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Hydrological Studies of Groundwater Pollution Status Around Limestone Mining of Hial Area, Bolangir District, Odisha, India

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Abstract: Water is the most essential resource for mankind. As most surface water bodies are polluted by anthropogenic activities groundwater remains a safe option for various uses for people. Ground water is a scarce resource in most part of Odisha as 80 percent of its area consists of hard rocks. As the study area is drought prone most people depend on groundwater for drinking and agriculture. Hence, constant monitoring and assessment of water resource of this area is necessary. With this purpose the present study area Hial, a part of Bolangir district of Odisha, India is chosen. They were analyzed for physical parameters such as pH, EC, TDS and chemical parameters such as Ca, Mg, Na, K, Cl, HCO_3, CO_3, SO_4. Suitability of groundwater for drinking and irrigation was evaluated following various classification schemes and water quality standards. Most ground water samples are of Mg-HCO^3 and Ca-HCO^3 type. From Richard's salinity diagram it is observed that most of the samples are plotted in C3-S1 field indicating low Sodium Adsorption Ratio and high salinity hazard. Fluoride contamination is found in most of the water samples.

Keywords:- Groundwater, Post monsoon, Contamination , Bolangir , Odisha, India.

I. INTRODUCTION

Water is most precious natural resource. Most part of this resource is saline in nature and is confined to the ocean, leaving only 2.8% as fresh water. Out of this about 2.2% is available as surface water and 0.6% as ground water. Ground water is one of the earth's most widely distributed resources and is increasingly catering to the need of the domestic, industrial and agricultural sectors. Ground water is located in the pore space of soil and rock. The value of ground water as a resource lies in the fact that it is dependable even during the period of scarcity and drought, widely distributed and can be put into use with ease and speed. Surface water and groundwater are closely interconnected. The occurrence and availability of groundwater is governed by the interactions of numerous environmental factors especially climate, topography, vegetation, soil and geology of an area. However, considering its use for drinking and agriculture its quality assessment is essential. With this purpose the present study was carried out in Hial area of Bolangir district of Odisha.

II. LOCATION AND HYDROGEOLOGICAL SETTING

The study area belongs from 82^0 47' 30" to 82^0 56' longitude and 20^0 24' to 20^0 30" latitude and belong to Bolangir district of Odisha. The area consists of khondalites, granite gneisses, calc-sillicate rocks, anorthosites and quartzites. They all belong to Eastern Ghat Super Group. Water occurs 5 to 10 meters below the ground level in most part of the area. Most people of the area depend on agriculture for their livelihood. As surface water source is limited people use ground water both for drinking and agriculture .

III. MATERIALS AND METHODS

A. Sample Collection

Thirty water samples were collected from tube wells of the area during post monsoon period of 2010 (Fig.1).Air tight rectified polythene bottles were used to collect the samples. Sample bottles were thoroughly washed with ground water collected at the spot. Bottles were completely filled with water without air gaps and were sealed.

B. Measurement of Physical Parameters

The pH and electrical conductance were measured on the spot by using pH meter and conductivity meter respectively.

C. Measurement of Chemical Parameters

Ca and Mg were determined by titration method using standard EDTA . Chloride was determined by silver nitrate solution . Phenolphthalein Alkalinity and total Alkalinity is determined by titrating the samples against HCl solution using phenolphthalein indicator and methyl orange indicator

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Carbonate and bicarbonate in the samples were determined from alkalinity. Sulphate was determined gravimetrically by precipitating $BaSO_4$ from $BaCl_2$. Na and K were determined by flame photometer. Total hardness of the water was determined by complex metric titration with EDTA. EDTA acts as a completing reagent, which forms soluble complexes with metal ions like Ca^{++} and Mg^{++}.

D. Analysis by Selective Electrode Method

Fluoride is measured by ion selective electrode method.

IV. RESULT AND DISCUSSION

A. Water Quality Study

The water quality study reveals that pH of the water varies from 7.28-8.35, EC ranges from 441.6-898.5 µmho/cm, total dissolved solids(TDS) values range from 282.62 to 575.04 mg/l, total alkalinity(TA) values range from 161.5-403.7 mg/l, total hardness(TH) values range from 60.02 to 453.2 mg/l.

B. Analytical Study

Analytical study of water samples reveals that calcium varies from 7.2 to 172 mg/l, magnesium varies from 2.44 to 75.2 mg/l, sodium varies from 8.4 to 162 mg/l, potassium varies from 0.2 to 11.4 mg/l, chloride values range from 7.54 to 138.6 mg/l, carbonate values range from 0 to 33.6 mg/l, bicarbonate values range from 200.1 to 507.5 mg/l, sulphate values range from 0 to 70 mg/l, fluoride values range from 0.25 to 2.80 mg/l (Table-1).

C. Hydrochemistry of Groundwater

The hydrochemistry of groundwater is evaluated by plotting the captions and anions in percent of total Meq/l, in Piper's Trainer diagram (Piper, 1944, 1953), Facies mapping approach (Back, 1961).

It was found that Ca^{2+} and Mg^{2+} are dominant among captions and HCO_3^{-2} is dominant among anions in the collected water samples of the study area in both pre monsoon and post monsoon period.

The hydro chemical variation and distribution of fancies of groundwater throughout the study area are as follows:

4 samples are of calcium-magnesium fancies, 7 samples are of sodium-calcium facies, 19 samples(70%) are of calcium-sodium facies. As per anion facies, 4 samples are of bicarbonate facies, 10 samples are of chloride-sulphate-bicarbonate facies and 16samples(55%) are of bicarbonate-chloride-sulphate facies.

D. Ground Water Quality

Ground water quality is evaluated to know the suitability of groundwater for drinking ,agricultural uses.

E. Drinking Water Quality

The drinking water quality of the area can be evaluated by comparing with Indian Standard Specification for drinking water (BIS-1991).In pre monsoon, 63 percent of samples exceeds the Highest Desirable Limit(HDL) for TDS, 36 percent samples exceeds the HDL for total hardness, 83 percent samples exceeds the HDL for total alkalinity, 46 percent exceeds the HDL for fluoride. 50 percent samples are not suitable for drinking.(Table:1)

Quality parameter	BIS-1991		Number of samples exceeding HDL	% of samples Exceeding HDL
	Highest Desirable Limit (HDL)	Maximum Permissible Limit(MPL)		
pH	6.5-8.5	No relaxation	Nil	
TDS	500	2000	7	23
TH	300	600	8	25
TA	200	600	25	83
Ca^{+2}	75	200	2	7
Mg^{+2}	30	100	13	43
Cl^{-}	250	1000	Nil	Nil
$SO4^{-2}$	200	400	Nil	Nil
F^{-}	1	1.5	16	53

Table 1: Water Quality of Post Monsoon Samples.

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All values are in mg/l except pH

23 percent of samples exceed the Highest Desirable Limit (HDL) for TDS, 25 percent samples exceeds the HDL for total hardness, 83 percent samples exceeds the HDL for total alkalinity, 53 percent exceeds the HDL for fluoride. 50 percent samples are not suitable for drinking.(Table:3)

F. Agricultural Quality

The following are important characteristic properties of groundwater to determine its suitability for irrigation in the present study:

a). Based on Sodium Adsorption Ratio (SAR)

Sodium Adsorption Ratio is one of the criteria to study the suitability of water for irrigation. On the basis of SAR value, the suitability of groundwater for irrigation purposes is determined. The SAR values of the groundwater for the study area varies from 0.22 (Bichhabahali) to 8.99 (Mankarchuan).

b). Based on Salinity Diagram

The United States Salinity Laboratory (USSL) (Richards,1954;USSL,1954) has constructed a diagram for classification of irrigation water describing 16 classes with reference to SAR as an index for Sodium hazards(S) and EC as an index of salinity hazards (C).Sodium and salinity hazards are two important parameters, which can indicate the suitability of water for irrigation uses. USSL diagram for water samples of the area reveal that 3no. of samples fall in C3S2 field and 9no. of samples fall in C2-S1 field.18 samples fall in C3-S1 field. From Richard's salinity diagram it is observed that most of the samples are plotted in C3-S1 field indicating low Sodium Adsorption Ratio and high salinity hazard. Plotting of different water samples are given in Fig.1.

