International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

$Cl^-/(CO_3^{2-} + HCO_3^-)$ Ratio to Evaluate Salt Water Intrusion: A Case Study of Gnanapuram Area of Visakhapatnam, AP, India

Dr. P. Sarada[1], Dr. P. Bhushanavathi[2]

[1]Reader in Chemistry & IQAC Coordinator

[2]Selection Grade Lecturer in Chemistry, St Joseph's College for Women (Autonomous), Visakhapatnam.

Abstract: ***A systematic study has been carried out to evaluate salt water intrusion in the coastal aquifers around Visakhapatnam Port (Gnanapuram, Kobbarithota, Allipuram and Sevanagar) AP, India. The study area(latitude 83°17' and longitude 17°65') is at a distance of 2.5 to 3.0Km from the sea (Bay of Bengal) shore. Salt water intrusion can be one of the possible causes for ground water contamination. An attempt has been made to assess the impact of sea shore proximity on the ground water quality in the study area. Water samples have been collected from 12 open and bore wells (30-60ft deep) in the area and analysed to determine quantitatively the levels of carbonate and bicarbonate along with chloride. $Cl^-/(CO_3^{2-} + HCO_3^-)$ ratio is considered to be one of the important criteria to evaluate salt water intrusion in the study area. $Cl^-/(CO_3^{2-} + HCO_3^-)$ in all the samples is found to be less than 0.5. Therefore salt water intrusion is ruled out in the aquifers in the study area.***

Keywords: Water quality, Groundwater, Alkalinity, carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), Chloride.

1. Introduction

About 50% of the world's population lives within 60Km of the shore line. At present one third of fresh water used is ground water. Groundwater is believed to be comparatively much clean and free from contamination than surface water. But prolonged discharge of industrial effluents, domestic sewage, sea water intrusion and solid waste dump causes the groundwater to become polluted and creates health problems[1].The pollution of groundwater is of major concern because of its increasing use for human needs and industrial activity in the study area.

The city of Visakhapatnam is located on the east coast of India abutting Bay of Bengal (latitude 83°17' and longitude 17°65'). The topography of the city is sloping towards the Bay of Bengal. Average annual rainfall of the city is around 970mm. The city has a natural harbour which has been developed into a major port. Gnanapuram in Visakhapatnam is located on reclaimed marshy land. This area is at a distance of 2.5 to 3.0 Km from the sea shore and is very close to Visakhapatnam Port. It is also surrounded by many small and medium industrial establishments. Two huge storm water drains (geddas) carrying sewage flow perennially in this area. They flow east wards and join the Bay of Bengal. This area is densely populated by BPL families. People here depend on ground water extensively for their domestic needs and occasionally for drinking purpose as well. As is the case in other industrial areas, ground water potential as well as quality is facing a downward trend here. Salt water intrusion could be one of the reasons for the ground water problems in this area. Hence, it is felt necessary to undertake analysis of groundwater in the area in order to evaluate and ascertain the prospect of salt water intrusion. Cl^- is a dominant ion in sea water and bicarbonate is predominantly found in ground water. Therefore an appropriate assessment of salt water intrusion aspect requires establishing the levels of Cl^-, CO_3^{2-} & HCO_3^- quantitatively.

CO_3^{2-} & HCO_3^- levels are quantitatively determined by establishing the alkalinity of the water samples. Alkalinity is a measure of the capacity of water to neutralise acid in terms of $CaCO_3$(2). It is also a measure of the buffering capacity(3)of water. It is caused by the dissolved salts in ground water. Alkalinity is primarily due to the presence of carbonate(CO_3^{2-}), bicarbonate(HCO_3^-) and hydroxide(OH^-) ions in water. Whereas the source of carbonate and bicarbonate ions in ground water is the presence of their Na, Mg, Ca and K salts in rocks and soil, hydroxide ions are introduced by manmade activity. Total alkalinity is therefore a measure of carbonate, bicarbonate and hydroxide ion concentration in water. The pH value of the study samples was found to be in the range of 8.3 to 9.2. Chloride in ground water originates from both natural and anthropogenic sources. High chloride content indicates heavy pollution. Permissible limit of Cl^- in the groundwater as per WHO standards is 200 and as per BIS standards it is 250mg/l. All the samples showed Cl^- within the permissible limit.

Bicarbonate and carbonate ions are abundant in ground water but Chloride generally occurs in small amounts in ground water but is abundant in sea water. Salt water intrusion may be identified by the relative concentrations of some of the characteristic ions of sea water such as Cl^-, Na and Mg. Roger(4) recommended that $Cl^-/(CO_3^{2-} + HCO_3^-)$ ratio as a criterion to evaluate salt water intrusion aspect. This ratio is considered to be indicative of ground water contamination by sea water (Simpson (5)).

Table 1: Range of $Cl^-/(CO_3^{2-} + HCO_3^-)$ Vs Salt water contamination level

Range of $Cl^-/(CO_3^{2-} + HCO_3^-)$	Remarks with reference to salt water contamination
< 0.5	Normal ground water(no salt water contamination)
0.5 - 1.30	Slightly contaminated ground water
1.30 - 2.80	Moderately contaminated ground water
2.80 - 6.60	Injuriously contaminated ground water
6.60 - 15.50	Highly contaminated ground water(near sea water)
> 200.0	Sea water

Study Area

Visakhapatnam is a coastal city situated along Bay of Bengal. The study area is located right behind the stockyard of Visakhapatnam Port and extends upto 5 Sq Km. (latitude 83°17' and longitude 17°65'). It is about 2.5 Km away from the sea shore. Two large sewage drains (supposed to be storm water drains) perennially flow eastwards through it and join the Bay of Bengal. Ground water table is shallow in this area.

2. Materials and Methods

The groundwater samples were collected from 12 bore and open wells(25 to 70 feet deep) in selected stations of Gnanapuram. The samples were collected as per the standard methods recommended by APHA [6]. Before water sampling, all the double-stoppered polythene containers were cleaned and rinsed thoroughly with water samples to be analyzed. All reagents used were of analytical grade. The chemical analysis was done using the standard methods[6].

Sample collection and analysis: The groundwater samples are collected in the pre and post monsoon periods in the year 2014. Sampling was done thrice in the pre monsoon period and twice in the post monsoon time. Twelve ground water samples have been collected from the study area each time. The samples were then analyzed for alkalinity and Cl^- by following standard methods of APHA [6]. Samples were unfiltered and the concentration of the different parameters could correspond to their total concentration if the groundwater is used for drinking purpose.

Alkalinity is determined titrimetrically by titration against H_2SO_4. H_2SO_4 is standardised with standard Na_2CO_3 solution. Phenolphthalein alkalinity is determined by titration to pH 8.3. It corresponds to the total hydroxide and one half of the carbonate present in the ground water. Total alkalinity is determined by by titration to pH 4.3 using Green Bromocresol indicator. Total alkalinity measures all carbonate, bicarbonate and hydroxide in the sample. All the three ions have been quantitatively determined by measuring phenolphthalein alkalinity and total alkalinity. Cl^- is also determined titrimetrically by titration against $AgNO_3$. $AgNO_3$ is standardised with standard NaCl solution.

3. Results and Discussion

The average of concentration values (pre and post monsoon) for carbonate, bicarbonate and chloride (in mg/l) along with Phenolphthalein alkalinity and total alkalinity (in mg/l of $CaCO_3$) are separately presented in table-1. All the samples showed higher concentrations for the three ions in the post monsoon period than during the pre monsoon time. The same trend was also observed by Prtyanka et al. [8]. Blum[7] reported that higher concentrations of ions in summer is due to stagnation. Phenolphthalein alkalinity of all the samples is found to be less than one half of total alkalinity. This indicated the absence of hydroxide contribution to alkalinity. Therefore carbonate alkalinity is taken as twice Phenolphthalein alkalinity and bicarbonate alkalinity is taken as the difference between total alkalinity and carbonate alkalinity. The permissible limit of alkalinity is 20 - 200 mg/l as per WHO and BIS standards [9,10]. All the samples far exceeded the permissible limit. Alkalinity of >60 mg/l indicates hard water (11).

