International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 617–622, Article ID: IJCIET_08_08_063
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

GROUNDWATER CONTAMINATION IN A PART OF WESTERN DELTA OF KRISHNA RIVER BASIN

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ABSTRACT

The management and maintenance of groundwater quality play a vital role in the development of a region as well as health aspects of living beings in that area. The contamination of groundwater also affects crop yield and production of crop. Hence a systematic study has been carried out to assess the ground water quality in Vallabharaopalem (Latitude: 16.0558^0 N; Longitude: 80.5251^0 E) and Upparapalem (Latitude: 16.0804^0 N; Longitude: 80.5013^0 E) villages of Ponnur mandal in Guntur district, which is a part of western delta of Krishna river in Andhra Pradesh state of India. The formations in the study area belong to recent alluvium. Groundwater occurs under unconfined conditions. The groundwater is analyzed for various physico-chemical parameters. Values of most of these parameters such as electrical conductivity fall beyond the standard limits for drinking water. The chloride-bicarbonate ratio more than 6 as per Revel's classification suggested that the groundwater is injuriously contaminated with saline water. The present attempt is made to understand the contamination in the groundwater quality. Suitable precautionary measures are suggested for sustainable development of ground water quality to maintain the environmental balance in the study area. The present study can be extended in similar critical contaminated areas throughout the world.

Keyword: Groundwater pollution, Krishna river basin, Andhra Pradesh, Groundwater quality

Cite this Article: R. V. Ramana, Groundwater Contamination in A Part of Western Delta of Krishna River Basin, International Journal of Civil Engineering and Technology, 8(8), 2017, pp. 617–622.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

Groundwater use and its dependency is increasing day by day especially in rural areas of Guntur District, Andhra Pradesh, India for irrigation and drinking purposes. Transgression and incursion of saline water deteriorates the quality of groundwater in coastal regions and

many river basins in the country (Bhatt and Saklani 1996; Elampooranan et al. 1999; Umar and Absar 2003; Aravindan et al. 2004;Khurshid and Zaheerudin 2004; Subba Rao et al. 2005; Subramani et al. 2005; Rajmohan and Elango 2006; Gopinath and Seralathan 2006; Jeevanandam et al. 2006;Shankar et al. 2011; Subba Rao et al. 2012b) [4, 7, 27, 3, 12, 23, 25, 15, 8, 10, 16, 24]. Earlier studies carried out in the area are on geochemistry of groundwater (Subba Rao 2002) [19], prospecting and management of groundwater resources (Subba Rao 2003a) [20] and seasonal variation of groundwater quality (Subba Rao 2006) [21]. Literature suggests that little work on this aspect has so far been done in India (Durvey et al 1991; Agrawal and Jagetia 1997; Niranjan Babu et al 1997; Majumdar and Gupta 2000; Khurshid et al 2002; Sreedevi 2004; Subba Rao 2008) [6, 1, 14, 13, 11, 18, 22]. By knowing various geochemical processes responsible for deterioration of groundwater quality, the managers can plan and to be maintain and monitor the groundwater quality in that area. Hence an attempt is made in this paper to examine the associated hydro geochemical processes.

2. STUDYAREA

2.1. Location

The area is located west of Ponnur town in ponnur mandal of Guntur district in Andhra Pradesh and lies in between East longitude 80.5013^0 and 80.5251^0 and North latitude 16.0558^0 and 16.0804^0 and shown in map enclosed (Figure 1). The Vallabharaopalem and Upparapalem villages are situated west side of the Tungabhadra drain which drains north to southwards into the Bay of Bengal. The study area has gentle slope and scattered drainage pattern.

