Hydrochemistry and Groundwater Quality Assessment of Dantewada District, Chhattisgarh, India

Rubina Sahin[1] KavitaTapadia[2*]
1.Department of Chemistry, National Institute of Technology, Raipur, Department of Chemistry, NMDC DAV Polytechnic, Dantewada
2.Department of Chemistry, National Institute of Technology, Raipur, CG, INDIA,492010
E. mail- akavita9@rediffmail.com ktapadia.chy@nitrr.ac.in

Abstract
Hydrogeological investigation have been carried out in Dantewada district. Groundwater samples were collected from selected locations in month of September 2013 and analyzed for major and minor cations & anions. Piper Diagram identified Ca-Mg-HCO_3 dominantin water in most of the samples. The dominance of anions and cations were of the order of HCO_3^-> SO_4^{2-}>Cl^-> NO_3^-> PO_4^{2-} and Mg^{2+}>Ca^{2+}> Na^+> K^+.Ionic plots indicating the predominance of alkaline earth over alkali and bicarbonate is due to the reaction of the feldspar minerals with carbonic acid in the presence of water. Water chemistry is guided by complex weathering process, ion exchange along with influence of geochemical condition.
Keywords: hydrochemistry, weathering, ion-exchange, water-quality

1. Introduction

Water quality analysis is one of the most important aspects in groundwater studies. The hydro chemical study reveals quality of water that is suitable for drinking, agricultural and industrial purposes. Further, it is possible to understand the change in (Kelley et al., 1940, Wilcox et al., 1948) quality due to rock interaction or any type of anthropogenic influence. Groundwater often consists of seven major chemical elements- Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, Na^+, K^+ and SO_4^{2-}. The chemical parameters of groundwater play a significant role in classifying and assessing water quality. The chemical composition of groundwater is controlled by many factors, including the composition of the precipitation, geological structure, mineralogy of the watersheds, aquifers and geological process within the aquifers along with influence of external pollution agencies like effluent from agricultural return flow, industrial and domestic activities. An understanding the geological evolution of groundwater is important for a sustainable development of water resources in the present state of art. Demarcating the character of the groundwater in varied space was proved to be an important technique in solving different geochemical problems (Chebotarev1955., Hem 1959., Back and Hanshaw 1965., Srinivasamoorthy et al 2011).

Chemical Classification also throws light on the concentration of various predominant cations, anions and their interrelationship. A number of techniques and methods have been developed to interpret the chemical data. Presentation of chemical analysis in graphical form makes understanding of complex groundwater system simpler and quicker. Methods representing the chemistry of water like Collin's bar diagram (Hem 1985, Zaporozee 1972) radiating vectors of Maucha (Maucha 1950) and parallel and horizontal axes of stiff (Stiff 1940) have been used in many parts of the world to show the proportion of ionic concentration in individual samples.

The objective of the present work is to discuss the major ion chemistry of groundwater of Dantewada district. In this case the methods proposed by Piper, Box tables and statistical analysis along with stoichiometric ratio method used to study the critically the hydro chemical characteristic of groundwater of study area.

- The distribution of major, minor and trace elements in the crystalline bedrock groundwater's of study area.
- Extent in groundwater chemistry dependent on aquifer lithology.
- Possible factors of variations of Concentration of ions in water.

2. Study Area

Dantewada district is located in the Southern part of the Chhattisgarh state between longitude (East) 80° 10' to 82°10' Latitude (North) 17° 09' to 18° 04'.The total geological area covered by this district is 10827.71 sq.km. The major sources of employment are agriculture, animal husbandry and mining of iron ore which engage almost 85% of the workforce. Occurrence, movement and storage of groundwater are influenced by lithology, thickness and structure of rock formation. Weathered and fractured granities, grantitic gneiss, igneous rocks form the main aquifer in study area.(Figure 1)

3. Materials & Method

Groundwater samples were collected from 40 locations of Dantewada district during September 2012. The collected samples were filtered with Watmann filter paper 41 and immediately stored in polyethylene bottles and analyzed for major and minor cations & anions using standard procedures (APHA, 1995). Ion like bicarbonate, chloride, calcium and magnesium were analyzed using titration. Sulphates and Phosphate were determined by the using of spectrophotometer Nova 60. Sodium & Potassium were determined by using flame photometer Elico CL-361. The analytical precision for the measurements of ions was determined by calculating the ionic balance error that varies by about 5-10%.

4. Result & Discussion

Box plots were used to represent temporal concentration of the major ions (Figure 2). The upper and lower quartiles of the data define the top and the bottom of a rectangle box. The line inside the box represent the median value and the size of the box represent the spread of the central value (Taheri and Voudouris., 2008). The ions like Mg^{2+}, Ca^{2+}, HCO_3^- and SO_4^{2-} shows increasing trend due to the effective leaching from rock matrix along with anthropogenic activities (Srinivasmoorthy et al., 2011). HCO_3^- is mainly formed due to the action of atmospheric CO_2 and CO_2 released from organic decomposition (Bouwer, 1978). Concentration of SO_4^{2-} indicates lithogenic sources of sulphate noted in the study area. (Srinivasmoorthy et al., 2008). Nitrogen in groundwater derived from organic industrial effluents, fertilizers or nitrogen-fixing bacteria leaching of animal dung sewage and septic tanks through soil and water matrix to groundwater. In general, increase of nitrate in groundwater may be an indicator of bacterial pollution (Sundaray et al., 2009). The large variations in mean, median and standard deviation values of ions suggest that the water chemistry in the study region is heterogeneous and influenced by complex hydro chemical process and complex contaminants sources (Vasanthavigar et al., 2012)

Maximum and minimum concentration of major ions present in the groundwater from the study area is present in Table 1. The Piper –Hill diagram is used to infer hydro-geochemical facies. These plots include two triangles, one for plotting cations and anions fields are combined to show a single point in a diamond shaped field, from which inference is drawn on the basis of hydro-geochemical facies concept. These tri-linear diagrams were useful in bringing out chemical relationships among groundwater samples in more definite terms rather than with other possible plotting methods. Chemical data of representative samples from the study area presented by plotting them on a Piper-tri-linear diagram. (Figure 3)

This diagram reveals the analogies, dissimilarities and different types of water in the study area, which are identified and listed in Table 2. The concept of hydro chemical facies was developed in order to understand and identify the water composition in different classes.

Facies are recognizable parts of different characters belonging to any genetically related system. Hydrochemicalacies are distinct zones that possess action and anion concentration categories. The interpretation of distinct facies from the 0 to 10% and 90 to 100% domains on the diamond-shaped cation to anion graph is more helpful than using equal 25% increments. The percentage of samples failing under Ca-Mg-type was 100. HCO_3-type of water predominant with 70%. The reason is groundwater passing through igneous rocks dissolves only small quantities of matter because of the relatively insolubility of the rock composition. The variation of concentration of ions is due to the weathering and leaching of granites rocks and maximum contact time of aquifers.

4.1 Ionic Ratios

The (Ca+Mg) versus TZ^+ (Total Cations) plots (Figure 4A) shows that the contribution of alkalis (Na and K) as like that of alkaline earth (Ca+ Mg) due to leaching from silicates weathering from the aquifers of the study area. In the plot for (Ca+Mg) versus HCO_3^-(Figure 4C), indicating the predominance of alkaline earth over bicarbonate due to silicate weathering. Major representations in bicarbonate is also due to the reaction of the feldspar minerals with carbonic acid in the presence of water, releasing HCO_3^-(Elangoer al., 2003). The plot for (Na+K) versus TZ^+(Figure 4B)indicates weathering of both alkali and alkaline earth from Feldspars along with additional sources from alkali/ saline soil and residence time. The plot Ca+Mg versus SO_4+HCO_3(Figure 4D) , the pointer of ion exchange process shits the points to the right side of the plot due to excess SO_4+HCO_3. The reverse ion exchange is the process points shifts due to excess Ca+Mg and excess of bicarbonate. The overall plots confirm that Ca, Mg and Na concentration in the groundwater is derived from aquifers materials (Srinivasamoorthy et al., 2008)

5. Conclusion

The study shows that the quality of water varies from locations to locations. In the present situation, few water sources are not safe for use in respect to higher nitrate, magnesium and calcium content which may lead to poor drinking water quality. It is suggested the groundwater should be analyzed to check pot ability. So that it become suitable for domestic purpose. It can reveal from the present study that the contamination problem is not alarming at present but groundwater quality may deteriorate with time. Therefore periodical monitoring can help to avoid contamination of groundwater of the region.

