Assessment of ground water quality using water quality index and GIS

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Abstract. Ground water demand in India has significantly increased as a result of the country's fast population development, industrialization, and urbanization. Using a water quality index, or WQI helpful numerical instrument for deriving complex information from any water body and for reporting and analyzing it. WQI is essentially a mathematical method for calculating a single value from a set of test results. Any WQI model can explain the degree of water contamination with a single number, depending on several of water quality indicators at a particular place and time. In this work, an effort has been made to understand whether ground water is fit for human consumption. The study area included various residential and industrial areas that do get their water from groundwater resources. This study evaluates When compared to WHO drinking and residential water quality criteria (WQI), the physical, chemical, and biological properties of various groundwater samples taken from various sites are examined. The spatial evaluation of several groundwater quality parameters in this investigation has been done using the GIS approach. The study's goal is to determine the WQI of ground water determine if it is fit for human consumption in the study area using the GIS technique.

Keywords. GIS, Ground water, WQI, Water Quality

1 Introduction

Water is an a vital source of drinking water for population around the world. For economic growth and a healthy population, proper access to safe water is crucial. Groundwater demand in India has significantly increased as a result of the country's fast population development, industrialization, and urbanization. When man-made things such as chemicals, oil, road salts and petrol end up in groundwater, they pollute it.They cause it to become contaminated and dangerous for human use [1]. Surface-level soil materials can

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permeate the soil and end up in groundwater. Pesticides and fertilizers, for example, can damage groundwater over time. [2]. Moreover, discarded motor oil, hazardous compounds from mining sites, and road salt can leak into the groundwater. A Water Quality Index (WQI) is a useful statistical tool for extracting complex data from any body of water and reporting and analyzing it. WQI is essentially a mathematical method for calculating a single value from a set of test results [3].

Any Water quality index model can explain the level of water pollution with a single number, Based on several water quality indices at a particular location and period [4]. The parameters of water quality are measures that are used to establish the acceptable limit of water quality in order to achieve water that is safe for people to consume. They are usually categorized into physical, chemical and bacteriological parameters [5]. Geographic Information System (GIS) technology has recently been used to assess and monitor groundwater quality on a regular basis. GIS has shown to be a useful tool for evaluating and analyzing spatial data of water resources [6]. In this work, an effort has been made to understand whether groundwater is fit for human consumption. Excellent, good, bad, and other categories of water quality have been established using the water quality index (WQI) [7]. This analysis purpose is to determine the Water Quality Index of ground water to evaluate whether it is fit for human consumption in study area using the GIS technique [8].

Groundwater in India has a number of water quality problems, including fluoride, nitrate, and uranium pollution, all of which are harmful to people's health [9]. Using a Geographic Information System (GIS) software combined with the IDW interpolation method has been used in recent years to regularly assess and monitor the quality of groundwater In this study, the spatial evaluation of numerous groundwater quality criteria has been done using GIS technology [10]. On the basis of weighing and grading numerous water quality parameters that are generated Researchers created multiple WQI models using the weighted arithmetic method. The WQI is a number without dimensions, with ranging from 0 to 100 [11]. The WQI is a distinctive digital rating expression that, based on multiple water quality measures, conveys overall water quality status, such as outstanding, good, or bad, at a particular location and period [12].

1.1 Aim and Objectives of the Study

Switches study's aim is Using GIS, assess the WQI of groundwater in the study area in order to evaluate its suitability for consumption by humans.

- To evaluate the degree of water contamination with a single number based on several water quality parameters at a particular location.
- To determine whether the water quality is excellent, good, or poor using (WQI).
- To demonstrate the impact of individual parameters for a specific area using QGIS software.

2 Materials and Methods

2.1 Study Area

At Nizampet, Hyderabad a study is conducted to examine the quality using water quality indices as shown below in fig.1. Fifteen borehole water samples are taken and all of them are tested in the lab using conventional methods.

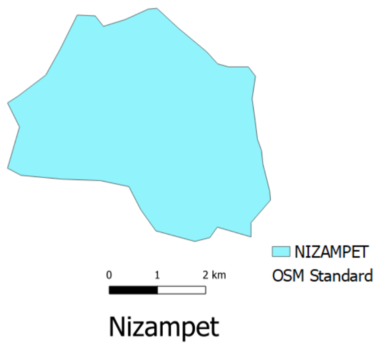

Fig. 1. Study Area

2.1.1 Sample Details

Nizampet location's fifteen samples details are shown in Table 1 with latitudes and longitudes data. https://goo.gl/maps/1Uc7CwRLJvjiYWZQA

Table 1. Sample Details

Samples	Latitudes	Longitudes	Samples	Latitudes	Longitudes
1	17.52086	78.37791	9	17.51585	78.38238
2	17.52281	78.37123	10	17.52878	78.38887
3	17.52166	78.37567	11	17.51026	78.38463
4	17.52865	78.36285	12	17.50466	78.38669
5	17.52864	78.36018	13	17.50898	78.39029
6	17.52352	78.35925	14	17.51001	78.38759
7	17.52256	78.35814	15	17.53179	78.39286
8	17.51757	78.37409			

2.2 Proposed Approach

2.2.1 Water Quality Index Calculations

The Water Quality Index is determined using the World Health Organization's recommended water quality standards for drinking water (WHO 2017). The Water Quality Index was computed based on the weighted arithmetic method introduced by Horton (1965) and developed by Brown et al (1972). The World Quality Index (WQI) is presented as follows:

$$WQI = W_i Q_i / Q_i \quad (1)$$

where n = number of parameters, Wi= unit weight for the i^{th} parameter, Qi=quality rating (sub-index) of the i^{th} water quality parameter

$$W_i = K / S_n \quad (2)$$

S_n =standard value for parameters, K=proportional constant

$$K=1/\sum (1/S_n) \quad (3)$$

Brown et al. (1972) use the equation to calculate the value of the quality rating or sub-index (Qi) as given below

$$Q_i = 100\,((V_o - V_i) / (S_n - V_i)) \quad (4)$$

V_o = observed value of that parameter at a given sample location , V_i = ideal value of that parameter of pure water, S_n = standard permissible value

Based on the above WQI values, The quality of ground water is classified as excellent, good, poor, very poor, and unfit for human consumption. as mentioned in Table 2.

Table 2. WQI Categories

Water Quality Index(WQI)	Rating of Quality	Grading
0-25	Excellent	A
26-50	Good	B
51-75	Bad	C
76-100	Very Bad	D
100 & above	Unfit	E

2.2.2 QGIS Software

QGIS, also known as Quantum GIS, is a free and open-source Geographic Information System (GIS) software. It offers a strong set of tools for working with geospatial data, making it a valuable tool for anyone interested in visualizing and analyzing spatial information. QGIS is used to represent water quality parameters distribution and WQI for fifteen locations.

3 Results and Discussion

Samples collected from fifteen locations at Nizampet site are subjected to a series of tests. The results and observations of the tests performed are presented in the tables 3 and 4 as shown below.

Table 3. Experimental Analysis of sample 1 to 8

Parameters (permissible limits) and (Weightage (Wi))	S -1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Iron (0.3mg/l) (Wi =1)	0	0.25	0.29	0	0.27	0.28	0	0.25
p^H (6.5-8.5) (Wi =4)	6.8	7	6.5	7.2	8	7.9	6.5	6.9
Conductivity (250µS/cm) (Wi =2)	80	69	120	189	49	98	200	78
Residual chlorine (0.2mg/l) (Wi =2)	0	0	0	0	0	0	0	0
Turbidity (5NTU) (Wi =2)	9	12.5	11	7	7.9	7.2	7	20
Alkalinity (100-200mg/l) (Wi =3)	58	70	98	78	89	72	91	82
Chlorides (250-600mg/l) (Wi =3)	225	200	198	159	147	178	220	178
Total hardness (300-600mg/l) (Wi =2)	926	850	987	954	702	862	951	856
BOD (1mg/l) (Wi =2)	1.2	1.29	1.34	1.67	1.43	1.52	1.5	1.76
DO (4-5mg/l) (Wi =2)	8.47	6.93	7.12	8.39	8.79	9.12	9.7	9.07

Table 4. Experimental Analysis of sample 9 to 15

Parameters (permissible limits) and (Weightage (Wi))	S-9	S-10	S-11	S-12	S-13	S-14	S-15
Iron (0.3mg/l) (Wi =1)	0.18	0	0	0	0.1	0.2	0.15
p^H (6.5-8.5) (Wi =4)	7.2	8	7.3	8	6.9	7	7.1
Conductivity (250µS/cm) (Wi =2)	129	155	99	195	191	83	91
Residual chlorine (0.2mg/l) (Wi =2)	0.1	0.1	0.1	0.1	0	0	0
Turbidity (5NTU) (Wi =2)	22	25	18	13	14	11	5
Alkalinity (100-200mg/l) (Wi =3)	76	92	87	48	98	78	63
Chlorides (250-600mg/l) (Wi =3)	200	159	299	162	149	139	220
Total hardness (300-600mg/l) (Wi =2)	900	789	888	759	853	952	689
BOD (1mg/l) (Wi =2)	1.85	1.11	1.59	1.24	1.56	1.32	1.12
DO (4-5mg/l) (Wi =2)	8.95	9.32	8.75	8.89	9.25	8.55	9.34

3.1 *Representation of individual Parameters in QGIS*

Total Hardness and Electrical Conductivity water quality parameters are illustrated at fifteen locations using QGIS Software as shown in fig.2.

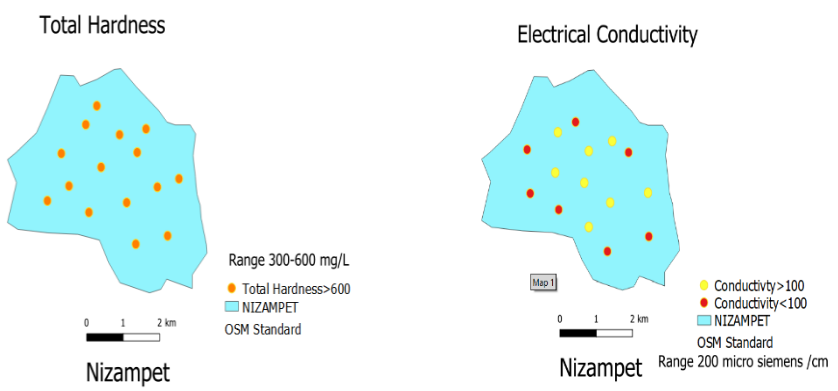

Fig. 2. Representation of Total Hardness and Conductivity in QGIS

The map above indicates that the overall hardness of all the samples is greater than 600, yet it is beyond the allowable limit and the conductivity of 15 samples are having less than 200 mg/l. and it is within the permissible range.

p^H and Electrical Conductivity water quality parameters are illustrated at fifteen locations using QGIS Software as shown in fig.3.

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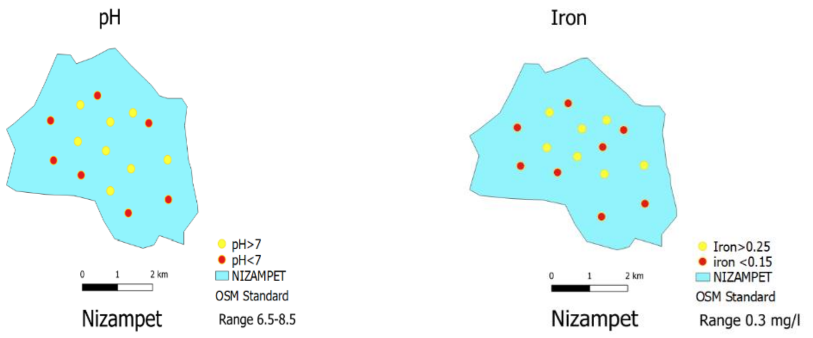

Fig. 3. Representation of P^H and Iron in QGIS

The above map indicates that the p^H of 15 samples ranges between 6.5 and 8.5, which is within the allowable range and the iron of 15 samples is less than 0.3 mg/l, which is within the allowable range.

Chlorine and Residual Chlorine water quality parameters are illustrated at fifteen locations using QGIS Software as shown in fig.4.