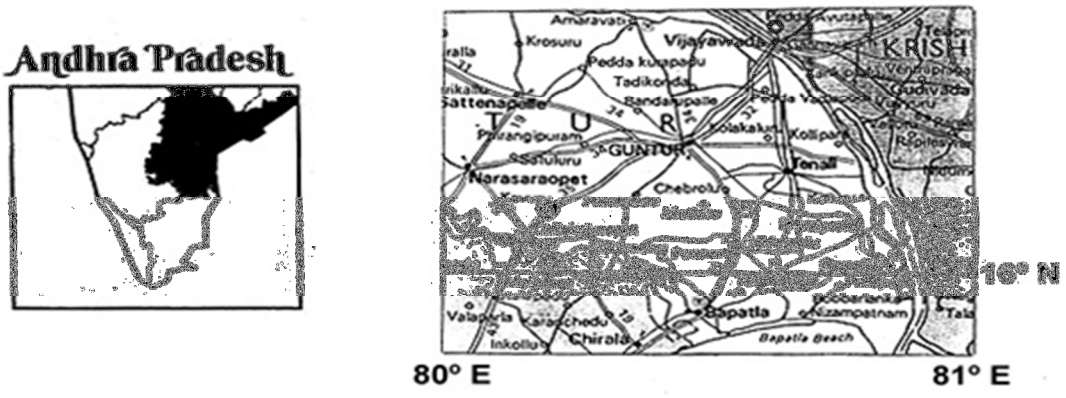

Figure 1 Location map of Vallabharaopalem and Upparapalem villages in Guntur district, A.P.

2.2. Physiography

The area is plain and has gentle dip towards the Bay of Bengal. In general the drainage is not well defined and scattered drainage pattern have developed as irrigation channels and drains.

2.3. Hydrogeology

The area contains alluvium of recent age. The alluvium consists of both sands and clays in this area (CGWB) [5]. The alluvium comprises of coarse permeable to medium sands and all along the Tungabhadra drain and also in and around the villages of Vallabharaopalem and Upparapalem. The permeable sandy deposits occur down to a depth range of 10 to 22 meters, underlained by thick clay in which the quality of ground water is saline. Fresh Ground water occurs in sandy aquifer. Rainfall and canal water are the direct recharge sources of the groundwater. Ground water is extracted by means of shallow filter points for irrigation

purpose. The depth to water level varies from 3.2 to 4.6 meters below ground level. The thickness of alluvium sands range from 10 to 26 meters.

3. QUALITY STUDIES

During the hydro geological reconnaissance investigations carried out in Vallabharaopalem and Upparapalem areas, it is observed that in the recent past, quality of ground water has deteriorated significantly. This feature is predominant in the areas nearer to Tungabhadra drain. Keeping in view of this quality problem in this area, 6 samples of ground water from each village during Pre monsoon and post monsoon of 2016 were collected to examine the associated hydro geochemical processes leading to salinity by a number of anthropogenic activities within the flow path (Todd, 1980; Hem, 1991) [26, 9]. Physical parameters of water samples such as P^H and spot electrical conductivity (EC) were measured in the field, immediately after the sampling, using portable EC meter. All standard precautions, necessary for reliable estimation were observed during field measurement. The accuracy of measurement was ± 0.1 units. The groundwater samples after collection were subjected to determination of hydrochemical parameters such as calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl), sulphate (SO_4) ions. The sampling, preservation and analytical techniques used are as per the reputed laboratories for analysis of groundwater samples and American Public Health Association (APHA) manual of 'Standard Methods for Examination of Water and Wastewater. The accuracy of chemical data for major ions is estimated from the electro neutrality condition. Spot/ field EC is selected for assessment of groundwater quality as it represents total ionic content in water. It indicates the extent of mineralization in groundwater and generally increases with contamination, flow, and residence time of water in the aquifers. It is one of the important parameters that reflect even minor changes in the quality of groundwater from shallow aquifers. Average chemical analysis data of ground water samples for the year 1976 (APSGWB, 1976) [2], Pre monsoon and post monsoon of 2016 is considered and compared. The data is presented in the Table 1.

