PRE-MONSOON GROUNDWATER QUALITY FOR IRRIGATION PURPOSES IN KEONJHARGARH AND PATANA BLOCKS OF KEONJHAR DISTRICT, ODISHA, INDIA

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Abstract: A total of 99 numbers of groundwater samples were collected from Keonjhargarh and Patana Blocks of Keonjhar District of Odisha, India to assess its suitability for irrigation purposes. The various physicochemical parameters were determined and irrigational parameters like %Na, SAR, RSC, MR, PI, PS and KR were calculated. It was found that the majority of water samples were suitable for irrigation purposes. The Wilcox diagram was plotted to determine the irrigational suitability of groundwater and the result shows that majority samples fall on "excellent to good" and "good to permissible" field. Similarly, the U.S. Salinity Diagram suggests that most of the samples fall on the region C2-S1 and C3-S1 indicating medium to high salinity with low sodium hazard.

IndexTerms **– Irrigational water quality, Salinity hazard, Kelly's ratio, Wilcox diagram, Keonjhar District.**

I. INTRODUCTION

The water is life, without which the existence of life is impossible for all organisms. The quality and quantity of water are very important for the survival of life. Because of rapid growth in population, urbanization, industrial and agricultural activities, water needs have been increased to a considerable extent. This problem has been compounded because of uncertain and erratic rainfall as a result of which people have started looking at groundwater as a viable resource instead of surface water (Mahanta, 2017). Groundwater plays a significant role in Indian agriculture and in shaping the country's economy. Good quality of groundwater can help in the better yield of crops (Mahanta et al., 2012). As there is no major dam project in the study area, peoples generally depend on monsoon rainfall for their everyday life. The shortage of surface water due to scanty rainfall put the people in problem in the area of study for which most of the people depend on groundwater as a result of which the water table is declined. The present study was carried out to assess the quality of groundwater with respect to chemical properties in Keonjhargarh - Patana Blocks of Keonjhar Subdivision in Keonjhar District of Odisha The scientific method of development and management of groundwater quality with respect to physicochemical parameters along with hydrogeochemistry is the need to depict its suitability of water for agricultural purposes.

II. STUDY AREA

The study area lies in the central part of the Keonjhar District and part of the northern upland of Odisha, India. The total geographical area is around 1022.81 sq. km. and is bounded by north latitude 21°30′ to 21°52′ and east longitude 85°18′ to 86°00′ which is falling in the Survey of India Toposheet numbers 73G/10 and 73G/14. (Fig. 1). The area enjoys a sub-tropical monsoon to tropical climate.

The study area has varieties of rock types belonging to Singhbhum Granite, occupies great batholithic mass of a several hundred square kilometres from Chaibasa in the North and to Keonjhargarh in the South. The Singhbhum Granite has suffered a long process of weathering and erosion, which led to the formation of lateritic soil i.e development of non-conformity. According to Saha (1970), batholith consists of several domed shaped intrusion varying in composition from biotite- trondhjemite and leucogranite. The great batholith mass is mainly intruded in the Iron Ore Group and Older Metamorphic Group.

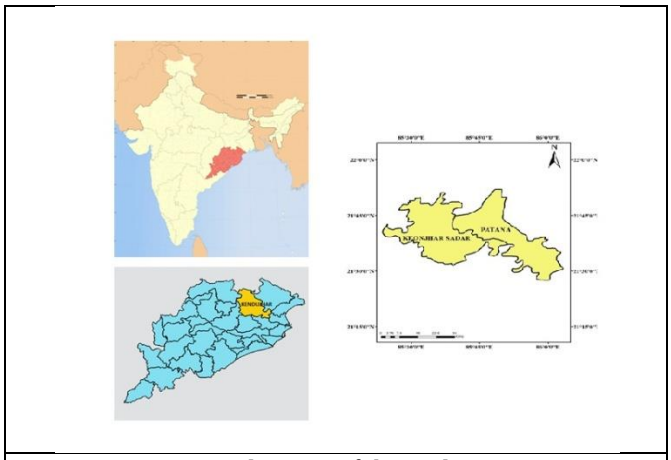

Fig.1 Index map of the study area

III. MATERIALS AND METHODS

From the study area, altogether 99 water samples were collected from various tube wells in the pre-monsoon period, 2016. The parameters like pH, electrical conductance (EC) and total dissolved solids (TDS) were measured immediately after the sampling. The hydrogeochemical parameters were evaluated in the laboratory as per standard analytical procedures followed by APHA, 1985; Brown et al. 1974; Trivedi and Goel 1984; Vogel, 1964; Dash et al. 2014.The chemical parameters which were analysed in the laboratory are 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-}), nitrate (NO_3^-) and fluoride (F^-) etc.

IV. RESULTS AND DISCUSSIONS

The maximum and minimum values of various parameters are recorded. This quality determines the suitability for irrigation purposes. The quality of groundwater mostly depends on the mineralogical composition of the host rocks through which it flows and where it is stored. The chemical analysis data of collected water samples are given in Table 1.

