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Hydrochemical Evalution of Groundwater in an Industrial Area Chrompet

P. Vijayalakshmi*, C. Sandeep Kumar Reddy and G. Tharun

Department of Civil Engineering, Sathyabama University, Chennai – 600119, Tamil Nadu, India; vijayalakshmisound@gmail.com, cskr.jan.16@gmail.com, tharunkmr789@gmail.com

Abstract

Objectives: To analyze the physical and chemical characteristics of a groundwater samples (Tannery industrial area). The suitability of groundwater for domestic purpose has been interpreted using Geographical Information system. **Methods/Materials:** Groundwater samples were collected and analyzed for various physico-chemical parameters as per the standard procedures prescribed by American Public Health Association (APHA) using standard techniques, to determine Colour, Odour, Turbidity, conductivity, pH, Total Dissolved Solids (TDS), alkalinity, Methyl Orange Alkalinity Total Hardness, Carbonate Hardness, Non Carbonate Hardness, Phenopthenlein, Calcium, Magnesium, Chloride, sulphate, Iron, Nitrate, and Silica and compared with water quality standards. **Findings:** Colour, pH (ranges 7.36 to 8.33), Methyl Orange Alkalinity (ranges 2 to 67mg/l), Phenopthenlein Alkalinity (maximum 82mg/l), Calcium (<0.01), Magnesium (ranges 4.7 to 14.8 mg/l), Chloride ranges 325 to 642), Sulphate (ranges 24 to 52 mg/l), Iron (<0.01), Nitrate (2 to 28mg/l), were within the permissible limit. The study reveals that the concentration of Turbidity (5 to 25 NTU), EC (1752 to 4365 micromhos/cm), Total dissolved solids (ranges 863 to 2952mg/l) and Total Hardness (ranges 300 to 2143 mg/l), exceeding the permissible limit. Groundwater is unsuitable for domestic uses. **Application/Implements:** By implementing new technology like permeable reactive barrier near the effluent discharged area and around the solid waste dumping area it can minimize the groundwater contamination. Thus, this study indicates the impact of effluents from tanneries. To highlight the impact of tannery effluent on groundwater, strategically analyzed results are presented based on GIS.

Keywords: Domestic, Groundwater Quality, Spatial Distribution, Tanneries, GIS

1. Introduction

Groundwater is the major source of water supply for various domestic activities. Only about 20% of the large number of chemicals used in the tanning process is absorbed by leather and the rest is released as waste¹. For social and economic infrastructure, water is the basic element. Rapid Population growth, unplanned urbanization, over exploitation of groundwater resources, dumping of solid waste in non-engineered methods is enhancing the infiltration of harmful compounds to the groundwater. For healthy society and sustainable development, it is essential. As a result, the surface water and groundwater level is decreasing. Today there are numerous waste water treatment technologies available for treating the tannery wastewater. And these technological solutions appeared to be out of reach due to several economical factors². An unfavourable release from industries is detrimental to human, animal health and safety3. TDS is the measure of certain substances that are dissolved in water is the measured based on total dissolved solid content4. Adopting cleaner technologies, such as organic tanning agents, softeners and reverse osmosis for treating the effluent is mandatory for these industries and engineered landfill for solid waste disposal to prevent infiltration of leachate5. The tannery wastewater retains in the stagnant ponds for prolonged periods of time. This allows the dissolved constituents from the wastewater to percolate into the subsurface⁶. Water hardness has adverse effects in heart disease7. Groundwater pollution is difficult to detect, because of institute one and monitoring is costly, time consuming and hard to resolve8. The protection and management of groundwater quality is the major problem, once contaminated it is very difficult to restore its quality9.

^{*} Author for correspondence

2. Methodolgy

2.1 Study Area

The study area is in and around Nagalkeni, Rajaji Nagar; Pammal which is located South of Chennai Figure 1 Topography of this region gently slopes towards west to east.

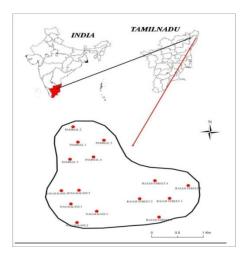


Figure 1. Location of a study area (Chromepet Industrial Area).

2.2 Sampling Location

Groundwater samples (15 Nos.) from the three selected sites namely Nagalkeni, Pammaland Rajaji Nagar were collected and analyzed in laboratory by using standard methods. The sampling locations and the details of latitude and longitude of the sampling locations are shown and presented in Figure 2 and Table 1 respectively.



Figure 2. Locations of sampling wells.

2.3 Physical and Chemical Analysis

The collected samples were analyzed for physicochemical parameters like Colour, Odour, Conductivity, Turbidity, pH, Total Dissolved Solids (TDS), Total Hardness(TH), Carbonate Hardness (CH), Non-Carbonate Hardness (NCH), Methyl Orange Alkalinity, Phenopthenlein Alkalinity, Calcium, Magnesium, Chloride, Sulphate, Iron, Nitrate, Silica by using APHA methods. The results have been tabulated in Tables 2-4.

| Table 1. Latitude and longitude of a sample lo | ocation |
|--|---------|
|--|---------|

| Details of Sampling location | Latitude | Longitude |
|------------------------------|------------------|-------------------|
| Nagalkeni [S 1] | 80° 8' 8.512" E | 12° 57' 53.262" N |
| Nagalkeni [S 2] | 80° 8' 12.416" E | 12° 57' 38.654" N |
| Nagalkeni [S 3] | 80° 8' 25.093" E | 12° 57' 47.563" N |
| Nagalkeni [S 4] | 80° 8' 2.308" E | 12° 58' 3.667" N |
| Nagalkeni [S 5] | 80° 8' 13.615" E | 12° 58' 4.010" N |
| Pammal [S 6] | 80° 8' 12.842" E | 12° 58' 41.859" N |
| Pammal [S 7] | 80° 8' 12.416" E | 12° 57' 38.654" N |
| Pammal [S 8] | 80° 8' 7.790" E | 12° 58' 28.338" N |
| Pammal [S 9] | 80° 8' 22.866" E | 12° 58' 30.222" N |
| Pammal [S 10] | 80° 8' 29.548" E | 12° 58' 43.414" N |
| Rajaji Street [S 11] | 80° 9' 11.884" E | 12° 57' 57.830" N |
| Rajaji Street [S 12] | 80° 9' 23.856" E | 12° 58' 7.950" N |
| Rajaji Street [S 13] | 80° 9' 5.182" E | 12° 57' 43.109" N |
| Rajaji Street [S 14] | 80° 9' 2.441" E | 12° 58' 11.719" N |
| Rajaji Street [S 15] | 80° 8' 52.676" E | 12° 57' 57.500" N |

 Table 2.
 Parameter analyses of ground water samples

| Samples | Colour (TCU) | Odour | Conductivity | Turbidity NTU | pH Value | Total Dissolved Sol- |
|---------|--------------|-----------------|--------------|---------------|----------|----------------------|
| | | | Micromhos/cm | · | | ids (mg/l) |
| S1 | 5 | Unobjectionable | 1752 | 7.8 | 8.20 | 863 |
| S2 | 5 | Unobjectionable | 2752 | 7.85 | 7.85 | 1365 |
| S3 | 7.5 | Unobjectionable | 3287 | 8.5 | 7.36 | 1652 |
| S4 | 5.5 | Unobjectionable | 3522 | 12.3 | 8.2 | 1557 |
| S5 | 10 | Unobjectionable | 2894 | 15.5 | 7.9 | 1450 |
| S6 | 10 | Unobjectionable | 3594 | 8.2 | 7.6 | 2543 |
| S7 | 10 | Unobjectionable | 6482 | 10.9 | 8.1 | 2952 |
| S8 | 15 | Unobjectionable | 3684 | 8.2 | 8.33 | 2420 |
| S9 | 20 | Unobjectionable | 4365 | 10.5 | 8.10 | 2001 |
| S10 | 25 | Unobjectionable | 2347 | 12.7 | 7.63 | 1756 |
| S11 | 7.5 | Unobjectionable | 3441 | 8.5 | 7.84 | 1796 |
| S12 | 5 | Unobjectionable | 4253 | 7.6 | 8.11 | 2143 |
| S13 | 20 | Unobjectionable | 3740 | 8.5 | 8.1 | 2569 |
| S14 | 22 | Unobjectionable | 4225 | 8.7 | 7.9 | 2745 |
| S15 | 5 | Unobjectionable | 3855 | 7.9 | 8.2 | 1764 |

