RESEARCH PAPER | Applied Geochemistry | Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

Hydro Geochemical Studies in Nagavali Micro Watershed, Vizianagaram District, Andhra Pradesh, India

KEYWORDS: Hydro-chemical, Micro-Watershed, Nagavali.

G. Sakram	G. Chandra Mouli	Sripada Narala
Department of Applied Geochemistry, Osmania University, Hyderabad-07.	Department of Applied Geochemistry, Osmania University, Hyderabad-07.	Department of Environmental Science, Osmania University, Hyderabad-07.

Soujanya	Praveen Raj Saxena
Department of Environmental, Osmania University, Hyderabad-07.	Department of Applied Geochemistry, Osmania University, Hyderabad-07.

ABSTRACT *Hydro geochemical studies were carried out in Nagavali Micro watershed Vizianagaram District Andhra Pradesh, India. The major variables affecting the ground water quality and suitability for domestic, agricultural and industrial purposes were studied. Forty two water samples were analyzed for various physico-chemical attributes and correlated with those of World Health Organization (WHO, 2006) standards. Major cations (Mg +2, Ca+2, Na+, K+,) and anions (CO3- , HCO3-, NO3-,Cl-, F-) . An overall view is that all samples falls within the permissible limits expect for few locations.*

INTRODUCTOIN:

Water is an essential natural resource for sustaining life and environment that we have always thought to be available in abundance and free gift of nature. However chemical composition of surface or subsurface water is one of the prime factors on which the suitability of water for drinking, irrigation and industrial purpose depends. Fresh water occurs as surface water and ground water. Groundwater contributes only 0.6% of the total water resources on earth. Groundwater is the most important source of drinking, irrigation and industrial water supply in the world. It is the major and preferred source of drinking water in rural and urban areas particularly in India. Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Mirribasi et al., 2008). The quality of groundwater is constantly changing in response to daily, seasonal and climatic factors. Rock weathering, Atmospheric precipitation, Evaporation and Crystallization control the chemistry of water (Gibbs, 1970). The influence of geology on chemical water quality is widely recognized (Gibbs, 1970; Langmuir, 1997; Lester and Birkett, 1999). The influence of soils on water quality is very complex and can be ascribed to the processes controlling the exchange of chemicals between the soil and water (Hesterberg, 1998). Hence, the knowledge of hydro geochemistry is very essential as it seeks to determine the origin of the chemical composition of ground water and the relationship between water and rock chemistry, particularly as they relate to ground water movement (Zaparozec, 1972).

Apart from natural factors influencing water quality, human activities such as domestic, agricultural and industrial practices impact negatively on groundwater resources. Continuous monitoring of water quality parameters is highly crucial because changes in the quality of water have far reaching consequences in terms of its effects on man and biota (Sakram et al, 2013 and madhusudhana reddy et al, 2014). Water quality data is essential for the implementation of responsible water quality regulations for characterizing and remediating contamination and for the protection of the health of humans and the ecosystem. Ground water quality data gives important clues to geologic history of rocks and indication of ground water recharge, discharge, movement and storage (Walton, 1970). Regular monitoring of groundwater resources thus play a key role in sustainable management of water resources. Therefore, determination of groundwater quality is important to observe the suitability of water for various purposes. Hence the main objective of this study is to assess the hydro geochemistry of ground water in Nagavali micro-watershed for utilizations in drinking, irrigation and industrial purposes.

STUDY AREA:

The area is about 100 sq.km in extent and lies around 80kms north of the vizianagram town of Andhra Pradesh, India. The study area is located in the Survey of India Toposheet No. 65 N/5 and lies within the latitudes 18^0 46′ to 18^0 52′ N and longitudes 83^0 21′ to 83^0 32′ E (FIG 1).The average precipitation of the study area is 1219.20 mm, the monsoon generally sets in the middle of June and withdraws by middle of November during this period 80% rainfall is received. Precipitation was experienced by both North-East and South-West monsoon in different degrees.

GEOLOGY OF STUDY AREA:

The study area is mostly underlain by Archaean group of rocks consisting of Khonadalites occurs in eastern and southern parts of the district. Charnokites are exposed in the north-western part of Salur, eastern parts of Paravathipuram and parts of vizianagram. Quartz veins are intruded into Khondalites and occur in the Chandalangi village. Granite and granite-gneisses occurs in parts of vizianagram no exposure seen in study area .And finally sub-recent formations consisting of lateritic also exist in some areas.

MATERIALS AND METHODS:

The water samples were collected in various villages of Paravathipuram division. Pre-cleaned two liter polythene

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

bottles were used to collect 42 water samples (36 ground water samples and 6 surface water samples) and numbered sequentially. The bottles were rinsed with same water which is to be taken sample to avoid possible cross contamination and every precautionary measure is followed for the best results. Various sample points were shown in (FIG 2). The water samples were analyzed for major ion chemistry as per standard methods (APHA, 1998).

