Identification of source(s) of pollution (high TDS) in groundwater in north of Rasipalayam village, Sulur Taluk, Coimbatore district, Tamil Nadu

A Project Sponsored by TNPCB

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1. BACKGROUND

The people of Rasipalayam village, Sulur Taluk, Coimbatore District made complaints to Tamil Nadu Pollution Control Board mentioning that the groundwater pollution in their area is due to the nearby industrial activities. The industrial units in that area have their own effluent treatment plants and recycling the treated effluents. However, few groundwater samples analyzed from different sites of the above mentioned area reveal that parameters like total dissolved solids (TDS), chlorides, and total hardness are exceeding the prescribed limits. Hence, the Tamil Nadu Pollution Control Board (TNPCB) made a request to the Director, CSIR-National Geophysical Research Institute (NGRI), Hyderabad, to conduct hydrogeochemical studies on groundwater from north of Rasipalayam village, Sulur Taluk, Coimbatore district of Tamil Nadu, leading to this short term project awarded to CSIR-NGRI.

2. Objective(s)

To identify the possible source(s) responsible for groundwater contamination (high TDS) in north of Rasipalayam village.

3. (a) Approach:

Geomorphological investigations of the study region are based on topo-sheet and GPS measurements. Hydrogeological set up has been carried by mapping the sub-surface and collating the hydrogeological information (wherever available) from open and bore wells in the area. Geohydrological investigations like groundwater flow direction have been attempted for possible pollutant movement direction, using the well inventory information.

(b) Scope:

- Detailed well inventory to be done with the help of GPS.
- Identification of hydrogeological features/barriers that control groundwater movement around the contaminated site.
- Preparation of groundwater level contour maps based on detailed well inventory and their elevations.
- Collection of water samples from all available sources (surface water bodies, dug
wells, bore wells etc.) in between the contaminated area and industries located
around the contaminated area.

- Assessment of groundwater quality in between possible contaminate sources
  (industries) and contaminated area.
- Identification of source(s) of contamination.

4. **Reconnaissance and Preliminary Assessment**
   - Reconnaissance, visual site inspection of contaminated area;
   - Discussion with local people who are affected by groundwater contamination
   - Basic features of the site, i.e. collection of available information on the site.
   - Study of previous investigation reports on groundwater, if available;
   - Visiting the suspecting industry/s and enquiring about their products, processes,
     raw material used, waste generation and waste disposal methods.
   - Identification of previous and current land use pattern of the site;
   - Conduct a drainage survey;
   - Collection of random groundwater and surface water (if available) sampling for
     initial assessment
   - Identification of areas where detailed sampling should be undertaken and explore
     the existing groundwater structures;

A reconnaissance visit was made by the CSIR-NGRI Scientist accompanied by the TNPCB
official on August 22, 2017. This visit provided us with an overview of the physical,
environmental, social and geological characteristics of the area. During discussions, local
people told that their well water was contaminated with high TDS. The main agriculture
activity in the area is of Coconut plantation. Groundwater levels are deep (> 20 m), may be
due to overexploitation as a result of free power supply to the Agriculture pump sets. Visited
the Industry (Pioneer Fertiliser Ltd), believed by the locals responsible for contaminating the
groundwater. To get the first hand information on groundwater quality, 11 groundwater
samples (including 2 samples from the premises of Pioneer Fertiliser Ltd.) collected randomly
and also one surface water (Achchankulam Lake, the potential source of groundwater
recharge for this area, Fig. 1). However, we could not get any historical reports of
hydrochemical data of this region from any Government department or agency, except the
data (about a year old) for a single well, based on which present work is initiated. Though
people say that the increase of salinity (high TDS) started about 20 years back and is being
continued.
Water samples collected during the reconnaissance were analysed for the major ion chemistry. TDS (1340 mg/l) of surface (lake) water sample is much higher than the normal surface water value of about 100 to 200 mg/l (Ramesh and Subramanian, 1988), which may be due to the mixing of polluted municipal waste water. TDS of collected 11 groundwater samples range between 940 to 8800 mg/l. Major ion chemistry of groundwater shows Cl>SO\textsubscript{4}>HCO\textsubscript{3} and Ca=Na>Mg>K. High TDS in association with majority of major ions found around the dug well belongs to Mr. A. K. Jaganathan. However, two samples collected from the industrial area (suspected source of pollutant) has minimum ionic concentration and normal (for this region) TDS values.