References

APHA Standard Methods for Analysis of water and wastewater, (18th Ed.), American Public Health Association. Inc. Washington DC, 1995.

Cheboterev, G.(1955).Metamorphism of natural waters in the crust of weathering-I.Geochimica et Cosochima Acta,8 (1-2): 22-48.

Back, W., Hanshaw, B.(1965). Chemical Geohydrology Advances in Hydroscience (Back W. Hanshaw B eds) Academic Press, USA.

Srinivasamoorthy, K., Nanthakumar, C., Vasanthavigarm, C.(2011).Groundwater quality assessment from a hard rock terrain, Salem district of Tamilnadu. *Arabian Journal of Geosciences*, 4(1), 92-102.

Zaporozee, A.(1972). A Graphical symbolization of water quality data.Groundwater. 10,32-43.

Hem, J.D.(1989). Study and interpretation of the chemical characteristics of natural water. US *Geological survey water supply paper,* 2254 P.

Maucha, R. (1940). The graphic symbolization of the chemical composition of natural waters, Hiderol, Kozlony .29

Groundwater Brochure of Dantewada district, Chhattisgarh 2008-09

Taheri, T.A., Voudouris, K.S.(2008). Groundwater quality in the semi-arid region of the Chahardouly basin, West Iran.*Hydrological Processes*, 22, 3066-3078.

RaoTamma, G.,GurunadhaRao, V.V.S. (2007). Hydrochemistry and groundwater quality assessment of Ranipetinsdustrial area, Tamil Nadu, India.4, 45-54.

Srinivasamoorthy, K., Chidambaram, S., Prasanna, M,V.(2008).Identication of major sources controlling Grounwater Chemistry from a hard rock terrain- A case study rom Metturtaluk, Salem district, Tamilnadu, India. *Journal of Earth System Sciences*, 117, 49-58.

Sundaray, S. K., Nayak, B.B., Bhatta, D. (2009). Environmental studies on river water quality with reference to suitability for agricultural purposes: Mahanadi river estuarine system, India-a case study. *Environmental Monitoring and Assessment*, 155, 227-243

Piper, A.M.(1953). A graphic procedure for the geo-chemical interpretation of water analysis, USGS Groundwater Note No .12..

Hem, J.D.(1959).Study and interpretation of the chemical characteristic of natural water.Water supply paper 2254, USGS, USA.

Razack, M.,Dazy, J.(1990). Hydro chemical characterization of groundwater mixing in sedimentary and metamorphic reservoirs with combined use of Piper's Principal and factor analysis.*Journal of Hydrology*. 114, 371-393

Elango, L., Kannan, R., Senthil, K.M. (2003). Major ion chemistry and identification of hydrogeological processes of groundwater in part of Kancheepuram district, Tamil Nadu. *Indian Journal of Environmental Geosciences*, 10, 157-166.

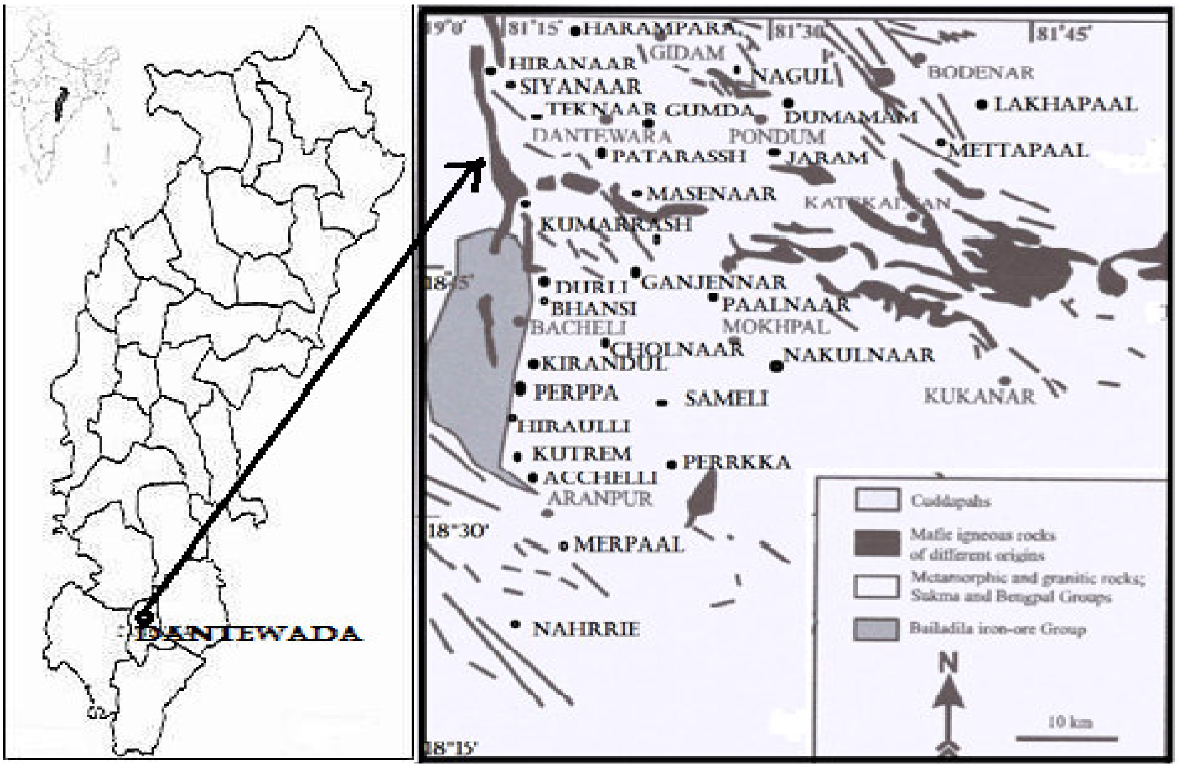


Figure1. Location, geology and sampling point of the study area.

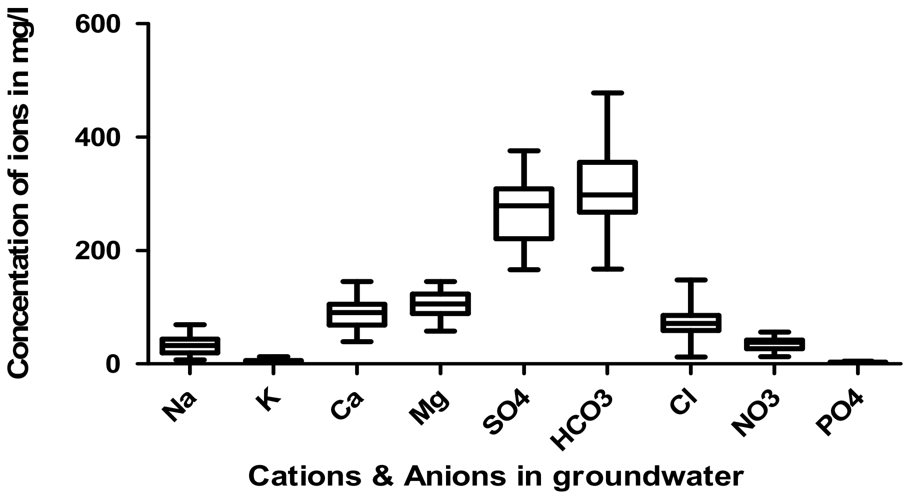


Figure 2. Box plots for the major ion constituents in groundwater.

