Evaluation of Groundwater Quality at Oragadam – A GIS Approach

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Abstract

Background/Objectives: In recent years, an increasing threat to groundwater quality due to human activities has become of great importance. This study aims to investigate the effect of industrial discharge of waste water on groundwater quality using GIS. Methods/Statistical Analysis: Oragadam Industrial area which is part of Sriperumbudur Taluk in Tamil Nadu has been chosen as study area owing to presence of about 35 industries. 25 physico-chemical parameters governing the water quality are determined from 50 samples collected in the study area. These have been mapped and spatial analysis has been carried out using GIS. Findings: Groundwater quality maps have been prepared using GIS. Effectiveness of GIS in evaluating the groundwater quality of the study area is determined. Turbidity of all 50 samples was within BIS standards. TDS of 43 samples (86%), electrical conductivity of 46 samples, alkalinity of 41 samples (82%), hardness of 41 samples (82%), chloride levels of 26 samples, iron content of 3 samples, fluoride levels of 3 samples, pH of two samples exceeded the BIS Standards. Pollution concentration maps were prepared for all 25 parameters in all 50 sampling stations. Applications/Improvements: Spatial distribution of water quality parameters has been represented through groundwater quality maps in and around industrial area of Oragadam, Sriperumbudur Taluk. This study has shown increased salinity levels of groundwater. This study will serve as an aid to Government authorities in groundwater quality monitoring.

Keywords: Concentration Maps, GIS, Groundwater Quality, Industries, Physico-Chemical Parameters, Spatial

1. Introduction

The quality of groundwater depends on a large number of individual hydrological, physical, chemical and biological factors. An important industrial place in Sriperumbudur has seen rapid industrialization attracting huge investments due to its proximity of upcoming Chennai Airport. In Tamil Nadu, Kancheepuram district lakes receive partially treated and untreated sewage effluent, sewage polluted surface run-off and untreated effluent from nearby residence and industrial areas.

1Reported that groundwater of the study area is bacteriologically not safe and requires treatment. 2Emphasized the necessity of the riparian bed as a common property resource to be used for better community health instead of short-term benefit. Assessment of groundwater quality status was done by using the Water Quality Index method by1. 4Carried out studies on water quality index of groundwater of Aland taluka, Gulbarga (India). 5Carried out the analysis of groundwater quality parameters. 6Undertook the study of groundwater quality in Aurangabad. 7Undertook the study to assess the drinking water quality in Manachanallur taulk, Trichy. Reported that drinking water at almost all the locations of Erode district were found to be highly contaminated, except few locations where it was found to be moderately contaminated for both the monsoons. 9Took up the physic-chemical and biological quality study of Anekal Taluk to evaluate its
suitability for potable purposes. 10Evaluated hydro-chemical characteristics of groundwater in Krishnagiri district, Tamil Nadu based on different indices for drinking, irrigation and industrial uses. 11Studied concentration of heavy metals in Libya. Reddy V. H.12 concluded that sixty percent of the samples were found to heavy fair quality groundwater and surface water in different locations of Tirupati, Chittoor District. An assessment of the groundwater quality was carried out in and around Dindigul town, Tamil Nadu, India13. 14Established that groundwater is highly contaminated and account for health hazards for human use. 15Studied seasonal variation on physico-chemical parameters and trace metals of groundwater in and around Ambattur Industrial area, Chennai were determined. S. Chitradevi16 stated that the major factor affecting the chemical budget of water is due to anthropogenic activities in addition to rock-water interaction. 17Evaluated from Wilcox plot and Piper trilinear diagram that the samples in some areas of Hyderabad are alkaline. 18Assessed the groundwater of Gwalior region was assessed for its irrigational suitability. 19Evaluated the groundwater quality in and around the Kancheepuram town of Tamil Nadu with reference to drinking and irrigation purposes with an objective to study the effect of dyeing units. There is no literature on the effect of automobile industrial effluents on groundwater quality pertaining to Oragadam Industrial area, Sriperumbudur taluk.

In this study, physico-chemical parameters of 50 samples have been evaluated in industrial area of Oragadam and Sriperumbudur. Pollution concentration maps have been prepared for 25 physico-chemical parameters using GIS.

2. Study Area

Figure 1 shows the study area. Sriperumbudur is a sub district (tehesil or taluk) in the Kancheepuram district, in the state of Tamil Nadu. The total population in Sriperumbudur sub district is 510,836 as per the survey of census during 2011 by Indian Government. Of this about 220,796 people are living in the urban (towns and cities) area and about 220,796 are living in villages (rural areas). There are 125,938 House Holds in this sub district. There are 258,881 males (51%).

Sriperumbudur belongs to the Sriperumbudur formation, which is characterized by arenaceous and argillaceous rock units composed of splintery green shale, clays, and sandstones with iron stone intercalation. The rock units conformably overlie either the Precambrian basement or Precambrian boulder beds and green shales. The beds contain marine intercalations. Monsoon season is brief and gets a little rainfall. During the summer temperatures range from a minimum of 32°C and can rise up to a maximum of 40°C. Sriperumbudur gets rainfall during October and November from the North East Monsoon.

In this study part of Sripreumbudur Taluk which lies between 79°54’0” and 80°0’0” E Longitude and between 12°48’0” and 13°0’0” N Latitude is chosen as study area. It comprises of about 35 industries around Oragadam and Sriperumbudur.

3. Material and Methods

Water samples were collected in 2 L polythene container from 50 different localities (Table 1) in and around Oragadam and Sriperumbudur area for 25 physico-chemical characteristics.

The standard methods and procedures20 were used for quantitative estimation of water quality parameters. Polythene containers were rinsed two times with water to be sampled. Sample was collected in the container without any air gap. It was covered with 10 cm x 10 cm polythene sheet and lid was covered again with 10 cm x 10 cm polythene sheets. It was tied with rubber band and
was tested within 24 hours of sampling. Sampling locations are shown in Figure 2. Physico-chemical parameters were compared with acceptable limits as per BIS 10500:2012. Groundwater quality standards as per BIS 10500:2012 are shown in Table 1.

4. Results and Discussions

Table 2 shows 25 physico-chemical parameters for 50 samples with their locations. All the 50 samples were clear in appearance, colorless and odorless. Turbidity of all 50 samples was within BIS standards. TDS of 43 samples (86%) were above BIS standards. Minimum value of TDS was 38 mg/l and maximum value was 1996 mg/l. Mean value of 1138.28 mg/l exceeded the standard value. Electrical conductivity of 46 samples exceeded standards. Minimum value of EC was 54 micro mho/cm and maximum value was 2984 micro/mho/cm with a mean value of 746 micro mho/cm. pH of two samples was above the range of 6.5-8.5. Minimum value of pH was 6.09 and maximum being 8.4. Mean pH was 7.31. Alkalinity of 41 samples (82%) exceeded the standards. Minimum value of alkalinity was 14 mg/L and maximum value was 564 mg/l. Mean value of alkalinity was 289.16 mg/l. Hardness of 41 samples (82%) were above standards. Minimum value of hardness was 18 mg/l and maximum value was 667 mg/l. Mean value of hardness was 353.92 mg/l. Calcium of 37 (74%) samples were above standards. Minimum value of calcium was 5 mg/l and 194 mg/l with a mean of 101.66 mg/l.

Iron content of 3 samples exceeded the prescribed limits with minimum of 0.06 mg/l and maximum of 0.34 mg/l with a mean of 0.24 mg/l. None of the samples contained manganese. Chloride levels of 26 samples were above the prescribed standards of BIS. Minimum chloride level was 7 mg/l and maximum level was 680 mg/l with a mean value of 244.22 mg/l. Fluoride levels of 3 samples exceeded the standards. Minimum value of fluoride was 0.11 mg/l and maximum value was 1.1 mg/l with a mean value of 0.72 mg/l. Maximum and minimum values are shown in Table 3.

Pollution concentration maps were prepared for all 25 parameters in all 50 sampling stations as shown in Figure 3.

Table 1. Groundwater quality standards as per BIS 10500:2012

| Parameter | Standard Value (mg/L) | Parameter | Standard Value (mg/L) | Parameter | Standard Value (mg/L) |
|-----------|----------------------|-----------|----------------------|-----------|----------------------|
| Appearance | Clear | Na | - | Alkalinity | 200 |
| Colour | Colour Less | K | - | Hardness | 200 |
| Odour | None | Fe | 0.3 | Ca | 75 |
| Turbidity | 1 | Mn | 0.1 | Mg | 30 |
| TDS | 500 | NH3 | 0.5 | Cl | 250 |
| EC | 1500 | NO2 | - | F | 1 |
| Ph | 6.5-8.5 | NO3 | 45 | SO4 | 200 |
| Alkalinity | 200 | Cl | 250 |
| Sl No | Sample | T | TDS | EC | pH  | Alkalinity | Hardness | Ca  | Mg  | Na  | K  | Fe   | NH₃ | NO₂ | NO₃ | Cl  | F   | SO₄ | PO₄ | O₂ |
|-------|--------|---|-----|----|-----|------------|----------|-----|-----|-----|----|------|-----|-----|-----|-----|-----|-----|-----|-----|
| Units |        | NTU| mg/l|    | mg/l| mg/l       | mg/l     | mg/l| mg/l| mg/l| mg/l| mg/l | mg/l| mg/l| mg/l| mg/l| mg/l| mg/l| mg/l| mg/l|
| 1     | P1     | 0.5| 812 | 1160| 6.90| 260        | 288      | 86  | 17  | 114 | 8  | 0.26 | 0.18| 0.01| 12  | 164 | 0.69| 32  | 0.02| 1  |
| 2     | P2     | 0.5| 498 | 711 | 7.32| 248        | 210      | 63  | 12  | 54  | 4  | 0.28 | 0.07| 0.02| 6   | 50  | 0.71| 18  | 0.01| 0.9|
| 3     | V1     | 0.8| 862 | 1231| 6.53| 164        | 280      | 86  | 15  | 144 | 9  | 0.25 | 0.06| 0.01| 14  | 242 | 0.68| 44  | 0.01| 0.9|
| 4     | V2     | 0.2| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 5     | M1     | 0.5| 325 | 464 | 6.64| 84          | 96       | 31  | 4   | 56  | 4  | 0.26 | 0.12| 0.01| 6   | 82  | 0.34| 8   | 0.01| 0.9|
| 6     | M2     | 0.5| 711 | 1016| 6.74| 160         | 172      | 53  | 10  | 141 | 9  | 0.23 | 0.18| 0.01| 16  | 182 | 0.61| 30  | 0.01| 0.9|
| 7     | V1     | 0.8| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 8     | V2     | 0.2| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 9     | M1     | 0.5| 325 | 464 | 6.64| 84          | 96       | 31  | 4   | 56  | 4  | 0.26 | 0.12| 0.01| 6   | 82  | 0.34| 8   | 0.01| 0.9|
| 10    | M2     | 0.5| 711 | 1016| 6.74| 160         | 172      | 53  | 10  | 141 | 9  | 0.23 | 0.18| 0.01| 16  | 182 | 0.61| 30  | 0.01| 0.9|
| 11    | V1     | 0.8| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 12    | V2     | 0.2| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 13    | M1     | 0.5| 325 | 464 | 6.64| 84          | 96       | 31  | 4   | 56  | 4  | 0.26 | 0.12| 0.01| 6   | 82  | 0.34| 8   | 0.01| 0.9|
| 14    | M2     | 0.5| 711 | 1016| 6.74| 160         | 172      | 53  | 10  | 141 | 9  | 0.23 | 0.18| 0.01| 16  | 182 | 0.61| 30  | 0.01| 0.9|
| 15    | V1     | 0.8| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 16    | V2     | 0.2| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 17    | M1     | 0.5| 325 | 464 | 6.64| 84          | 96       | 31  | 4   | 56  | 4  | 0.26 | 0.12| 0.01| 6   | 82  | 0.34| 8   | 0.01| 0.9|
| 18    | M2     | 0.5| 711 | 1016| 6.74| 160         | 172      | 53  | 10  | 141 | 9  | 0.23 | 0.18| 0.01| 16  | 182 | 0.61| 30  | 0.01| 0.9|
| 19    | V1     | 0.8| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|
| 20    | V2     | 0.2| 38  | 54  | 6.40| 14          | 18       | 5   | 1   | 4   | 0  | 0.06 | 0.04| 0.02| 0   | 7   | 0.11| 1   | 0.01| 0.5|