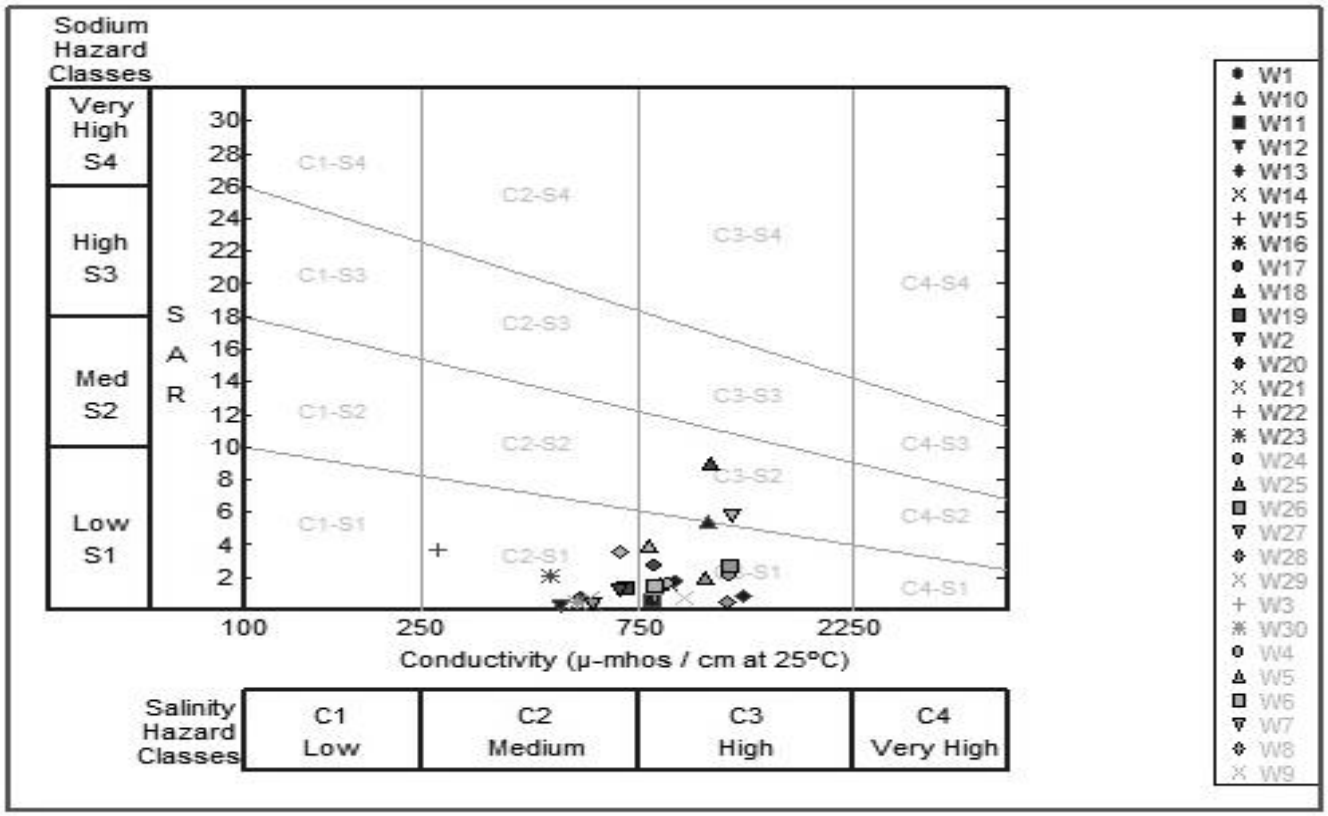

Fig:1- US Salinity Diagram of the Water Samples

C. Based on Sodium Percentages (% Na)

The different water classes for irrigation on the basis of % Na value are given in Table-2.