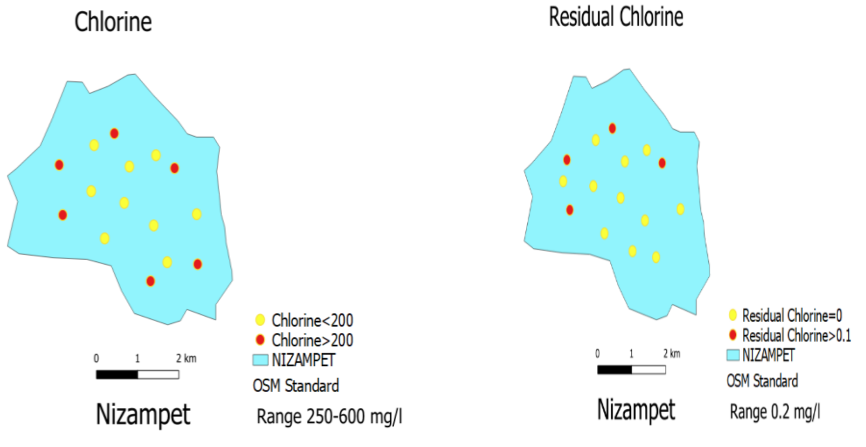

Fig. 4. Representation of Chlorine and Residual Chlorine in QGIS

The map above illustrates that the chlorine content of 15 samples ranges from 250 to 600 mg/l. It's within the acceptable range. The residual chlorine content of 15 samples are having less than 0.2mg/l . It's within the acceptable range.

Alkalinity and BOD water quality parameters are illustrated at fifteen locations using QGIS Software as shown in fig.5.

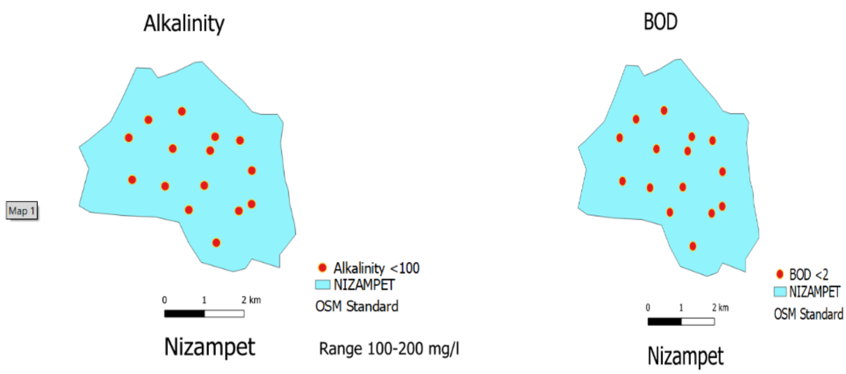

Fig. 5. Representation of Alkalinity and BOD in QGIS

The map above illustrates that the alkalinity of 15 samples are having less than 100 mg/l It's within the acceptable range. It is not within the acceptable range. BOD (Biochemical Oxygen Demand) of 15 samples are having less than 2mg/l . It's within the acceptable range.

Dissolved Oxygen and Turbidity water quality parameters are illustrated at fifteen locations using QGIS Software as shown in fig.6.

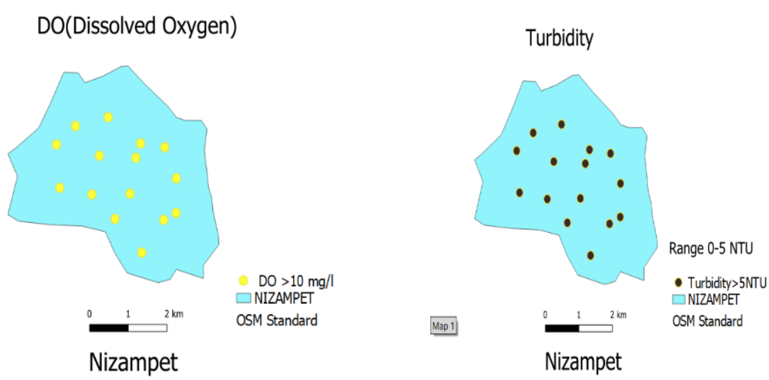

Fig. 6. Representation of DOand Turbidity in QGIS

The map above illustrates that the Dissolved Oxygen content of 15 samples are having less than 10 mg/l. It is within the acceptable range.

https://doi.org/10.1051/e3sconf/202339101208

3.2 *Water Quality Indices*

WQI for fifteen locations are calculated and shown in Table 5.