5. **Study area**

For present investigations, the study area covers about 5.5 km in the east-west and 3.5 km in the north-south directions i.e., between 77° 5’ 727’’ and 77° 8’ 989’’ longitudes and 11° 2’ 798’’ to 11° 4’ 890 latitudes (Fig.2) with NH-47 (Salem-Coimbatore highway) marking its boundary in the NW and railway line in the SE. This area is located about 20 km north-east of Coimbatore city centre and about 8 km NE of Airport. Figure 1 provides an over view of the study area and its surroundings. The Noyil River originating in the Boluvampatty valley of the Vellingiri hills, broadly flows towards east but in the study area, it flows south-west to north-east and forms the southern boundary of the study area. As expected, the topographic gradient is towards river from both the sides i.e., NW and SE. The area is dominated by undulating surface topography with dome like structures having elevation of 410 m and 380 m exist in the NW and NE corners. In between these two dome structures, four small streams are originating and flowing towards south east. One first order and one second order streams from western side join to form a single stream which merges into the Noyil river. Due to the higher topographic gradient in the eastern side, stream path is not clearly demarcated. All these streams are ephemeral type.

The Coimbatore district receives the rainfall due to both southwest and northeast monsoons with major contribution from the former. Annual average rainfall of six stations in the district varies from about 550 to 900 mm with a minimum of 550 mm around Sulur (study area). District statistics (Department of Economics & Statistics, Govt. of Tamil Nadu (cross ref. from CGWB Repot, Subbaraj, 2008) indicate major source of irrigation though groundwater extracted from dug wells. In the Sulur Block, area irrigated under dug wells is about 3270 Ha.
and only 752 Ha under tube wells. However, in the study area present conditions, irrigation under bores increased enormously and many of the dug wells defunct.

Geologically, the study area is covered with hard consolidated crystalline rocks, represented by weathered and fractured Granite Gneisses and pink granites. About 60 per cent of the district is covered by red soils, of which red calcareous soil is predominant. Ground water occurs under phreatic conditions in the weathered mantle and under semi-confined conditions in the fractured zones.
6. **Field observations and sampling**

After awarding the project to CSIR-NGRI, a detailed field study was carried during January 8 to 13, 2018 which included:

- Interaction with the locals to find out the groundwater structures and their assessment of the groundwater quality.
- Observation of geomorphological set up and drainage system.
- Inventory of the available groundwater structures in the area.
- Labelling of different groundwater structures with the help of GPS.
- In field measurements of groundwater for initial quality assessment
- Collection of groundwater samples, wherever it required for detailed chemical analysis.
- Measurement of depth to groundwater level (with reference to ground surface) from all available dug wells in the area.
- Identification of Benchmark/Background samples;
- Outlining the extent of contaminated area through surfer or similar tools for generating maps.
- Development of conceptual site plan comprising of three elements (1) Potential ions of contamination, (2) Possible sources of contaminants and (3) Potential pathways linking the two

Overall this field work provided the data pertaining to the geology, hydrogeology and the Contaminants of Concern (CoC) and aided in creating a site-specific conceptual model.

During the field work, total 63 well (including 24 dug wells) water samples were scanned for TDS contents. Out of these, 47 samples were collected for detailed analysis in the laboratory (Fig. 2). Scanning/sampling was made both from dug wells as well as bore wells.

Depth of the dug wells, mainly distributed in the low lying areas, varies from 20 to 40 m. Many of these are no longer in use due to deep water table and low yield. Depth to groundwater level measured in these dug wells varies from 16 to 34 m (Fig. 3). Due to the 24 hour electrical power supply, groundwater is being pumped all the time subject to availability of water, hence the groundwater levels measured during the field excursion are not reflective of the true water table depth. Depth of the bore well vary from about 50 m to 100 m.

7. **Companies visited around the study area**

There are several small scale industries in the area. Medium scale industries located in and around the study area were visited along with TNPCB official, to find out the raw material used in the industry, chemicals involved at different stages, waste management measures adopted the company premises etc.
Fig. 2: Location of scanned/sampled wells. Sampled wells with their corresponding sample codes is shown in the figure.