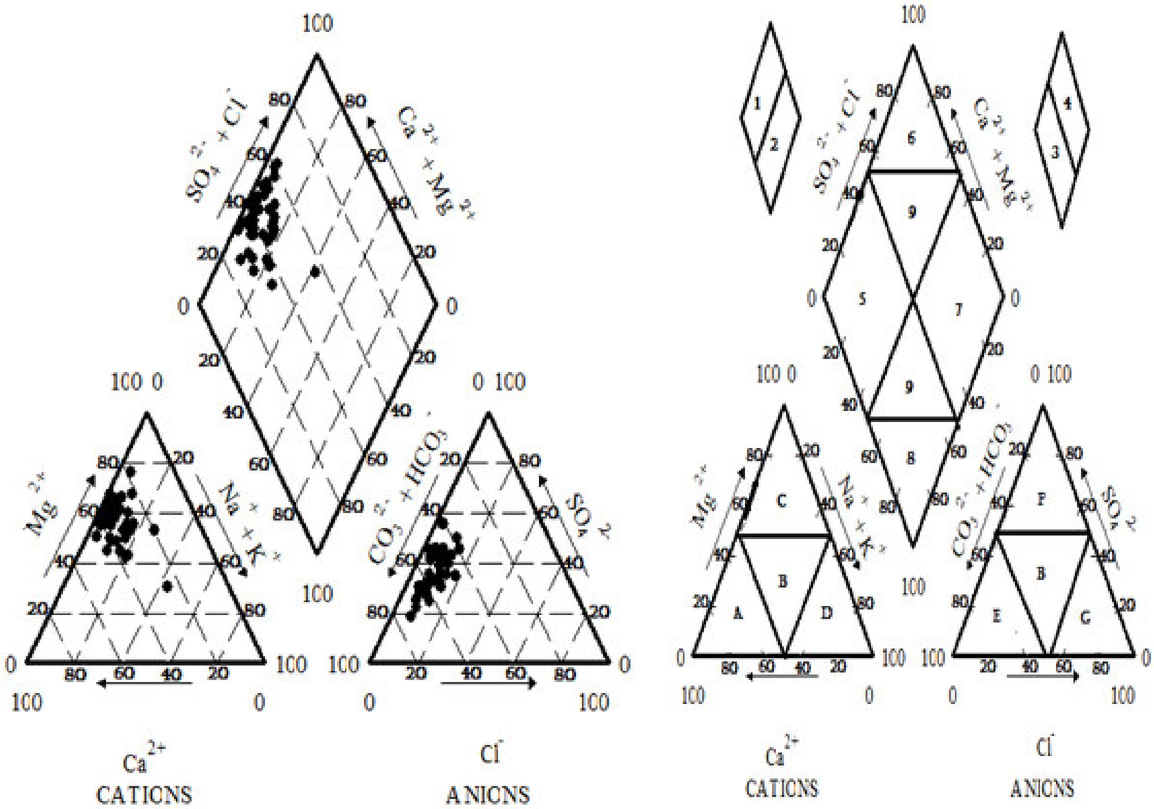
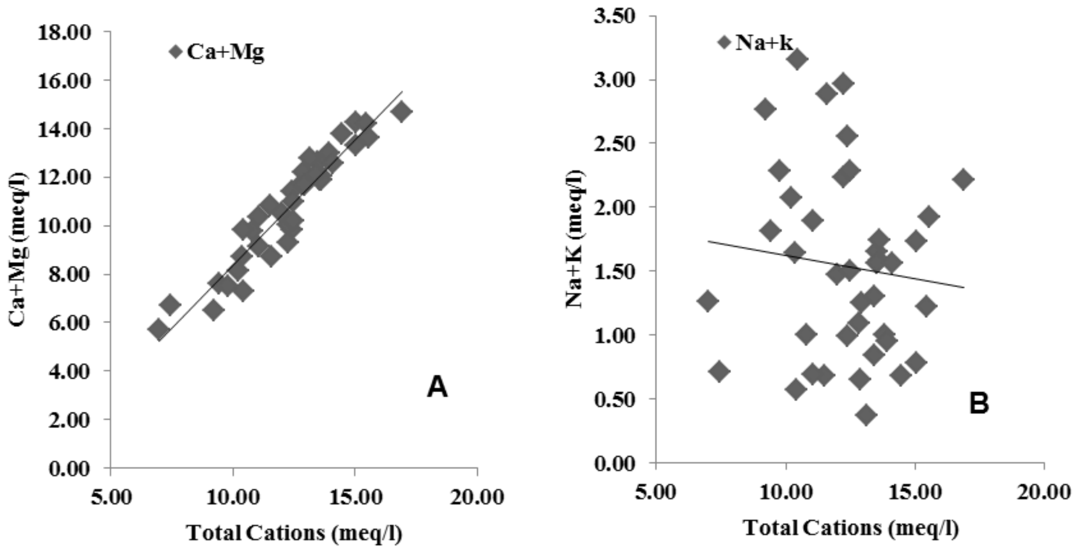


Figure 3.Geochemical classification of groundwater by Piper's diagram (1944).



.

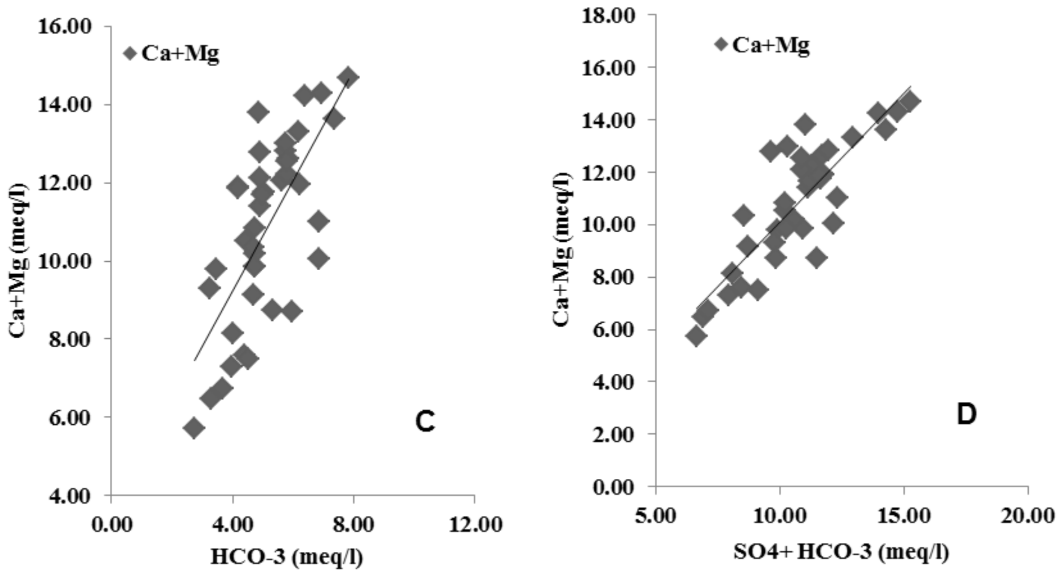


Figure 4. (A-D) Inter-relation of ions.

Table 1. Maximum and Minimum concentration of major ions in groundwater samples

S.No	Ions	Min	Max
1	Na^{+}	7.3	69.2
2	K^{+}	1.2	12.6
3	Ca^{2+}	39	145
4	Mg^{2+}	58	162
5	SO_4^{2-}	166	376
6	Cl^{-}	12.1	148.1
7	HCO_3^{-}	147	478
8	NO_3^{-}	12.5	56.4
9	PO_4^{3-}	0.4	4.5

Table 2. Characterization of groundwater of Dantewada district on the basis of Piper tri-linear diagram

Subdivisionof the diamond	Characteristic of corresponding subdivision of diamond-shaped fields	Percentage of samples in this category
1	Alkaline earth (Ca+Mg) exceed alklies (Na+K)	100
2	Alkalies exceeds alkaline earths	0
3	Weak acids (CO_3+HCO_3) exceeds Strong acids (SO^{-}_4+Cl^{-})	70
4	Strong acids exceeds weak acids	30
5	Magnesium bicarbonate type	50
6	Calcium-Chloride type	35
7	Sodium-Chloride type	0
8	Sodium-Bicarbonate type	0
9	Mixed type (No cation-anion exceed 50%)	15

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar