RESEARCH ARTICLE
QUALITY ASSESSMENT OF POTABLE WATER IN SURROUNDING OF CHANDHUPATLA, ANDHRA PRADESH, INDIA

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ABSTRACT
Groundwater is the most important natural resource which cannot be optimally used and sustained unless its quality is properly assessed. The present study was carried out to analyze groundwater quality in selected villages surrounding Chandhupatla, Andhra Pradesh, India, where groundwater is the main source of drinking water. Seventeen groundwater samples were collected from hand pumps/bore wells and analyzed for pH, electrical conductivity, total dissolved solids (TDS), total hardness, anions (HCO3-, SO42-, NO3 and F) and cations (Ca2+, Mg2+, Na+ and K+). The suitability for drinking purpose was evaluated by comparing the physicochemical parameters of groundwater in the study area with drinking water standards prescribed by the World Health Organization (WHO) and Bureau of Indian Standards (BIS). Total hardness, TDS and concentrations of NO3, Ca2+ and Mg2+ exceeded the desirable limits at a few sites and fluoride concentration varies from 0.3 to 2 mg/L. At two sampling locations that are Cheimmalagadda – 1 and 2 the concentration exceeded the maximum permissible limit. However, except SO42 all these values were below the maximum desirable limits.

INTRODUCTION
In the past, most researches regarding drinking water distribution systems focused on source water protection and water treatment processes. Nevertheless, more and more emphasis had been placed on distribution systems and storage facilities, which play a critical role in drinking water qualities. However, in general groundwater consists of major ions, minor ions, trace metals, heavy metals, radio nuclides, organic matter etc. It is often used for drinking and domestic purposes apart from agricultural and industrial purposes due to its wide distribution and as it is comparatively less polluted than surface water. The quality of water has been continuously declining globally in general and in developing countries in particular because of natural and anthropogenic processes (Carpenter et al, 1998; Chen et al, 2002). Living standards and well being of a population is greatly impacted by the quality and quantity of water that is accessible and available, thus global and local efforts are widespread at ensuring adequate provision of clean and safe water. Freshwater plays unique role for society and for economic development through provision (e.g., products, food), support (e.g., wastewater processing, supply of clean water), enrichment (e.g., aesthetic, recreational, cultural) and services (Yang et al, 2007). The growing demand for freshwater resources to sustain human activities, coupled with adverse effects of human activities, such as discharge of industrial wastewater and domestic sewage, are likely to cause a crisis in the near future if water resources are not appropriately managed (Charkhabi and Sakizadeh 2006). The groundwater quality needs to be monitored regularly so as to check that its composition do not exceed the limits of drinking water quality standards.

The quality of water for drinking and domestic purposes depends on the physical as well as socio-economic development of the area. A number of studies on water quality with respect to potable water have been carried out in different parts of Andhra Pradesh (Brindha et al, 2011; Narsimha and Sudhakar 2013; Subba Rao 2003; Narsimha and Sudarsan 2013; Ramamohana et al, 1993; Narsimha et al, 2012a; 2012b; Narsimha et al, 2013). Therefore, there is a great need to ascertain the physicochemical characteristics of the water used for drinking and domestic purposes by residents of surrounding of Chandhupatla, Nalgonda district, Andhra Pradesh, India. This paper examines the various physicochemical characterizations including pH, EC, TDS, TH, Ca2+, Mg2+, Na+, K+, HCO3-, SO42-, NO3 and F. MATERIALS AND METHODS

Seventeen groundwater samples from bore wells and hand pumps were collected from various locations from the entire area and were analysed for pH, electrical conductivity (EC), total hardness (TH), calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, nitrate and fluoride as per the standard analytical procedures (APHA 1991) and the results are presented in Table 1 and 2. Hydrogen ion concentration (pH) and electrical conductivity (EC) were measured, using pH meter and EC meter. Total dissolved solids (TDS) were computed by multiplying the EC by a factor (0.55–0.75), depending on the relative concentrations of ions. The cations like sodium (Na+) and potassium (K+) were measured by flame photometer. Total hardness (TH) as CaCO3, calcium (Ca2+) and magnesium (Mg2+) were found out titrimetrically, using standard EDTA. Chloride (Cl-) was estimated by standard

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AgNO₃ titration. Carbonate (CO₃²⁻) and bicarbonate (HCO₃⁻) were estimated by titrating with HCl. The fluoride concentration in water was determined electrochemically, using fluoride ionselective electrode (APHA 1991). This method is applicable to the measurement of fluoride in drinking water in the concentration range of 0.01 - 1, 000 mg/L. The electrode used was an Orion fluoride electrode, coupled to an Orion electrometer. Standards fluoride solutions (0.1 - 10 mg/L) were prepared from a stock solution (100 mg/L) of sodium fluoride. As per experimental requirement, 1 ml of ionic strength adjusting buffer grade III (TISAB - III) was added in 10 ml of sample. The ion meter was calibrated for a slop of ~59.2 ± 2.

The composition of TISAB solution was 385.4 g ammonium acetate, 17.3 g of cyclohexylamine diaminotetraacetic acid, and 234 ml of concentrate hydrochloric acid per liter. Nitrate (NO₃⁻) and sulphate (SO₄²⁻) concentrations was estimated using UV spectrophotometer. All parameters are expressed in milligrams per litre (mg/L), except pH (units) and EC. The EC is expressed in microsiemens per centimetre (µS/cm) at 25°C.

RESULTS AND DISCUSSION

The results of various physico-chemical analyses are summarized in Tables 1. The statistical parameters of analyzed constituents in groundwater samples of the study area (BIS 2003 for drinking water) are shown in Table 2. It can be seen that the pH varies from 6.7 to 7.4 and mean value is 7.18.

Table1 Physicochemical parameters of the groundwater samples

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>pH</th>
<th>EC µS/cm</th>
<th>TDS</th>
<th>TH</th>
<th>HCO₃⁻</th>
<th>NO₃⁻</th>
<th>F⁻</th>
<th>SO₄²⁻</th>
<th>Na⁺</th>
<th>K⁺</th>
<th>Ca²⁺</th>
<th>Mg²⁺</th>
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<tbody>
<tr>
<td>Babasahebgudem - 1</td>
<td>7.13</td>
<td>1250</td>
<td>400</td>
<td>100</td>
<td>40</td>
<td>0.3</td>
<td>30</td>
<td>0.4</td>
<td>82.8</td>
<td>3.939</td>
<td>57</td>
<td>84</td>
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<td>1250</td>
<td>400</td>
<td>100</td>
<td>390.4</td>
<td>100</td>
<td>0.4</td>
<td>40</td>
<td>82.8</td>
<td>3.939</td>
<td>57</td>
<td>84</td>
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<tr>
<td>Babasahebgudem - 3</td>
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<td>1020</td>
<td>400</td>
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<td>71</td>
<td>60</td>
<td>0.3</td>
<td>30</td>
<td>46</td>
<td>3.393</td>
<td>121</td>
<td>50</td>
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<tr>
<td>Vasavi college</td>
<td>7.27</td>
<td>810</td>
<td>490</td>
<td>100</td>
<td>85.4</td>
<td>50</td>
<td>0.5</td>
<td>28</td>
<td>41.9</td>
<td>3.627</td>
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<tr>
<td>Inpamula - 1</td>
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<td>680</td>
<td>300</td>
<td>100</td>
<td>549</td>
<td>10</td>
<td>0.5</td>
<td>20</td>
<td>46</td>
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<tr>
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<td>590</td>
<td>480</td>
<td>300</td>
<td>329.4</td>
<td>30</td>
<td>1</td>
<td>30</td>
<td>45.3</td>
<td>3.861</td>
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<td>112</td>
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<tr>
<td>Tipparthi - 1</td>
<td>7.38</td>
<td>580</td>
<td>490</td>
<td>100</td>
<td>390.4</td>
<td>30</td>
<td>0.5</td>
<td>25</td>
<td>41.9</td>
<td>3.666</td>
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<tr>
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<td>600</td>
<td>310</td>
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<td>10</td>
<td>0.5</td>
<td>22</td>
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<tr>
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<td>580</td>
<td>80</td>
<td>622.2</td>
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<td>0.9</td>
<td>50</td>
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<td>510</td>
<td>70</td>
<td>268.4</td>
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<td>1</td>
<td>37</td>
<td>43.2</td>
<td>2.301</td>
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<td>94</td>
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<tr>
<td>Nomula - 1</td>
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<td>1010</td>
<td>100</td>
<td>195.4</td>
<td>100</td>
<td>0.5</td>
<td>74</td>
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<td>33</td>
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<td>5.694</td>
<td>156</td>
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</table>

However, the pH values were well within the acceptable limits for drinking water (6.5 – 8.5) as specified by the BIS (2003) and WHO (1984) and is shown in Figure 1; Table 2. EC is a measure of the dissolved constituents in water, which affect its taste and thus play a vital role towards the potable character of water (Pradeep 1998). EC varies from a minimum of 550 µS/cm to a maximum of 2200 µS/cm. Generally, groundwater tends to have high electrical conductivity due to presence of high amount of dissolved salts (Prakash and Somashekar 2006).

The TDS in the water samples of study area ranged from 371.2 to 1408 mg/L (Table 1). Only eleven sampling locations (Babasahebgudem - 1, 2 and 3; vasavi college; Cheimmalagadda – 1 and 2; Tipparthi - 2; Palayema -1 and 2; Nomula – 1 and 2) were exceeding desirable limits of 500 mg/L (Fig 2; Table 2) and none of the samples surrounding the study area exceeded the maximum permissible limit of 2000 mg/L (BIS, 2003; Table 2). Most of the dissolved matter in the groundwater samples are organic compounds, dissolved gases and inorganic salts, which contribute to TDS. Hardness of the water is the property attributed to the presence of multivalent cations in the water. Water can be classified in to soft (<75 mg/L), moderately hard (75–150 mg/L), hard (150–300 mg/L) and very hard (>300 mg/L) based on the total hardness (Sawyer and McCarty 1967). The total hardness (TH) of the groundwater of the study area varies between 280 and 1010 mg/L (mean 497.3 mg/L; Table 1 and 2) indicating very hard types of water (Fig 3). Subsequently, about only 15 of the samples are within maximum permissible limit and remaining about two samples exceed the maximum permissible limit of 600 mg/L (BIS, 2003; Table 2).

The concentration of Na⁺ values varies from 28.29 to 128.8 (mean 50.1 mg/L) is higher than that of K⁺ value varies from 2.3 to 5.8 (mean 3.6 mg/L; Table 1). The higher concentration of Na⁺ among the cationic concentrations reflects a rock weathering and/or dissolution of soil salts stored by the influence of evaporation (Stallard and Edmond 1983) and also indicates its higher solubility behavior, while the lower concentration of K⁺ (mostly less than 5 mg/L) is because of its fixation on clay minerals (Hem 1991).

![Fig.1 pH of groundwater in surrounding of Chandhupatla, Andhra Pradesh.](Image)
The source of fluoride in these water samples may be due to the weathering of rocks (Nayak et al., 2008), the phosphatic fertilizers used for agriculture (Oelschlager, 1971) and the discharge of domestic/industrial wastes (Bhosle et al., 2001). In present study fluoride concentration in groundwater varies from 0.3 to 2 mg/L and mean is 0.879 mg/L (Table 1). Groundwater samples in only two locations were exceeding the maximum permissible limit, which were located in villages of Cheimmalagadda – 1 and 2 (Fig 4). The maximum permissible limit of fluoride in drinking water specified by the World Health Organization WHO (1984) and BIS (2003), is 1.5 mg/L. Ingestion of water with fluoride concentrations above 1.5 mg/L results in dental fluorosis characterized initially by opaque white patches, staining, mottling and pitting of teeth (Kundu et al., 2001).

The concentration of sulfate in the study area varies from 20 to 74 mg/L (Table 1) with all the samples falling within the desirable limit of 200 mg/L (BIS 2003; Table 2). It is well known that HCO₃⁻ comes mainly from natural inputs and NO₃⁻ is mostly derived from anthropogenic sources. In groundwater of present study area, the values of bicarbonate range from 85 to 622 mg/L (mean 381 mg/L; Table 1). A maximum permissible limit of nitrate is 45 mg/L has been prescribed by BIS (2003) and WHO (1984) for drinking water supplies. In the present study, the value of nitrate in the groundwater varies from 10 to 100 mg/L (Table 1 and 2). Groundwater from only seven sampling locations (Tipparthy – 2; Palyema – 2; Vasavi College, Babasahebgudem – 1 & 2 and Nomula – 1 and 3) were exceeding maximum permissible limit (Table 1 and 2; Fig 5). Its concentration above 45 mg/L may prove detrimental to human health.

CONCLUSION

pH varies from 6.7 to 7.45 and mean value is 7.18. However, the pH values were well within the acceptable limits for drinking water (6.5 – 8.5) as specified by the BIS (2003) and WHO (1984). The study has indicated that the concentration of total dissolved solids exceeds the desirable limit of 500 mg/L in about only 64% of the samples but the values are well within the maximum permissible limit of 2,000 mg/L in all the samples. From the hardness point of view, about only 15 of the samples are within maximum permissible limit and remaining two samples exceed the maximum permissible limit of 600 mg/L. Fluoride concentration in groundwater samples from fifteen locations are within desirable limits and remaining two samples exceed the maximum permissible limit of 1.5 mg/L. In the case of nitrate concentrate seven samples (Tipparthy - 2; Palyema - 2; Vasavi College, Babasahebgudem 1 & 2 and Nomula - 1 and 3) were exceeding maximum permissible limit of 45 mg/L. is the sulfate, calcium and magnesium contents are within the desirable limit in all the samples.

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Reference


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