The PH and Electrical conductivity (EC) were measured with PH meter and Electrical conductivity meter (CM-180); Total Hardness (TH) as $caco_3$ and (Ca^{+2}) were analyzed titrimetrically using standard EDTA solution, carbonates (CO_3^-) and bicarbonates (HCO_3^-) were estimated by titrating with standard H_2SO_4 solution, Chloride (Cl^-) was estimated by standard $AgNo_3$.Sodium and potassium by Inductively Coupled Plasma Mass Spectrometer (ICPMS). Nitrates, Sulphates and Fluoride were measured using spectrophotometer. Magnesium was computed taking the reference values of TH and Ca^{+2} values. Total Dissolved Solids (TDS) calculated from electrical conductivity using empirical equation. All the parameters are expressed in mg/l expect PH and EC. EC is expressed in microsiemens/centimeter (µs/cm) at 25°c.

RESULTS AND DISCUSSION:
The analytical results of water samples in study area shown in table.1. The statistical parameters of the variables minimum, maximum and mean along with standards (WHO, 2006) of chemical parameters summarized in Table.2

SUITABILITY FOR DRINKING PURPOSE:
The quality of 42 water samples are considered to determine its suitability for different purposes depending on the specific standards .WHO (2006) standards was the basis for determining water sample quality for drinking purposes.

PHYSICAL PARAMETERS:
The PH of the water samples in study area ranges from 6.47 to8.5 with a mean of 7.1 hence, 100% of water samples within the permissible limits. There were no abnormal trends found in the distribution patterns of temperature maximum and minimum recorded respectively 35.9°c and 17.2°c during the period of study. EC of the water samples ranges from 211µs/cm to 1987µs/cm with a mean of 1005µs/cm. 23.3% of samples exceeding the permissible limits. High conductance was observed in most of the samples this may be attributed to high concentration of chloride in ground waters (Davis and Dewist 1996) and also due to ion exchange, evaporation, rock water interaction sulphate reduction and oxidation process (Ramesh 2008).

CHEMICAL PARAMETERS:
The dissolved solids of water samples in the study area varying from 137 to 1291mg/l with a mean of 660mg/l max concentration observed in Paravathipuram and mini at Nagavali around 21.4% of samples exceeding the limits. Higher concentration of TDS in study area is due to combined effect of litho-chemistry, sewage contamination and agricultural activities. Total hardness in the study area varies from 40.6 to 478mg/l with an average of 150mg/l. Max concentration observed in laxminarayanapuram and mini at Paravathipuram town. According to WHO standards the TH is 500mg/l all samples are within the limits in study area.

MAJOR ION CHEMISTRY:
Calcium concentrations are varying from 21.3 to 264 mg/l with an average of 75.26mg/l. The standard for drinking is specified as 75mg/l (WHO 2006). 28.57% 0f samples exceeding the limits max concentration observed in Chinabondapalli & krishnapalli and mini in Kallikota village at Komrada mandal.Ca^{+2} is derived mainly from weathering of silicate minerals like feldspars, amphiboles and pyroxenes (Karanth, 1987). Magnesium concentration varies from 18.6 to 214mg/l with a mean of 63.02mg/l.50% 0f samples exceeding the limits max conc is observed in laxminarayanapuram and mini at Kallikota area. The sources of Mg^{+2} is mainly due to ion exchange of minerals in rocks & soils by water and also dissolution of some carbonate minerals like Dolomite .Sodium concentration ranges from 0.135 to 56.894mg/l with a mean of 4.99mg/l. In the study area all the samples fall within the permissible limits max conc is observed in Kottavalasa and mini P.N.R.valasa village. Potassium concentration varies from 0.77 to 96.64mg/l with an average of 36.93mg/l 19.04% of samples exceeding the limits. Max conc observed in krishnapalli village.

Carbonates concentration varies from 0 to 43.2mg/l with an average of 8.22mg/l according to WHO standards the concentration of carbonates varies. Max conc observed in Patakallikota. Bicarbonates concentration ranges from 104.3 to 839.9mg/l with a mean of 357.44mg/l .In study area all the samples are within the permissible limits, max conc is observed in Paravathipuram town. Chlorides (Cl) concentration varying from 8.094 to 741.95mg/l with an average of 136mg/l.19.04% of water samples exceed the limits max conc is observed from Kallikota village and mini at sunki village. The source of Cl in water samples is due to weathering of phosphate mineral apatite present in granite and granodiorites of study area. Sulphates (SO_4^{-2}) concentration ranges from 4 to 230mg/l with a mean of 72.26mg/l the drinking water standards for SO_4^{-2} is specified as 400mg/l according to WHO (2006).Hence all the water samples falls within the permissible limits. Max conc is observed from Kallikota, Duggi, Addapuseela village and mini from Artham, Santhospuram village. Fluoride (F) concentration of the water samples in study area ranging from 0.1 to 1.0mg/l with a mean of 0.45mg/l. All the samples are within the permissible limits as per WHO (2006) standards .Nitrate (NO_3^-) concentration of the study area ranging from 6 to 100mg/l with an average of 35.52mg/l.23.80% of samples exceeding the limits. Max conc were observed from Kallikota, pedamariki, rajyalaxmipuram, artham, sivini, seetarampuram, Paravathipuram (Rythu bazar), M.R.Nagaram, kandivalasa and laxminarayanapuram village and mini conc from venkampeta village. The source of NO_3^- in study area is mostly due to cultivation and excessive use of fertilizers (90% of people depend on agriculture).

