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Hydrogeochemistry and qualitative assessment of groundwater resources in Digapahandi block of Odisha, India

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Abstract

Digapahandi area of Ganjam is a chronically drought prone and economically poor region in Orissa. The economy of the area is basically agrarian. Surface water irrigation is not adequate. Drinking water scarcity is very acute during summer. The systematic and logical evaluation of groundwater resources qualitatively is essential for sustainable utilization and management of groundwater in this area. Comparison of the potable water standards (ISI, 1983) with the various water quality parameters of ground water from aquifers reveals that groundwater comes under potable category with respect to maximum permissible limit. It is a general observation that the water from deeper aquifers have superior quality than that of the shallow aquifers. Therefore, from the quality aspect, the water from deep bore wells is most suitable. Ions of higher concentration are normally observed in villages like S.Tikarapada, Samantarapur, Pentha, Ankorda, Kusapada, Baligudi and Basudevpur with respect to SAR, RC, TDS, Percent Sodium, Magnesium Hazard and P.I., the ground water of both dug wells and bore wells falls within good to excellent category for agricultural uses except very few cases.

Keywords: Hydro geomorphology, draft, aquifer, sustainable, hydrogeochemistry.

Introduction

Digapahandi of Ganjam district is a chronically drought prone area. The area experiences drought frequently because of erratic nature of rainfall over time and space. The development of agrarian economy demands stabilized agriculture and crops insurance against drought. The expansion of agriculture is inevitable. The area requires development of ground water through suitable structures to combat drought and to increase crop yield by covering more areas under irrigation. Drinking water problem is very acute. For a planned management and development of groundwater, it is essential to assess groundwater resources qualitatively in the block[1-5]. Studies on the hydrochemistry and groundwater quality in different parts of the country emphasized the need of qualitative evaluation for sustainable development of ground water resources[6-15]. Located on the east coast of India, Digapahandi block of Ganjam district, Orissa is bounded by $19^0 11'30"$ to $19^0 24'0"$N Latitude and $84^0 19'50"$ to $84^0 41'24"$E longitude (Figure-1) falling in the Survey of India Topo sheet Nos. 74A/7, 74A/8 and 74A/11.

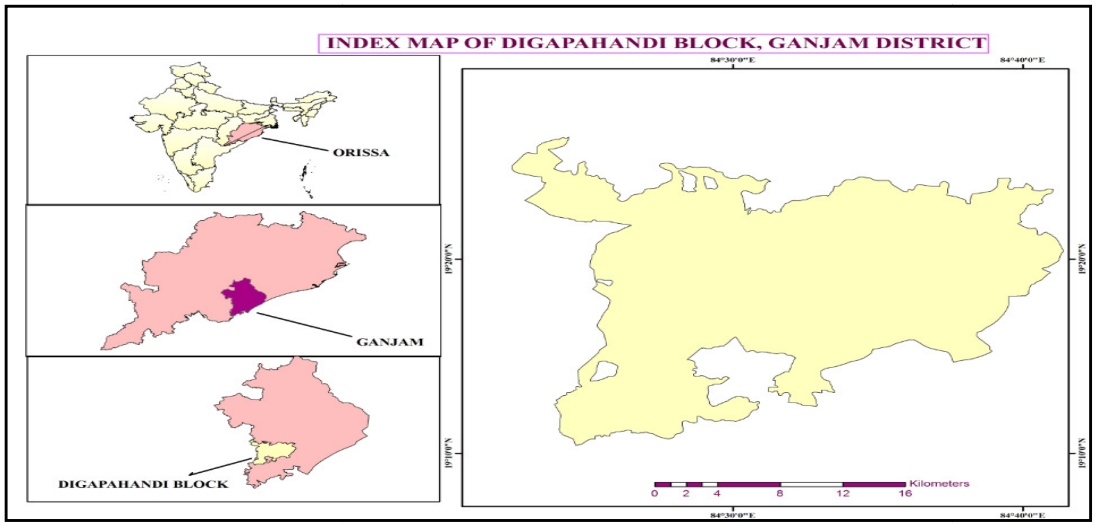

Figure-1: Location map of Digapahandi Block Ganjam District.