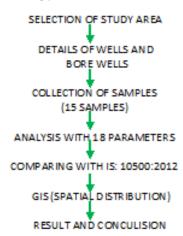
 Table 3.
 Parameter analysis with ground water samples

| Samples | Total Hard- | Carbonate | Non Carbonate | Phenopthenlein | Methyl Orange | Calcium (mg/l) |
|---------|-------------|-----------|-----------------|-------------------|-------------------|----------------|
| | ness (mg/l) | Hardness | Hardness (mg/l) | Alkalinity (mg/l) | Alkalinity (mg/l) | |
| S1 | 300 | 124 | 167 | Nil | 2 | < 0.01 |
| S2 | 432 | 257 | 105 | 76 | 36 | < 0.01 |
| S3 | 500 | 211 | 255 | 82 | 42 | < 0.01 |
| S4 | 422 | 201 | 187 | 19 | 36 | < 0.01 |
| S5 | 514 | 356 | 100 | 20 | 42 | < 0.01 |
| S6 | 766 | 421 | 136 | Nil | 7 | < 0.01 |
| S7 | 1058 | 325 | 422 | Nil | 8.5 | < 0.01 |
| S8 | 845 | 177 | 200 | Nil | 7.3 | < 0.01 |
| S9 | 563 | 201 | 258 | Nil | 6.5 | < 0.01 |
| S10 | 458 | 125 | 305 | Nil | 7.2 | < 0.01 |
| S11 | 842 | 366 | 176 | Nil | 58 | < 0.01 |
| S12 | 471 | 200 | 256 | Nil | 67 | < 0.01 |
| S13 | 2143 | 200 | 307 | Nil | 47 | < 0.01 |
| S14 | 2140 | 176 | 255 | Nil | 42 | < 0.01 |
| S15 | 2025 | 196 | 175 | Nil | 36 | < 0.01 |

 Table 4.
 Parameter analysis with ground water samples

| Samples | Magnesium (mg/l) | Chloride (mg/l) | Sulphate (mg/l) | Iron (mg/l) | Nitrate (mg/l) | Silica (mg/l) |
|---------|------------------|-----------------|-----------------|-------------|----------------|---------------|
| S1 | 8 | 369 | 28 | < 0.01 | 5 | 4 |
| S2 | 7 | 542 | 24 | < 0.01 | 4 | 28 |
| S3 | 5 | 325 | 47 | < 0.01 | 5 | 37 |
| S4 | 7 | 595 | 52 | < 0.01 | 7 | 42 |
| S5 | 5 | 458 | 36 | < 0.01 | 5 | 36 |
| S6 | 5.5 | 422 | 31 | < 0.01 | 2 | 7 |
| S7 | 7.5 | 563 | 42 | < 0.01 | 7 | 5 |
| S8 | 10.8 | 642 | 35 | < 0.01 | 5 | 2 |
| S9 | 7.3 | 358 | 42 | < 0.01 | 28 | 1 |
| S10 | 14.8 | 420 | 36 | < 0.01 | 14 | 5 |
| S11 | 4.7 | 522 | 27 | < 0.01 | 5 | 12 |
| S12 | 5.5 | 420 | 28 | < 0.01 | 7 | 10 |
| S13 | 5 | 415 | 32 | < 0.01 | 5 | 7 |
| S14 | 7 | 325 | 47 | < 0.01 | 7 | 2 |
| S15 | 5 | 421 | 52 | < 0.01 | 2 | 7 |

2.4 Methodology Flow Chart



3. Result and Discussion

The groundwater samples were collected and the concentration with the limits recommended by Bureau of Indian Standards (BIS) is discussed. Geographical Information System (GIS) is used to understand the spatial distribution and variation of the ions with respect to the location.

The maximum Color was recorded as 25 at sampling location S10 and the minimum was 5 at S1, S2, & S12 to S16 and compared with the standard values of IS: 10500:2012, the values exceeds the permissible limit 5. Figure 3 shows the variation in colour.

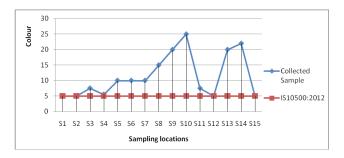


Figure 3. Groundwater quality variations in colour.

The maximum pH was recorded as 8.33 at sampling location S8 and the minimum was 7.6at S6 and compared with the standard values of IS: 10500:2012, and the within the permissible limit 6.5 to 8.5. pH variation shown in Figure 4.

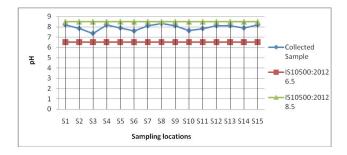


Figure 4. Groundwater quality variations in pH.

The maximum turbidity was recorded as 15.5NTU at sampling location S5 and the minimum was 7.8NTU at S1. The values are within the permissible value (5NTU) on compared with the standard values of IS: 10500:2012. Variations in turbidity are shown in Figure 5. The maximum chloride was recorded as 642mg/l at sampling location S8 and the minimum was 3254mg/l at S3, S14 and compared with the standard values of IS: 10500:2012 are within the permissible limit (250 – 1000mg/l). Variations in chloride are shown in Figure 6.

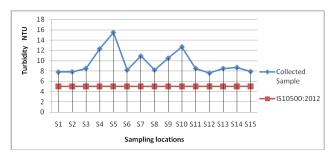


Figure 5. Groundwater quality variations turbidity.

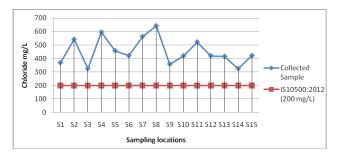


Figure 6. Groundwater quality variations in chloride (mg/l).

The maximum carbonate hardness was recorded as 421mg/l at sampling location S6 and the minimum was

124mg/l at S1 and compared with the standard values of IS: 10500:2012. Carbonate Variations in hardness are shown in Figure 7. The maximum magnesium was recorded as 14.8mg/l at sampling location S10 and the minimum was 4.7mg/l at S11 and compared with the standard values of IS: 10500:2012 are within the permissible limit (30 – 100mg/l). Groundwater quality variation in Magnesium was presented in Figure 8.

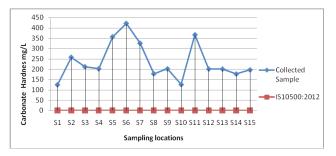


Figure 7. Groundwater quality variations carbonate hardness (mg/L).

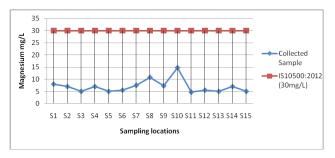


Figure 8. Groundwater quality variations in magnesium (mg/l).

The maximum nitrate was recorded as 28mg/l at sampling location S9 and the minimum was 2mg/l at S6, S15 and compared with the standard values of IS: 10500:2012 Variations in nitrate are shown in Figure 9.

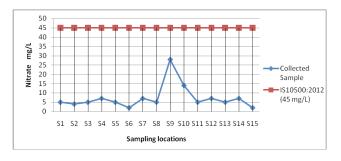


Figure 9. Groundwater quality variations in nitrate (mg/L).

The maximum Caco3 was recorded as 67mg/l at sampling location S12 and the minimum was 2mg/l at S1 and compared with the standard values of IS: 10500:2012, the samples are found to be permissible limit 30 – 100mg/l. Groundwater quality variation in Calcium carbonate was presented in Figure 9. The maximum Non Carbonate Hardness was recorded as 422mg/l at sampling location S7 and the minimum was 105mg/l at S2 and compared with the standard values of IS: 10500:2012. Variations in non-carbonate hardness are shown in Figure 10.