Fig. 3: Groundwater levels (approximate) measured in the dug wells during the field work (many wells pumps are in running condition).
Coimbatore Pioneer Fertilizer Ltd.:

This particular industrial unit (IU) is mainly doubted by the locals for groundwater contamination in the area. Established during 1965, their initial products were single super phosphate and sulphuric acid. However, they stopped producing sulphuric acid since last 10 years and are purchasing the same from other commercial units. Presently, the company is producing only single super phosphate from the rock phosphate as raw material and using the concentrated sulphuric acid in the processes. However, there is no liquid discharge from the company. Liquid waste generated in the cooling towers etc. is being evaporated in the tanks and solid waste generated in the evaporation process is sent to nearby Treatment, Storage, and Disposal Facilities (TSDFs). Overall, the factory premises are clean.

This IU is using groundwater from the big open well located in its premises for the company purpose and also for the adjacent colony. As per their records, though the TDS of groundwater is ~ 3300 mg/l, they are using that. The water from one bore well drilled in the premises is not being used. We collected samples from the dug well as well as bore well during reconnaissance and detailed sampling

Ranganathan Valves Ltd.:

The company established during 1999 and has two units. Unit I is foundry and Unit II is Machine shafts. They have been using the nitric acid and hydrofluoric acid in the processing, they are diverting these to settling tanks and finally evaporation tanks and sludge is stored in the drums, which goes to TSDFs. Within the Company premises, they have a bore well, from which the water is used for domestic purpose in the colony and RO water is purchased for using in the furnace cooling and drinking purposes. No liquid spillage found during the visit.

Flow Links Systems Pvt. Ltd.:

Flow Links too has two units. Foundry unit established during 1997 and Machine division during 2003. Raw materials, processes and products are same as for Ranganathan Valves Ltd. In the Company premises, each unit has 2 bore wells, however one in each unit has dried up. Groundwater is being used for raw works, gardening etc. and purchased RO water is used for the furnace cooling and drinking purposes. However, they say groundwater from bore wells is good quality. Samples were collected from two bore wells in operation.

PEPS industries:

The industry established during 2007 subsequently expanded in 2011 and 2015. It manufactures foam and mattresses. In the processes, no water is used and no liquid waste is
generated. The company is using rainwater harvesting in their premises. One bore well is located close to rainwater harvesting structure and another one with poor yield are being used for routine needs while RO plant is installed for drinking water purpose.

8. **Laboratory investigations: Hydrochemical measurements**

pH, electrical conductance (EC) and TDS of the water samples were measured using the Consort C533 portable multi-parameter analyser. Carbonate alkalinity was measured by titration. Other anions and cations were measured using a Dionex Ion Chromatograph. An AS-14A Ion Pac was used with 8.0 mM sodium carbonate and 1.0 mM bicarbonate as eluent and H₂SO₄ as regenerant with a mixed standard of F, Cl, NO₂, Br, NO₃, PO₄ and SO₄ made in the required proportions from the standards purchased from Merck, Germany. A CS-17 column was used for cation separation with 6 mM methane-sulfonic acid as eluent, and a mixed standard of Li, Na, K, Mg and Ca prepared in accordance with the approximate sample values. As a result of the high TDS values (>600 mg/l), the samples were diluted to measure both anions and cations. Several routine checks on standards were made to ensure data quality. Measurements have a precision of ±5% of the total value. The majority of analysed samples had ionic charge imbalances of <5%.

9. **Results and discussions**

The problem reported from the study area is high TDS in groundwater. TDS in water represents sum of various ions, and is also called water salinity. Technically, it is defined as total mass in milligrams in a litre of water. Salt content is an important factor in water use. Different ions present in the water are responsible for changes in its taste and odour. Main source for any groundwater is rain water, which normally has very low TDS value. However, when the rainwater percolate through earth layers, soluble ions in the soil and earth strata get dissolved leading to high TDS value. TDS values of groundwater are mainly controlled by the local rock type, thickness of soil cover, weathering processes, residence time of groundwater, quantity of rainfall and above all, the climate of the area. Hence salinity always exists in groundwater but in variable amounts.

Apart from the above mentioned natural processes, TDS values may increase several folds due to human intervention, which can also be called as groundwater pollution. In most cases, the groundwater pollution originates due to waste dumps on the surface or beneath
the ground, underground disposal of contaminated water or liquids mainly from industries. A large number of human induced sources like septic tanks, irrigated agricultural activity can also cause for high salinity or TDS.

Generally, salinity of groundwater is classified based on its TDS values (https://water.usgs.gov/edu/saline.html):

- Fresh water - Less than 1,000 mg/l,
- Slightly saline water - From 1,000 mg/l to 3,000 mg/l
- Moderately saline water - From 3,000 mg/l to 10,000 mg/l
- Highly saline water - From 10,000 mg/l to 35,000 mg/l
- By the way, ocean water contains about 35,000 mg/l of salt.

During the detailed sampling, measured TDS values range from 730 mg/l to 8000 mg/l (Fig. 4). Based on the above salinity classification, only one sample from the bore well contain fresh water. 50% of bore well waters and 30% of dug well waters indicate slightly saline conditions and the rest are under moderately saline condition. As the dug wells are located in the low lying areas, naturally they are more vulnerable to contamination.

Fig. 4: Total dissolved solids (mg/l) in selected well waters in the study area.

Spatial distribution of TDS values and contours (Fig. 5 and Fig. 6) shows that moderate salinity (3000 to 8000 mg/l) spreads over about 1.6 km length in the NWW to SEE direction.
and about 700 m width at north of Rasipalayam village. Low salinity is observed in the west as well as in the northern side of the study area. Based on the samples availability, a gradual increasing trend of salinity is observed from west to east and a rapid change from north to south. By virtue of the north to south general topographic gradient in the study area, one can expect the natural groundwater flow direction from north to south. However, as the regional topographic trend is from west to east (evident by west to east flow of Noyil River), fracture system in the bed rock is also in the east-west direction. Surface water from the Achankulam lake located in the south-west corner of the study area, have the TDS value of 1030 mg/l indicating that it is highly contaminated.

Fig. 5: Spatial distribution of TDS values (mg/l) and few medium size industries located in the area also shown.
Different ion concentrations in groundwater

Statistical distribution of different hydrochemical parameters are shown in Table 1 and Figure 7. Hydrogen ion concentration (pH) of groundwater ranges from 6.68 to 7.74, indicating slightly acidic to slightly alkaline character. Overall, most of the samples are neutral in nature. Na, the predominant cation varies between 234 mg/l to 1447 mg/l with an average of 700 mg/l. Ca, the second most dominant cation, is almost close to Na concentrations, even though its maximum and minimum values (89 and 1824 mg/l, respectively) deviated from Na values. Mg concentration ranges between 10 and 840 mg/l with a standard deviation of 223. K concentration varies from 8 mg/l to 45 mg/l. Cl is predominant anion with a large variation (standard deviation 1349) between minimum (258 mg/l) and maximum (5447 mg/l). Sulphate concentration is the second highest in anion, ranging from 206 mg/l to 2387 mg/l, which is almost half of the Cl concentration. HCO$_3$ is much lower in comparison to the other two anions ranging from 120 to 460 mg/l. No fluoride found in any of the samples but NO$_3$ concentration varies between 1 mg/l to 83 mg/l with an average of 29 mg/l.
Table 1: Statistical distribution of different ions in groundwater

<table>
<thead>
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<th></th>
<th>pH</th>
<th>EH</th>
<th>Cond</th>
<th>TDS</th>
<th>Na</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>Cl</th>
<th>SO₄</th>
<th>HCO₃</th>
<th>NO₃</th>
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</thead>
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<tr>
<td>Maximum</td>
<td>7.74</td>
<td>-22</td>
<td>14300</td>
<td>8000</td>
<td>1447</td>
<td>45</td>
<td>840</td>
<td>1824</td>
<td>5447</td>
<td>2387</td>
<td>460</td>
<td>83</td>
</tr>
<tr>
<td>Minimum</td>
<td>6.68</td>
<td>-102</td>
<td>1360</td>
<td>730</td>
<td>234</td>
<td>8</td>
<td>10</td>
<td>89</td>
<td>258</td>
<td>206</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td>Average</td>
<td>7.04</td>
<td>-58</td>
<td>6772</td>
<td>3696</td>
<td>700</td>
<td>26</td>
<td>394</td>
<td>677</td>
<td>2316</td>
<td>1101</td>
<td>335</td>
<td>29</td>
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<td>Stdev</td>
<td>0.22</td>
<td>13</td>
<td>3296</td>
<td>1835</td>
<td>303</td>
<td>8</td>
<td>223</td>
<td>397</td>
<td>1349</td>
<td>634</td>
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<td>21</td>
</tr>
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</table>

Fig. 7: Minimum, maximum and average ion concentrations in studied groundwaters.

