Status of Groundwater for Drinking Purposes During Post Monsoon- 2013 in Upper Thirumanimuttar Sub Basin, Cauvery River South India

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Abstract—Water is the world’s lifeblood. Groundwater is a vital resource for human survival at many places of the world and it is the only available alternative source of water. Groundwater is a hidden resource whose value is not well understood or appreciated. The analysis of groundwater chemical characteristics provides much important information useful in water resources management. Detailed knowledge of the geochemical evolution of groundwater and assessing the water quality status for special use are the main objective of any water monitoring study. In the present study, the physicochemical characteristics of groundwater of Upper Thirumanimuttar sub basin Cauvery river South India were assessed for its suitability for drinking purposes. A total of 30 water samples were collected from the wells from different parts of the study area during post monsoon 2013. In order to assess the ground water quality, the water samples were analyzed for different physico-chemical properties, e.g., Na, K, Ca, Mg, CO₃, HCO₃, Cl, SO₄, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), total alkalinity (TA) concentrations. The results were compared with the standards prescribed by World Health Organization (WHO) and Bureau of Indian Standard (BIS). All the physicochemical parameters were found to be in the prescribed permissible limit. From the pH values it is clear that the ground water of the study area is alkaline in nature and the TDS varies in between 554-3398 mg/l, which indicates that water in the deep aquifer is moderately hard. Hence it is suggested to soften the groundwater water before consumption.

Keywords—Groundwater, Drinking quality, WHO, BIS, Post monsoon, Thirumanimuttar, TDS

INTRODUCTION

Water covers 78% of the earth’s surface, yet water available for human use is limited. Water is the world’s lifeblood. Groundwater is a vital resource for human survival at many places of the world and it is the only available alternative source of water. Groundwater is a hidden resource whose value is not well understood or appreciated. The analysis of groundwater chemical characteristics provides much important information useful in water resources management. Detailed knowledge of the geochemical evolution of groundwater and assessing the water quality status for special use are the main objective of any water monitoring study. Based on the World Bank, India is using groundwater resources nearly a quarter of the world’s total consumption. Groundwater is the primary source of drinking water in the study area. The water resources available are also not uniformly distributed and the changing land use pattern and population growth and resulting water resources development has resulted in stress in the environment. The extraction of excessive quantities of ground water has resulted in drying up of wells in the study area. It is occurred mainly due to the rapid urbanisation activities. Agricultural, urban & industrial wastes are increasingly threatening groundwater quality, which is likely to become more serious issue than the quantity in coming years. Considering the above factors the assessment of groundwater quality for drinking purposes along the study area (upper Thirumanimuttar sub basin) has been done.

LOCATION OF STUDY AREA

The study area lies in the N latitudes 11 25’ and 11 40’ and E longitude 78.5’ and 78 25’ in the Survey of India toposheet numbers 58-I/1,58-I/2,58-I/5 and...
58-I/6 (Map No-1). The study area mainly covers Salem City other adjacent place viz. small towns and villages. The Thirumanimuttar river is the main river flowing in the study area and it is one of the minor tributaries of river Cauvery of South India. The Thirumanimuttar rises in the Shevaroys Hills and Manjavadi Ghats, North East of Salem city and it confluences with the river Cauvery at Kooduthurai in Paramathai taluk of Namakkal district after 102 kms journey through Salem and Namakkal Districts. The study area is mainly covered by Archean rocks of Chamockite, Fissile Hornblende Biotite Gneisses. The drainage pattern in the study area shows parallel drainage pattern, dendritic to sub dendritic and parallel drainage Pattern. The study area enjoys subtropical climate with moderate humidity and temperature. The weather is quite pleasant from November to February and becomes very hot in March to June. December and January are coldest months. The minimum and maximum temperature ranges from 20°C to 40°C respectively. The relative humidity percentage ranges from 60% to 90%. Highest relative humidity values were found during east-west monsoon period. The average annual rainfall is 737.50 mm based on 12 years average (2000 to 2011) (VIJAYAKUMAR N et al.-2015).

MAP-1. STUDY AREA LOCATION MAP

MATERIALS AND METHODS

Thirty groundwater samples were collected on Post monsoon Season at December 2013 covering Upper Thirumanimuttar. Water samples were collected in pre cleaned, sterilized, polyethylene bottles of one liter capacity as per the standard sampling procedures. They were then carefully sealed and labeled and taken for analyses.

