CONTENTS

ABSTRACT

CHAPTER I
INTRODUCTION
1.1 General .................................................................................................. 1
1.2 Groundwater .......................................................................................... 3
1.3 Geophysics .............................................................................................. 6
1.3.1 Geoelectricity ..................................................................................... 8
1.3.2 Resistivity methods ............................................................................ 9
1.3.3 Vertical electrical sounding (VES) .................................................. 10
1.4 Groundwater geochemistry ................................................................. 11
1.5 Integrated approach ............................................................................. 14
1.6 Statement of the Problem .................................................................... 15
1.7 Objectives of the study ....................................................................... 16
1.8 Scope of the present work .................................................................. 16
1.9 Organization of thesis ........................................................................ 17

CHAPTER II
REVIEW OF LITERATURE
2.1 General .................................................................................................. 19
2.2 Reviews on Geophysical studies .......................................................... 20
2.2.1 International view ............................................................................ 20
2.2.2 National view .................................................................................. 25
2.3 Reviews on Geochemical studies ......................................................... 27
2.3.1 International view ............................................................................ 27
2.3.2 National view .................................................................................. 29
2.4 Reviews on integrated studies ............................................................. 34
2.4.1 International view ............................................................................ 34
2.4.2 National view .................................................................................. 37

CHAPTER III
SALIENT FEATURES OF THE STUDY AREA
3.1 General .................................................................................................. 40
3.2 Physiography ....................................................................................... 40
3.3 Relief ...................................................................................................... 42
3.4 Drainage pattern .................................................................................. 42
3.5 Land use pattern .................................................................................. 45
3.6 Climate and Rainfall ........................................................................... 46
3.7 Geology .................................................................................................. 47
3.8 Soils ....................................................................................................... 49
3.9 Geomorphology ................................................................................... 50
3.10 Hydrogeology ..................................................................................... 50
CHAPTER IV
GEOELECTRICAL STUDY

4.1 Introduction ............................................................... 53
4.2 Basic Theory .............................................................. 57
  4.2.1 Resistivity ............................................................. 57
  4.2.2 Apparent Resistivity .............................................. 59
4.3 Electrode Configuration ................................................ 60
  4.3.1 Wenner arrangement ............................................. 61
  4.3.2 Schlumberger arrangement .................................... 63
4.4 Constant Space Traversing (CST) .................................. 64
4.5 Vertical Electrical Sounding (VES) ................................ 65
4.6 Equipment ............................................................... 68
4.7 Data acquisition and processing .................................... 69
4.8 Interpretation ............................................................. 74
4.9 Results and Discussion ................................................. 77
  4.9.1 Vertical electrical sounding .................................... 77
  4.9.2 Geoelectrical parameters ....................................... 92
  4.9.3 Correlation of the VES results with litholog data ........ 93
  4.9.4 Pseudo cross – sections ......................................... 95
  4.9.5 Depth to the bedrock ............................................ 100
  4.9.6 Spatial and Vertical distribution of resistivity .......... 101
4.10 Summary of geoelectrical method ................................ 108