% Na	Water Class	No of Samples	% of Samples
Up to 20	Excellent	10	33
20 - 40	Good	10	33
40 - 60	Permissible	7	23
60 - 80	Doubtful	2	7
> 80	Unsuitable	1	3

Table- 2: Classification of water based on % Sodium

The % Na value of the water for the study area varies from 6.88 (Bichhabahali) to 86.45 (Mankarchuan). Out of the 30 samples, 10 samples are excellent to good class for irrigation and 10 samples are good class for irrigation. One sample of Mankarchuan is found as not suitable for irrigation. All samples are shown in Fig.4.

The PI values of the study area varies from 33.81 to 114.64. Two samples (PI > 80) fall in class III of Doneen's chart (Doneen,1962) indicating its unsuitability for irrigational

purpose for the soil. Five samples fall in Class-II field.23 samples fall in Class-I field.

D. Based on Potential Soil Salinity (Ps)

Potential Soil Salinity is calculated by using the following formula

$$PS = Cl + \sqrt{SO_4}$$

Here all the values are in meq/l.

The PS values of the study area varies from 0.20 to 4.36.Out of 30 samples all samples are excellent to good.(Table-3)

Class	Potential Soil Salinity in epm	No. of Samples
Excellent to Good	<5	30
Good to Injurious	5-10	0
Injurious to Unsatisfactory	>10	0
Total		30

Table-3: Classification Based on Potential Soil Salinity.

E. Based on Residual Sodium Carbonate (Rsc)

The RSC values vary from 0 to 4.34.

With respect to RSC values, the groundwater can be classified into following categories.(Table- 4)

RSC	Category	No. of Samples	% of Samples
< 1.25	Good/Safe	21	70
1.25 - 2.5	Medium/Marginal	4	17
> 2.5	Bad/Unsuitable	5	13

Table-4: Classification of Groundwater Based on RSC

RSC values of 70% of the water samples of the study area are less than 1.25.They are classified under good and safe category. Hence, they are good for irrigational purposes.

V. CONCLUSION

The water chemistry of the area is controlled by litho logy of the area. Suitability of most water samples for irrigation purposes is suggested by SAR, %Na, PI values. Low sodium and medium to high salinity hazard is observed in most of the water samples which are plotted in C2-S1 and C3-S1 field in Richard's salinity diagram it. Suitable de fluoridation technique may be applied before using the water for drinking because of the fact that fluoride content in more than fifty percent of the samples exceeds highest desirable limit for drinking water standard.

REFERENCES

[1]. Back, W.(1961) Techniques for mapping of hydro chemical facies. USGS Prof. Paper 424-D, pp 380-382.
[2]. Domenico, P.A. and Schwartz, F.W.(1990)Physical and chemical Hydrogeology. John Wiley and sons. New York. pp 410-420.
[3]. Doneen, L.D.(1962)The influence of crop and soil on percolating water.Proc.1961Biennial conference on Groundwater Recharge,pp.156-163.
[4]. BIS(1991) Indian standard drinking water specification, Bureau of Indian standard.
[5]. Kelly, W.P (1957): Adsorbed Sodium, cation exchange capacity and percentage sodium adsorption in alkali soils, sci.,vol.84, pp. 473-477.
[6]. Kelly, W.P (1963): Use of saline irrigation water, soil science, 95 (4), pp. 355-391.
[7]. Piper, A.M (1944**):** A graphic procedure in the geochemical interpretation of water analysis. Am. Geophysics. Union Trans, 25: pp. 914-923.
[8]. Piper, A.M. (1953). A graphic procedure in geochemical interpretation of water analysis, U.S. geol. Surv. Groundwater note 12, 63.
[9]. Richards, L.A (1954): Diagnosis and improvement of saline and alkali soils, U.S. Dept. Agri. Hand book, No.60, pp.160.
[10]. U.S salinity laboratory (1954): Diagnosis and Improvement of Saline and Alkali soils, U.S Dept. Agriculture Handbook, pp.60.
[11]. Sarkar, S.N. &Saha, A.K. (1977): The present status of the Precambrian stratigraphy, tectonics, and geochronology of Singhbhum – Keonjhar-Myurbhanj region, Eastern India, Ind. Jour. Earth Sc. S. Roy Vol. pp. 37-65.
[12]. Sarkar,S & Naik, K.C.(2011):Role of ground water in sustainability and development of a drought prone area-a case study from Bolangir district, DRS spl. Publ. in Geology,Utkal University,pp84-91.
[13]. Saha,A.K.(1994):Crustal evolution of Singhbhum-North-Odisha, Eastern India.Geol Soc.Ind Mem 27, pp 341.
[14]. Wilcox, L.V (1955): Classification and use of irrigation water, U.S. Dept. of Agriculture, Circular 969, Washington DC, USA, p.16.

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Table No: 1. Chemical Parameter Values of the Water Samples From the Study Area.(All Values Are In Mg/L Except Ph And EC)

Sl. No.	Place	pH	EC	TH	Ca	Mg	Na	K	Cl	So4	CO3	HCO3	F
1	Banjipali	7.92	672	200.5	32	29.28	58	1	114.18	15	9.6	254.2	1.35
2	Kuibahal	7.89	572.9	254.6	66	21.8	56	1	24.6	42	0	224.5	0.5
3	Mandla	8.32	521.8	177.3	19.6	31.16	24.4	1.8	83.59	15	14.4	212.3	0.5
4	Khatlumunda	8.32	810.4	329.3	21.6	66.86	55	6.4	69.41	15	4.8	473.4	2
5	Dhusamunda	8.34	641.3	160.9	16	29.36	105	1.8	19.7	40	28.8	324.5	2.1
6	Samarsingh	8.2	898.5	453.2	62.4	72.22	58	0.6	54.72	25	0	497.8	2.1
7	Malpamunda	8.35	785.4	144.7	9	29.68	162	8	53.88	10	0	424.6	2.6
8	Hial	8.34	745.9	212.9	7.2	47.33	140	4.8	42.6	25	9.6	318.4	2.8
9	Dabari	7.48	733	389.3	76	48.46	35.6	0.4	45.38	10	0	419.7	1.8
10	Punjiparha	7.85	869.1	180.3	36	21.96	148	2.5	73.74	40	0	468.5	0.5
11	Dumerchuan	7.65	705.9	393.6	33.6	75.2	30.5	1	8.508	8	0	507.5	2
12	Bichhabahali	8.32	488.5	270.6	46.4	37.58	8.4	0.8	24.52	8	9.6	261.1	0.25
13	Komeimunda	8.32	656.9	262.8	31.2	44.9	28.8	2.4	117.2	0	33.6	227	1.25
14	Patimal	8.06	829	252.8	40	37.13	86	6	119.1	30	0	341.6	1.25
15	Saleparha	8.1	720.4	323.6	34.6	57.59	56.1	1.1	112.8	5	0	222	1.25
16	Khagsa	8.32	837.4	329.3	21.6	66.86	65	5.4	79.41	15	4.8	472.4	0.5
17	Karlabahali	8.34	498.3	130.5	9.6	25.86	72.4	0.8	14.18	0	4.8	344	2.2
18	Mankarchuan	7.92	662.7	60.02	17.6	3.904	160	2.4	67.74	0	0	317.2	1.8
19	Birna	8.08	571.7	228.4	48	26.35	45	0.9	17.02	60	0	273.3	2
20	Dhamandanga	7.72	528.4	274.2	73.6	21.96	30	1.2	23.52	10	0	263.5	2.6
21	Jamutjhula	8	475.3	238.2	60	21.47	9.5	0.8	56.39	5	0	200.1	0.5
22	Chhatrang	8.34	466.8	112.3	19.2	15.64	87	0.8	12.18	10	9.6	252.8	0.25
23	Talchkel	8.32	550.3	146.3	25.6	20.01	58	1.1	26.57	70	9.6	253.6	1.5
24	Khujenbahal	8.19	707.6	308.4	71.2	31.72	76	3	42.38	5	0	353.8	0.25
25	Dangia	7.82	820.1	296.4	68.8	30.26	77	11.4	138.6	10	0	258.5	0.25
26	Sargul	8.06	830.6	297.1	40	37.13	88	6	119.1	30	0	341.6	0.5
27	Sargigurh	7.4	499.5	270.1	76.8	19.03	12.8	0.4	11.34	5	0	344.6	0.5
28	Pipalmunda	7.28	790.2	439.5	172	2.44	24	0.6	98.9	0	0	317.2	0.25
29	Dongarparha	8.06	540.2	268.5	49.6	35.14	26.8	1.1	54.56	5	0	231.8	0.25
30	Karuamunda	7.72	441.6	224	72	10.74	18	0.2	7.54	0	0	292.8	2.1