Table 5. WQI of all 15 Samples

Samples	Water quality index	Status of water
1	13.58	Excellent
2	68.14	Bad
3	46.93	Good
4	11.14	Excellent
5	74.855	Bad
6	50.35	Good
7	10.30	Excellent
8	46.61	Good
9	66.69	Bad
10	46.69	Good
11	42.95	Good
12	41.44	Good
13	25.73	Excellent
14	36.50	Good
15	28.14	Good

Water quality indices of fifteen samples are shown in fig.7 using QGIS and represented in bar graph as shown in fig.8. It comes out that samples 2, 5, and 9 have water quality indices ranging from 51 to 75, indicating that the water quality is poor. Other samples, such as 3,6,8,10,11,12,14, and 15, have a range of 26 to 50, indicating that the water quality is good. Other samples, such as 1,4,7,13, with a range of 0 to 25, indicate that the water quality is excellent.

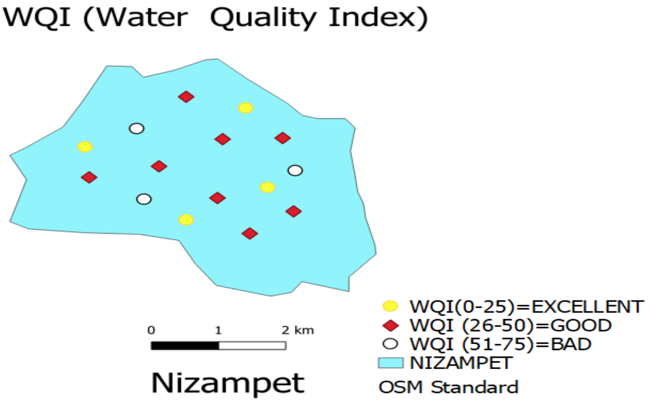

Fig. 7. Water Quality Indices in QGIS

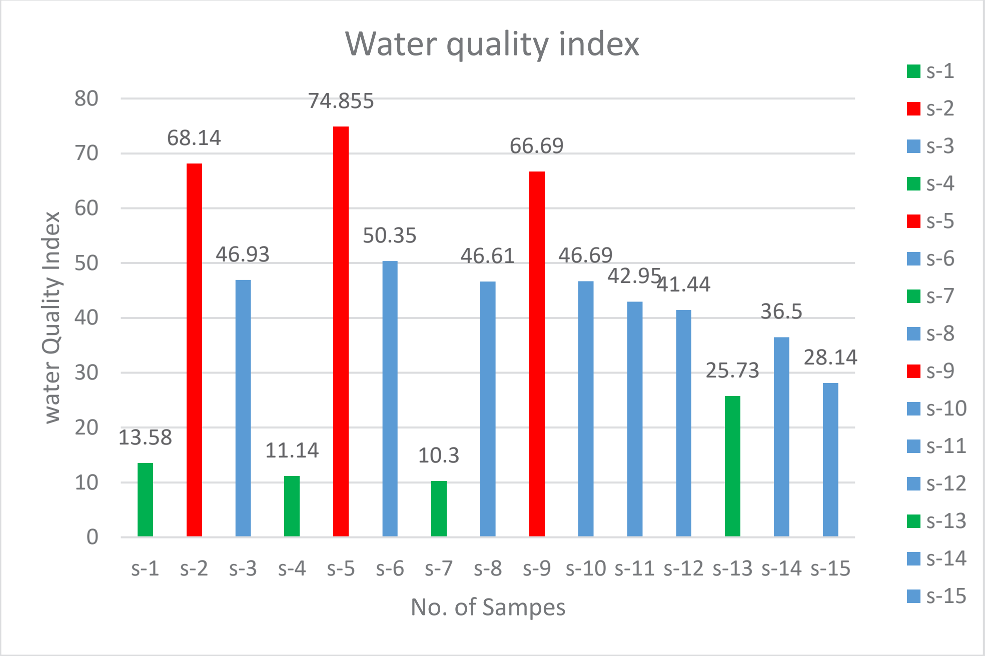

Fig. 8. Bar Chart for Water Quality Indices

4 Conclusion

The analysis clearly shows that water from a few locations in Nizampet is unsafe for human consumption. It should be treated before being consumed. As a result, by calculating the Water Quality Index (WQI), we can determine if the water is safe to drink. In this work, we utilize a systematic technique that allows us to compare the water quality of samples from a certain place (say, Nizampet). This WQI is extremely important for people to understand water quality and use as a tool for water quality management. This information is also useful for developing preventive steps to lessen the risk to the public who have been consuming the water.

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