CHAPTER V
GEOCHEMICAL STUDY

5.1 Introduction .................................................................. 110
5.2 Methodology .............................................................. 113
5.3 Water quality ............................................................. 114
  5.3.1 pH ......................................................................... 114
  5.3.2 Total Dissolved Solids (TDS) .................................. 117
  5.3.3 Total Hardness (TH) .................................................. 118
  5.3.4 Major Cations ____________________________________ 119
    5.3.4.1 Sodium .............................................................. 119
    5.3.4.2 Potassium .......................................................... 120
    5.3.4.3 Calcium ........................................................... 121
    5.3.4.4 Magnesium ....................................................... 121
  5.3.5 Major anions ............................................................ 122
    5.3.5.1 Bi-Carbonate .................................................... 122
    5.3.5.2 Chloride ........................................................... 123
    5.3.5.3 Sulphate .......................................................... 124
<table>
<thead>
<tr>
<th>List of Figures</th>
<th>Page numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 3.1 Study area map</td>
<td>41</td>
</tr>
<tr>
<td>Figure 3.2 Relief map of the study area</td>
<td>43</td>
</tr>
<tr>
<td>Figure 3.3 Drainage pattern of the study area</td>
<td>44</td>
</tr>
<tr>
<td>Figure 3.4 Geology map of the study area</td>
<td>48</td>
</tr>
<tr>
<td>Figure 3.5 Geomorphology map of the study area</td>
<td>51</td>
</tr>
<tr>
<td>Figure 4.1 Current flow in homogenous ground in geoelectrical method</td>
<td>56</td>
</tr>
<tr>
<td>Figure 4.2 Wenner electrode configuration</td>
<td>62</td>
</tr>
<tr>
<td>Figure 4.3 Schlumberger electrode configuration</td>
<td>62</td>
</tr>
<tr>
<td>Figure 4.4 Field Procedure of Vertical electrical sounding by Schlumberger</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Figure 4.5 DDR3 Resistivity meter</td>
<td>68</td>
</tr>
<tr>
<td>Figure 4.6 Study area map showing VES locations</td>
<td>71</td>
</tr>
<tr>
<td>Figure 4.7 Field photos during VES data acquisition-1</td>
<td>72</td>
</tr>
<tr>
<td>Figure 4.8 Field photos during VES data acquisition-2</td>
<td>73</td>
</tr>
<tr>
<td>Figure 4.9 Standard curves for VES interpretation</td>
<td>76</td>
</tr>
<tr>
<td>Figure 4.10 VES curves obtained from the stations S1 – S6</td>
<td>78</td>
</tr>
<tr>
<td>Figure 4.11 VES curves obtained from the stations S7 – S12</td>
<td>79</td>
</tr>
<tr>
<td>Figure 4.12 VES curves obtained from the stations S13 – S18</td>
<td>80</td>
</tr>
<tr>
<td>Figure 4.13 VES curves obtained from the stations S19 – S24</td>
<td>81</td>
</tr>
<tr>
<td>Figure 4.14 VES curves obtained from the stations S25 – S30</td>
<td>82</td>
</tr>
<tr>
<td>Figure 4.15 VES curves obtained from the stations S31 – S36</td>
<td>83</td>
</tr>
<tr>
<td>Figure 4.16 VES curves obtained from the stations S37 – S42</td>
<td>84</td>
</tr>
<tr>
<td>Figure 4.17 VES curves obtained from the stations S43 – S48</td>
<td>85</td>
</tr>
<tr>
<td>Figure 4.18 VES curves obtained from the stations S49 – S54</td>
<td>86</td>
</tr>
<tr>
<td>Figure 4.19 VES curves obtained from the stations S55 – S58</td>
<td>87</td>
</tr>
<tr>
<td>Figure 4.20 Map showing fresh and saline groundwater zones</td>
<td>91</td>
</tr>
<tr>
<td>Figure 4.21 Correlation of VES results with nearby litholog (a). S21 with Varioor, (b). S27 with Agastheeswaram, (c). S40 with Kottaram, (d). S41 with Mylaudy</td>
<td>94</td>
</tr>
<tr>
<td>Figure 4.22 Location map showing the profiles</td>
<td>96</td>
</tr>
<tr>
<td>Figure 4.23 Psuedo cross-section along profiles 1, 2 and 3</td>
<td>97</td>
</tr>
<tr>
<td>Figure 4.24 Psuedo cross-section along profiles 4, 5 and 6</td>
<td>98</td>
</tr>
<tr>
<td>Figure 4.25 Spatial distribution of resistivity in (a). First layer, (b). Second layer</td>
<td>102</td>
</tr>
</tbody>
</table>
Figure 4.26 Spatial distribution of resistivity in (a). Third layer, (b). Aquifer ................. 103
Figure 4.27 Spatial distribution of thickness in (a). First layer, (b). Second layer ............. 104
Figure 4.28 Iso-resistivity distribution for AB/2 at (a) 5m, (b) 10m .............................. 106
Figure 4.29 Iso-resistivity distribution for AB/2 at (a) 25m, (b) 50m ............................ 107
Figure 5.1 Location map showing water sampling stations ........................................ 112
Figure 5.2 Spatial distribution of total dissolved solids (TDS) during
(a) post monsoon, (b) pre monsoon .......... 128
Figure 5.3 Spatial distribution of total hardness (TH) during
(a) post monsoon (b) pre monsoon .......... 129
Figure 5.4 Spatial distribution of sodium (Na$^+$) during
(a) post monsoon (b) pre monsoon .......... 130
Figure 5.5 Spatial distribution of potassium (K$^+$) during
(a) post monsoon (b) pre monsoon .......... 131
Figure 5.6 Spatial distribution of calcium (Ca$^{2+}$) during
(a) post monsoon (b) pre monsoon .......... 132
Figure 5.7 Spatial distribution of magnesium (Mg$^{2+}$) during
(a) post monsoon (b) pre monsoon .......... 133
Figure 5.8 Spatial distribution of chloride (Cl$^-$) during
(a) post monsoon (b) pre monsoon .......... 134
Figure 5.9 Spatial distribution of sulphate (SO$_4^{2-}$) during
(a) post monsoon (b) pre monsoon .......... 135
Figure 5.10 Spatial distribution of bicarbonate (HCO$_3^-$) during
(a) post monsoon (b) pre monsoon .......... 136
Figure 5.11 Piper diagrams illustrating the chemical composition of groundwater
(a) Post monsoon (b) Pre monsoon .......... 138
Figure 5.12 Gibbs diagrams showing the mechanisms controlling the chemistry of
groundwater. a. Major cations vs TDS for post monsoon,
b. Major cations vs TDS for pre monsoon ...................... 140
Figure 5.13 Gibbs diagrams showing the mechanisms controlling the chemistry of
groundwater. a. Major anions vs TDS for post monsoon
b. Major anions vs TDS for pre monsoon ...................... 141
Figure 5.14 Ion scatter diagrams of the groundwater in the study area.
a. Na$^+$ versus Cl$^-$ scatter plot for post monsoon
b. Na$^+$ versus Cl$^-$ scatter plot pre monsoon
c. \( \text{HCO}_3^- \) versus \( (\text{Ca}^{2+} + \text{Mg}^{2+}) \) plot for post monsoon