ANALYTICAL METHODS

The collected samples were chemically analyzed in Soil and Water testing Laboratory Salem, using standard procedures. The concentration of major cations (Na+, K+, Ca2+, Mg2+) and anions (HCO3-, Cl-, NO3-, SO42-) in the water samples were determined by chemical analyses in Government Soils and water testing laboratory at Seelanayakanpatti, Salem. The water samples were analysed for pH, electrical conductivity (EC), total dissolved solids (TDS), total calcium (Ca2+), magnesium (Mg2+), total hardness (TH), sodium (Na), potassium (K+), total alkalinity (TA), chloride (Cl-), and sulphate (SO42-). The geochemical of ground water data are tabulated and graphically represented (Table-1).
RESULTS AND DISCUSSION

WATER QUALITY

Information on the quality of groundwater is an important aspect of any Hydrogeological investigation. The chemical quality of groundwater generally varies even at short distances. This variation may be attributed to the variation in Hydrogeological process. In addition to this, the chemical quality of groundwater in an area is influenced by various factors like geology, geomorphology, structural and agricultural practices. Drinking water quality the analytical results of physical and chemical parameters of groundwater were compared with the standard guideline values as recommended by the World Health Organization (WHO, 2011) for drinking and public health purposes and BIS(2012) (Table 2).

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The pH is the hydrogen ion concentration, which expresses the intensity of acidity or alkalinity of the water. The pH of water is an important indication of its quality and provides important pieces of information in many types of geochemical equilibrium or solubility calculations. The pH value is the negative logarithm of the concentration of hydrogen ions in moles per litre. pH value in analysed water samples varied from 7 to 8.2. The low pH does not cause any harmful effect (Boominathan and Khan, 1994). (Table –3)

<table>
<thead>
<tr>
<th>S.NO</th>
<th>LIMITING pH VALUES</th>
<th>POTABILITY NATURE</th>
<th>WATER SAMPLE LOCATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>&lt;6.5</td>
<td>Not potable</td>
<td>NIL</td>
</tr>
<tr>
<td>2.</td>
<td>6.5 – 9.5</td>
<td>Potable</td>
<td>ALL THE SAMPLES(30)</td>
</tr>
<tr>
<td>3.</td>
<td>&gt;9.2</td>
<td>Not potable</td>
<td>NIL</td>
</tr>
</tbody>
</table>

As per the WHO standards all the samples are falls within the recommended limit (6.5 to 9.2) for human consumption.

### TDS (TOTAL DISSOLVED SOLIDS)

High value of TDS influences the taste, hardness, and corrosiveness property of water (Saleem et al; 2012, S. Devi et al; 2003). Based on TDS Classified groundwater quality Table given below (Table –4)

<table>
<thead>
<tr>
<th>TYPE OF WATER</th>
<th>TDS RANGE (mg/l)</th>
<th>SAMPLE LOCATION CODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Water</td>
<td>0 – 1000</td>
<td>6,8,12,15,16, 17,20,21,29(9)</td>
</tr>
<tr>
<td>Brackish Water</td>
<td>1000 – 10000</td>
<td>1,2,3,4,5,7,9,10,11, 13,14,18,19,22,23,24 25,26,27,28,30 (21)</td>
</tr>
<tr>
<td>Salt Water</td>
<td>10000 – 100000</td>
<td>-</td>
</tr>
<tr>
<td>Brine Water</td>
<td>&gt;100000</td>
<td>-</td>
</tr>
</tbody>
</table>

In study area, TDS was observed the minimum value ranges from 554 to 1737. SUKKAMPATTY, SENKATTUR, RAMALINGAPURAM, PANAMARATHUPATTY, CHINNASEERAGAPADI, KONDAPPANAYAKKANPATTY and REDDIYUR and the maximum value ranges from 2468 to 3398 at VEERAPANDI, and KATTUR. In the study area 30% samples are of fresh water and other 70% are of brackish water.

### CALCIUM:

The limit of Ca for drinking water is specified as 200mg/l (WHO, 2012). In the study area, calcium was observed maximum of 420 ppm at KATTUR and minimum at 20ppm in ELIMEDU. As per the drinking water standards nearly 13% of the samples are acceptable limit, 67% of the samples are allowable limit and 20% of samples are not potable. Ca is lower during the rainy season recorded in the dry season, due to dissolution of CaCO$_3$ and CaMg(3CO$_3$)$_2$ during the recharge (Datta et al., 1996).

### MAGNESIUM:

The maximum acceptable limit of Mg for drinking water is 50mg/l. In the study area, the minimum Mg concentration observed in MURUNGAPATTY (47 ppm) and maximum is Observed in VEERAPONDI (325 ppm). The result shows 63% of samples are acceptable limit and remaining 37% of samples are not potable. Mg$^{2+}$concentration is higher during dry season it may be derived from dissolution of magnesium calcite, gypsum and/or dolomite from source rock (Garrels and Mackenzie 1967).

### SODIUM:

In the study area the sodium concentration was observed maximum of 621ppm at ANDAGALUR GATE and minimum of 9 ppm at MURUNGAPATTY. The limit for drinking water is specified as 200 ppm (WHO 2012). In study area, 47% of samples are in...
desirable limit and 37% samples are in permissible limit, 17% samples are not potable limit from ANDAGALURGATE (621), KATTUR (547.40), ELACHIPALAYAM (407.10), KUMARAMANGALAM (268.0), and SUKKAMPATTY (289.80) are exceeding the limits.

POTASSIUM:
In the study area, potassium value ranges from 4 to 39 ppm. In the study area 60% samples are of potable limit, 3% samples are in Acceptable limit as seen in KOOTATHUPATTY (3.91), KARUMAPALAYAM (4.96), PANAMARATHUPATTY (6.26), SUKKAMPATTY (7.14), RAMALINGAPURAM (7.04), REDDIYUR (5.87) and remaining places. 37% samples are of the exceeding permissible limits as seen in ANDAGALURGATE, ERUMAPALAYAM etc. K⁺ is higher in the rainy season due to weathering of K-feldspars and clay minerals from aquifer matrix than the concentration value recorded in the dry season (Lakshmanan et al., 2003).

CHLORIDE:
The maximum acceptable limit of Cl for drinking water is 200 ppm and maximum allowable limit is 600 ppm (WHO, 2011). The Chloride concentration was observed maximum of 1378 ppm at ANDAGALURGATE and minimum of 57 ppm at KONDAPPANAYAKKAN PATTY in the study area. 40% samples are exceeding the potable limit. 7% samples are acceptable limit and 53% samples are not potable limit. Cl⁻ is higher in rainy season than in the dry season due to industrial, domestic wastages and/or leaching from upper soil layers in dry climates (Srinivasamoorthy et al., 2008).

BICARBONATE:
The maximum acceptable limit of HCO₃ for drinking water is 300 ppm. In the study area, the minimum Bicarbonate concentration was observed of 281 ppm ELIMEDU and maximum of 866 ppm at ELACHIPALAYAM. Nearly 97% samples exceed the limit in the study area.

SULPHATES:
Sulphate occurs mostly as Calcium Sulphate (Gypsum). Sodium and Magnesium Sulphate are readily soluble in water while Calcium Sulphate is less so. Sulphur is useful to plants (Offodile, 2002). High levels of sulphate in drinking water can cause diarrhea. The WHO standard for Sulphate in drinking water is 400 ppm. Sulphate concentration was observed maximum of (393.85) ppm at ANDAGALURGATE and minimum of (4.80) ppm in ELIMEDU in the study area. 90% samples fall in potable limits, remaining 10% are acceptable limit.

DUROV DIAGRAM:
The principle of the Durov plot is to permit the cation and anion compositions of many samples to be represented on a single graph, in which major groupings or trends in the data can be seen visually.
For the Durov plot, the cation and anion composition is considered in conjunction with a central rectangle. In addition, the Durov plot allows for the direct comparison of two other groundwater parameters, typically pH and the total dissolved solids (TDS).
On the Durov plot, the left-hand triangle is for the cations. The calcium percentages are plotted along the top scale, following the grid lines extending in a NW-SW direction. The magnesium percentages are plotted following the vertical grid lines. The sodium plus potassium percentages are plotted along the bottom scale, following the grid lines extending in a NE-SW direction.
The top triangle is for the anions. The chloride percentages are plotted along the left scale, following the grid lines extending in a NW-SW direction. The sulphate percentages are plotted following the horizontal grid lines. The bicarbonate percentages are plotted along the
right scale, following the grid lines extending in a NE-SW direction.

In the study area, 56% of water fall within no contamination, the remaining water samples are within moderately contaminated (Table-5)(MAP-2)

<table>
<thead>
<tr>
<th>S.No</th>
<th>SEGMENTS</th>
<th>CLASSIFICATION</th>
<th>% OF SAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A</td>
<td>Pure</td>
<td>Nil</td>
</tr>
<tr>
<td>2.</td>
<td>B</td>
<td>No contamination</td>
<td>56%</td>
</tr>
<tr>
<td>3.</td>
<td>C</td>
<td>Moderate contamination</td>
<td>44%</td>
</tr>
<tr>
<td>4.</td>
<td>D</td>
<td>High contamination</td>
<td>Nil</td>
</tr>
</tbody>
</table>

CONCLUSION

The outcome of the research is given below. Geologically, the igneous and metamorphic group of rocks are occupying in the study area. The study area receives an annual rainfall of 737.50 mm. Based on the WHO and BIS limiting Standards, pH of all the samples fall in the permissible limits. Based on TDS 30% Water samples are in fresh water category 70% samples are in brackish water category and. Based on Ca, K, SO₄, Concentrations of the study area are observed and all the samples are within permissible limits. Mg is in permissible limits and Na concentrations of the samples are exceeding the limit. Based on HCO₃ 97% samples exceed the limit. The high concentrations of Mg and Na in the groundwater samples may be due to the total chemical weathering of feldspar minerals in the country rocks. All samples require one or an other kind of treatment before drinking. Based on Durov’s plot 56% of Groundwater samples fall in No contamination category. A special attention for removal of hardness is required as 70% of the samples are found to be of very hard category.

REFERENCES


Geological society of India Vol.69, pp.970-982. AND


[36]. VIJAYAKUMAR N.(2014) A Drinking and Irrigational use
Assessment of Groundwater in Part of Thirumanimuthar Sub Basin (Cauvery), Tamil Nadu, India.