Table 1 Summary of the various parameters of groundwater during the pre-monsoon period, 2016

Parameter	Pre-Monsoon Samples			
	Min.	Max.	Mean.	SD
Temperature	26.7	32.8	30.32	1.69
pH	7.62	8.97	8.24	0.25
EC	220	1050	543.10	187.59
TDS	145	675	356	120.11
TH	25	465.4	147.07	76.03
TA	27.52	250.2	132.92	54.93
Na^+	2.24	89.78	35.57	14.13
K^+	0.82	12.34	3.078	1.93
Ca^{2+}	8.02	148.3	39.54	22.33
Mg^{2+}	0	66.83	11.85	10.13
Fe^{2+}	0.002	2.173	0.187	0.24
HCO_3^-	5.04	240.19	124.43	54.59
Cl^-	21.5	390	102.3	80.11
SO_4^{2-}	0.314	15.337	2.97	2.69
NO_3^-	0.008	0.625	0.090	0.08
F^-	0.101	2.17	0.46	0.39

All the values are in mg/l except EC and pH and temp., EC is in µmho/cm, temp in °C

IRRIGATION WATER QUALITY

Certain quality specifications are required for water used for irrigation purpose. These are based on the tolerance of plants to certain properties of soils, chemical constituents of water, climate and irrigation practices. Since groundwater contains some dissolved constituents, their presence affects the soil structure, permeability etc. which ultimately affect the growth plant (Mahanta et al., 2016).To interpret the suitability of water for irrigational practices, certain irrigational parameters such as %Na, SAR, RSC, MR, PI, PS and KR were determined. The minimum, maximum, mean and standard deviation values of various irrigational parameters are given in Table 2 whereas the classifications of water for suitability of irrigational parameters are given in Table 3.

PERCENT SODIUM (%Na)

The percent sodium is calculated by using the following formula.

$$\%Na = \frac{(Na^+ + K^+) * 100}{(Ca^+ + Mg^{2+} + Na^+ + K^+)}$$

Here, all the values are expressed in meq/l.

The %Na value of the water samples of the study area varies from 1.12 to 27.96 with a mean of 8.41. When the percent sodium value is plotted against EC in the Wilcox diagram, about 85% samples are "Excellent to Good", 15% samples are "Good to Permissible" for irrigation purposes (Fig. 2).

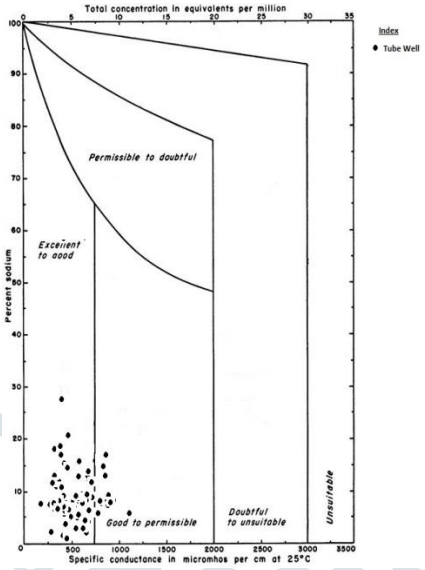

Fig. 2. Wilcox diagram

SODIUM ADSORPTION RATIO (SAR)

The sodium adsorption ratio is calculated by using the following formula

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/_2}}$$

The SAR value of the water samples ranges from 0.040 to 1.225 with an average of 0.51. The classification of water samples on the basis of SAR value in Table 3 indicates that all the samples have SAR value <10 and it falls under the “excellent” category for irrigation. When SAR is plotted against EC in the U.S. Salinity diagram (Richards, 1954), the water samples fall in the field of C1-S1, C2-S1 and C3-S1 indicating low salinity hazards in pre-monsoon periods, which is suitable for irrigation purposes (Fig. 3).

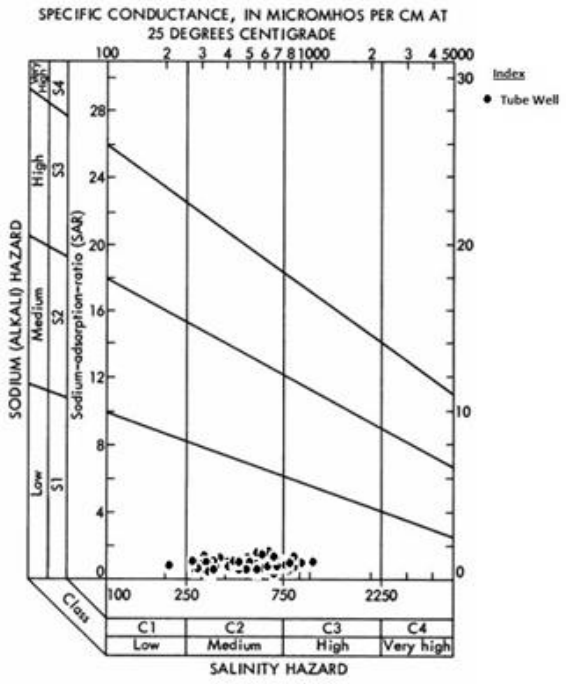

Fig. 3 U.S salinity diagram

RESIDUAL SODIUM CARBONATE (RSC)

The relative abundance of sodium with respect to the excess of carbonate and bicarbonate over alkaline earth affected the suitability of water for irrigation purpose (Mahanta et al., 2018). The term Residual Sodium Carbonate was proposed by Eaton (1950). Further, in 1985 Lloyd and Heathcote proposed a classification for irrigation water on the basis of RSC. This excess is expressed in meq/l.

$$RSC= (CO_3^{2-} + HCO_3^{-}) – (Ca^{2+} + Mg^{2+})$$

The RSC value of the water samples varies between -179.716 to -3.231 with an average of -20.09. With respect to RSC values, all the samples of pre-monsoon of the study area can be classified as "good" for irrigation purposes.

MAGNESIUM RATIO (MR)

Szabolcs and Darab (1964) proposed the concept of magnesium hazard (MH), which is assessed from the magnesium ratio.

$$MR= \frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}} * 100$$

Where all the values are expressed in meq/l.

The MR value of the water samples varies from 0 to 35.47 with mean value 5.45. As all the samples have values less than 50, they are suitable for irrigation purposes.

POTENTIAL SALINITY (PS)

The Potential Soil Salinity (PS) is given by Doneen (1962) where the ionic concentrations are expressed in meq/l.

$$PS = Cl + \frac{1}{2}SO_4^{2-}$$

Where all the values are expressed in meq/l.

The PS values of the analysed samples varied from 0.614 to 11.021 with an average of 2.917.

PERMEABILITY INDEX (PI)

The permeability index as formulated by Doneen (1964) is used to classify the irrigation water.

$$P.I. = \frac{Na^{+}+\sqrt{HCO_3^{-}}}{Na^{+}+Ca^{2+}+Mg^{2+}} * 100$$

Here, all the values are expressed in meq/l.

The PI of the groundwater samples varies from 1.499 to 46.236 with an average of 15.343

KELLY'S RATIO (KR)

Kelly's ratio is given by Kelly's (1957) to calculate this parameter.

$$K.R=\frac{Na^{+}}{Ca^{2+}+Mg^{2+}}$$

Here, all the values are expressed in meq/l.

Kelly's ratio varies from 0.008 to 0.379 with an average of 0.09. Kelly's ratio of more than one indicates an excess level of sodium and is unsuitable for irrigation whereas, KR value less than one is suitable for irrigation. As all the values of KR of the water samples are below 1, they are suitable for irrigation.

Table 2 Chemical parameters of ground water for irrigation purposes

Parameters	Pre-monsoon (99) samples			
	Min	Max	Mean	S.Dev.
EC(µmho/cm)	220	1050	543.1	187.59
TDS	145	675	355.94	120.11
%Na	1.12	27.96	8.41	4.07
SAR	0.040	1.225	0.51	0.174
RSC	-179.716	-3.231	-20.091	19.508
MR	0	35.47	5.45	4.97
PS	0.614	11.021	2.917	2.259
PI	1.499	46.236	15.343	6.521
KR	0.008	0.379	0.09	0.050

Table 3 Classification of groundwater on the basis of SAR, KR, %Na, RSC, MR

Parameter	Range	Water Class	Sample of pre-monsoon	% of Sample of pre-monsoon
TDS(mg/l)	<1000	Non-saline	99	100
	1000-3000	Slightly saline	--	--

	3000-10000	Moderately saline	--	--
	>10000	Very saline	--	--
Salinity Hazard (EC)(µS/cm)	<250	Excellent	01	1.02
	250-750	Good	85	85.85
	750-2000	Permissible	13	13.13
	2000-3000	Doubtful	--	--
	>3000	Unsuitable	--	--
%Na	<20	Excellent	97	97.97
	20-40	Good	02	2.03
	40-60	Permissible	--	--
	60-80	Doubtful	--	--
	>80	Unsuitable	--	--
SAR	<10	Excellent	99	100
	10-18	Good	--	--
	18-26	Doubtful	--	--
	>26	Unsuitable	--	--
RSC	<1.25	Good	99	100
	1.25-2.50	Doubtful	--	--
	>2.5	Unsuitable	--	--
MR	<50	Suitable	99	100
	>50	Unsuitable	--	--
KR	<1	Suitable	99	100
	>1	Unsuitable	--	--

V. CONCLUSION

The groundwater samples of the study area were analysed to assess its suitability of irrigation purposes. Based on the obtained values of %Na, SAR, RSC, MR, PI, PS and KR, it can be concluded that the majority of samples are appropriate for irrigation purposes. Based on SAR, RSC, MR and KR values, all the samples are excellent for irrigation purposes. On the basis of %Na, 97.97% samples are excellent and 2.03% is good for irrigation purposes. The Wilcox diagram depicts that all the samples fall on "excellent to permissible" field for irrigation. Similarly, the U.S. Salinity Diagram shows that the samples fall on the region C1-S1, C2-S1 and C3-S1, out of which C2-S1 is predominant indicating medium salinity with low sodium hazard followed by C3-S1. It can be concluded that the majority of samples are good for irrigation purposes except few.

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