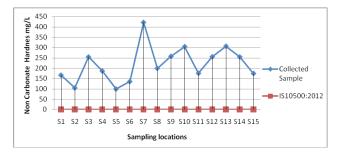


Figure 10. Groundwater quality variations in non-carbonate hardness (mg/L).

The maximum total dissolved solids were recorded as 2952mg/l at sampling location S7 and the minimum was 8635mg/l at S1 and compared with the standard values of IS: 10500:2012. Variations in TDS are shown in Figure 11.

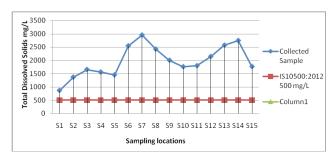


Figure 11. Groundwater quality variations in total dissolved solids (mg/l).

The maximum sulphate was recorded as 52mg/l at sampling location S4, S15 and the minimum was 24mg/l atS2 and compared with the standard values of IS: 10500:2012 are within the permissible limit (200 – 400mg/l). Variations in sulphate are shown in Figure 12.

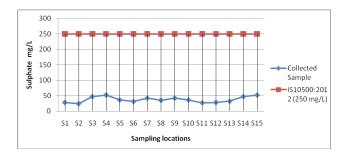


Figure 12. Groundwater quality variations in sulphate (mg/l).

Except S1 location, the maximum total hardness was recorded as 2143mg/l at sampling location S13 and the minimum was 300mg/l at S1 and compared with the standard values of IS: 10500:2012 are not within the permissible limit (300 – 600mg/l). Variations in total hardness are shown in Figure 13. A major portion of groundwater of this area is hard water.

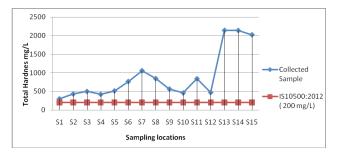


Figure 13. Groundwater quality variations in total hardness (mg/l).

4. Geographical Information System

4.1 General

GIS may be defined as an integrated system to manage, collect and manipulate information in a spatial context. This system also stored and maintained in a computerized system of files and databases to facilitate recording, management, analysis and reporting of information. This consist set of software, processes and organization and hardware that integrates the value of spatial data.

The four functions of GIS are:
Data acquisition and pre-processing
Data management, storage and retrieval
Manipulation and analysis
Product generation

4.2 Components of GIS

Computer hardware, sets of application software modulus and proper organizational setup are the important components of GIs.

4.3 Hardware

The general hardware components of a graphical information system are digitizer, network and CDROM driver, computer, plotter and printer. The digitizer and scanner are used to convert map and document into digital form. The plotter or printer is used to prevent the results of the data processing.

4.4 Software

The software for a geographical information system may be split into five functional groups

- Data input verification
- Data storage and management
- Data output and presentation
- Data information data transformation
- Data information

In addition to the core GIS software, various additional software components can be to access additional forms functionally.

4.5 Data

Data for GIS are geographic data and attribute data. Spatial data contain an explicit geographic location in the form of a set of coordinates. Attribute data are descriptive sets of data that contain various information relevant to a particular location e.g. depth, height, sales, figures etc. and can be linked to a particular location by means of an identifier e.g. address, pin code, etc.

4.5.1 Steps

Step 1: Create a layer for top sheet of coastal region by clicking Add Data then load the top sheet to the layer.

Step 2: Above the top sheet the GCP points are located in GCS measurements.

Step 3: Using the option Add Control Points, the control points are fixed on the top sheet.

Step 4: Four valid control points are fixed.

Step 5: The top sheet is rectified on placing fourth control point on top sheet.

Step 6: Link table with the list of GCPs are shown.

Step 7: Open Arc Catalog and create a file with polygon attribute.

Step 8: Add the shape file to the layer.

Step 9: On editor toolbar, click start editing the boundary of top sheet is edited by starting at one point and closing at some point. Thus a closed polygon feature of required boundary is thus obtained

Spatial Distribution

To highlight the impact, the spatial distributions are presented on GIS platform and the same has been analyzed below.