Correlation of TDS with other chemical parameters

Dissolved species and their relationship with each other, can reveal the origin of solutes and the processes that generated the measured composition of the groundwater. The plots of TDS versus major ions (Fig. 8) show that the mineralization is mainly controlled by calcium ($R^2 = 0.9194$) and magnesium ($R^2 = 0.9236$) for cations while chloride ($R^2 = 0.9855$) and sulphate ($R^2 = 0.8798$) for anions. Though the sodium concentration is in second position and closer to calcium concentrations, TDS and Na correlation coefficient is 0.7107. Bicarbonate concentration in groundwater is much less and has poor correlation with TDS.
Fig. 8: Plots showing total dissolved solids (TDS) vs different ion concentrations in groundwater
Correlation coefficient of different ions in groundwater is presented in Table 2. Apart from the above correlation, Na, Ca and Mg also have good correlation with Cl and SO₄. HCO₃ does not have any correlation with any of the ions. Often the Na⁺ vs. Cl⁻ relationship has been used to identify the mechanism for acquiring salinity. Being the granitic terrain, such relation may not exist for the study area, as the sources of these may be different. Main source of Na in granitic region is weathering of plagioclase feldspars. However, mineral of which Cl is an essential component, are not very common and Cl is likely to present as an impurity (Hem, 1991). Cl enters in groundwater mainly through precipitation, but later due to evaporation, enrichment and recirculation processes, its concentration increases. If the Cl concentration of higher-salinity water is approximately 1/10 of that in seawater (1950 mg/L) and half of the Cl ions are derived from biotite dissolution (Kamineni, 1987). Hence, in the present study area, combination of both the processes resulted high Cl content in the groundwater. Sulphur is widely distributed in igneous rock as metallic sulphides. Due to weathering process in the presence of aerated water, sulphur oxidizes and forms the sulphate in the groundwater. Due to this reaction, hydrogen ions are produced in considerable quantities. Hence the groundwater in the study are has slightly acidic conditions. Strong relationships Cl⁻-Mg²⁺ and Cl⁻-Ca²⁺ suggest that cation exchange can also significantly affect groundwater composition.

Table 2: Cross-correlation coefficients of different ions in groundwater

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>TDS</th>
<th>Na</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>Cl</th>
<th>SO₄</th>
<th>HCO₃</th>
<th>NO₃</th>
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<td>pH</td>
<td>1</td>
<td>-0.181</td>
<td>0.314</td>
<td>-0.137</td>
<td>-0.322</td>
<td>-0.217</td>
<td>-0.105</td>
<td>2.90E-02</td>
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<td>-0.183</td>
</tr>
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<td>TDS mg/L</td>
<td>1</td>
<td>0.7107</td>
<td>0.2774</td>
<td>0.9236</td>
<td>0.9194</td>
<td>0.9855</td>
<td>0.8798</td>
<td>0.0586</td>
<td>0.8243</td>
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<td>Na mg/L</td>
<td>1</td>
<td>0.47</td>
<td>0.529</td>
<td>0.585</td>
<td>0.791</td>
<td>0.709</td>
<td>0.709</td>
<td>0.259</td>
<td>0.331</td>
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<tr>
<td>K mg/L</td>
<td>1</td>
<td>0.552</td>
<td>0.446</td>
<td>0.578</td>
<td>0.347</td>
<td>7.30E-03</td>
<td>0.17</td>
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<tr>
<td>Mg mg/L</td>
<td>1</td>
<td>0.906</td>
<td>0.911</td>
<td>0.827</td>
<td>-0.177</td>
<td>0.811</td>
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<tr>
<td>Ca mg/L</td>
<td>1</td>
<td>0.909</td>
<td>0.888</td>
<td>-0.305</td>
<td>0.861</td>
<td></td>
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<tr>
<td>Cl mg/L</td>
<td>1</td>
<td>0.844</td>
<td>-0.265</td>
<td>0.732</td>
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<tr>
<td>SO₄ mg/L</td>
<td>1</td>
<td>-0.367</td>
<td>0.755</td>
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<td></td>
<td></td>
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<tr>
<td>HCO₃ mg/L</td>
<td>1</td>
<td>-0.363</td>
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<tr>
<td>NO₃ mg/L</td>
<td>1</td>
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Hydrochemical facies