Table 1 Showing the chemical analysis of ground water samples in Vallabharaopalem and Upparapalem villages in Guntur district, A.P. (in meq/l)

Chemical Parameter	A – Vallabharaopalem Village			B – Upparapalem village		
	1976	Post monsoon 2016	Pre monsoon 2016	1976	Post monsoon 2016	Pre monsoon 2016
^{H}	7.59	8.98	9.12	7.51	8.99	9.26
EC (µs/cm)	1.85	2.92	3.05	1.49	3.14	2.98
CO_3^2 (meq/l)	0.28	3.58	3.78	0.17	3.49	3.61
HCO_3	5.78	2.37	2.47	3.02	2.25	2.56
Cl	8.36	18.51	17.81	5.22	18.84	18.78
SO_4^2	0.43	3.92	5.04	3.30	7.06	7.38
Ca^{2+}	2.22	1.25	1.51	1.03	1.20	1.41
Mg^{2+}	2.12	1.62	1.78	0.97	1.36	1.74
Na^+	3.80	38.32	37.26	1.72	36.54	36.17
K^+	0.18	0.37	0.57	0.08	0.28	0.68
Ratio(Cl^- /HCO_3^-)	1.43	7.77	7.17	1.72	8.45	7.37

Table 2 Chloride/Bicarbonate ratio as per Revel's classification

S. NO	Name of Category	Range Ratio of Chlorite/Bicarbonate
1	Non-contaminated (fresh water)	<1
2	Slightly contaminated	1-2
3	Moderately contaminated	2-6
4	Injuriously contaminated	6-15
5	Highly contaminated	15-25
6	Very highly contaminated sea water	>25

3.1. Chloride / Bicarbonate ratio (Cl^-/HCO_3^-):

It is observed from Table 1 that the chloride / bicarbonate (Cl^-/HCO_3^-) ratio of ground water in Vallabharaopalem area is 1.43 in 1976 ranges from 7.17 to 7.77 during Pre monsoon and post monsoon of 2016. The chloride bicarbonate (Cl^-/HCO_3^-) ratio is 1.72 in Upparapalem area in 1976 and 7.37 and 8.45 during Pre monsoon and post monsoon of 2016 respectively.

Chloride is dominant anion of ocean water, and normally occurs in only small amounts in fresh ground water. On the other hand bicarbonate is usually most abundant anion in ground water and occurs in only minor amounts in sea water. The chloride-bicarbonate ratio, more than 6 indicates the injuriously contaminated ground water with sea water as per table 2. Accordingly the ratio is 1.43 in Vallabharaopalem and 1.72 in Upparapalem during the year 1976 indicates that there is no contamination of ground water during that period. The ratio ranges from 7.17 to 8.45 in the Pre monsoon and post monsoon of 2016 years indicating the injuriously contamination of ground water with sea water.

The quality deterioration of ground water in the area may be due to increasing in ground water development through filter points and subsequently ingress of back waters from Tungabhadra drain. The number of filter points increased to 928 in Vallabharaopalem and 792 in Upparapalem areas. In the study areas, the aquifer is highly potential because of paleo channel which runs north to south and passing through the villages of Vallabharaopalem and Upparapalem. In spite of the fact that the exploitation of ground water in the area is more, there is no declination of water table because of potential aquifer in the burned channels. The more or less stable ground water level maintained also may be due to the contribution of back water from drain. These two factors are responsible for stable condition of the water table. This stable nature of water table is confirmed with water levels recorded in Ponnur observation wells. However, the studies indicated that the wells which are nearer to the drain shows a decrease in ground water quality than the wells which are far away.

4. CONCLUSIONS

Based on the hydro geological investigations and considering the historical quality data of groundwater, it is confirmed that the deterioration of groundwater quality in the villages of Vallabharaopalem and Upparapalem closer to the Tungabhadra drain due to ingress of back water from Tungabhadra drain into ground water. The following measures can be taken up to prevent deterioration of ground water quality in the area. Tidal regulators should be constructed on the drain to prevent back waters in the area at suitable places after consulting with Drainage Engineers. Exploitation of ground water should be controlled and regulated. Artificial recharge wells should be constructed in the contaminated area. For recharging these wells, surface water from canal can be used. The ground water department should be monitored the quality of ground water by establishing observation wells in the area.

5. ACKNOWLEDGEMENTS

Author is thankful to Andhra Pradesh State Groundwater Board (A.P.S.G.W.B) for providing information regarding groundwater quality in the villages of Mamillapalli and Aremanda villages in Ponnur mandal in the year 1976.

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