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Assessment of Groundwater quality through GIS for Khed Taluka, District Ratnagiri, India

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Abstract

The present study was undertaken to evaluate groundwater quality and maps the spatial distribution for Khed taluka, Ratnagiri district through the Geographical Information System (GIS). Khed taluka is experiencing development at a faster rate, due to this settlement depends on groundwater resources. The IDW geospatial technique was used to prepare the geospatial distribution concept of ground water parameters which was very useful for deciding the water quality index maps. To prepare a water quality index map ArcGIS environment is used. The groundwater status of Khed taluka is good for drinking and domestic utilization.

Keywords: Water quality index, Inverse distance weighted, Geospatial distribution, *Geographical Information System.*

Introduction

Water is crucial for diversified purposes to all living beings. It is used for consumption and other household uses, irrigation, transportation, electricity generation, industry and mining, etc. Water is most likely the only natural resource to touch all aspects of human evolution from agricultural, industrial development, cultural and religious values rooted in civilization. The ground water is mainly available and low-priced water sources.

Groundwater had crucial significance for supporting health, life and reliability of ecosystems and most important natural resource with ecological and economic value. Due to increase in population and increasing food demand the over-extraction of groundwater, this has hazardous elongated effects. Scarcity and mistreat of groundwater cause a serious danger to sustainable development.

The ease of use of groundwater is tremendously uneven, due to spatial and temporal variation, erratic and stochastic nature of the rainfall and this make management difficult. The uneven distribution of groundwater is mainly due to extremely heterogeneous lithology and regional variation of rainfall[1].

'Water Quality' is used to express the chemical, physical or biological condition of water. This in turn, may be related to the appropriateness of water for a particular use or reason. The quality of water is expressed in form of its chemical, physical and biological parameters[2] and deliberate as Water Quality Index to evaluate whether water is drinkable or not. WQI provides an only number that describe entire water quality at certain location, based on several water quality parameters[3]. Hence, for whichever location, a groundwater quality map becomes a valuable parameter for evaluating portability and also as a precautionary suggestion of potential environmental health problems[4]. Remote sensing and Geographical Information System was used widely to assess the water quality all over the world[2,5-8].

The progression of Geographical Information System and Spatial Analysis tools help to integrate the laboratory analysis data with the geographic data and to model the spatial allocation of water quality parameters, most strongly and precisely.

The intention of the study is to assess the groundwater quality and map the same for Khed taluka, District Ratnagiri. To estimate the spatial distribution of the water quality parameters, Inverse Distance Weighed spatial interpolation technique was used.

Study Area: The study area is Khed taluka. It covers an area of 1023.72 km^2 and in northern part of Ratnagiri district (Figure-1). The study area lies between latitude 17°33'11.077" N and 17°54'23.873" N and longitude 73°18'.7.084" E and 73°42'51.349" E. Mean annual daily max and min temperatures of the Khed taluka varies between 30.5°C to 23°C.

The relative humidity is in the ranges of 70-75% with annual rainfall is at about 337.23 cm. Rainfall mainly occurs during June to September. Khed taluka is in development phase at much faster rate, the settlement of housing colonies was started using groundwater as a main source of water provide for household utilization.

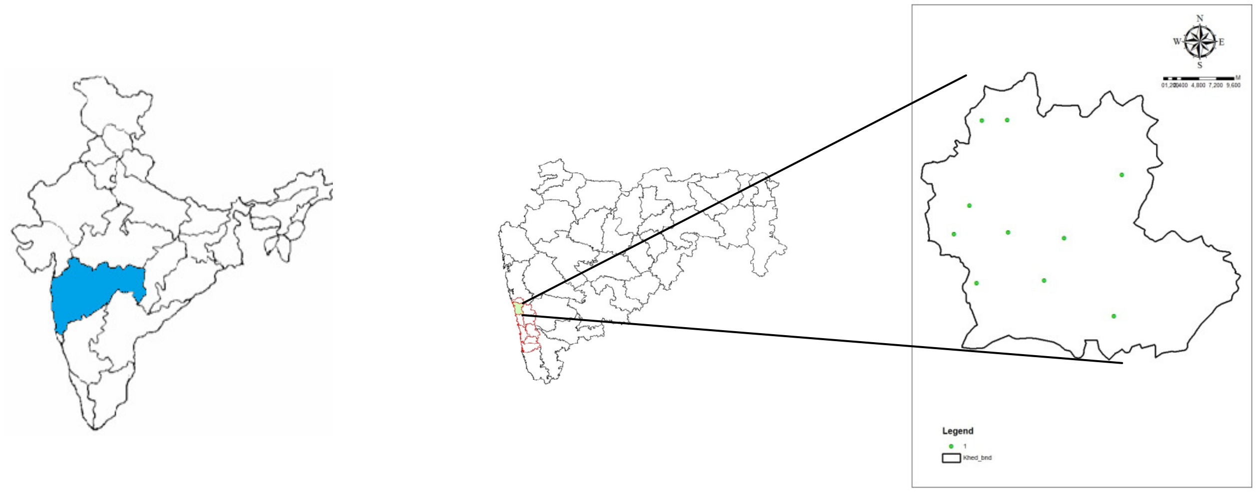

Figure-1
Study area

Methodology

Input Datasets: Bore wells and dug wells located within the study area were used as sampling points for groundwater collection. The coordinates of location was recorded with the help of GPS. The following parameters were recorded viz pH, EC, Hardness, Alkanity, TDS, Cl, SO_4, Ca, Mg and F. GPS data is used in a shape file to locate the locations of sampling well and the characteristic information i.e., water class parameters, joined to the respective sampling location. Figure-1 shows the locations map of the study area.

Water Quality Index: Water Quality Index (WQI) is a technique of rating the composite effect of each water quality parameters on the overall quality of water for consumption of human being[7]. To demarcate groundwater quality and its suitability for domestic purpose Water Quality Index (WQI) calculation is an important technique[9]. The contrast of the water quality parameter is carried out with dictatorial standards, on this concept WQI is based[10] and provides a sole value that utter on the whole water quality at particular site based on various water quality parameters[3]. Water quality issues could be improving through WQI by integrating complex data and calculating a score that proves water quality status and examine water quality trends[11].

The bulky water quality data is computed to reduce to a sole numerical value i.e. WQI by using principles of drinking water quality suggested by the BIS[12] and ICMR. WQI reflects the composite influence of different water quality parameters on the overall quality of water. The entire process of developing a water quality index map is shown in Figure-2 and classes of water quality index as shown in Table-1. To determine the suitability of the groundwater for drinking purpose WQI was estimated by subsequent method of[11,13],

$$\mathrm{WQI} = \mathrm{Antilog}\left(\sum_{i=1}^{n} W_i \log_{10} q_i\right) \quad (1)$$

Where: w_i = weightage of i^{th} factor, q_i = quality score of i^{th} factor, w_i is calculated as follow s, $w_i = k/s_n$.

Where:

$$k = \frac{1}{\frac{1}{VS_1} + \frac{1}{VS_2} + \cdots\cdots\cdots \frac{1}{VS_n}} \quad (2)$$

s_n = standard value of i th factor

q_i is as follows

$$q_i i = ((V_i a - V_i i)/(V_i s - V_i i)) \times 100 \quad (3)$$

Where: v_a = actual value from lab analysis of i^{th} factor, v_s = standard value of i^{th} factor, v_i = ideal value (Rest of parameters =0 and pH=7), Vstandard = BIS / ICMR standard of the water quality parameter.

The standard value of groundwater quality parameter is given in Table-1. All ten water quality parameters are tabulated in Table-2. Values of WQI were estimated by means of above formulae. The WQI values organize into different categories to evaluate the portability of groundwater (Table-3).

Interpolation GIS model: The diverse well positions of the groundwater samples were added into GIS environment. Each groundwater sample was allotted an exclusive identification code and save in attribute table. Value and a sample unique identification code for each sampling station of all parameters is located in the data base file. All groundwater quality parameters are shown spatially distributed in GIS map and WQI were prepared by adopting Inverse Distance weighted (IDW) technique using Arc GIS 9.3 software.