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Table-2:Derived Parameters of Water Samples.

Sl. No.	Place	water type	SAR	RSC	%Na	KR	PS	PI
1	Banjipali	Na-HCO3	1.78	0.33	38.83	0.63	3.75	69.86
2	Kuibahal	Ca-HCO3	0.48	0	32.67	0.48	1.59	57.96
3	Mandla	Mg-HCO3	0.79	0.18	24.12	0.31	2.91	64.72
4	Khatlumunda	Mg-HCO3	1.32	1.28	28.01	0.36	2.51	57.70
5	Dhusamunda	Na-HCO3	3.60	2.6	59.64	1.46	1.39	89.42
6	Samarsingh	Mg-HCO3	1.19	0	21.85	0.28	2.25	46.47
7	Malpamunda	Na-HCO3	5.86	4.01	71.15	2.40	1.97	96.98
8	Hial	Na-HCO3	4.18	1.14	59.06	1.42	1.91	80.68
9	Dabari	Mg-HCO3	0.79	0	16.70	0.20	1.73	44.73
10	Punjiparha	Na-HCO3	4.80	3.88	64.36	1.79	2.97	91.75
11	Dumerchuan	Mg-HCO3	0.67	0.09	14.70	0.17	0.64	45.71
12	Bichhabahali	Mg-HCO3	0.22	0	6.88	0.07	1.10	42.09
13	Komeimunda	Mg-HCO3	0.77	0	19.97	0.24	3.31	48.90
14	Patimal	Na-HCO3	2.35	0.48	43.46	0.74	4.13	69.39
15	Saleparha	Mg-HCO3	1.36	0	27.55	0.38	3.50	48.80
16	Khagsa	Mg-HCO3	1.56	1.26	30.81	0.43	2.79	59.64
17	Karlabahali	Na-HCO3	2.76	3.12	54.66	1.20	0.40	95.59
18	Mankarchuan	Na-HCO3	8.99	3.89	86.45	6.33	1.91	114.64
19	Birna	Ca-HCO3	1.30	0	30.23	0.43	1.62	62.43
20	Dhamandanga	Ca-HCO3	0.79	0	19.53	0.24	1.15	49.83
21	Jamutjhula	Ca-HCO3	0.27	0	8.11	0.08	1.91	42.85
22	Chhatrang	Na-HCO3	3.57	2.07	62.40	1.65	0.79	95.79
23	Talchkel	Na-HCO3	2.09	1.4	46.44	0.86	1.91	83.66
24	Khujenbahal	Ca-HCO3	1.88	0	35.43	0.54	1.52	60.38
25	Dangia	Ca-HCO3	1.95	0	38.14	0.57	4.36	58.35
26	Sargul	Na-HCO3	2.41	0.48	44.03	0.76	4.15	69.70
27	Sargigurh	Ca-HCO3	0.34	0	9.40	0.10	0.64	49.19
28	Pipalmunda	Ca-HCO3	0.50	0	10.68	0.12	2.79	33.81
29	Dongarparha	Mg-HCO3	0.71	0	18.14	0.22	1.86	47.70
30	Karuamunda	Ca-HCO3	0.52	0.14	15.12	0.18	0.20	56.54