The results are presented in (Table1) and summarized in (Table2) the water samples are congenial for drinking purpose except for few location of samples which can be treated using standard methods

CLASSIFICATION OF GROUND WATER:
Major cations Mg^{2+}, Ca^{+2} K^+, Na^+ and anions SO_4^{2-}, NO_3^-, F^-, Cl^-, CO_3^{2-},$^-$, HCO_3^- (in meq/l) were plotted in Piper Trilinear diagram(Piper 1944) to evaluate the hydrochemistry of ground water of Nagavali micro-shed.

The plots show that most of the ground water samples fall in the fields of alkaline earth metals (Ca^{2+},Mg^{2+}) dominat-

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

ing over the alkalies (Na^+, K^+) and weak acids (CO_3^{2-}, HCO_3^-) exceeds the weak acids (SO_4^{-2}, Cl^-, F^-). The ground water shows secondary salinity and alkalinity dominate over primary salinity and alkalinity. According to Hydro-chemical facies water types classified into cations(Mg>Ca>Na) and anions(HCO_3>SO_4>Cl).

SUITABILITY FOR AGRICULTURE PURPOSES:

The suitability of ground water for agricultural or irrigation purposes depend upon the effects of mineral constituents of water on both plants and animals. Water quality criteria can be used as guidelines by the farmers for selecting appropriate management practice, if the quality of water would pose any problem to maintain soil productivity with the benefit of high crop field irrigation. The general methods which were employed to assess the irrigation water quality are SAR, USSL Method, RSC and TDS. 36 ground water samples were assessed and compared with their respective standards.

ALAKALINITY HAZARD (SAR)

SAR is an important parameter for determining the suitability of ground water because it is a measure of alkali/ sodium hazard to crops. SAR is calculated by the following formula

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

The calculated value of SAR is > 10. All samples fall in the excellent type of water class.

U.S SALINITY LABORATORY METHOD (USSL):

This method is based on SAR. The analytical data plot on U.S salinity diagram(Fig: 5) shows that 55.55% of the ground water samples fall in the field of C_3S_1 indicating high salinity and low sodium waters which are well suitable for all types of soils with a little danger of exchangeable sodium. 41.66% of the ground water samples fall in $C2S_1$ indicating low salinity and medium sodium which have appreciable sodium hazard in fine textured soils.

RESIDUAL SODIUM CARBONATE (RSC)

In water having high concentrations of bicarbonates there is a tendency for Ca^+ and Mg^+ to precipitate as carbonates. To qualify this effect an experimental parameter termed as residual sodium carbonate (Eaton 1950) was used. RSC is calculated as follows:

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

All the samples fall in good category with RSC>1.25 which is safe for irrigation.

TOTAL DISSOLVED SOLIDS (TDS)

The TDS of the ground water in the study area has been classified by Carroll (1962). Around 80.95% of samples fall in fresh water class. Salts of calcium, magnesium, sodium, potassium present in the irrigation water may prove to be injurious to plants. When present in excessive quantities, they reduce the osmotic activities of the plants and may prevent adequate aeration. Accordingly, all the sampling stations considered suitable for irrigation uses. Classification of ground waters for irrigation purposes is as follows (Table 3).

SUITABILITY FOR INDUSTRIAL PURPOSES:

The quality requirements for industrial water supplies range widely and almost every industrial unit has its own standards. Water used by industries can be classified as cooling, boiler and process waters. Industries frequently suffer from incrustation and corrosion, which are chemical reactions caused by poor waters and has adverse effects on processing, steaming and cooling. In the present study, the following water quality criteria have been adopted (Subba et al., 2005) for defining the incrusting and corrosive properties of waters. (Table: 4)

Based on the given (Table:4) it can be observed that TH is high in the ground water samples compared to industrial standards which can cause incrustation. PH, SO_4^{-2}, HCO_3^-, TDS and Cl are according to the industrial standards. Except for TH all the samples are within the limits safe and suitable for industrial purpose.

CONCLUSION:

The ground water quality of Nagavali area, