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Hydrological Analysis and Assessment about the impact of Limestone Mining on water Pollution in Hial Area , Bolangir district, Odisha, India

S.R. Barick[1], B.K. Ratha[2]

Associate Professor in Geology ,
PG Department of Geology ,Utkal University ,Bhubaneswar
Research Scholar
PG Department of Geology ,Utkal University ,Bhubaneswar

Abstract
80 percent area of Odisha are underlain by hard rock .Therefore Ground water resource is very scarce inmost part of the state. Bolangir district is known as drought prone area .Our study area comes under drought prone zone. Most people depend on ground water for agricultural and drinking purpose. Water is a scarcere source there. A number of Lime Stone mines are being operated in the study area adds to further scarcity as contamination may render a part of available resource as unsuitable for use . Lithology controls the water chemistry of the area . There is a direct relationship between the rock type and water composition of the area. Rock type is the main factor which is responsible for controlling water quality mechanism of the study area. While Lime Stone affects the water pollution , simultaneously host rock in the area and variation of the rock type is also notable factor in its hydrology. Therefore it is essential to make a detailed hydrological study of the area under observation in order to assess the impact of Lime Stone Mining on water pollution .For quality evaluation during pre monsoon period and post monsoon period from 2010 to 2015 water samples were collected from the study area and were analysed in Laboratory .

Key words: Hydrology, Water Pollution, Limestone, GeoChemistry ,Odisha

1.Introduction :

Hydrological analysis of the area is essential to determine the controlling mechanism of water quality .A well covered survey of limestone mines being operated and closed down in the area shows the path for correlating results.Assessment about the impact of Lime Stone Mining on water Pollution in the Hial area which comes under Bolangir district of Odisha state. A complete study of hydrology is essential in the drought prone area to know better about the scarce resources .

2. Location and Hydrogeological Setting

The study area belong to Bolangir district of Odisha which comes in the Toposheet No. 64L/15 .It extends between 82° 47’ 30” to 82° 56’ longitude and 20° 24’ to 20° 30” latitude . Geological set up, rainfall distribution and degree of primary and secondary porosity in the geological formations controls the hydrogeological framework of the area .Granite gneisses, khondalites calc-sillicate rocks, anorthosites and quartzites are main rock types in the area . Calc-sillicate rocks occur associated with khondalites and form low hills in the area. The water bearing properties of the formations also vary to a great extent because the major part of the area is underlain by hard rock of diverse lithological composition and structure .

3. Materials And Methods

A detailed hydrological study was conducted from 2010 to 2016 by collecting water samples twice each year in pre monsoon season and post monsoon season. The samples were analysed to obtain physical parameters (pH,TDS) and chemical parameters (such as major cations and major anions). The values were entered in appropriate format in a register yearwise in order to confirm similarity of observation for every

place of sample collection over the years. The values were used to

i-Draw Gibb's Diagram to determine the mechanism controlling the water Quality

ii-Determine enrichment process of Calcium ,Magnesium , Carbonate ,BiCarbonate and Fluoride .

iii-To classify the water based on total hardness and Residual Sodium Carbonate (RSC) . Here Total hardness of the water was determined by complexometric titration with EDTA.

iv- To draw equiline diagram for silicate weathering vs carbonate weathering to analyse weathering Process

v- Hydrochemistry of Ground water was determined by calculating the ratio of $HCO3^-/Na^+$

The results were used for scientific interpretation .

4.Survey of Limestone mining of study area:

Twenty three discontinuous crystalline limestone bodies are found in Dhamandanga, Malpamunda, Karlabahali and Hial area of the study area . These limestone bodies are associated with Khondalites and calcgranulites. The lime stone of Karlabahali and Hial area contain 48-53.5% CaO, 0.1-1.2% MgO and silica 1.8-13%.

5. Result and Discussion

A. Determination of Quality Controlling Mechanism for Water Resources by Gibb's Diagram

Prior to observation of the mechanism controlling the water quality in the region the most notable factor came to our notice that the dominant majority share of water resources in this area is claimed by groundwater. To determine the controlling mechanism trend among evapouration crystallisation dominance, rock dominance and precipitation dominance the help of Gibb's diagram was taken. Gibb's diagram was plotted taking TDS value in vertical axis and cation values(of sodium,calcium etc) in horizontal axis.

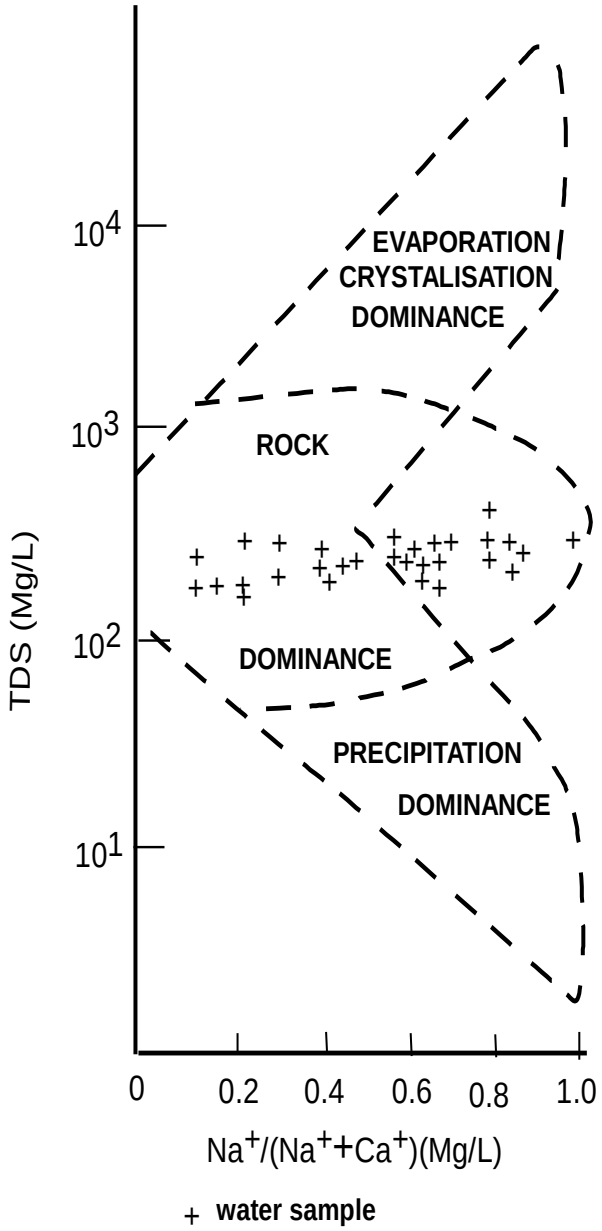

Fig. 1: Gibbs diagram for Cations of groundwater samples collected during Post Monsoon period

Gibbs diagram suggests that chemical interaction between rock forming minerals of aquifer and the groundwater is the main mechanism in contributing ions to the ground water. Hence, Fluoride may have been leached out from rocks contaminating ground water. Calc-sillicate rocks associated with khondalites may have contributed the calcium and magnesium ions in abundance to the groundwater

B. Determination of value of major Cations

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i.Calcium (Ca^{2+}):

Silicate group members like plagioclase, pyroxene and amphibole in igneous rocks and limestone, dolomite and gypsum in sedimentary rocks are the main sources of calcium in groundwater here. Calcium is released into groundwater by weathering of silicate minerals in presence of carbon dioxide. Major contributor of calcium in ground water of the study area seems to be weathering of minerals in limestone and calcgranulite. Calcium has also got a high affinity to be absorbed in soil particles. On the solubility of calcium carbonate, calcium sulphate and rarely calcium chloride in groundwater the range of calcium content is largely dependent.

In the collected samples from the study area, the calcium content varies from 8 to 174.4 mg/l in pre monsoon and 7.2 to 172 mg/l in post monsoon water samples.

As per BIS-1991 guide line the highest desirable limit of calcium is 75 mg/l. Calcium content of 20% of samples in pre monsoon and 10% of sample in post monsoon exceed the desirable limit.

ii.Magnesium (Mg^{2+}):

Magnesium occurs along with calcium in groundwater in lower concentration. The source of magnesium in groundwater is dolomite in sedimentary rocks, olivine, hornblende, biotite and augite in igneous rocks and serpentine, talc, diopside and tremolite in metamorphic rocks. The presence of carbon dioxide controls the decomposition of ferromagnesian minerals it may contribute magnesium to the groundwater .

According to BIS-1991 guide lines the highest desirable limit for magnesium is 30 mg/ l.

In the water samples of the study area the magnesium value varies from 2.928 to 78.0 mg/l in pre monsoon 2.44 to 75.2 mg/l in post monsoon

TABLE No.1

Classification of Water Based on Total Hardness

CLASSIFICATION OF WATER BASED ON TOTAL HARDNESS			
Category	**Range of hardness**	**No. of samples Pre monsoon**	**No. of samples Post monsoon**
Soft	0 - 75	0	1
Moderately hard	75 - 150	2	4
Hard	150 - 300	19	20
Very hard	> 300	9	5

C. Weathering Process analysis by equiline diagram:

To assess the weathering process that occurs in ground water the ratio of $HCO3^-/Na^+$ can was used. Carbonate weathering occurs when the ratio is greater than 1, and occurrence of silicate weathering was indicated while a ratio less than 1. Carbonate weathering predominates in post monsoon although results indicated prevalence of both types of weathering in groundwater . The plot of (Ca+Mg) vs (HCO_3+SO_4) was drawn. The diagram showed that most of the samples are above the equiline. The Placement of most of the samples above equiline indicated that carbonate weathering is a dominant process controlling ground water chemistry of the area .

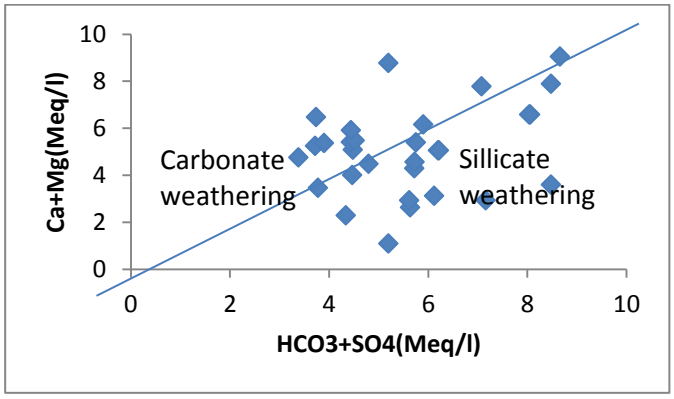

Fig.2 : Equiline diagram for carbonate weathering vs.sillicate weathering for

groundwater samples of the study area collected during Post Monsoon period

D. Assessment of Carbonate (CO_3^{2-}) and Bicarbonate (HCO_3^{2-}):

At the time of weathering of parent minerals, the bicarbonates are derived, mainly, from soil zone CO_2 . The soil zone CO_2 in the subsurface environment produced due to decay of organic matter combines with rain water to form bicarbonate. From the dissolution of carbonate and/or silicate minerals by the carbonic acid also Bicarbonate may be derived. The reactions involved in limestone area are as follows:

$CO_2+H_2O=H_2CO_3$

$H_2CO_3=H^++HCO_3^-$

$CaCO_3+H_2CO_3=Ca^{+2}+2HCO_3^-$

(Limestone)

$CaMg(CO_3)_2+2H_2CO_3=Ca^{+2}+Mg^{+2}+4HCO_3^-$

(Dolomite)

The bicarbonate concentration in groundwater ranges mainly from 100 to 800 ppm under normal conditions . When carbon dioxide is produced within the aquifer due to the organic decomposition or other chemical reactions, the bicarbonate concentration is more than 300 ppm . The collected water samples from the study area were analysed where carbonate varies from 0 to 33.6 mg/l in both pre monsoon and post monsoon. The bicarbonate varies from 190.32to 512.4mg/l in water samples .