Majority of groundwater samples with high TDS show Ca-Mg-Na-Cl-SO₄ water quality type and few of them Mg-Ca-Na-SO₄ and Na-Ca-Mg-Cl-SO₄ type. In order to find out the overall groundwater quality and the relation between different samples, hydrochemical data plotted in the Piper (1944) diagram (Fig. 9) which shows that the groundwater evolves toward the Cl+SO₄ and Ca+Mg pole. Low HCO₃ indicates low present day recharge conditions. Out of 47 samples, only three samples (having lowest TDS and much higher Na in comparison to Mg+Ca) formed a group considered as Group I. Out of three samples, one is surface water from Achankulam lake, and other two are, a bore well sample and one dug well sample. Five wells forming Group II are two dug wells and three bore wells. Except one bore well located at southern boundary of high TDS wells, other four wells are located at western side. These samples also have higher Na and Cl concentrations. The rest 39 samples form as one group with higher Ca+Mg and Cl+SO₄ irrespective of their location. As almost all the samples concentrated at one corner, it shows similar type of chemical processes undergone all the samples.

Fig. 9: Piper plot of groundwater samples.
Real time monitoring of electrical conductivity in Mr. A. K. Jaganathan’s dug well

The dug well, which is having high TDS, encountered very good east-west fracture system at the level of water table. The well owner believes that, major groundwater source to the well is existing fracture system and groundwater flows into the well from the existing fractures. To understand the groundwater flow from the preferred path ways and its relation with high TDS, CTD divers were installed in the well to record the electrical conductivity (EC) and groundwater level in real time with 30-minute interval. We expected some changes in the EC during pumping of groundwater and non-pumping hours. Measurements were continued for about 20 days. Unfortunately, the water level sensor did not work, but EC measurements are shown in Figure 10.

![Electrical conductivity of groundwater monitored in real time at 30-minute interval in the dug well of Mr. A. K. Jaganathan.](image)

The farmer is pumping the groundwater for few hours every day. Due to that pumping we expect some drop in water level. Due to the drop in water level, we expect some change in chemistry, if certain portion water contributing from preferred pathways (fractures). In the figure 10, we could not see such systematic change in the EC in 24 hours’ time. The change observed over a period of 20 days’ time may be the natural change seasonal change. It shows that, fractures are not yielding any different quality type of water into the well.
10. Summary and Concluding remarks

Hydrochemical data compiled from all over India, Central Ground Water Board (CGWB, 2010) reported that along with many districts in India, Coimbatore in Tamil Nadu, is one of the district where, average TDS values exceed 3000 mg/l. However, they did not give any explanation for this high salinity. Present study results (based on salinity classification) show that, there is only one fresh water sample from the entire study area and rest of the samples can be classified as either slightly saline or moderately saline. Most of the moderately saline samples are concentrated in a small zone, north of Rasipalayam village. Even though, there is some variation in TDS and other hydrochemical values within the study area, high correlation coefficients between TDS and other ions; and between different major ions, indicate that the ions dissolved in the groundwater are from a single source. Hence, the source for high TDS/high ionic concentration could be the water rock interaction or geogenic. This argument is strengthened by the distribution of hydrochemical facies in the Piper Diagram (Fig. 9). Low bicarbonate content indicates low present-day groundwater recharge associated with low rainfall conditions in the area. Long residence time of groundwater can lead to long interaction between host rock and groundwater resulting in high TDS. Lack of variation in the EC during pumping and non-pumping hours, indicates lack of high TDS groundwater from preferred path ways existing in the study area. Though there are few medium size industries around the study area, they are not producing either solid or liquid waste and groundwater in their premises has relatively better quality. Many samples in and around the Coimbatore Pioneer Fertilizers Ltd. Industrial unit, have relatively better quality groundwater. Concentration of moderately saline groundwater in a limited area, may be due the specific geological formation and structures (dense network of fracture system) in the area, which may require further geophysical investigations.
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19
References:

CGWB 2010. Groundwater quality in shallow aquifers of India. A report from Central Ground Water Board, Faridabad, GoI.


Few Field Photographs: