PHYSICOCHEMICAL CHARACTERIZATION OF GROUNDWATER AROUND KATANG PANCHAYAT, SUNDARGARH DISTRICT, ODISHA, INDIA

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Abstract: The physicochemical properties of groundwater from various locations in Katang Panchayat of Kutra Block of Sundargarh District, Odisha, were analysed by using standard methods. The samples were collected from twenty two different locations revealed that the study area has a mean of, TH value 322.9 mg/l, pH of 7.1, TDS of 485 mg/l, TA of 265.9 mg/l, Electrical Conductivity of 757.9 µmho/cm, K^+ of 8.8 mg/l, Ca^{2+} of 110 mg/l, Mg^{2+} of 4.6 mg/l, Cl^- of 106.4 mg/l and HCO_3^- of 397 mg/l. The result shows that the TDS value of 31.81% groundwater samples are beyond the acceptable limit. The 45.45% samples show the hardness value beyond the desirable limit. The Ca^{2+} value of 63.63% of water samples is more than the highest desirable limit. The Gibb's diagram depicts that the chemistry of the water is governed by the rock of that particular area. The predominant facies of that area is $Ca-HCO_3^-$ type. Piper's plot shows that most of the water samples were of magnesium bicarbonate and calcium chloride type.

***IndexTerms*–Katang Panchayat, Gibb's diagram, Piper's Trilinear diagram, Groundwater Quality**

I. INTRODUCTION

Water is one of the most indispensable resources on earth. Life is not possible on this planet without water. About 97.2% of the water on earth is salty and only 2.8% is present as fresh water from which about 20% constitutes groundwater. Groundwater is the key source of water for industrial, agricultural and domestic uses and its contamination has been recognized as one of the most serious problems (Belkhiri et al., 2010, Bakhara et al., 2019). Because of rapid growth in population, urbanization, industrial and agricultural activities, water needs have been increased to a considerable extent which also led to the deterioration of the surface and sub-surface water (Mahanta, 2017). Unscientific development of groundwater and less than average rainfall over the years leading to relatively less recharge has resulted in the decline of groundwater levels. Anthropogenic as well as geogenic causes have also led to the deterioration of water quality causing different diseases (Mahanta and Sahoo, 2016). Water, a natural resource which has been used for different purposes, namely for drinking, domestic, irrigation and industrial, mainly depends on its intrinsic quality hence it is of prime importance to have prior information on quality and quality of water resources available in the region while planning developmental projects. The variations in monsoon rainfall and geomorphic setup of the area have affected the groundwater level of the area, which has put people in crisis in and around Katang Panchayat.

II. STUDY AREA

The area study i.e.Katang Panchayat is situated in Kutra block of Sundargarh District of Odisha. It is 59 km away from the District Head Quarter Sundargarh and 9k.m from Kutra Block The total geographical area is about 12.85 sq. km and surrounded by numbers of villages like Lanjiberna, Kandeimunda, Litibeda, Telighana, Jharbeda, Naktisan, Tunmura, Sialjora, Gariamunda, Bailama etc. The area of study lies between latitude 22° 14′ 0″N and 84° 24′ 0″E and fall in the survey of India toposheet number 73B/7, 73B/8, 73B/11, 73B/12.The area experiences a seasonal monsoon climate with an annual average rainfall of about 1308.5. Physiographically the area is characterized by plain lands with few hills.

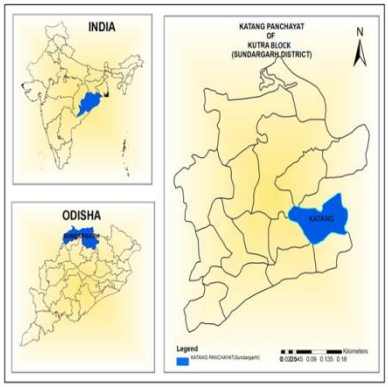

Fig. 1 Index map of the study area

III. GEOLOGY AND HYDROGEOLOGY

The slope of the study area is mainly characterized by topsoil, dolomite, dolomitic limestone and limestone, which are well jointed. Geologically, Langiberna limestone area belongs to Biramitrapur Stage of the Gangpur Series of Indian. In Lanjiberna, there are almost two parallel, bands of limestone running E-W by a band of dolomitic limestone of about 200 to 300m width. The important rock types of Gangpur Series are represented by mica-schists, quartzite, phyllites, calcitic and dolomitic marbles and limestone, carbon phyllites. The general strike of the rocks in the area varies from E-W in the eastern and central part to NE-SW between Lanjiberna and the Ib River at the western part. The limestone is the most predominant rock of this area. Water occurs in limestone in fractures or in solution openings that have been dissolved out of the rock by water containing dissolved carbon dioxide. The occurrence of fractures and solution openings is very irregular, making it difficult to predict where water will be found in limestone.

IV. METHODOLOGY

Groundwater samples of the study area were collected from 22 locations in the pre-monsoon period in 2017 and the hydrogeochemical parameters were evaluated. It includes the study of parameters like pH, electrical conductance and total dissolved solids, which were measured immediately after the sampling. Other chemical parameters like alkalinity as $CaCO_3$ (TA), total hardness(TH), sodium(Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}) and nitrate (NO_3^-) were analyzed in the laboratory as per standard analytical procedures (APHA, 1985; Brown et al. 1974; Trivedi and Goel 1984; Vogel, 1964; Das et al. 2014).

V. RESULT AND DISCUSSIONS

The quality determines the suitability of water for drinking, domestic, irrigation and industrial purposes. The chemistry of the groundwater is largely dependent on the composition of the minerals and rocks through which it flows and is stored (Mahanta et al., 2018). The physicochemical analysis of pre-monsoon groundwater samples of Katang Panchayat was carried out. The minimum, maximum and average values of different parameters were given in Table 1 and the comparison with that of BIS (2012) standards are given in Table 2.

The increase in the temperature of water leads to speeding up of the chemical reactions in water, which reduces the solubility of gases and amplifies the taste and odour (Trivedi and Goel, 1984). The maximum temperature is 36.1°C and minimum is 34.9°C with an average is 35.5^0C. The pH value of the groundwater of the study area varies from 6.06 to 8.65 with a mean of 7.72. Water having a pH value of 7.0 to 7.3 is normally regarding as neutral. It implies that the groundwater of the study area is neutral to slightly alkaline in nature. The TDS value of the study area varies from 85.12 to 1049.6 mg/l with an average of 485mg/l. Only 31.81% of the samples were beyond the desirable limit. The Electrical Conductivity (EC) mainly depends upon the concentration of the ions. The EC value of the water sample is varied between 133 and 1640µmho/cm. with an average of 757.9 µmho/cm. The Total Alkalinity (TA) is the total concentration of bases which is affected by environmental factors like rain; acidic sanitizers, the addition of fill water etc. The total alkalinity of the water samples varied from 30 mg/l to 410 mg/l with an average of 265.9 mg/l. With respect to BIS (2012), only 6.36% of samples were beyond the maximum desirable limit for drinking purposes. The total hardness of the water sample varies from 80 to 580 mg/l with an average of 287.9 mg/l. With respect to BIS (2012), 45.45% of samples were beyond the maximum desirable limit.

Among the cations, calcium is the most abundant alkaline earth metals and is a major constituent of many common rock minerals. The calcium values of the water samples ranged from 7.5 to 270 mg/l with a mean of 110 mg/l. The minimum value of calcium in the study area is 7.5 mg/l and the maximum is 270mg/l with an average value of 110mg/l. The magnesium concentration in the water sample ranges between 0 and 35.97 mg/l with a mean of 4.6 mg/l. With respect to magnesium, only 9.09% of samples were beyond the desirable limit for drinking purposes. The sodium concentration in the water sample varies from 1.52 to 62 mg/l with an average of 14.8mg/l. whereas potassium value ranges from 1.24 to34.94 mg/l with a mean of 8.8 mg/l.

Among the anions, the bicarbonate values ranged from 30.5 to 475.8mg/l. The chloride values range from 40 to 290 mg /l with an average is 106.4mg/l. Only 4.54% of samples of chloride are beyond the desirable limit with respect to BIS (2012). The sulphate ranges from 0.31 to 94.39mg/l with an average of 15.26 mg/l. The fluoride values are in between 0.059 to 0.833mg/l, which is absolutely safe for drinking purpose.

Table 1 Average groundwater quality of Katang area

Parameters	Min	Max	Mean
Temperature (°C)	34.9	36.1	35.5
pH	6.06	7.72	7.1
Electrical Conductance	133	1640	757.9
Total Dissolved Solids	85.12	1049.6	485
Total Alkalinity	30	410	265.9
Total Hardness	80	580	287.9
Calcium	7.5	270	110
Magnesium	0	35.97	4.6
Sodium	1.52	62	14.8
Potassium	1.24	34.94	8.8
Chloride	40	290	106.4
Carbonate	0	0	0
Bicarbonate	30.5	475.8	397

All values are expressed in mg/l except temperature, pH and EC. The temperature and EC are expressed in ^{0}C and µmho/cm respectively.

VI. MECHANISM CONTROLLING THE GROUND WATER CHEMISTRY:

Gibbs (1970) proposed a concept to understand the effect on controlling factors like precipitation, rock dominance and evaporation crystallization over groundwater chemistry.

In Gibb's diagram, the TDS values are plotted against Na/ (Na+Ca) values and Cl/(Cl+HCO_3) values in two different diagrams respectively (Fig.2a and 2b). After plotting the TDS values against Na/ (Na+Ca) values, it was found that all the samples fall within the region of "Rock-dominance" field. Similarly, when the TDS values are plotted against Cl/(Cl+HCO_3) values, it was found that except one, rest of the samples fell within the region of "Rock-dominance" field.

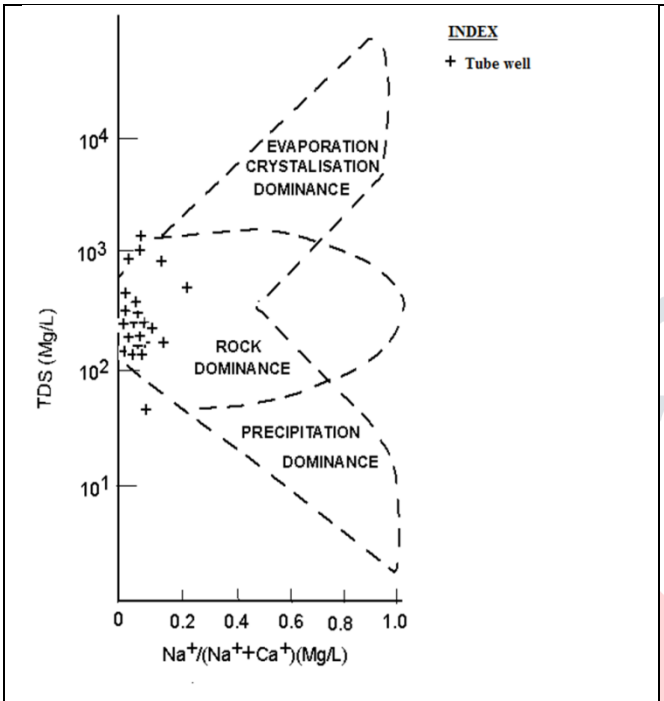

Fig.2.a Gibb's Diagram for Cations

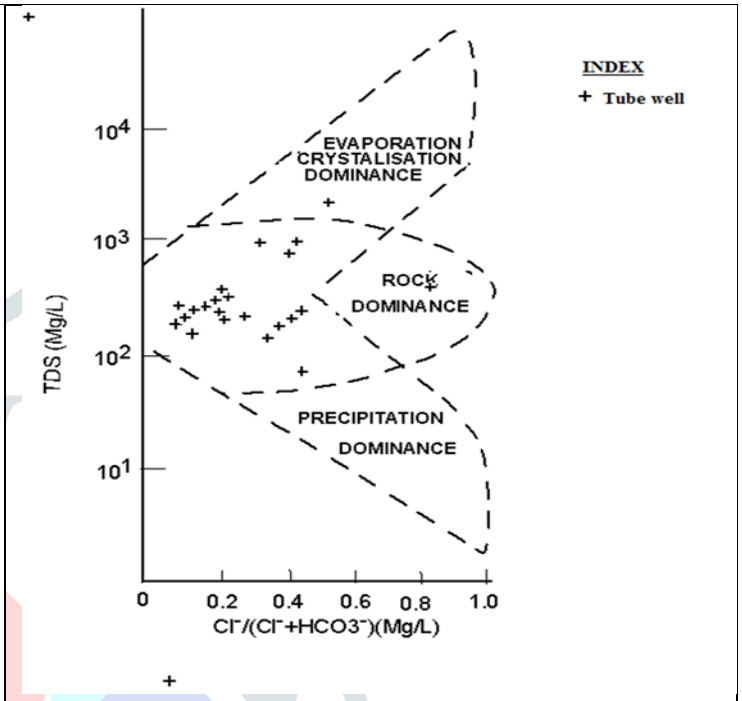

Fig.2.b Gibb's Diagram for Anions

VII. PIPER'S TRILINEAR CLASSIFICATION:

The Pipers trilinear classification system (1953) is used to find out the nature of groundwater of the study area based on meq/l values of a group of major ions. This is one of the most useful graphs for representing and comparing water quality analysis in the form of a Trilinear diagram (Todd, 1995). From the Pipers Trilinear diagram (Fig. 3), it is found that the most of the plots lie in the field 5 and 6 indicating that water of the area is magnesium bicarbonate and calcium chloride type.

