Water Pollution Prevention Study Using Remote Sensing and GIS

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Assistant Professor, Dept. of Environmental Sciences, Acharya Nagarjuna University, Guntur (D.t) A.P, India

Abstract:
Increasing industrialization and population have resulted in a consequent increase in the pressure on basic civic amenities, which directly affects the quality of environment. Due to lack of basic services in industries, most of the lakes and rivers are forced to serve as drainage channels, which in turn affect the ground water quality of the surrounding area. Ground water, which is an important, yet, often neglected global source of water supply can be adversely affected in quality as well as quantity with changing industrialization and urbanization and information on these changes is limited to quantification of physico-chemical characteristics only. Need for a study to understand the correlation between industrialization and groundwater parameters is felt and a methodology to derive this correlation has been worked out using remote sensing and GIS. Keeping this in view an attempt has been made to identify the problematic areas in surrounding areas of Tandava Reservoir through generation of spatial distribution patterns of groundwater quality and to correlate the impact of Agriculture, Industry, Landuse/Landcover, and industrialization with it. Water Quality Index (WQI) is calculated to determine the suitability of water for human consumption and suitable recommendations to prevent further deterioration of water quality are suggested.

Key words: Groundwater Quality, Remote Sensing and GIS

I. INTRODUCTION
Water is a vital natural resource which forms the basis of all life. We depend on water for irrigation, industry, domestic needs, shipping and for sanitation and disposal of waste. But today we are wasting more water than we are actually using whether it is in our irrigation, urban system or anywhere else. Agriculture, which is a major part of the Indian economy and the backbone of our self-reliance, is dependent primarily on water. Water which was considered to be in plenty has now come to be realized as a limited resource, which is further accentuated by the failure of monsoons and recurrence of droughts. No water-resources management or development, whether it be for the purpose of water supply for the population, agriculture, industry or energy production, is possible without an assessment of the quantity and quality of the water available. Since water is unique chemical with properties of dissolving and carrying in suspension a huge variety of chemicals, it may get contaminated easily. To improve the management of water resources, with an improvement of Environmental quality, greater knowledge about their quantity and quality is required. There is also a need for regular and systematic of

II. STUDY AREA
The study area lower Tandava a sub catchment starting from downstream in Visakhapatnam District up to Bay of Bengal a stretch of 110 Kms, and about 55Kms downstream of Visakhapatnam town. All the overflow of waste waters from Visakhapatnam and its surrounding are presently joining Tandava River. The extent covered includes all areas irrigated by Tandava River and ground water. The area is located between 17030’and 17045’ North latitude and 82015’and 82030’ East longitude is included in Survey of India topsheets 65k/6.

A. OBJECTIVES OF THE STUDY

➢ To collect the water samples and analyze physico-chemical parameters.
➢ Preparation of Attribute database.
➢ Creation of Water Quality Index using the ARC/INFO GIS platform.

III. METHODOLOGY

A. Data collection
Different data products required for the study include Survey of India (SOI) topsheets bearing with numbers 65H/6, 7.10 and 11 on 1:50,000 scale. Fused data of IRS–1D PAN and LISS-III satellite imagery obtained from National Remote Sensing Agency (NRSA), Hyderabad, India. Collateral data collected from related organizations, comprises of water quality and demographic data.

B. Database creation
Satellite imageries are georeferenced using the ground control points with SOI topsheets as a reference and further merged to obtain a fused, high resolution (5.8m of PAN) and colored (R,G,B bands of LISS-III) output in EASI/PACE Image processing software. The study area is then delineated and subsetted from the fused data based on
the latitude and longitude values and a final hard copy output is prepared for the generation of thematic maps using visual interpretation technique. These thematic maps (raster data) are converted to vector format by scanning using an A0 flatbed desk jet scanner and digitized using AutoCAD software for generation of digital thematic maps using Arc/Info and ARC VIEW GIS software. The GIS digital database consists of thematic maps like land use/land cover, drainage, road network using Survey of India (SOI) toposheets and fused data of IRS - ID PAN and IRS-ID LISS-III satellite imagery.

1. Spatial Database

Thematic maps like base map and drainage network maps are prepared from the SOI toposheets on 1:50,000 scale using AutoCAD and Arc/Info GIS software to obtain a baseline data maps of the study area was prepared using visual interpretation technique from the fused satellite imagery (IRS-ID PAN + IRS-ID LISS-III) and SOI toposheets along with ground truth analysis. All the maps are scanned and digitized to generate a digital output.

2. Attribute database

Fieldwork is conducted and ground water samples are collected from 21 predetermined locations based on the land use and drainage network maps in the study area. Care is taken in collecting the water samples for uniform distribution and density of sampling locations. The water samples were analyzed for various physico-chemical parameters adopting standard protocols (APHA, AWWA, WPCF 1998). The water quality data thus obtained forms the attribute database for the present study (Table 1).

### Table 1: Attribute database

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard Value (Sn and S), Ideal Value (V), Weightage (Wn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.5, 7, 0.1428</td>
</tr>
<tr>
<td>Chloride</td>
<td>250 mg/l, 0, 0.0048</td>
</tr>
<tr>
<td>Sulphate</td>
<td>250 mg/l, 0, 0.0048</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>120 mg/l, 0, 0.0101</td>
</tr>
<tr>
<td>Nitrate</td>
<td>50 mg/l, 0, 0.0242</td>
</tr>
<tr>
<td>Total hardness</td>
<td>300 mg/l, 0, 0.0040</td>
</tr>
<tr>
<td>Total Dissolved Solids (TDS)</td>
<td>1000 mg/l, 0, 0.0012</td>
</tr>
<tr>
<td>Sodium</td>
<td>200 mg/l, 0, 0.0060</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.5 mg/l, 0, 0.0099</td>
</tr>
</tbody>
</table>

### Table 2: Water Quality Parameters, Their WHO/ICMR Standard, Ideal Values and Assigned Weightage

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard Value</th>
<th>Ideal Value</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.5</td>
<td>7</td>
<td>0.1428</td>
</tr>
<tr>
<td>Chloride</td>
<td>250 mg/l</td>
<td>0</td>
<td>0.0048</td>
</tr>
<tr>
<td>Sulphate</td>
<td>250 mg/l</td>
<td>0</td>
<td>0.0048</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>120 mg/l</td>
<td>0</td>
<td>0.0101</td>
</tr>
<tr>
<td>Nitrate</td>
<td>50 mg/l</td>
<td>0</td>
<td>0.0242</td>
</tr>
<tr>
<td>Total hardness</td>
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<td>0</td>
<td>0.0040</td>
</tr>
<tr>
<td>Total Dissolved Solids (TDS)</td>
<td>1000 mg/l</td>
<td>0</td>
<td>0.0012</td>
</tr>
<tr>
<td>Sodium</td>
<td>200 mg/l</td>
<td>0</td>
<td>0.0060</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.5 mg/l</td>
<td>0</td>
<td>0.0099</td>
</tr>
</tbody>
</table>

The water quality data (attribute) is linked to the sampling location (spatial) in ARC/INFO and maps showing spatial distribution are prepared to model the variation in concentrations of the above parameters in the 30 ground water samples at various locations using curve fitting technique of ARC/VIEW GIS.

### D. Estimation of water quality index (WQI)

To determine the suitability of the groundwater for drinking purposes, Water Quality Index (WQI) is computed adopting the method proposed by Tiwari and Mishra, 1985 (Mahuya Das Gupta, 2001, Pradhan, S.K, 2001, Srivastava, A.K., 1994). WQI is computed using the formula given in equation (1), and a water quality index map is prepared. The water quality parameter, their WHO/ICMR standards, Ideal value and the corresponding weightage are given in Table 2.

\[
WQI = \text{Antilog} \left[ \sum_{n=1}^{m} \log_{10} q_n \right] 
\]

Where, Weightage factor (W) is computed using equation (2)

\[
W_n = \frac{K}{S_n} 
\]

Where, 
- \(S_n\) = Standard value of the parameter 
- \(K\), Constant = \(\frac{1}{(\sum_{n=1}^{m} 1/S_n)}\) 
- \(S_i\) = Standard value of the parameter

Quality rating (q) is calculated by the formula given in equation (3)

\[
q_{\text{ni}} = \left[ \frac{\left( V_{\text{actual}} - V_{\text{ideal}} \right)}{V_{\text{standard}} - V_{\text{ideal}}} \right] \times 100
\]

Where, 
- \(q_{\text{ni}}\) = Quality rating of \(i^{th}\) parameter for a total of ‘n’ water quality parameters
- \(V_{\text{actual}}\) = Value of the water quality parameter obtained from laboratory analysis
- \(V_{\text{standard}}\) = Value of the water quality parameter obtained from the standard tables.
- \(V_{\text{ideal}}\) for pH = 7 and for other parameters it is equal to zero.

### IV. RESULTS AND DISCUSSION

#### A. pH

PH value of the water indicates the logarithm of reciprocal of hydrogen ion concentration present in water; it is thus an indicator of the acidity or alkalinity of water. pH for the water samples is determined by pH meter. pH value should be made to keep the pH as close as possible. However, the permissible pH value for public supplies may range between 6.8 to 8.5

- **Nature:** Acidic range: 0-7
- **Cause:** Presence of mineral acid like sulfuric acid, iron, Cadmium (Industrial Effluents).
- **Effect:** Tuberculosis and erosion.
- **Alkaline range:** 7.0 – 14.0
- **Cause:** Presence of bicarbonates, Calcium, Magnesium Potassium, sodium etc.
- **Effects:** Indigestion, Sedimentation deposition.

#### C. Integration of spatial and attribute database

The spatial and the attribute database generated are integrated for the generation of spatial distribution maps of selected water quality parameters namely pH, alkalinity, chlorides, sulphates, nitrates, TDS, total hardness and fluorides. The water quality data (attribute) is linked to the sampling location (spatial) in ARC/INFO and maps showing spatial distribution are prepared to model the variation in concentrations of the above parameters in the
B. Specific Electrical Conductance and Resistance

The term specific electrical conductance (conductivity) and specific electrical resistance (resistivity) denote the characteristics of a medium to the passage of electricity. In water quality determination conductivity, defined as the conductance of a cube of one-centimeter side of a substance is reported in mhos/cm. Conductivity of most of the natural waters is much less then unity, for convenience conductivity is therefore in micro mhos/cm.

C. Alkalinity

Alkalinity is a measure of water to neutralize acids. It is a measure of the quantity of ions that will react to neutralize H⁺ ions. It is mainly caused due to bicarbonate, carbonate and hydroxyl ions. Highly alkaline waters are usually unpalatable. Alkalinity reacts with cations of water and forms precipitate which damages the pipes and valves. The permissible value of alkalinity as recommended by the Indian Standards is 200 mg/L as CaCO₃. The presence of basic salts generally sodium and potassium has been indicated when the alkalinity exceeds the hardness. If the alkalinity has been less than the hardness then salts of calcium and magnesium would be present in association with sulfates, chlorides and nitrates. Most alkalinity is due to the presence of the bicarbonate ion, which is derived from the dissolution of carbonates by carbonic acid. Minor contributors to alkalinity in India include carbonate and hydroxide ions. Raising the alkalinity nearly raises the pH. Alkalinity is often related to hardness because the main source of alkalinity is usually from carbonate rocks (limestone), which are mostly CaCO₃. If CaCO₃ actually accounts for most of the alkalinity, hardness in CaCO₃ is equal to alkalinity. Since hard water contains metal carbonates (mostly CoCO₃) it is high in alkalinity. Conversely, unless carbonate is associated with sodium or potassium, which don’t contribute to hardness, soft water usually has low alkalinity and little buffering capacity. So, generally, soft water is much more susceptible to fluctuations in pH from acid rains or acid contamination.

D. Total Hardness

Total Hardness denotes the concentration of calcium and magnesium in waters, and is usually expressed as the equivalent of CaCO₃.

\[ \text{TH} = 2.497 \text{ ca} + 4.115 \text{ Mg} \]

Hardness of water is a measure of its capacity to form precipitate with soap and is caused by multivalent cations like calcium, magnesium etc. The desirable limit of hardness in water is 300 mg/L as CaCO₃. Hard water forms scales in hot water pipes and boilers. It causes cardiovascular diseases and makes food tasteless. The desirable limits against the quality of ground water are given below:

<table>
<thead>
<tr>
<th>Concentration (mg/L)</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50</td>
<td>Soft</td>
</tr>
<tr>
<td>50 - 150</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>150 - 300</td>
<td>Hard</td>
</tr>
<tr>
<td>300 mg/L and up</td>
<td>Very hard</td>
</tr>
</tbody>
</table>