d. \( \text{HCO}_3^- \) versus \( (\text{Ca}^{2+} + \text{Mg}^{2+}) \) plot for pre monsoon

Figure 5.15 Ion scatter diagrams of the groundwater in the study area.

a. \( \text{Cl}^- \) versus \( (\text{Na}^+ + \text{K}^+) \) plot for post monsoon

b. \( \text{Cl}^- \) versus \( (\text{Na}^+ + \text{K}^+) \) plot for pre monsoon

c. \( \text{EC} \) versus \( \text{Na}^+/\text{Cl}^- \) plot for post monsoon

d. \( \text{EC} \) versus \( \text{Na}^+/\text{Cl}^- \) plot for pre monsoon

Figure 5.16 Rating of groundwater samples by Wilcox diagram on the basis of
\( \text{EC} \) and \%Na. a. Post monsoon, b. Pre monsoon

Figure 5.17 Salinity and alkalinity hazard of groundwater samples depicted in
USSL Diagrams. a. Post monsoon, b. Pre monsoon

Figure 6.1 Spatial distribution of TDS in a. pre-monsoon, b. post-monsoon

Figure 6.2 Map showing Aquifer resistivity distribution

Figure 6.3 Relation between Aquifer Resistivity and Electrical Conductivity
## List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Land use details</td>
<td>46</td>
</tr>
<tr>
<td>3.2</td>
<td>Stratigraphical succession of the study area</td>
<td>49</td>
</tr>
<tr>
<td>4.1</td>
<td>Resistivities of various minerals</td>
<td>54</td>
</tr>
<tr>
<td>4.2</td>
<td>Interpreted VES results</td>
<td>88, 89</td>
</tr>
<tr>
<td>5.1</td>
<td>Ranges of chemical parameters and their comparison with the WHO</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>and the Indian standards for drinking water (Post-monsoon)</td>
<td></td>
</tr>
<tr>
<td>5.2</td>
<td>Ranges of chemical parameters and their comparison with the WHO</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>and the Indian standards for drinking water (Pre-monsoon)</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Classification of groundwater on the basis of TDS (USGS, 2000)</td>
<td>117</td>
</tr>
<tr>
<td>5.4</td>
<td>Classification of groundwater on the basis of Total Hardness (TH)</td>
<td>118</td>
</tr>
<tr>
<td>5.5</td>
<td>Classification of groundwater on the basis of Na%, SAR and RSC</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>for irrigation</td>
<td></td>
</tr>
<tr>
<td>5.6</td>
<td>Correlation matrix for the water samples during post monsoon</td>
<td>154</td>
</tr>
<tr>
<td>5.7</td>
<td>Correlation matrix for the water samples during pre monsoon</td>
<td>154</td>
</tr>
<tr>
<td>6.1</td>
<td>Water resistivity and aquifer resistivity in the study area</td>
<td>158</td>
</tr>
<tr>
<td>6.2</td>
<td>Correlation matrix of Aquifer resistivity with water quality parameters</td>
<td>162</td>
</tr>
</tbody>
</table>