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# Hydrochemical concept of groundwater in and around Atmakuru area, Anantapur District, Andhra Pradesh, India

**Narsimha. A[1], Sudarshan. V[1], Srinivasulu. P[2], Venkateswarlu. P[1] and Rajeswara Reddy. B[1]**

[1]*Department of Applied Geochemistry Osmania University, Hyderabad. 500 007*
[2]*Department of Geology, Osmania University, Hyderabad. 500 007*

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**ABSTRACT**

*Groundwater is used for domestic, industrial water supply and for irrigation all over the world. Although three-fourth of earth is being surrounded by sea only a little portion of it can be used for drinking purpose. To classify the ground water ability for different purposes various graphical plots like Piper tri-linear and Durov have been drawn. On the basis of piper diagram illustrated that the alkaline earth metals ($Ca^{2+}$ + $Mg^{2+}$) significantly exceed the alkalis ($Na^{+}$ + $K^{+}$) and strong acids exceeds weak acids. The dominant cation found in groundwater is $Mg^{2+}$ and the dominant anion is $Cl^{-}$ type. The groundwater quality of Atmakuru is influenced by various natural and anthropogenic factors.*

**Keywords**: Piper tri-linear, Durov diagrams, Hydrochemical and water type

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## INTRODUCTION

Water is the most valuable and vital resource for sustenance of life and also for any developmental activity. With the surface water sources dwindling to meet the various demands, groundwater has become the only reliable resource [18]. The indiscriminate use of this vital natural resource is creating groundwater mining problem in various parts of world [19]. The geochemical processes occurring within the groundwater and the reaction with aquifer minerals have a profound effect on water quality, and further leaching of pollutants from the landfill causes changes in groundwater quality [14].

**Study Area:**
Anantapur District is located in the South-Western part of Andhra Pradesh, India. The study area lies between longitudes 77° 15’ - 77° 30’ E and latitudes 14° 35’- 15° 0’ N and falls in the Survey of India Toposheet No: 57 F/5. The study area is mainly underlain by peninsular gneisses of Archean age.

## MATERIALS AND METHODS

Ten groundwater samples were collected from ten different locations of the surrounding of Atmakuru area, Anantapur district, Andhra Pradesh. The samples were collected from bore wells which were extensively used for drinking and other domestic purposes. The samples were collected in pre-cleaned and sterilized polyethylene bottles of two litre capacity. The groundwater samples were analyzed using [1] procedure, and suggested precautions were taken to avoid contamination. The various parameters determined were pH, EC (electrical conductivity), total dissolved solids (TDS), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), carbonate ($CO_3^{2-}$), bicarbonate ($HCO_3^-$), chloride ($Cl^-$), sulfate ($SO_4^{2-}$), Sodium ($Na^+$), potassium ($K^+$) and Nitrate ($NO_3^-$). pH and EC were determined by pH, conductivity meter, the total dissolved solids (TDS) were estimated from cation and anion content by calculation method [12], $Ca^{2+}$, $Mg^{2+}$, $CO_3^{2-}$, $HCO_3^-$ and $Cl^-$ were estimated by titrimetry, where as $Na^+$ and $K^+$ by flame photometry. All concentration values were expressed in milligram per liter unless otherwise indicated.

## RESULTS AND DISCUSSION

The groundwater has the mean pH of 8.87 and most of the samples (60%) have pH value ranging between 7.49 and 7.98 reflecting a weak alkaline nature of the water. The EC is <1,000 µS/cm in eight locations and only two locations have EC >1,000 µS/cm and TDS is <1,500 mg/L in most of the samples (except one location). The $Ca^{2+}$ content is moderate with an mean of 100.5 mg/L whereas $Mg^{2+}$ concentration is high, the mean being 227.9 mg/L (Table 1). The mean values of $Na^+$ and $Cl^-$ are moderate being 67.62 and 200.5 mg/L, respectively, but their content varies widely among the samples which is reflected in the form of high SD values for these ions. High $Cl^-$ concentration, which ranges from 53 to 426 mg/L (50% have <200 mg/L). The $NO_3^-$ concentration ranges from 14 to 48 mg/L (only one location have >45 mg/L).

### Piper and Durov diagram:

The Piper diagram [15] is the most widely used graphical form and is quite similar to the diagram proposed by Hill [10]. The central diamond-shaped field (quadrilateral field) is used to show the overall chemical character of the water [11, 16]. [2, 3] defined the subdivisions of the diamond field that represent water-type categories that form the basis for one common classification scheme for natural waters.

Classification of waters was based on the principles of [9] (International Association of Hydrogeologists). Hydrochemical concepts can help to elucidate the mechanisms of flow and transport in groundwater systems, and unlock an archive of paleoenvironmental information [17, 12, 13]. Piper (1944) has developed a form of trilinear diagram, which is an effective tool in segregating analysis data with respect to sources of the dissolved constituents in groundwater, modifications in the character of water as it passes through an area and related geochemical problems [16]. The ionic concentration of major cations and anions found in groundwater of the study area are plotted in Piper's trilinear diagram (Fig. 1) by the geochemical software AquaChem.

**Table 1. Location wise distribution of groundwater samples belonging to particular water type**

| S. No | water type | pH | EC | TDS | $Ca^{2+}$ | $Mg^{+2}$ | $Na^+$ | $K^+$ | $Cl^-$ | $HCO_3^-$ | $NO_3^-$ | $SO_4^{-2}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mg-Na-Ca | 7.98 | 278 | 177.92 | 120 | 220 | 16.8 | 30 | 426 | 91.5 | 20 | 50 |
| 2 | Mg-Cl | 7.94 | 415 | 265.6 | 125 | 320 | 152 | 43 | 142 | 73.2 | 14 | 80 |
| 3 | Mg-Na-Cl | 8.3 | 1880 | 1203.2 | 12 | 170 | 129 | 37 | 284 | 48.8 | 19 | 84 |
| 4 | Mg-Ca-Na-Cl | 8.53 | 850 | 544 | 140 | 206 | 118 | 22 | 213 | 146.4 | 48 | 86 |
| 5 | Mg-Ca-Na-Cl | 8.46 | 1260 | 806.4 | 162 | 110 | 106 | 35 | 191 | 116 | 14 | 83 |
| 6 | Mg-Na-Cl | 7.91 | 360 | 230.4 | 61 | 290 | 18.6 | 28 | 266 | 73 | 22 | 120 |
| 7 | Mg-Na-Cl | 7.82 | 725 | 464 | 12.5 | 225 | 91 | 39 | 106 | 55 | 20 | 110 |
| 8 | Mg-Cl | 7.49 | 172 | 110.08 | 65 | 410 | 14.8 | 49 | 71 | 122 | 19 | 95 |
| 9 | Mg-Ca | 8.5 | 740 | 473.6 | 105 | 146 | 10.3 | 3 | 53 | 152.5 | 29 | 86 |
| 10 | Mg-Ca-Cl | 7.81 | 426 | 272.64 | 203 | 182 | 19.7 | 12 | 253 | 30.5 | 35 | 190 |
| **Min** | | **7.49** | **172** | **110.08** | **12** | **110** | **10.3** | **3** | **53** | **30.5** | **14** | **50** |
| **Max** | | **8.53** | **1880** | **1203.2** | **203** | **410** | 152 | **49** | **426** | **152.5** | **48** | **190** |
| **median** | | **7.96** | **575.5** | **368.32** | **112.5** | **213** | 55.35 | **32.5** | **202** | **82.35** | **20** | **86** |
| **Mean** | | **8.07** | **710.6** | **454.78** | **100.5** | **227.9** | **67.62** | **29.8** | **200.5** | **90.89** | **24** | **98** |
| **Std. Dev** | | **0.35** | **522.6** | **334.49** | **62.58** | **89.52** | **56.57** | **14.2** | **113.5** | **41.92** | **10** | **37** |

The classification for cation and anion facies, in terms of major ion percentage and water types, is according to the domain in which they occur on the diagram segment [4]. The location wise details of hydrochemical water type are given in Table 1. From the plot it is observed that, majority of the groundwater samples exhibit that the alkaline earth metals ($Ca^{2+}$+$Mg^{2+}$) significantly exceed the alkalis ($Na^+$ + $K^+$) and strong acids exceeds weak acids. The Durov plot is an alternative to the Piper plot (Fig. 2). This diagram was developed in 1948 and modified by [4]. The trilinear Durov diagram (Fig. 1, 2) is based on the percentage of major ion milliequivalents. The cation and anion values are plotted on two separate triangular plots and the data points are projected into a square grid at the base of each triangle.

The main purpose of the Durov diagram [6] is to show clustering of data points to indicate samples that have similar compositions. Chemical facies that determine the water type are calculated by first converting the concentration (meq/L) of the major cations ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$) and anions ($Cl^-$, $SO_4^{2-}$, $HCO_3^-$ ) to percentages [8]. All ions with concentrations surpassing 10% of the molar concentration in the solution are considered to be major ions [8]. The Piper and Durov diagrams indicate most of the samples were classified as Mg type of cation facies and $Cl^-$ type of anion hydrochemical facies. The Piper and Durov diagram shows temporal variation of these ions, indicating an increase in concentration of chloride ions because of anthropogenic input from the landfill, since there is no known natural source of chloride in the study area.

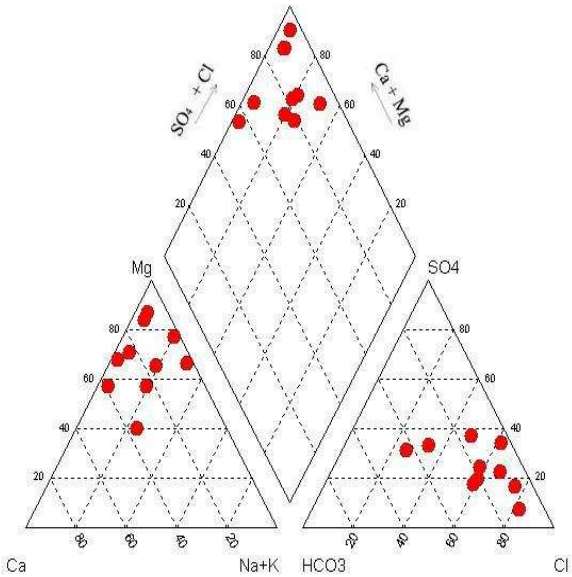


**Fig. 1 Piper diagram of groundwater samples of study area**

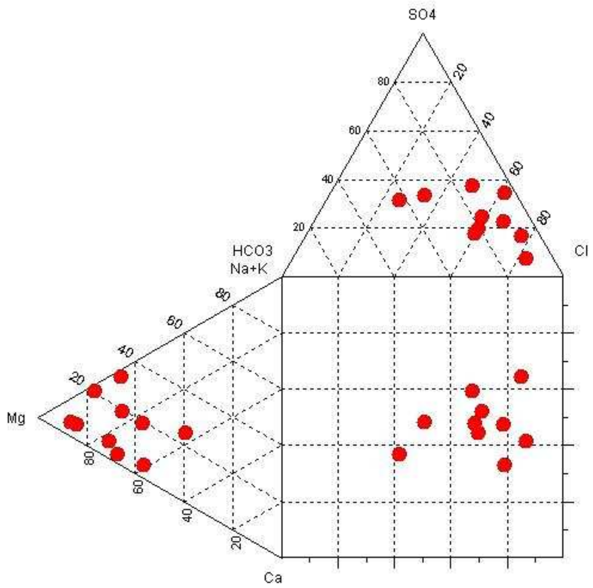


**Fig. 2 Durov diagram of groundwater samples of study area**

## CONCLUSION

Groundwater quality in the Atmakuru area consist of the alkaline earth metals ($Ca^{2+}$+$Mg^{2+}$) significantly exceed the alkalis ($Na^+$ + $K^+$) and strong acids exceeds weak acids. Within the study area, the dominant cation found in groundwater is $Mg^{2+}$ followed by $Ca^{2+}$ and the dominant anion is $Cl^-$ followed by $HCO_3^-$. According to diagrams illustrated that chloride type of anion ions increase, in these indicates that most of the anthropogenic inputs in the study area.

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