Permissible limit of Cl^- in the groundwater as per WHO standards is 200 and as per BIS standards it is 250mg/l[9,10]. All the samples showed Cl^- within the permissible limit. The ratio of $Cl^-/(CO_3^{2-} + HCO_3^-)$ is calculated. All the samples showed $Cl^-/(CO_3^{2-} + HCO_3^-)$ ratio of < 0.5. This indicated that there is no salt water intrusion in the ground water of the study area.

Table 2: The average of concentration values(pre and post monsoon)of CO_3^{2-}, HCO_3^- & Cl^- in mg/l

Sample No	Depth in feet	Phenolphthalein Alkalinity. mg/l($CaCO_3$)	Total Alkalinity. mg/l($CaCO_3$)	CO_3^{2-} mg/l	HCO_3^- mg/l	Cl^- mg/l	$Cl^-/(CO_3^{2-} + HCO_3^-)$
1	65	165.2	1073.8	198.24	906.95	98.3	0.089
2	69	165.2	991.2	198.24	806.18	80.1	0.080
3	70	165.2	1817.2	198.24	1813.9	75.2	0.037
4	62	247.8	2725.8	297.36	2720.84	100.9	0.033
5	30	247.8	1073.8	297.36	705.40	39.6	0.039
6	27	165.2	1652.0	198.24	1612.35	75.3	0.042
7	28	247.8	3304.0	297.36	3426.25	110.5	0.030
8	30	330.4	4047.4	396.48	4131.65	171.2	0.038
9	30	247.8	2147.6	297.36	2015.44	115.3	0.050
10	25	660.8	4130.0	792.96	3426.25	109.1	0.026
11	28	247.8	1982.4	297.36	1813.9	80.0	0.038
12	28	330.4	1652.0	396.48	1209.26	81.4	0.051

4. Conclusion

Above cited results show that the ground water in the study area is hard water with very high alkalinity. But there is no hydroxide ion contribution to alkalinity. Since none of the samples showed $Cl^-/(CO_3^{2-} + HCO_3^-)$ ratio of >0.5 salt water intrusion is totally ruled out. Though the Cl^- concentration of all the samples is within the permissible limit, overall water quality in the study area is unfit for drinking purpose but can be used for domestic chores.

5. Acknowledgements

One of the authors (Dr. P. Sarada) is thankful to UGC-SERO for the financial assistance extended to carry out the study.

References

[1] Raja, R. E.,Lydia Sharmila, Princy Merlin, J.,Chritopher, G. (2002). Indian J Environ Prot. 22(2), 137.
[2] Hammer, M. J. (1967). Water and Waste Water Technology. Chapter 2. 19.
[3] Ubale, M. B., Chamargore, J. J., Farooqui, M. and Pakhare, S. B. (2005). Indian Journal of Chemical Science. 3. 407.
[4] Roger, R. (1941). Am. Geophy Union Trans. 22. 503.
[5] Simpson, T. R. (1946) Salinas Basin Investigation Bull Calif. Div. Water Resource. Sacramento. 52. 230.
[6] APHA. (1995), Standard methods for the examination of water and waste water; Washington DC, USA.
[7] Blum, J. L. (1957). Hydrobiol. 9. 361.
[8] Trivedi, P., Bajpai, A., Thereja, S. (2010). Nature Sci. 8. 11.
[9] WHO. Guidelines for drinking water quality. 2004, Vol. I. 3rd Edn. World Health Organization, Geneva.
[10] BIS: Drinking Water Specifications, Bureau of Indian Standards, IS: 10500 (1991).
[11] Barret, P. H. (1953). Am. Fish. Soc.. 82. 708.