The maximum pH value is 8.33 and minimum value is 7.36 by analyzing 15 groundwater samples. Figure 14 shows the result of GIS map (spatial distribution of) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with pH (Moderate) the area specified with red colour the groundwater is mostly affected by pH.

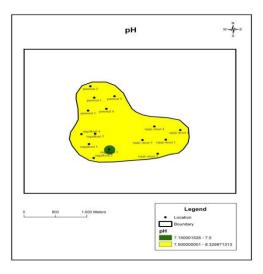


Figure 14. Spatial distribution of pH.

The maximum Conductivity value is 4365 Micromhos/ cm and minimum value is 1752 Micromhos/cm by analyzing 15 ground water samples. Figure 15 shows the result of GIS map (spatial distribution of Conductivity) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Conductivity (Moderate) the area specified with red colour the groundwater is mostly affected by conductivity. The maximum Carbonate Hardness value is 421 mg/l and minimum value is 124 mg/l by analyzing 15 groundwater samples Figure 16 shows the result of GIS map (spatial distribution of Carbonate Hardness). Based on the results, it has been noticed that the area specified with green colour, the Ground Water is within the permissible limit as per standards, and the area specified with yellow colour, the groundwater is affected with Carbonate Hardness (Moderate) and the area specified with red colour, the groundwater is mostly affected by Carbonate Hardness.

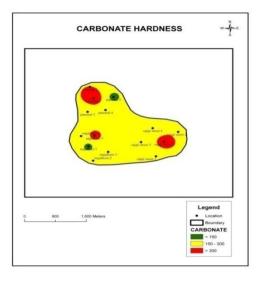


Figure 15. Spatial distribution of conductivity.

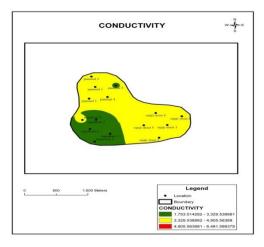


Figure 16. Spatial distribution of carbonate hardness.

The maximum Chloride value is 595 mg/l and minimum value is 358 mg/l by analyzing 15 groundwater samples. Figure 17 shows the result of GIS map (spatial distribution of Chloride) and based on the results, it has been notice that the area specified with green colour, the Ground Water is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Chloride (Moderate) the area specified with red colour the groundwater is mostly affected by Chloride. The Magnesium maximum value is 14.8 mg/l and minimum value is 5 mg/l by analyzing 15 ground water samples.

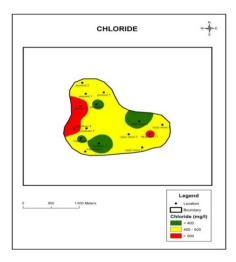


Figure 17. Spatial distribution of chloride.

Figure 18 shows the result of GIS map (spatial distribution of Magnesium) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the Groundwater is affected with Magnesium (Moderate) the area specified with red colour the ground water is mostly affected by Magnesium.

The Methyl Orange maximum value is 67 mg/l and minimum value is 2 mg/l by analyzing 15 groundwater samples. Figure 19 shows the results of GIS map (spatial distribution of Methyl Orange) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Methyl Orange (Moderate) the area specified with red colour the ground water is mostly affected by Methyl Orange. The Non Carbonate

Hardness maximum value is 422 mg/l and minimum value is 100 mg/l by analyzing 15 ground water samples.

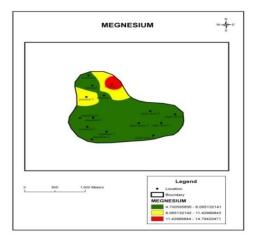


Figure 18. Spatial distribution of magnesium.

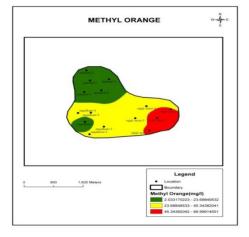


Figure 19. Spatial distribution of methyl orange.

Figure 20 shows the results of GIS map (spatial distribution of Non Carbonate Hardness) and based on the results, it has been notice that the area specified with green colour, the Ground Water is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Non Carbonate Hardness (Moderate) the area specified with red colour the groundwater is mostly affected by Non Carbonate Hardness. The Silica maximum value is 422mg/l and minimum value is 100mg/l by analyzing 15 groundwater samples.