Methodology

Collection of secondary data and Toposheets, references etc. have been made. Systematic collection of eighty numbers groundwater samples from dugwell and tubewell during pre and post monsoon period is made. Chemical analysis is done for ions like Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4, NO_3 and other parameters pH, Temp, TDS, EC etc. are measured in the field. Hydro-geochemical evaluation based on studies established by many workers have been carried out[16-19]. Comparison of the drinking water standards[20] with the various water quality parameters of ground water of the block is studied[20].

Results and discussion

Groundwater quality evaluation: Based on the chemical analysis of water samples collected during hydrogeological survey, the quality of ground water of both shallow and deeper aquifers of Digapahandi block has been assessed. In major parts of the block, the ground water is neutral to slightly alkaline in nature with specific conductance ranging from 254 to 1500 µs/cm at 25^0C except in pockets where higher values are noticed i.e. S.Tikarapada, Pentha, Kusapada, Balijodi and Basudevpur[6-8]. The ground water is characterized by low chloride, usually less than 500mg/l. In a few localized pocket, the concentration is ranging from 500 to 920ppm have been found (S.Tikarapada, Kusapada and Basudevpur). The concentration of NO_3, SO_4, HCO_3 in ground water ranges from nil to 37ppm, 9 to 105ppm and 21 to 238ppm respectively. The concentration of Ca, Mg, Na and K in the ground water ranges from 18 to 22ppm, 0.3 to 99ppm, 9 to 289ppm and 2 to 87ppm respectively. The general range of chemical constituents in the ground water of the block is presented in Table-1.

Table-1: Range of chemical constituents in groundwater of the block.

Chemical parameters	Concentration (ppm)
pH	7.1 – 8.8
TDS	162-1442
TH	108-975
TA	58-378
Ca	18-228
Mg	0.3-99
Na	9-289
K	2-87
CO_3	Nil-27
HCO_3	21-238
Cl	20-920
SO_4	9-105

Water quality for domestic use: The present study envisages the quality criteria of ground water from shallow and deeper aquifers and their comparison with ISI standards to assess its suitability for domestic purpose. Comparison of the drinking water standards[20] with the various water quality parameters of ground water of the block is presented in Table-2. From the chemical data it is evident that with some exception, the ground water from both the shallow and deeper aquifers come under potable category with respect to maximum permissible limit, as proposed by ISI[20]. It is also a general observation that the water from deeper aquifers have better quality than that of the shallow aquifers. Therefore, from the quality point of view of drinking purposes, the water from deep bore wells is most suitable. The higher concentration of ions are normally observed in villages like S.Tikarapada, Samantarapur, Pentha, Ankorda, Kusapada, Baligudi and Basudevpur.

Table-2: Comparison of ground water of the Block with ISI Standards.

Chemical Parameters	Total No. of sample Analysed	Total No. of Sample within permissible limit	Percentage
pH	80	80	100
TDS	80	80	100
TH	80	78	97.5
Ca	80	79	98.75
Mg	80	80	100
Cl	80	80	100
NO_3	80	80	100
SO_4	80	80	100

Quality Criteria for Irrigational use: Water used for irrigation purpose always contains some amount of dissolved constitutes (salts) which are the products of weathering of rocks and dissolution of minerals. The salts present in irrigation water affect the soil structure, permeability and aeration which ultimately affect the plant growth. Several factors such as Total Dissolved Solids (TDS), Percent Sodium (%Na), Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR) and Permeability Index (PI) affect the suitability of water for irrigation. The formulae used for calculating agricultural indices are given in Table-3.

