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Hydrological Studies in the Hial Area of Bolangir District, Odisha with Reference to Water Pollution due to the Limestone Mining in Order to Find Out Suitability of the Available Ground Water Resources for Agricultural and Industrial Use

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

P.G. Department of Geology, Utkal University, Bhubaneswar, Odisha, India
*Corresponding author: rathabk62@gmail.com
Address: P.G. Department of Geology, Utkal University, Bhubaneswar, Odisha, India

Abstract: ***As most of the surface water has been contaminated by anthropogenic intervention in India for all human beings safe drinking water is yet not available. In places of mining it is absolutely necessary to assess and monitor the quality groundwater to check its suitability for industrial use and drinking and agriculture production along with suitability for domestic use and drinking water purpose.The objective of the scientific observation in the study area are focused to ensure that the people, livestock, or crops of the area are not affected by contamination of the water. In the physical parameter analysis and chemical parameter analysis in the laboratory parameters such as pH, EC, TDS, Total Hardness, Alkalinity, cations and anions in water were determined. To find out the influence of monsoon on groundwater over six years of observation from 2010 to 2016 two sets of sampling, one in pre monsoon and another in post monsoon was done every year. From the analytical data facies and water types were determined. Water chemistry of the area seems to have influenced by Limestone mining in the area. Preventive measures and proper management strategies are required as fluoride content in groundwater is more than 1 mg/l in many samples***

Keywords: Hydrology, Limestone, Groundwater, Pollution, Suitability

1. Introduction

The two broad physiographic units (i) undulating plains (Pediments) dotted with residual hills and (ii) scattered hills and areas with high relief divideds Bolangir district. Here both in shallow and deeper horizons, Granite gneiss forms the most potential aquifer. Khondalite, Calc Silicate rocks and anorthosites are the next important to be mentioned. In the weathered horizon some considerable amount of yield may be obtained from the anorthosites. Alluvium forms potential shallow aquifers where as Anorthosites and Gondwana sediments are poor water yielders in deeper horizons.

2. Materials and Methods

The methods used for hydrological studies of the study area are as follows:

2.1 Hydrological and Geological Data Collection

In this geological research the proper toposheet in which the study area lies was selected first of all. The toposheet nos. 64O, 64P & 64L of Survey of India covers the study area. By a number of field visits the geology of the area was studied. Pre monsoon and post monsoon period starting from 2010 upto 2016 was chosen for sampling for the study of hydrogeochemistry of the study area. In the month of March of each year and October of the same year from 2010 to 2016 the Sampling of water was done. As because Monsoon dilutes the actual chemical concentration of water it was considered as the important factor in the hydrogeochemistry of an area,

2.2 Field Sampling

- The bottles were first rinsed thoroughly with water to be sampled, then filled with sample and were closed tightly.
- Samples collected for trace element analysis were acidified in the field itself to prevent change in concentration.
- All the locations selected for water sampling were arranged on the basis of field work and the corresponding samples were numbered accordingly.

2.3 Laboratory Analysis

2.3.1 Physical parameter Analysis

a) Hydrogen Ion concentration (pH)
pH of water samples were determined by systronics makes digital pH meter 335. The instrument was first standardized by buffer solution of pH value 7 and 4 by proper adjustment. After the standardization the samples were analyzed with the help of pH electrode and values were recorded.

b) Electrical Conductance (EC)
The EC was determined by water analyzer Model 371 of Systronics make. Instrument was standardized by three KCl solutions (0.1N, 0.01N, 0.001N) with proper adjustment.

c) Total dissolved solids (TDS):
TDS values were calculated by using Proper mathematical formulae with the help of EC values

2.3.2 Chemical Analysis

a) Phenolphthalein alkalinity (PA) and Total alkalinity (TA):

Few drops of phenolphthalein indicator were added to fixed volume of sample. If the solution remain colourless, PA =0 and Total alkalinity is determined by titrating this solution with 0.02N HCl.

Until the colour disappeared, the solution was titrated with a fixed normality of HCl, when the colour changes to pink after adding phenolphthalein

b) Total hardness (TH):

The indicators and essential chemicals are:

- EDTA (Ethylene Diamene Tetra-Acetic Acid)
- EBT (Erichrome Black T)
- Ammonia Buffer Solution

Until light pink colour changed to sky blue, a fixed volume of water sample was titrated with fixed normality of EDTA (0.01N).A few drops of ammonia buffer solution and a pinch of EBT indicator powder were mixed with a fixed volume of water sample

2.3.3 Major Cations

a) Calcium (Ca^{2+}):

Water sample was mixed with a fixed volume of NaOH solution and Murexide indicator the result gives pink colouration. With a fixed normality of EDTA (0.01N) till purple colour occurred, it was titrated.

b) Magnesium (Mg^{2+}):

By applying appropriate scientific formula, Mg^{2+} was determined by the help of TH value and Ca value

c) Sodium (Na^{+}) and Potassium (K^{+}):

- The instrument was standardized with 5 standard solutions of NaCl of different concentrations and then water samples were analyzed and results were observed on the digital window, for Na.
- 5 numbers of KCl solutions of different solutions were used to standardize the instrument. Then the results were observed on the digital window, for K, The water samples were analysed for K content after it.

2.3.4 Major Anions

a) Chloride (Cl-):

Till brownish red colour occurred K_2CrO_4 was added to the water sample which gives yellow colour and titrated with $AgNO_3$, for Cl content. The calculation for Cl was prepared in mg/L.

b) Carbonate (CO_3^{2-}) and Bicarbonate (HCO_3^{2-}):

If the solution remained colourless, after a few drops of phenolphthalein indicator were added to a fixed volume of sample, then it is free from carbonate. The solution was titrated with a fixed normality of 0.01 N HCl until the colour disappears, If the colour changed to pink after addition of phenolphthalein.

c) Sulphate (SO_4^{2-})

Fixed volume of water sample (10 ml) was mixed with 1ml of conditioning reagent and stirred with a magnetic stirrer. It was compared with that of standard sulphate solution undergoing the same process, by a spectrophotometer.

d) Fluoride (F)

Fluoride was measured in Ion Selective Electrode method. The Chemical analysis formed the basis of finding the suitability of the ground water resources for the purpose of agricultural and industrial use.

3. Result and Discussion

Suitability for Domestic Use

To find out finding the suitability of the ground water resources for the purpose of drinking water, agricultural and industrial use the physical parameters were tested and the results find out as follows.

Table 1: Physical parameter values of the samples from the study area.

Sl. No.	Place	pH	EC	TDS
1	Banjipali	7.92	672	430.1
2	Kuibahal	7.89	572.9	366.7
3	Mandla	8.32	521.8	334
4	Khatlumunda	8.32	810.4	518.7
5	Dhusamunda	8.34	641.3	410.4
6	Samarsingh	8.2	898.5	575
7	Malpamunda	8.35	785.4	502.7
8	Hial	8.34	745.9	477.4
9	Dabari	7.48	733	469.1
10	Punjiparha	7.85	869.1	556.2
11	Dumerchuan	7.65	705.9	451.8
12	Bichhabahali	8.32	488.5	312.6
13	Komeimunda	8.32	656.9	420.4
14	Patimal	8.06	829	530.6
15	Saleparha	8.1	720.4	461.1

Based on TDS values (Carroll, 1962)

TDS value is a convenient way to know the quality of groundwater whether it is saline or non-saline. TDS of the water samples analyzed in the study area ranges from172.8 to 860 mg/l in pre monsoon water samples and 282.624 to 575.04 mg/l in post monsoon water samples. All water samples are fresh water and are permissible for domestic use. As per TDS classification of water almost suitable for domestic use.

Table 2: Classification of water based on TDS

Type		TDS in mg/l	No. of samples Pre monsoon	No. of samples Post monsoon
Non-saline or fresh water		<1, 000	30	30
Brackish water	Slightly saline	1, 000-3, 000	0	0
	Moderately saline	3, 000-10, 000	0	0
Highly saline		10, 000-35, 000	0	0
Brine		>35, 000	0	0
Total			30	30

Industrial Use

The industries require water of highly variable quality. Because quality need of various industries different. EC and hardness of the water along with the magnesium concentration has been observed for finding the suitability of the water for various industrial uses. In addition to detailed qualities, to find out their suitability in industries, two important properties of water such as corrosion and incrustation need to be taken into account. The corrosion property of groundwater and the Incrustation is formed due to precipitation of the chemical constituents present in groundwater was observed using the chemical analysis of values of major anions and cations presence in the water. The samples are considered suitable for industrial purpose because most of the groundwater samples are free from any suspended impurities and pollution and are at constant temperature. Hence the water in the study area are suitable for industrial use.

Suitability for Agriculture

The suitability of water for irrigation uses are affected by two important parameters.They are Sodium and salinity hazards. In the study area, the % Na value of the water for varies from 6.88 (Bichhabahali) to 86.45 (Mankarchuan). 10 samples Out of the 30 samples are excellent to good class for irrigation and 10 samples are good class for irrigation. In permissible to doubtful category three samples fall and they are not suitable for irrigation. The suitability of groundwater for irrigation purposes is determined on the basis of Sodium Absorption Ratio (SAR) value and Kelly's Ratio. In pre monsoon and post monsoon water samples the SAR values of the groundwater varies from 0.248 (Bichhabahali) to 8.17 (Mankarchuan) for the study area.

Kelly defined the Kelly's Ratio as –

$$\mathrm{KR} = \frac{\mathrm{Na}}{\mathrm{Ca} + \mathrm{Mg}}$$

All the values are in meq/l (Kelly, 1963). Based on Kelly's Ratio (KR) when Kelly's Ratio is less than 1, the water quality is good for irrigation. Except five samples In pre monsoon, the KR values of the water samples of the study area indicate that all samples are good for irrigation. Only one sample indicating its unsuitability for irrigation, it has highest value of Kelly's Ratio i.e. 4.34.Except seven samples, the KR values of the water samples of the study area indicate that all samples are good for irrigation. With reference to SAR as an index for Sodium hazards(S) and EC as an index of salinity hazards based on the United States Salinity Laboratory (USSL) (Richards, 1954; USSL, 1954) diagram for classification of irrigation water the above suitability has been confirmed. The water in the study area are suitable for agricultural use. Where it has shown as unsuitable for irrigation, water can be supplied from nearby locality where it is suitable for the agriculture. As such areas having unsuitable water for irrigation are only a few, in general the water in the study area may be treated as suitable for the agricultural purpose. The same can be utilised for increasing the green cover in the area.

4. Conclusion

Under the confined to unconfined aquifer condition in weathered and fractured granite gneisses and khondalites the ground water of the area occurs. The lithology of the area controls the water chemistry of the area. Suitability of most water samples for irrigation purposes are suggested by the SAR, %Na, PI values. low sodium and medium to high salinity hazard is observed in the most of the water samples are indicated from Richard's salinity. Defluoridation technique may be applied before using the water for drinking as fluoride content in more than fifty percent of the samples exceeds highest desirable limit for drinking water standard suitable. The available groundwater resources may be used for enhancing agricultural production and industrial growth as it is suitable for use in both these areas. To use the green vegetation cover in the area the groundwater may be used as per long term planning.

References

[1] Back, W.(1961) Techniques for mapping of hydrochemical 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.

Table 3: Chemical parameter values of the samples from the study area.(All values are in mg/l)

Smpl. No.	TA	TH	Ca	Mg	Na	K	Cl	So4	CO3	HCO3	F
1	216.8	200.50	32.00	29.28	58	1.0	114.18	15	9.6	254.2	1.35
2	179.9	254.60	66.00	21.80	56	1.0	24.60	42	0.0	224.5	0.50
3	186.4	177.30	19.60	31.16	24	1.8	83.59	15	14.4	212.3	0.50
4	393.2	329.30	21.60	66.86	55	6.4	69.41	15	4.8	473.4	2.00
5	291.0	160.90	16.00	29.36	105	1.8	19.70	40	28.8	324.5	2.10
6	403.7	453.20	62.40	72.22	58	0.6	54.72	25	0.0	497.8	2.10
7	345.3	144.70	9.00	29.68	162	8.0	53.88	10	0.0	424.6	2.60
8	270.0	212.90	7.20	47.33	140	4.8	42.60	25	9.6	318.4	2.80
9	321.9	389.30	76.00	48.46	36	0.4	45.38	10	0.0	419.7	1.80
10	374.5	180.30	36.00	21.96	148	2.5	73.74	40	0.0	468.5	0.50
11	398.2	393.60	33.60	75.20	31	1.0	8.51	8	0.0	507.5	2.00
12	222.5	270.60	46.40	37.58	8	0.8	24.52	8	9.6	261.1	0.25
13	214.5	262.80	31.20	44.90	29	2.4	117.20	0	33.6	227.0	1.25
14	276.9	252.80	40.00	37.13	86	6.0	119.10	30	0.0	341.6	1.25
15	180.4	323.60	34.60	57.59	56	1.1	112.80	5	0.0	222.0	1.25
16	392.4	329.30	21.60	66.86	65	5.4	79.41	15	4.8	472.4	0.50
17	286.8	130.50	9.60	25.86	72	0.8	14.18	0	4.8	344.0	2.20
18	254.7	60.02	17.60	3.90	160	2.4	67.74	0	0.0	317.2	1.80
19	221.7	228.40	48.00	26.35	45	0.9	17.02	60	0.0	273.3	2.00
20	208.1	274.20	73.60	21.96	30	1.2	23.52	10	0.0	263.5	2.60
21	161.5	238.20	60.00	21.47	10	0.8	56.39	5	0.0	*200.1*	0.50
22	215.8	112.30	19.20	15.64	87	0.8	12.18	10	9.6	252.8	0.25
23	216.3	146.30	25.60	20.01	58	1.1	26.57	70	9.6	253.6	1.50
24	288.9	308.40	71.20	31.72	76	3.0	42.38	5	0.0	353.8	0.25
25	206.2	296.40	68.80	30.26	77	11.4	138.60	10	0.0	258.5	0.25
26	276.9	297.10	40.00	37.13	88	6.0	119.10	30	0.0	341.6	0.50
27	260.3	270.10	76.80	19.03	13	0.4	11.34	5	0.0	344.6	0.50
28	234.0	439.50	172.00	2.44	24	0.6	98.90	0	0.0	317.2	0.25
29	187.8	268.50	49.60	35.14	27	1.1	54.56	5	0.0	231.8	0.25
30	231.2	224.00	72.00	10.74	18	0.2	7.54	0	0.0	292.8	2.10

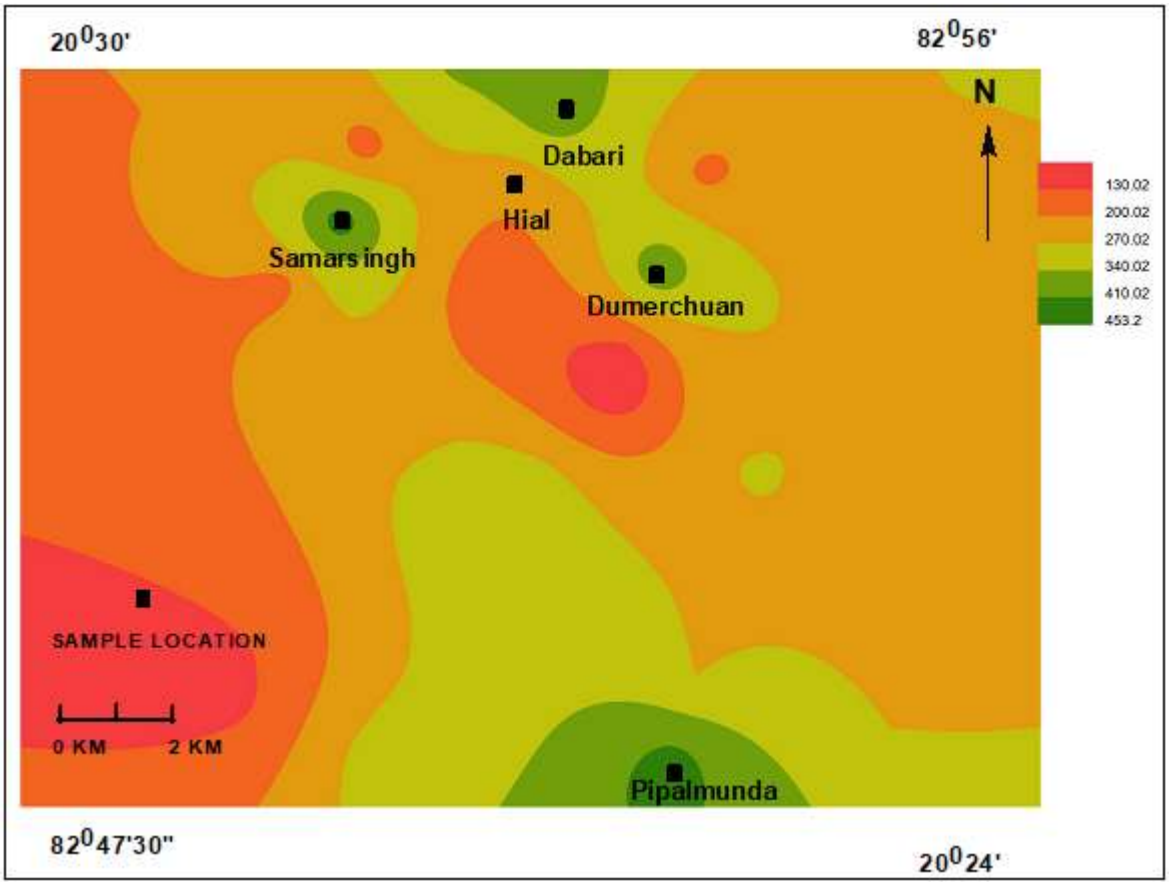

Figure 1: Spatial distribution of Total Hardness in mg/l in post monsoon water samples

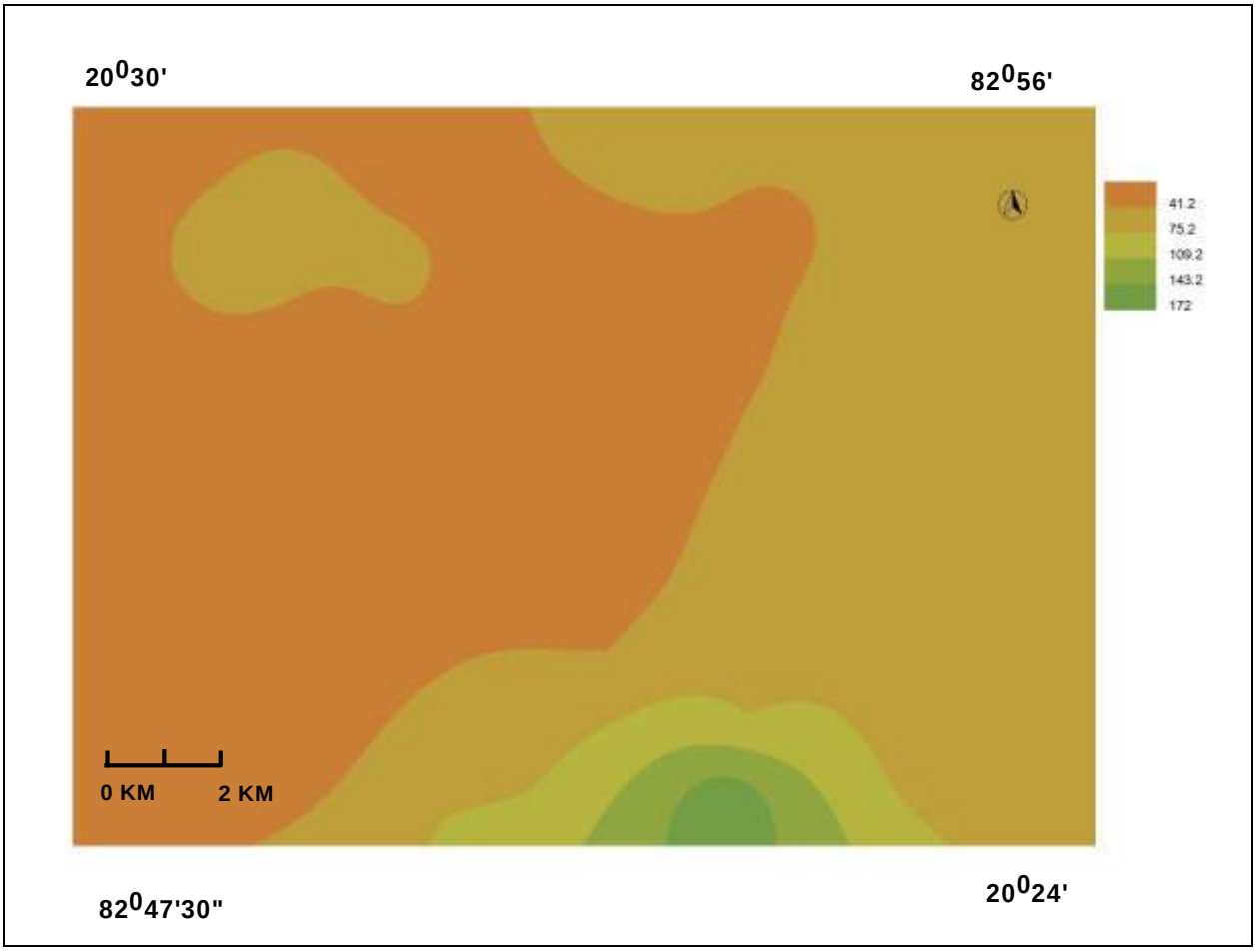

Figure 2: Spatial distribution of Calcium in mg/l in post monsoon water samples

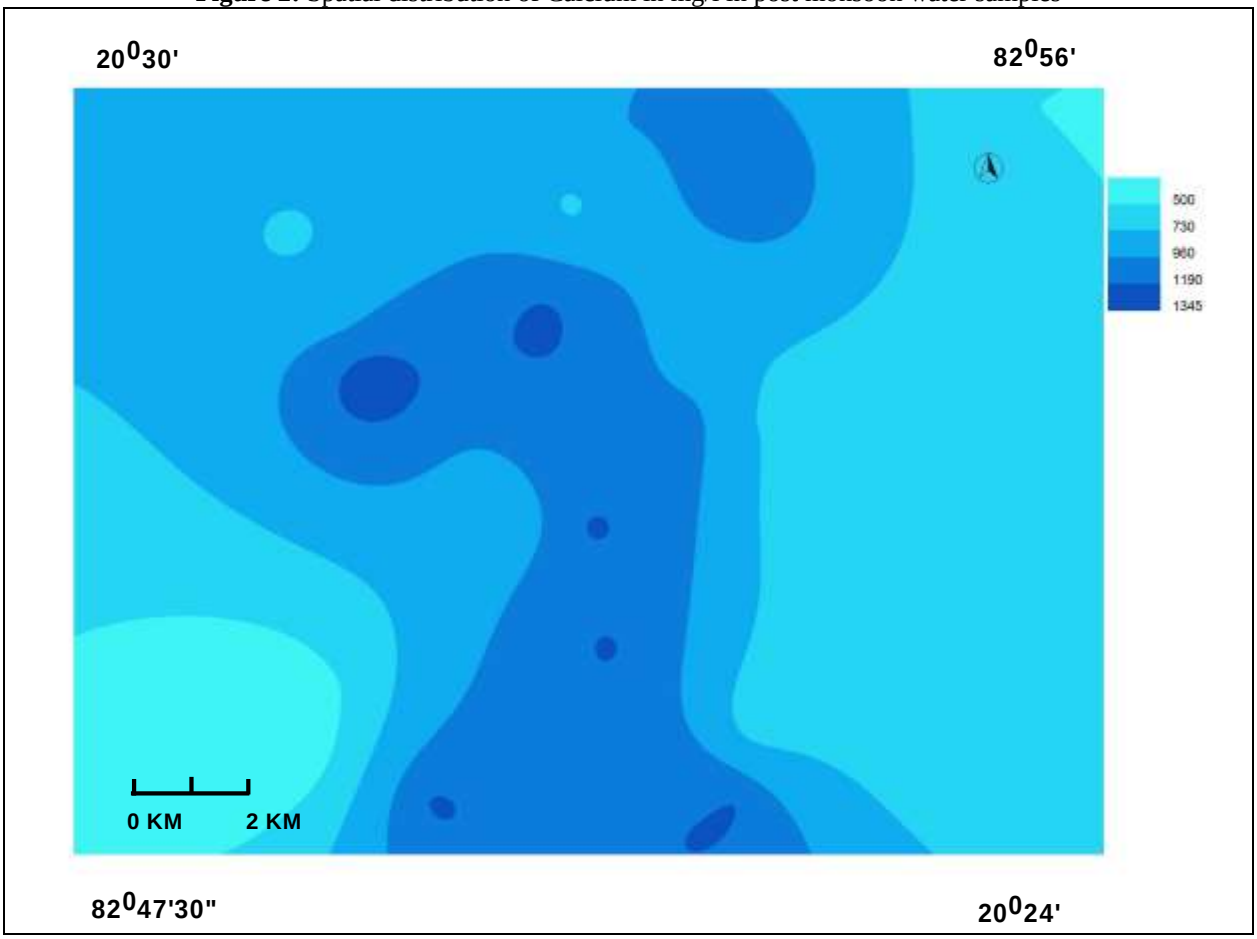

Figure 3: Spatial distribution of EC in µmho/cm in pre monsoon water samples

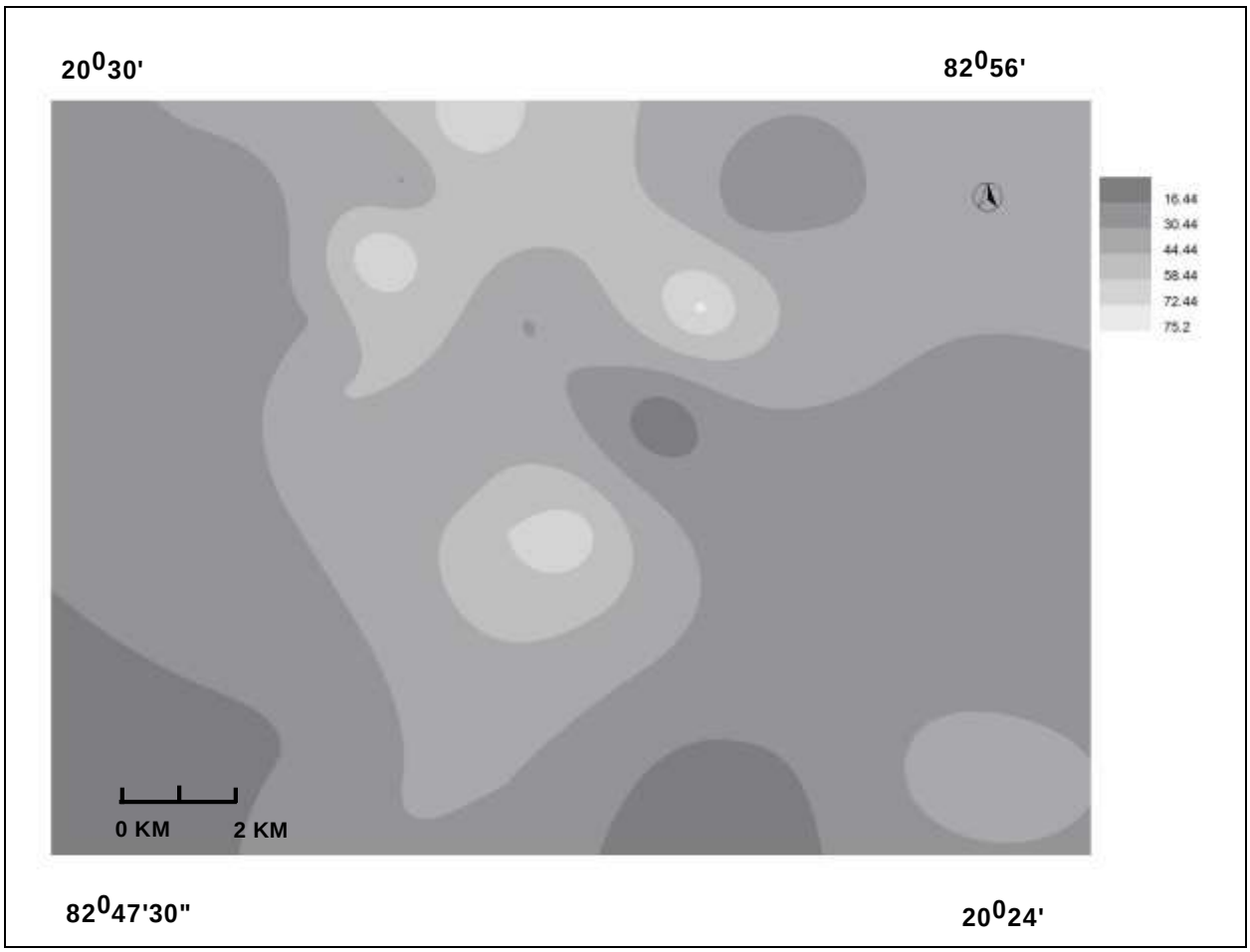

Figure 4: Spatial distribution of Magnesium in mg/l in post monsoon water samples

Author Profile

S.R. Barick is Research Scholar, PG Department in Geology, Utkal University, Bhubaneswar, Odisha, India

B.K. Ratha is Associate Professor in Geology, P.G. Department of Geology, Utkal University, Bhubaneswar, Odisha, India