Table 2. Physico-chemical parameters for 50 water samples
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 29 | Se1 | 0.6 | 1089 | 1328 | 7.12 | 309 | 398 | 94 | 9 | 128 | 6 | 0.3 | 0.12 | 0.02 | 24 | 309 | 0.98 | 63 | 0.01 | 0.8 |
| 30 | Pa1 | 0.5 | 969 | 1124 | 8.04 | 296 | 374 | 80 | 12 | 139 | 13 | 0.25 | 0.24 | 0.19 | 20 | 314 | 1.1 | 89 | 0.01 | 0.8 |
| 31 | E1  | 0.5 | 1400 | 1812 | 7.1 | 371 | 454 | 136 | 28 | 161 | 10 | 0.22 | 0.39 | 0.14 | 27 | 374 | 0.84 | 80 | 0.01 | 1 |
| 32 | E2  | 0.4 | 1374 | 1819 | 6.74 | 310 | 471 | 139 | 28 | 150 | 11 | 0.29 | 0.07 | 0.34 | 24 | 360 | 0.89 | 48 | 0.01 | 1 |
| 33 | Pan1| 0.6 | 947 | 1249 | 7.04 | 296 | 334 | 110 | 28 | 112 | 6 | 0.3 | 0.04 | 0.01 | 16 | 284 | 0.94 | 80 | 0.01 | 0.8 |
| 34 | Pan2| 0.2 | 714 | 1130 | 7.21 | 312 | 209 | 101 | 9 | 109 | 4 | 0.25 | 0.04 | 0.04 | 13 | 312 | 0.81 | 46 | 0.01 | 0.9 |
| 35 | Pk1 | 0.9 | 674 | 1011 | 8.01 | 376 | 214 | 98 | 6 | 91 | 3 | 0.26 | 0.09 | 0.02 | 12 | 304 | 0.78 | 44 | 0.01 | 0.8 |
| 36 | Va2 | 0.3 | 1977 | 2984 | 6.80 | 309 | 667 | 57 | 17 | 98 | 7 | 0.19 | 0.11 | 0.32 | 22 | 387 | 0.86 | 81 | 0.01 | 0.9 |
| 37 | V3  | 0.7 | 1476 | 1670 | 7.20 | 311 | 87 | 6 | 56 | 4 | 0.3 | 0.32 | 0.14 | 8 | 263 | 0.53 | 17 | 0.05 | 1 |
| 38 | V4  | 0.9 | 1563 | 1936 | 6.90 | 356 | 430 | 119 | 13 | 72 | 9 | 0.12 | 0.29 | 0.09 | 6 | 324 | 0.65 | 78 | 0.03 | 0.8 |
| 39 | sp4 | 0.8 | 1769 | 2184 | 7.60 | 312 | 378 | 94 | 19 | 90 | 6 | 0.23 | 0.15 | 0.28 | 12 | 291 | 0.73 | 65 | 0.01 | 0.9 |
| 40 | sp5 | 0.5 | 1780 | 1368 | 8.20 | 219 | 621 | 131 | 8 | 112 | 5 | 0.28 | 0.27 | 0.17 | 25 | 142 | 0.85 | 39 | 0.04 | 0.6 |
| 41 | sp3 | 0.6 | 1898 | 2890 | 7.42 | 498 | 639 | 108 | 29 | 217 | 4 | 0.29 | 0.21 | 0.34 | 37 | 378 | 0.74 | 67 | 0.02 | 1 |
| 42 | Po3 | 0.8 | 1996 | 2740 | 8.20 | 286 | 467 | 187 | 19 | 18 | 6 | 0.34 | 0.28 | 0.26 | 7 | 284 | 0.94 | 5 | 0.04 | 0.8 |
| 43 | Po4 | 0.6 | 1300 | 1416 | 7.09 | 564 | 387 | 99 | 9 | 64 | 3 | 0.2 | 0.1 | 0.16 | 28 | 308 | 0.8 | 89 | 0.02 | 0.7 |
| 44 | Th1 | 0.8 | 1871 | 2084 | 7.94 | 409 | 208 | 194 | 26 | 56 | 8 | 0.23 | 0.18 | 0.04 | 32 | 167 | 0.74 | 35 | 0.03 | 0.6 |
| 45 | Va1 | 0.4 | 1814 | 968 | 8.40 | 399 | 656 | 143 | 10 | 116 | 2 | 0.3 | 0.12 | 0.09 | 5 | 247 | 0.6 | 26 | 0.01 | 0.9 |
| 46 | T1  | 0.5 | 1674 | 2624 | 7.10 | 262 | 532 | 78 | 21 | 189 | 2 | 0.19 | 0.11 | 0.24 | 30 | 209 | 0.84 | 87 | 0.01 | 0.6 |
| 47 | Po1 | 0.7 | 1856 | 1927 | 7.00 | 385 | 324 | 86 | 10 | 36 | 5 | 0.22 | 0.16 | 0.32 | 17 | 321 | 0.64 | 76 | 0.03 | 0.7 |
| 48 | Po2 | 0.8 | 1873 | 589 | 6.09 | 421 | 307 | 182 | 16 | 83 | 3 | 0.1 | 0.24 | 0.06 | 8 | 189 | 0.7 | 13 | 0.04 | 0.5 |
| 49 | sp1 | 0.4 | 1630 | 2165 | 7.60 | 213 | 511 | 128 | 22 | 126 | 7 | 0.13 | 0.13 | 0.08 | 22 | 299 | 0.54 | 83 | 0.01 | 0.9 |
| 50 | sp2 | 0.9 | 1893 | 1968 | 8.10 | 319 | 384 | 113 | 7 | 16 | 4 | 0.31 | 0.19 | 0.19 | 15 | 367 | 0.6 | 16 | 0.02 | 0.6 |
5. Conclusion and Future Work