Table 3: Total Hardness limits on Ground water

Water hardness is the state or quality of being hard caused by various dissolved salts of calcium, magnesium or iron. Hard water precipitates carbonate mineral deposits, scale, and incrustations on pipes, hot water heaters, boilers and cooking utensils. Water hardness can cause other problems in the home such as increased soap consumption by preventing soap and detergents from lathering by giving rise to an insoluble curdy precipitation. Water hardness can be lessened on a small scale by softening the water. This can be done with the addition of ammonia, borax, or trisodium phosphate mixed together with sodium carbonate. Hard water can be softened on a large scale by adding just enough lime to precipitate the calcium as carbonate to remove the calcium salts. Home water softeners commonly use natural or artificial zeolite minerals to soften the water. Hardness of waters prevents foam formation when soaps are used in bathing and laundry. Hardness is critical when water is used in heaters and boilers. The scale formation in such units seriously reduces their thermal efficiency. Hard water produces intestinal problems and need more fuel and more time to cook. The excess soap used to produce the required lather may kill the natural antibiotics secreted by the skin and makes it more vulnerable for infections. Soft water affects the human cardiovascular system and causes heart attacks.

E. Chlorides

Chlorides are binary compounds of chlorine. It is formed naturally when hydrochloric acid reacts with any metal in the water. Chloride is common in areas with limestone Deposits, but is not found in most other soils, rocks or minerals. The presence of chloride where it does not occur naturally indicates possible water pollution. Sources of chloride are septic tank effluent, animal waste, rocks containing chlorides, agricultural runoff, wastewater industries and potash fertilizer (KCI). Other forms of chloride are iron chloride, calcium chloride and cupric chloride. Chloride contaminates rivers and groundwater and can make it unsuitable for humans to drink. High levels of chloride kill plants and wildlife. Sodium chloride is the main substance responsible for chloride concentration in water. 250 ppm being the desirable limit for chlorides, concentration greater than 250 ppm imparts a salty taste to the water and is therefore objectionable. Excess chloride in water causes cardiovascular diseases in humans and imparts permanent hardness to the water. It corrodes steel and affects the solidity and strength of concrete. Chlorides were determined by Argentometric method (Titrimetry) using...
silver nitrate as the titrant. Chlorine is a greenish-yellow gas that dissolves easily in water. It has a pungent, noxious odour that some people can smell at concentrations above 0.3 parts per million. Chlorine is an excellent disinfectant. In parts of the world where chlorine is not added to drinking water, thousands of people die each day from waterborne diseases like typhoid and cholera. Chlorine is also used as a disinfectant in wastewater treatment plants and swimming pools. It is widely used as a bleaching agent in textile factories and paper mills, and it’s an important ingredient in many laundry bleaches. Free chlorine (chlorine gas dissolved in water) is toxic to fish and aquatic organisms, even in very small amounts. However, its dangers are relatively short-lived compared to the dangers of most other highly poisonous Substances. That is because chlorine reacts quickly with other substances in water (and forms combined chlorine) or dissipates as a gas into the atmosphere. The free chlorine test measures only the amount of free or dissolved chlorine in water. The total chlorine test measures both free and combined forms of chlorine. If water contains a lot of decaying materials, free chlorine can combine with them to form compounds called trihalomethanes (THMs). Some THMs in high concentrations are carcinogenic to people. Unlike free chlorine, THMs are persistent and can pose a health threat to living things for a long time.

Table 4: Total Hardness limits on Ground water

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 ppm</td>
<td>Good</td>
</tr>
<tr>
<td>1-1.5 ppm</td>
<td>Very good</td>
</tr>
<tr>
<td>1.5 – 2 ppm</td>
<td>Tolerable</td>
</tr>
<tr>
<td>2 ppm</td>
<td>Polluted</td>
</tr>
</tbody>
</table>