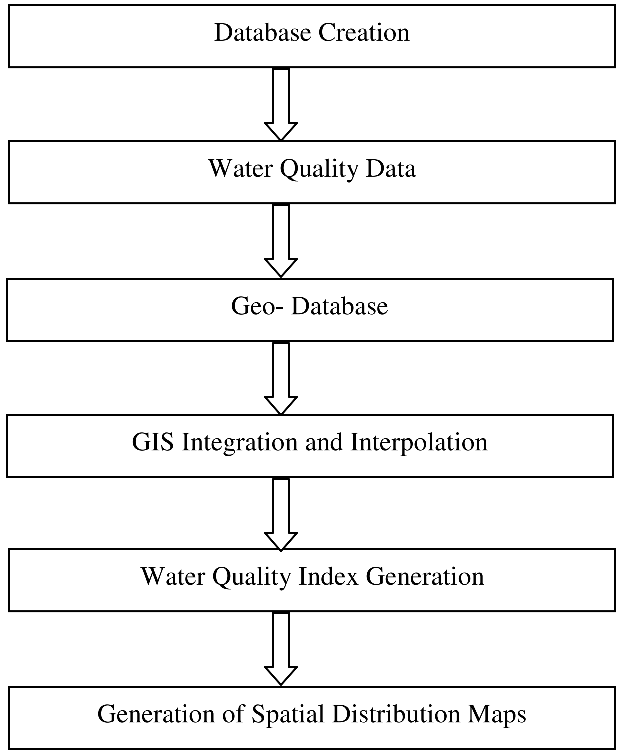

Figure-2
Flow chart of generation of WQI maps

Table-1
Groundwater quality standard, and assign weights

Parameter	**Standard, Sn**	**1/Sn**	**K**	**Wn**
pH	8.5	0.1176471	1.1853298	0.139451
EC	300	0.0033333	1.1853298	0.003951
Total Hardness	300	0.0033333	1.1853298	0.003951
Alkalinity	120	0.0083333	1.1853298	0.009878
TDS	500	0.002	1.1853298	0.002371
Cl	250	0.004	1.1853298	0.004741
SO4	200	0.005	1.1853298	0.005927
Ca	75	0.0133333	1.1853298	0.015804
Mg	50	0.02	1.1853298	0.023707
F	1.5	0.6666667	1.1853298	0.79022
	Total	**0.8436471**		**1**

Table-2
Values of Groundwater quality parameters

Sample	pH	EC	Hardness	Alkanity	TDS	Cl	SO4	Ca	Mg	F	WQI
1	7.4	234	112	101	150	16	5.00	8.40	22.11	0.88	**49.46**
2	7.2	206	56	47	132	4	6.00	5.20	10.45	0.05	**4.47**
3	7.3	198	128	119	127	10	3.00	9.60	25.27	0.05	**4.93**
4	7.2	178	108	101	114	10	2.00	6.40	22.36	0.05	**4.59**
5	7.4	263	128	115	168	12	6.00	14.00	22.60	0.90	**50.89**
6	7.5	234	120	137	150	10	2.00	9.60	23.33	0.05	**5.29**
7	7.1	152	84	90	97	6	1.00	11.60	13.37	0.05	**4.12**
8	8.3	294	124	104	188	6	6.00	12.80	22.36	0.05	**6.08**
9	7.6	247	104	101	158	8	3.00	10.80	18.71	0.05	**5.39**
10	7.2	162	140	137	104	10	1.00	8.80	28.67	0.05	**4.64**

Apart from conductivity & pH all other units in mg/l

Table-3
Status of water quality and water quality index

Water Quality Status	Water Quality Index
Excellent	0-25
Good	26-50
Poor	51-75
Very Poor	76-100
Unsuitable	>100

Results and Discussion

Spatial Distribution of Groundwater quality parameters: pH : various purposes of water depends upon the value of pH that is why important parameter. In area pH values of groundwater ranges from 7.10 and 8.25 and is in permissible boundary as suggested by the BIS/ ICMR. Spatial distribution of pH upto 7.5 indicating well permissible limits was observed in 829.71 km^2 (81%) of the study area (Figure-3.)

Electrical Conductivity: It is the ability of electrical current to pass all the way through the water. EC ranges from 152.034 to 293.99 µm/cm in study area. EC of groundwater in the Khed taluka is spatially distributed shown in Figure-4. The EC above 223 µm/cm was observed in 339.23 km^2 (33 %) of the study area.

Hardness: For drinking water, the boundary of hardness value is below 300 mg/l of $CaCO_3$. The groundwater hardness spatially distributed in Khed taluka is depicted in Figure-5. Hardness of ground water varies from 56.01 to 139.99 mg/l which indicate that entire study area is in permissible limits.

Calcium: The two most common minerals occur in groundwater is calcium and magnesium. It dissolved in water and it becomes hard. Calcium is plentiful substance occurred in the water. Calcium in groundwater is spatially distributed is depicted in Figure-6. Ca varies from 4.00 to 15.99 mg/l which indicate that entire study area is in acceptable limits.

Magnesium: Spatial allocation of Mg in the groundwater is given away in Figure-7. The value of Mg varies in the range of 10.45 mg/l to 28.67 mg/l which indicate that entire study area is in permissible limits.

Total Alkalinity: For potable water the standard enviable limit of total alkalinity is 120 mg/l. Total Alkalinity is spatially distributed over the study area is given away in Figure-8. It varies in the range of 47.02 to 136.99. High alkaline i.e. above 120 mg/l has been observed in 119.396 km^2 (11.66 %) area.

Total dissolved solid (TDS): Natural sources like urban runoff, sewage and industrial waste can increase the TDS in groundwater[14,15]. The advantageous limit of TDS is 500 mg/l as per BIS and ICMR standards. In the study area, TDS is spatially distributed ranges from 97.02 to 187.99 mg/l. throughout the study vicinity. TDS was found within acceptable limit as shown in Figure-9.

Sulphate: Sulphate concentration is varied from 1 to 5.99 mg/l. It was experienced that all water samples containing sulphates value under 200 mg/l drop inside permissible limit all over the study vicinity. Sulphate value in the groundwater of the study vicinity spatially distributed is shown in Figure-10.

Fluoride: In drinking water, BIS has suggested permissible limit of fluoride was 1.0 mg/l and ceiling range up to 1.5 mg/l. Fluorosis, dental mottling and bone diseases occurs when fluoride concentration increases in water above 1.5mg/l. Fluoride ranges between 0.05 to 0.89 mg/l falls in desirable limit in study area (Figure-11).

Chloride: In water higher the chloride concentrations, it test like salty. In assessing the water quality Chloride is one of the vital parameter and its higher concentration indicates higher degree of organic pollution[3]. In drinking water, BIS prescribes 250mg/l as permissible limit for chloride. Spatial allocation of Chloride is depicted in the study region (Figure-12). Chloride is variable in between 4.00 to 15.99 mg/l. Low concentration of chloride is found in entire study area.

Water Quality Index: WQI in the study region spatially distributed is as shown in Figure-13. WQI is varying from 4.00 to 55.00 in the study area. Out of 1023.72 km^2; 91.11 per cent (932.73 km^2) area comes under excellent category, 8.8 per cent (90 km^2) under good and 0.09 per cent (0.88 km^2) under poor category. The WQI around the Laval village shows poor ground water quality. The study region, potable ground water is present in most of the surrounding vicinity so that people may utilize it for drinking purpose.