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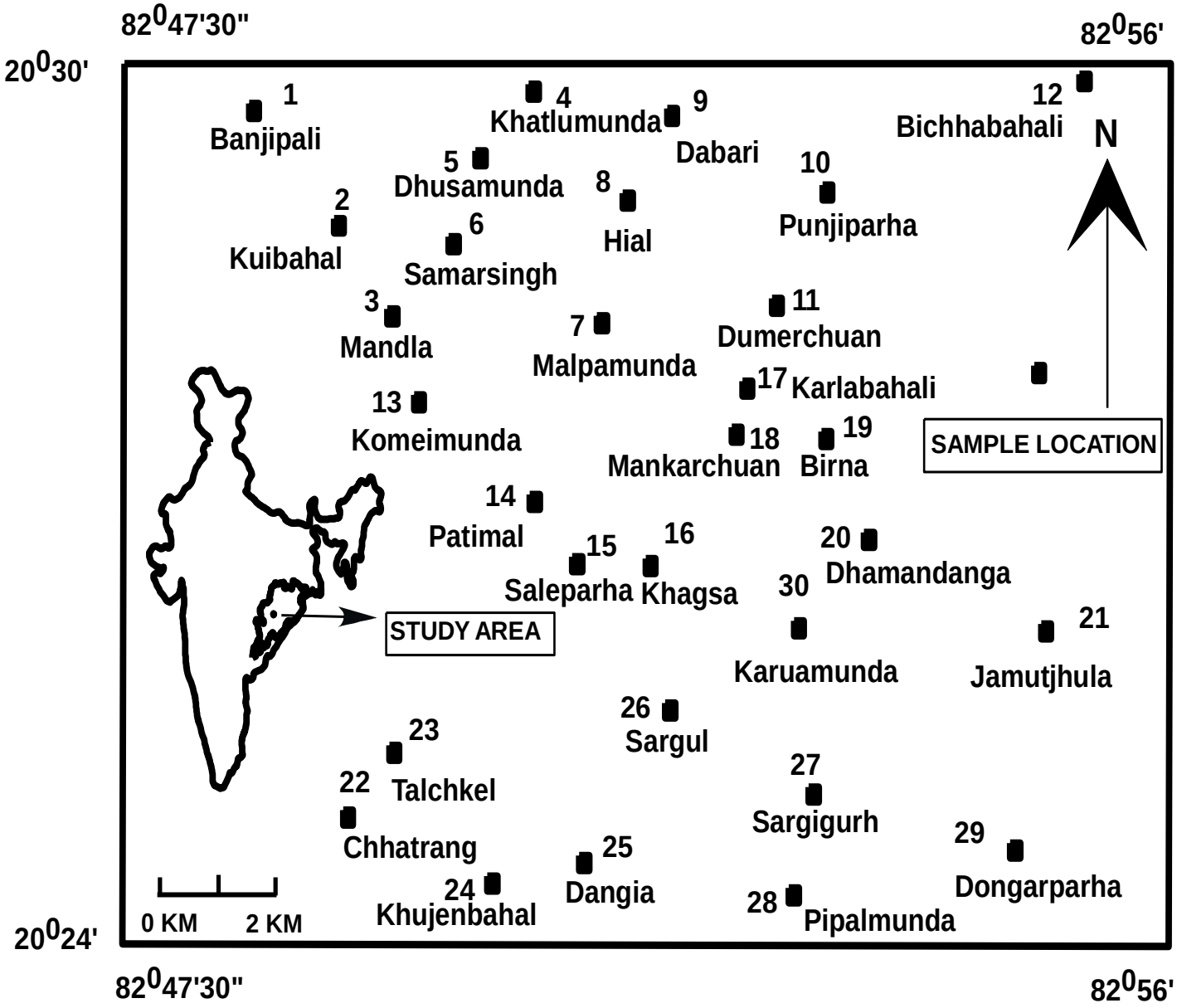

Fig.2. Location Map of water Samples.