Salinity hazard: The TDS content which determines the specific electrical conductance indicates salinity hazard to irrigation. Besides salinity hazard, excessive sodium content in water renders it unsuitable for soil containing exchangeable calcium and magnesium ions. The classification of well water

from the study area with respect to salinity hazard is given below (Table-4). Well waters falling under low salinity category can be safely used for irrigation purpose without any salinity control technique. Water falling under medium to high salinity classes can be used for irrigation purpose using some salinity control techniques for growing plants. The salt tolerant crops such as wheat, sunflowers etc. and vegetables such as cabbage, carrot, onion can be grown.

Table-3: Agricultural Indices.

Indices	Equation	Reference
SAR	$Na/\sqrt{(Ca+Mg)/2}$	18
% Na	(Na+K)/(Ca+Mg+Na+K)	19
PI	$Na+\sqrt{HCO_3}/(Ca+Mg+Na)X100$	16
R.S.C	$(CO_3+HCO_3)–(Ca+Mg)$	18
Mg Hazard	MgX100/(Ca+Mg)	--

Table-4: Salinity Hazard.

Salinity Category	TDS (mg/l)	No. of wells in each category	Percentage
Low	< 200	4	5.00
Medium	200-500	50	62.50
High	500-1500	26	32.50
Very High	>1500	Nil	--

Sodium Concentration: The sodium content of water is very important for its quality assessment for irrigation; Sodium replaces calcium which ultimately reduces the permeability of soil. This is known as "Sodium/ Alkali Hazards", because the degradation process helps in the formation of alkali soil. An alkali soil has an unfavorable structure, puddles easily and restricts the aeration. The Percent Sodium (%Na) is less than 60% in 95% of the water samples of the block collected. According to ISI standards[20], maximum percent sodium of 60 is recommended for irrigational purpose. Thus, water from most of the wells is suitable for irrigation from Percent Sodium point of view. Further, the sodium alkali hazard in irrigated water is indicated my Sodium Adsorption Ratio (SAR) expressed by the relation.

$$SAR = \frac{Na}{\sqrt{(ca+mg)/2}}$$

Where all the concentrations are expressed in ppm. The classification of well water of the block with respect to SAR is as given in Table-5.

Table-5: Classification of well water of the block with respect to SAR.

SAR	Class	No. of wells in each class	%
<10	Excellent	79	98.75
10-18	Good	-	-
18-26	Fair	01	1.25
>26	Poor	-	-

The above classification shows that the ground waters of almost all the wells are excellent for irrigational use from SAR point of view. The suitability of groundwater for irrigational purpose has been evaluated with the help of US, Salinity Diagram[17] (Figure-2). A study of the data indicates that generally the ground water falls in C_2S_1 and C_3S_1 class which are good and moderately good for irrigation respectively. The classification of irrigation of water based on the US salinity diagram is presented in Table-6.

Table-6: Classification of Irrigation water based on USSL.

SAR	Grade	No. of Samples	%
C_1S_1	Good	-	-
C_1S_2	Moderately good	-	-
C_1S_3	Unsuitable	-	-
C_1S_4	Highly Unsuitable	-	-
C_2S_1	Good	52	65%
C_2S_2	Moderately good	-	-
C_2S_3	Unsuitable	-	-
C_2S_4	Unsuitable	-	-
C_3S_1	Moderately good	26	32.50%
C_3S_2	Moderately good	-	-
C_3S_3	Unsuitable	-	-
C_3S_4	Unsuitable	01	1.25%
C_4S_1	Un suitable	01	1.25%
C_4S_2	Unsuitable	-	-
C_4S_3	Unsuitable	-	-
C_4S_4	Unsuitable	-	-

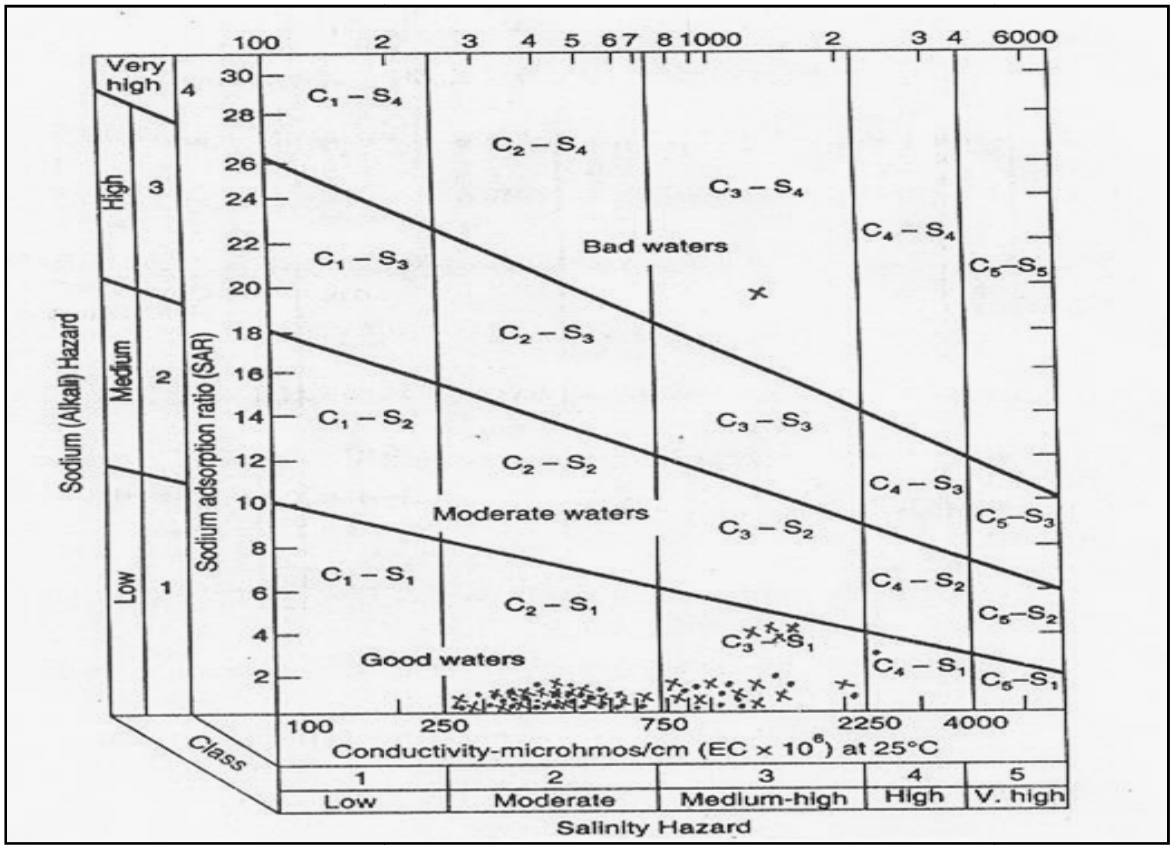

Figure-2: Classification of Irrigation Water[18].

Magnesium Hazard and Residual Sodium Carbonate: A ratio of (mgX100)/(Ca+Mg) was used as an index of Magnesium Hazard of irrigation water. All the well waters are excellent from magnesium hazard point of view as the ratio is less than 50 in all water samples. All most all the water samples have values less than 1.25 and falls under good category.

Table-7: Well respect to RSC values the groundwater.

RSC	Class	No. of wells in each class	Percentage
<1.25	Good	79	98.75
1.25-2.5	Medium	01	1.25
> 2.5	Bad	-	-

Permeability Index: Doneer[16] developed a criterion for assessing suitability of water of irrigation based on Permeability Index (PI). According to Doneen[16] chart (Figure-3) majority of well waters (98.75%) fall under class I and class II and the rest (1.25%) under class III category. From the above discussion it is evident that with respect to SAR, TDS, Percent Sodium, RSC values, Permeability Index (PI) and Magnesium Hazard, all the ground water samples fall within the excellent to good category for irrigation except very few cases.

Conclusion

The study envisages the quality criteria of groundwater and their comparison with ISI standards[20] to assess its suitability for domestic purpose.

From the chemical data it is evident that with some exception, the groundwater from both dug and tube well come under potable category with respect to maximum permissible limit, as proposed by ISI[20]. It is a general observation that the water from deeper aquifers has superior quality than that of the shallow aquifers. Therefore, from the quality aspect of drinking purposes, the water from deep bore wells is most suitable.

The higher amounts of ions are normally observed in villages like S.Tikarapada, Samantarapur, Pentha, Ankorda, Kusapada, Baligudi and Basudevpur. Drought conditions are quite frequent and the irrigation is inadequate. The groundwater development has not been at the desired level, despite having a basically agrarian economy and huge ground water resources. The groundwater in Digapahandi area shows very less seasonal variation in quality. Comparison of the hydro chemical parameters results of the study area with that of ISI standards[20] ensures the potability and other domestic utility of the ground water of the block except very few locations.

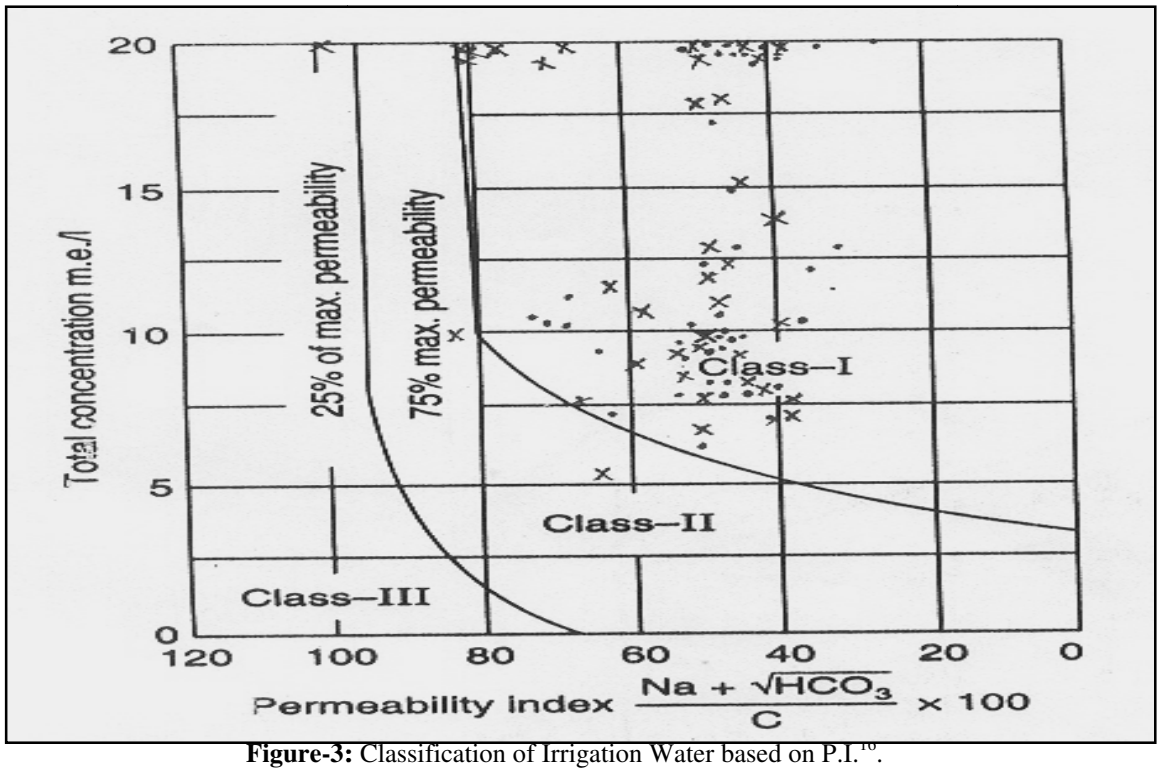

Figure-3: Classification of Irrigation Water based on P.I.[10].

References

1. Jasrotia A.S. and Singh R. (2007). Hydro chemistry and Ground water quality, Around Devak and Rui watersheds of Jammu Region. *J.K. Jour. Geol. Soc. India,* 69, 1042-1954.

2. Pandian K. and Sankar K. (2007). Hydrogeochemistry and Ground water quality in the Vaippar River Basin, Tamil Nadu. *Jour. Geol. Soc. India,* 69, 970-982.

3. Ramesh K., Li T. and Bhuvana J.P. (2012). Hydrogeochemical characteristics of Ground Water for Domestic and Irrigation purpose In Periyakulum Taluk of Theni District, Tamilnadu. *I. Res. J. Environmental Sci.,* 1(1), 19-27.

4. Garcia S.G., Lastoria G. and Henrique C.G. (2015). Hydrochemistry Applied to Water Supply System: A case study from a Brazilian Urban area. *Engineering Geology for society and Territory*, Springer, Chem. S, 1365-1368.

5. Haritosh A.K., Kaushik C.P., Kaushik A. and Yadav A.K. (2008). Suitability Assessment of groundwater for drinking, irrigation and Industrial use in some north India villages. *Environ. Monit Assess,* 145, 397-406.

6. Chen S. and Gui H. (2016). Quality Assessment and Hydrogeochemical characteristics of Ground water from coal bearing aquifer in Sunan Coal Mine, Anhui Province, China. *Nature Environment and Pollution Technology,* 15(4), 1341-1346.

7. Raghunath H.M. (1987). Groundwater. Wiley Eastern Ltd, New Delhi, 1-504, ISBN:81-224-1904-6.

8. Karanth K.R. (1987). Ground Water Assessment development and management. Tata McGrow Hill, New Delhi.

9. Aghazadeh N., Chitsazan M. and Golestan Y. (2017). Hydrochemistry and quality assessment of groundwater in the Ardabil area, Iran. *Applied Water Science*, 7(7), 3599-3616.

10. Wu H., Chen J., Qian H. and Zhang X. (2015). Chemical Characteristics and Quality Assessment of Ground water of exploited quibers in Beijiao water source of Yinchuan, China: A case study for Drinking, Irrigation and Industrial purposes. *Jou. Chem.*, 1-14.

11. Rao N.S., Vidyasagar G., Rao P.S. and Bhanumurthy P. (2017). Chemistry and Quality of Ground water in a coastal region of Andhra Pradesh, India. *Appl. Water Sc*, 7, 285-294.

12. Marghade D., Malpe D.B. and Zade A.B. (2011). Geochemical characterization of groundwater from northeastern part of Nagpur urban, Central India. *Environmental Earth Sciences*, 62(7), 1419-1430.

13. Rao P.N., Rao S.A. and Rao N.S. (2015). Suitability of groundwater quality for drinking, irrigation and industrial purposes in the Western Delta Region of the River Godavari, Andhra Pradesh. *Journal of the Geological Society of India*, 86(2), 181-190.

14. Prasanth R.S., Remya J. and Kumar R.B. (2015). Appraisal of Groundwater Quality Around two International Tourism Destinations, Kovalam and Vizhinjam, Thiruvananthapuram, Kerala, India. *Nature Environment and Pollution Technology*, 14(2), 307-312.

15. Raj D. and Kumar R.B. (2015). Judgement of Groundwater Quality Around Trivandrum Civil Station, Kerala, India: A GIS Based Approach. *Nature Environment and Pollution Technology*, 14(1), 157-160.

16. Doneen L.D. (1964). Notes on Water Quality in Agriculture published as a Water Science and Engineering Paper 4001. Department of Water Science and Engineering, University of California.

17. Richards L.A. (1954). Diagnosis and improvement of saline and alkali soils. Agricultural hand book 60. U.S. Dept. of Agriculture, Washington D.C., 160.

18. Regional Salinity Laboratory (US). (1954). Diagnosis and improvement of saline and alkali soils (No. 60). US Govt. Print. off.

19. Wilcox L.V. (1955). Classification and use of irrigation water. USDA circular 969, 19.

20. ISI (1983). Indian standards specifications for drinking water. IS: 10500.