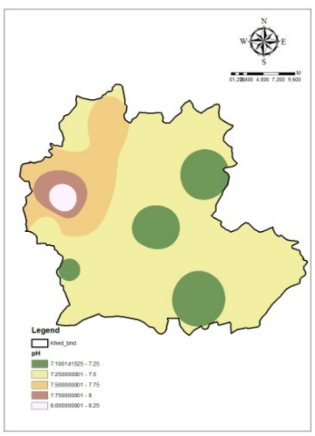

Figure-3
Spatial allocation of pH

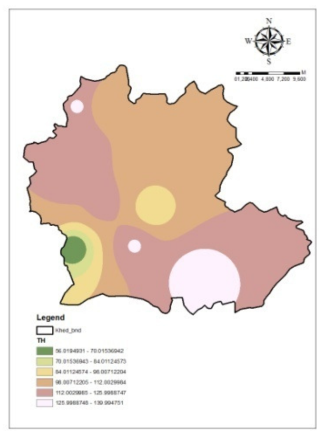

Figure-5
Spatial allocation of Hardness

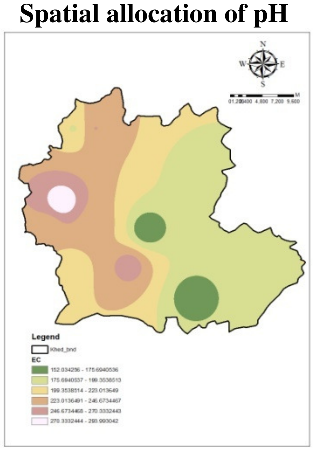

Figure-4
Spatial allocation of EC

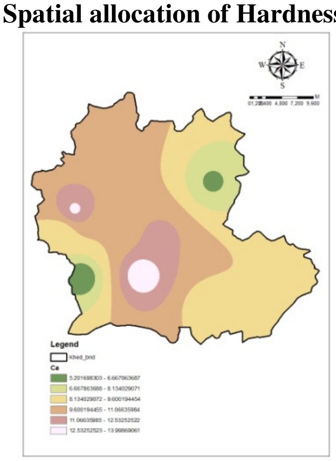

Figure-6
Spatial allocation of Calcium

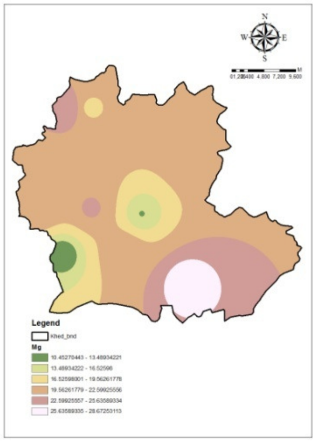

Figure-7
Spatial allocation of Magnesium

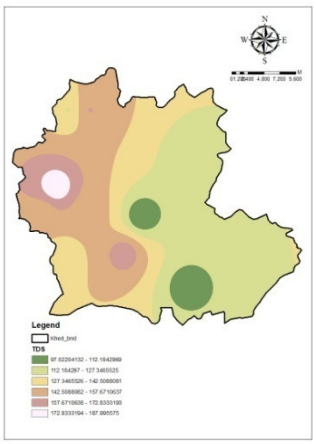

Figure-8
Spatial allocation of Total alkali

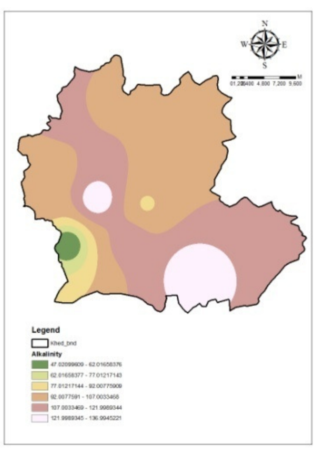

Figure-9
Spatial allocation of TDS

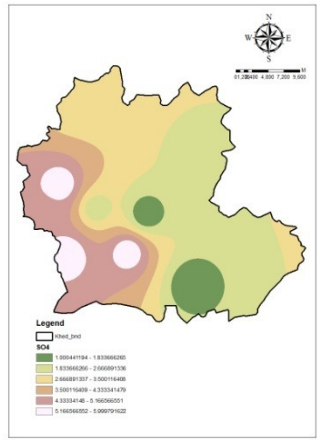

Figure-10
Spatial allocation of SO_4

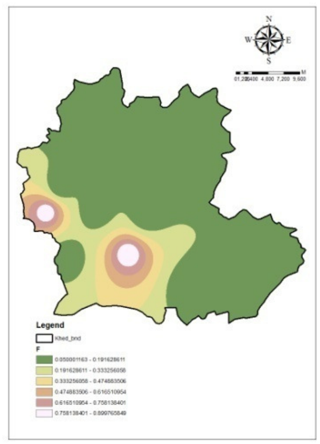

Figure-11
Spatial allocation of F

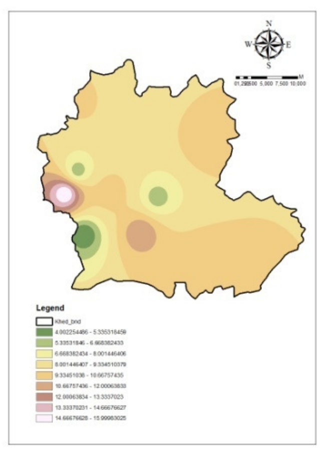

Figure-12
Spatial allocation of Cl

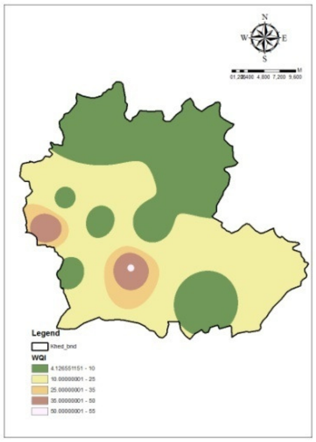

Figure-13
Spatial allocation of WQI

Conclusion

The ground water quality of Khed taluka, dist Ratnagiri assessed for domestic utility. Spatial distribution of pH, EC, Hardness, Calcium and Magnesium were found within the acceptable limit. Total Alkalinity has been observed higher than permissible limit in 11.66% area. In entire study area TDS, sulphates, fluoride and Chloride concentrations are in permissible limits. The overall WQI of the present study showed that 91.11 per cent area comes under excellent category, 8.8 per cent under good and 0.09 per cent under poor category. Thus it is observed that overall ground water is suitable for drinking purpose in the study area. Finally GIS environment could be useful for future development of water use strategies and policy makers from groundwater quality.

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