F. Nitrates

Nitrogen is a much more abundant element in nature than phosphorus. Nitrogen is known to be an important plant nutrient, thus it is used often as a fertilizer and is found in high concentrations in agricultural runoff. Nitrate concentrations result from improperly functioning septic systems. As with phosphorus, too much nitrogen also contributes to eutrophication of lakes and streams. Nitrates in river water often ranges from 0.01 ppm to 3 ppm. The presence of nitrates in groundwater indicates an oxidizing condition in the aquifer. Elevated concentrations (>0.10 mg/L) are indicative of the influences of man such as the use of nitrate fertilizer, septic tank failure and the vulnerability of the aquifer to infiltration by surface drainage. Extensive usage of nitrogenous fertilizers like urea and ammonium sulphate pollutes the groundwater as well as the surface waters. Occasionally nitrate is an important natural constituent; high concentrations may indicate sources of past or present pollution. Major natural sources of nitrates are legumes, plant debris and animal excreta (David Keith Todd, 1980). The primary source of nitrates in well water has been the leaching of nitrate salts into the underground water supply from agricultural fertilization and seepage of sewage. High concentration of nitrates in drinking water causes methemoglobinemia or blue baby disease, where nitrates are converted to nitrites in the human blood, which has a greater affinity for oxygen than hemoglobin resulting in oxygen deficiency. Nitrates are determined spectrophotometrically by UV method at 220nm. Nitrates can be reduced to toxic nitrites in the human intestine, and many babies have been seriously poisoned by well water containing high levels of nitrate-nitrogen.

G. Fluorides

Fluorides are compounds containing the element fluorine. Some of the most common of these compounds include the following: sodium fluoride (NaF), sodium silicofluoride (Na₂SiF₆), and calcium fluoride (CaF₂). Fluorine is the most reactive non-metallic element. It will form compounds with all elements except helium, neon and argon. It will also form salts by combining with metals Water in contact with natural deposits of fluoride such as fluor spar, calcium fluoride and cryolite (Na₃AlF₆) and waters contaminated with industrial effluents are found to contain excess fluoride. Fluorides can be categorized as:

Table 5: Fluorides categories

<table>
<thead>
<tr>
<th>INDEX</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>Excellent</td>
</tr>
<tr>
<td>26-50</td>
<td>Good</td>
</tr>
<tr>
<td>51-75</td>
<td>Poor</td>
</tr>
<tr>
<td>75-100</td>
<td>Very Poor</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>Unfit for drinking</td>
</tr>
</tbody>
</table>

Fluorides are determined using the Ion selective electrode method. Fluoride ions may be present either naturally or artificially in drinking water and are absorbed to some degree in the bone structure of the body and tooth enamel. Fluoride at extremely high levels can cause mottling (discoloration) of the teeth. Some fluoride compounds may also cause corrosion of piping and other water treatment equipment. Fluoride concentration in water to be used for domestic water supply should not exceed 1.0 mg/L.

1. Significance of Fluorides

- Fluoride present in drinking water in amount up to 1 mg/L is beneficial to the health, as it develops carries-resistant dental enamel.
- Fluoride in drinking water above 1.5 mg/l is proved to be toxic to human and animal physiology.
- The toxic effect on teeth involve development of chalky white patches and pitting with chipped off edges.
- Concentration above 2-3 mg/l give rise to skeletal abnormalities and pain in joints.
- Prolonged ingestion of the iron causes increased stiffness of spine and kyphosis.
H. Sulphates

Sulphates in the water are primarily related to the types of minerals in the soil and bedrock, and the acid rain. Industries and utilities that burn coal release sulphur compounds into the atmosphere to become a part of the acid rain problem. Dissolved sulphate is derived from the dissolution of gypsum or the oxidation of sulphide minerals such as pyrite. Sulphate is a naturally occurring anion found in all kinds of natural waters. Most of them originate from the oxidation of sulphite ores, the presence of shales etc. Sulphate can be readily leached from the zone of weathering by infiltrating waters and surface runoff. The desirable limit of sulphate concentration is 250 mg/L in waters intended for human consumption. Sulphates are determined spectrophotometrically at a wavelength of 420 nm. At concentrations exceeding 500-600 mg/L, it imparts a bitter taste and may cause laxative effects in some individuals.

Significance of Sulphates

- Sulphates like chlorides corrode steel and affect the solidity and strength of concrete.
- Sodium Sulphate causes foaming.
- Sulphates cause a laxative effect and magnesium Sulphate causes.
- Temporary diarrhea and disorders of alimentary tract.
- Sulphate in excess of 250 mg/L causes gastrointestinal irritation.
- Excess sulphate causes crown corrosion in sewers.

Table 5 shows water quality parameters, their desirable limits and their effects on human beings. In the present study, 30 samples have been taken at well-distributed locations and in the study area. The samples have been analyzed for different parameters like pH, EC, Alkalinity, total hardness, calcium, magnesium, nitrates, sulphates, etc., these values are tabulated in the Table 6.

1. SPATIAL DISTRIBUTION MAPS FOR WQI

Spatial distribution maps for water quality index are prepared based on the index computed from the results of the laboratory analysis using ARC INFO software. According to earlier investigations carried out by several authors on water quality index, a five point scale namely excellent, good, poor to poor, and unfit for drinking for water quality was developed. For soil quality index it is good, average and poor. The surface could be visualized as representing a third dimension to the 2-Dimensional x y data and the third axis can be represented by any attribute. The procedure for the generation of maps is given in detail in the earlier sections. The ranges of water quality index for 4 point scale are as given below:

The entire study area consisting of a number of polygons, and all these polygons are categorized into five groups for preparation of spatial distribution of water quality index and each group is colored with a different color, shown in the maps.

## Table 6: Values of Water Quality Index (WQI)

<table>
<thead>
<tr>
<th>Name of the Village</th>
<th>WQI</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheekikadai</td>
<td>25.52</td>
<td>Good</td>
</tr>
<tr>
<td>Konkasingi</td>
<td>26.83</td>
<td>Good</td>
</tr>
<tr>
<td>Godampalem</td>
<td>29.65</td>
<td>Good</td>
</tr>
<tr>
<td>Mallenpete</td>
<td>58.77</td>
<td>Poor</td>
</tr>
<tr>
<td>Tallacheekadai</td>
<td>59.23</td>
<td>Poor</td>
</tr>
<tr>
<td>Mallenpete1</td>
<td>35.13</td>
<td>Good</td>
</tr>
<tr>
<td>Pappusetipalem</td>
<td>44.97</td>
<td>Good</td>
</tr>
<tr>
<td>Pappusetipalem1</td>
<td>31.56</td>
<td>Good</td>
</tr>
<tr>
<td>Cheekikada1</td>
<td>78.76</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Chodyaml</td>
<td>54.95</td>
<td>Poor</td>
</tr>
<tr>
<td>Nagannadrapalem</td>
<td>74.65</td>
<td>Poor</td>
</tr>
<tr>
<td>Annapeta</td>
<td>54.95</td>
<td>Poor</td>
</tr>
<tr>
<td>Godampalem1</td>
<td>56.2</td>
<td>Poor</td>
</tr>
<tr>
<td>Golugonda</td>
<td>13.27</td>
<td>Excellent</td>
</tr>
<tr>
<td>Pogachhetlapalem</td>
<td>16.28</td>
<td>Excellent</td>
</tr>
<tr>
<td>Parikaly1</td>
<td>25.94</td>
<td>Good</td>
</tr>
<tr>
<td>Kothamallenpeti</td>
<td>61.85</td>
<td>Poor</td>
</tr>
<tr>
<td>Lingamdorapalem</td>
<td>25.48</td>
<td>Good</td>
</tr>
<tr>
<td>Pradesipakalu</td>
<td>88.04</td>
<td>Very Poor</td>
</tr>
<tr>
<td>Tallacheedikadai</td>
<td>133.5</td>
<td>Unfit for drinking</td>
</tr>
</tbody>
</table>

## REFERENCES

## Table 1: Water Quality Analysis Data

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Location</th>
<th>PH</th>
<th>E.C.</th>
<th>Alkalinity</th>
<th>T.H.</th>
<th>Ca</th>
<th>Mg</th>
<th>Cl</th>
<th>N03</th>
<th>F</th>
<th>SO4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mallenpeta</td>
<td>7.55</td>
<td>0.8</td>
<td>466</td>
<td>244.9</td>
<td>102</td>
<td>142</td>
<td>102.72</td>
<td>5.07</td>
<td>0.0343</td>
<td>27.4</td>
</tr>
<tr>
<td>2</td>
<td>Mallenpeta1</td>
<td>7.44</td>
<td>1.2</td>
<td>467.7</td>
<td>242.7</td>
<td>105</td>
<td>136</td>
<td>132.09</td>
<td>5.08</td>
<td>0.00897</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Pappusettipalem2</td>
<td>7.68</td>
<td>0.3</td>
<td>115.3</td>
<td>112.3</td>
<td>95</td>
<td>102</td>
<td>19.55</td>
<td>6.55</td>
<td>0.035</td>
<td>46</td>
</tr>
<tr>
<td>4</td>
<td>Pappusettipalem1</td>
<td>7.5</td>
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**Figure 2**

**Figure 3**

**Figure 4**

**Figure 5**
Figure 1: Flow chart showing the methodology adopted for the present study