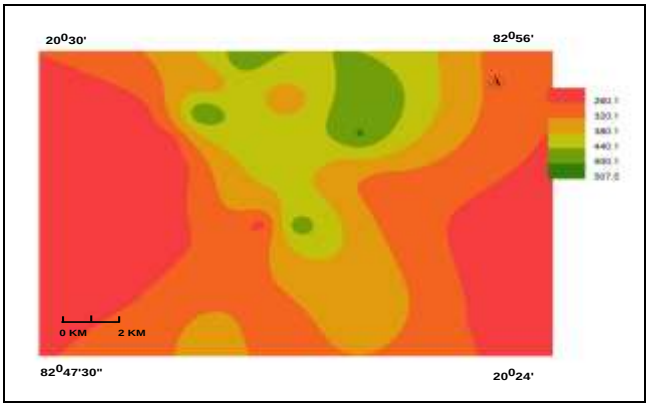

Fig.3 : Spatial distribution of Bicarbonate in groundwater samples collected during post monsoon period

E. Classification of groundwater based on Residual Sodium Carbonate (RSC):

The relative abundance of sodium with respect to excess of carbonate and bicarbonate was calculated by Residual Sodium Carbonate method by applying the following formula;

$$\mathbf{RSC = (CO_3 + HCO_3) - (Ca + Mg)}$$

Here all the values are in meq/l.

Table No.2: Pre monsoon RSC:

CLASSIFICATION 0F GROUNDWATER BASED ON RSC			
RSC	**Category**	**No. of Samples**	**% of Samples**
< 1.25	Good/Safe	24	80
1.25 - 2.5	Medium/Marginal	3	10
> 2.5	Bad/Unsuitable	3	10

All the RSC values of the water samples of the study area are less than 1 .

F. Determination of hydrochemistry of Ground water by the ratio of $HCO3^-/Na^+$

The cations and anions in groundwater must have been enriched by weathering of limestones . The ratio of $HCO3^-/Na^+$ was also used to assess the weathering process that occurs in ground water.The following inference was arrived at as described from 1 to 4.

1.The ratio less than 1indicate that ground water is more enriched in Mg^{2+}

2. The ratio higher than 1 indicate the increasing of Ca^{2+} in relation with Mg^{2+} in ground water.

3. When the ratio is greater than 1, carbonate weathering occurs

4. When a ratio less than 1 indicates silicate weathering

Table 3:Ca/Mg and HCO_3/Na

	Pre monsoon		Post monsoon	
SampleNo.	Ca/Mg	HCO3/Na	Ca/Mg	HCO3/Na
1	1.99	1.38	0.66	1.65
2	1.55	1.66	1.84	1.51
3	0.12	2.97	0.35	3.28
4	0.20	2.77	0.20	3.25
5	0.70	1.63	0.29	1.16
6	1.07	2.71	0.52	3.24
7	0.09	0.52	0.20	0.99
8	0.24	0.46	0.10	0.86
9	0.97	4.02	0.95	4.44
10	1.27	1.07	1.00	1.19
11	0.29	5.83	0.27	6.26
12	0.79	10.17	0.75	11.89
13	0.26	3.91	0.42	2.98
14	0.20	2.77	0.65	1.50
15	0.65	1.48	0.36	1.49
16	0.67	1.31	0.20	2.73
17	0.08	1.70	0.23	1.79
18	0.37	0.73	2.67	0.75
19	1.23	2.33	1.11	2.29
20	15.89	3.06	2.03	3.32
21	1.57	6.56	1.69	8.20
22	0.80	0.36	0.78	1.10
23	0.65	1.46	0.78	1.65
24	1.32	1.56	1.36	1.75
25	1.90	1.27	1.38	1.27
26	0.67	1.31	0.65	1.46
27	2.75	9.00	2.44	10.27
28	27.19	4.66	42.90	5.00
29	1.00	2.95	0.86	3.25
30	4.69	5.90	3.99	6.00

All cation and anion values are in Meq/l

6. Conclusion :

Area has been underlain by weathered and fractured granite gneisses and khondalites .Calc-sillicate rocks associated with khondalites have contributed to the abundance of calcium and magnesium ions in the groundwater .. Carbonate weathering is higher than Silicate weathering. From the dissolution of carbonate and silicate minerals by the carbonic acid Bicarbonate have been derived . The cations and anions in groundwater have been enriched by weathering of limestones .The ground water chemistry has been completely influenced by weathering of limestones .

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