig. 9:** Map showing Total Hardness in the study area.

Justification Of The Results

Remote Sensing and GIS are powerful tools and really helpful in the process of water chemistry data and to present data in a systematic manner for taking any decisions in effective and efficient management of water resources in arid and semi-arid area. The present study area falls in the semi-arid region.

7. Conclusion

Remote sensing and GIS tools have made more easier for calculating various parameters of the water chemistry data. Based on the present investigation in Kolar taluk chemical components of groundwater are in the safe zone. But some of the components like fluoride, total hardness, chlorides are beyond the permissible limits and have been shown in figures 3 to 9. The present over exploitation of groundwater can be reduced by checking the developmental activity well below the annual replenishable recharge quantum. Here again water conservation techniques such as drip and sprinkler irrigation system should be encouraged and financed, curbing the colossal waste of water in traditional agricultural practices. The conjunctive use of groundwater and surface water are to be the priorities in the area where over-exploitation of groundwater is observed. To control the further deterioration of the groundwater quality it is necessary to adopt modern techniques of water usage for domestic and irrigation in the study area.

8. Future Work

- In recent years, treated wastewater has been partially transferred to several reservoirs in the study area, and verification of the impact of this amount of water on groundwater quality is necessary.
- Controlling the groundwater table decline due over-exploitation and necessary control measure to mitigate decline further.

Acknowledgement:

The authors thank Sri Krishnadevaraya Educational Trust, the Management of Sir M Visvesvaraya Institute of Technology and the Principal for the support and encouragement for this research work.

References

[1] **P. Balakrishnan, Abdul Saleem and N. D. Mallikarjun**, "Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India" (2011) African Journal of Environmental Science and Technology Vol. 5(12), pp. 1069-1084.

[2] **Padmaja Vuppala and M. Anji Reddy** "Remote Sensing and GIS Techniques for Evaluation of Groundwater Quality in Municipal Corporation of Hyderabad (Zone-V), India" (2007) Int. J. Environ. Res. Public Health 2007, 4(1), 45-52.

[3] **Pandian M, and Jayachandran N.** "Groundwater Quality Mapping using Remote Sensing and GIS – A Case Study at Thuraiyur and Uppiliapuram Block, Tiruchirappalli District, Tamil Nadu, India" (2014) International Journal of Advanced Remote Sensing and GIS 2014, Volume 3, Issue 1, pp. 580-591.

[4] **Piyush Gupta and Surendra Roy**, "Evaluation of Spatial and Seasonal Variations in Groundwater Quality at Kolar Gold Fields, India" (2012) American Journal of Environmental Engineering 2012, 2(2): 19-30.

[5] S. Venkateswaran and Deepa S. "Assessment of Groundwater Quality using GIS Techniques in Vaniyar Watershed, Ponnaiyar River, Tamil Nadu". Published by Elsevier in 2015.

[6] **Shivanna,S., Anupama, V.S., Vyshnavi, D.R. and H.P. Mahendra Babu** : A GIS based Morphometric Analysis and Associated Landuse Study of Hesaraghatta Watershed, Bangalore District, Karnataka., IJRSI, Vol.4., pp.48- 52.(2017)

[7] Shivanna S., Vyshanvi D R., Sriram Mustapure: "Groundwater Quality and Management in Devanahalli Taluk, Bangalore Rural District, Karnataka, India - A Case Study" IJSTE, Vol.8, Issue 2, pp.37-41 (2021).