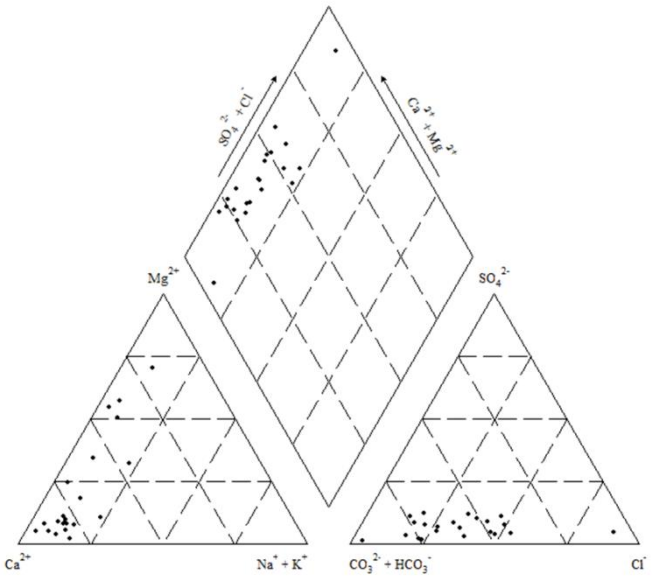

Fig. 3 Piper's Trilinear Diagram

VIII. HYDROCHEMICAL FACIES:

To explain the genesis of the principal type of groundwater the concept of hydrochemical facies has been proposed by Back (1960). The hydrochemical facies are determined by arranging the ionic percentage in decreasing order of abundance. This is very much helpful in distinguishing the chemical composition of water. It was found that Ca^{2+} is dominant among cations and HCO_3^- is among the anions in the collected water samples of the study area. The abundant cation next to Ca^{2+} is Na^+ and the dominant hydrochemical facies for cation is $Ca^{2+}>Na^+>K^+>Mg^{2+}$. Hence, the dominant hydrochemical facies for anion is $HCO_3^->Cl^->SO_4^{2-}>CO_3^{2-}$.

IX. QUALITY CRITERIA FOR FOR DRINKING PURPOSE

The term quality indicates the importance of groundwater whether it is useful or not. So, the study of groundwater quality is a major concern for human developmental activities like drinking, industries and irrigation. According to WHO (1971), above 80% of the diseases prevalent in the world are due to the poor quality of drinking water. To appraise the groundwater for drinking purpose in this area, Indian drinking water quality standard has been adopted. The term desirable limit in the standards applied to the water, which would be generally acceptable to the consumer. After comparing with Indian drinking water quality standard (BIS, 2012), it is found that most of the water of the study area is suitable for drinking purpose.

Table 2. Comparison of Water Quality of the Study Area with BIS (2012)

Parameter	Highest desirable limit (mg/l)	Maximum permissible limit (mg/l)	Undesirable effect outside the desirable limit	No of samples beyond the highest desirable limit	Percent of samples beyond the highest desirable limit
pH	6.5-8.5	9.2	Effect mucous membrane	Nil	Nil
TDS	500	800	Gastrointestinal disorder	7	31.81
Hardness	300	600	Encrustation, affect domestic use	10	45.45
Calcium	75	200	-do-	14	63.63
Magnesium	30	100	-do-	2	9.09
Chloride	250	1000	Taste, Corrosion, Palatability decrease	1	4.54
Sulphate	150	400	Gastro-intestinal irritation	*	*
Fluoride	0.6	1.2	Fluorosis	*	*

X. CONCLUSION

The overall study aims to determine the physicochemical characteristics of groundwater of the Katang Grampanchayat of Sundargarh District, Odisha. The analysed parameters were compared with the standards proposed by BIS(2012). The result shows that the TDS value of 31.81% groundwater samples are beyond the acceptable limit. 45.45% of water samples show the hardness value beyond the desirable limit. The Ca^{2+} value of 63.63% of water samples is more than the highest desirable limit. The Gibb's diagram depicts that chemistry of the water is governed by the rock of that particular area. The hydrochemical facies analysis shows that Ca^{2+} is dominant among cations and HCO_3^- among anions in the collected groundwater samples The Piper's plot shows that most of the water samples were of magnesium bicarbonate and calcium chloride type. So the groundwater of the area is suitable for drinking purpose in most locations besides few ones due to high TDS and hardness and calcium values.

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