Among groundwater quality parameters TDS, Alkalinity, Hardness and Calcium values are significant and higher percentage of samples exceed standards in these parameters. This indicates that salinity is the major problem in this study area with reference to physic-chemical parameters. Since this is rapidly growing industrial area, the risk of heavy metal contamination will only increase in near future. Also given the fact that high rise residential communities are coming up at a rapid rate in the vicinity of Oragadam evaluation of groundwater quality becomes

Table 3. Maximum and minimum value of each parameters

| Parameters | N | Minimum | Maximum | Mean  | Std. Deviation |
|------------|---|---------|---------|-------|----------------|
| T          | 50 | .00     | 1.00    | .4200 | .49857         |
| TDS        | 50 | 38.00   | 1996.00 | 1138.2800 | 568.60564 |
| EC         | 50 | 54.00   | 2984.00 | 1445.9800 | 746.98902  |
| Ph         | 50 | 6.09    | 8.40    | 7.3184 | .56612         |
| Alkalinity | 50 | 14.00   | 564.00  | 289.1600 | 106.12014   |
| Hardness   | 50 | 18.00   | 667.00  | 353.9200 | 168.81578   |
| Ca         | 50 | 5.00    | 194.00  | 101.6600 | 47.44776    |
| Mg         | 50 | 1.00    | 31.00   | 15.5400 | 8.35979      |
| Na         | 50 | 4.00    | 344.00  | 107.5000 | 69.56989    |
| K          | 50 | .00     | 18.00   | 6.8800  | 4.04384      |
| Fe         | 50 | .06     | .34     | .2462  | .05473       |
| Mn         | 50 | .00     | .00     | .0000  | .00000       |
| NH₃        | 50 | .04     | .48     | .1664  | .10737       |
| NO₂        | 50 | .01     | .54     | .1356  | .15852       |
| NO₃        | 50 | .00     | 37.00   | 15.6600 | 9.18875     |
| Cl         | 50 | 7.00    | 680.00  | 244.2200 | 143.56230 |
| F          | 50 | .11     | 1.10    | .7204  | .20088       |
| SO₄        | 50 | 1.00    | 94.00   | 47.1000 | 29.68997    |
| PO₄        | 50 | .01     | .05     | .0156  | .01053       |
| O₂₂        | 50 | .00     | 9.00    | 1.1200 | 1.15423      |

Valid N (list wise) 50

Figure 3. Pollution concentration maps of select parameters.
It is recommended that Government bodies monitor the groundwater quality of the study area and issue instructions to industries to maintain stringent disposal standards.

6. References

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