Figure 21 shows the results of GIS map (spatial distribution of Silica) and based on the results, it has been notice that the area specified with green colour, the Ground

Water is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Silica (Moderate) the area specified with red colour the ground water is mostly affected by Silica. The sulphate maximum value is 52 mg/l and minimum value is 24 mg/l by analyzing 15 groundwater samples. Figure 22 shows the results of GIS map (spatial distribution of sulphate) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with sulphate (Moderate) the area specified with red colour the groundwater is mostly affected by sulphate.

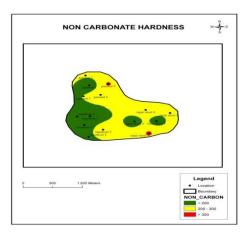


Figure 20. Spatial distribution of non-carbonate hardness.

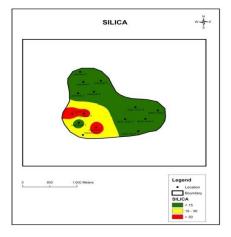


Figure 21. Spatial distribution of silica.

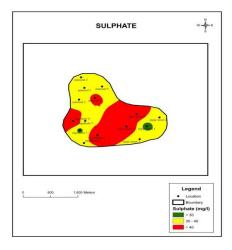


Figure 22. Spatial distribution of sulphate.

The Turbidity maximum value is 15.3 mg/l and minimum value is 7.6 mg/l by analyzing 15 groundwater samples. Figure 23 shows the results of GIS map (spatial distribution of Turbidity) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Turbidity (Moderate) the area specified with red colour the ground water is mostly affected by Turbidity. The TDS maximum value is 2952 mg/l and minimum value is 863 mg/l by analyzing 15 groundwater samples.

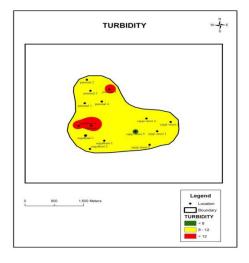


Figure 23. Spatial distribution of turbidity.

Figure 24 shows the results of GIS map (spatial distribution of TDS) and based on the results, it has been notice that the area specified with green colour, the Groundwater is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with TDS (Moderate) the area specified with red colour the groundwater is mostly affected by TDS.

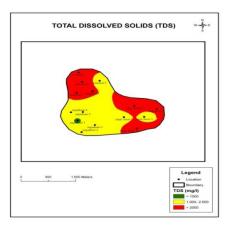


Figure 24. Spatial distributions of TDS.

The Total Hardness maximum value is 2143 mg/l and minimum value is 300mg/l by analyzing 15 groundwater samples. Figure 25 shows the results of GIS map (spatial distribution of Total Hardness) and based on the results, it has been notice that the area specified with green colour, the Ground Water is within the permissible limit as per standards, and the area specified with yellow colour the groundwater is affected with Total Hardness (Moderate) the area specified with red colour the groundwater is mostly affected by Total Hardness.

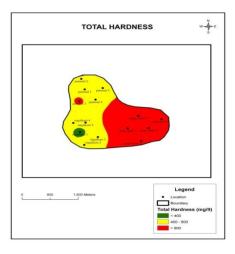


Figure 25. Spatial distribution of total hardness.

6. Conclusion

Total Hardness (TH) range between 300 to 2143 mg/l exceeds permissible value may cause scaling, excessive soap consumption and calcification of arteries. TDS range 863 to 2952 mg/l may cause gastro-intestinal irritation, corrosion and laxative. The groundwater quality can be improved by adopting rainwater harvesting, artificial recharge etc. Discharging toxic wastes into open drains (during the process of Tannery industries which is using large number of chemicals) and municipality solid waste dump site to the nearby land are the major reasons for deterioration of water quality in this area. Study concludes that the mixing up of toxic chemicals, fertilizers, improper disposal of industrial waste water and location of waste disposal sites are the main cause of groundwater contamination.

7. References

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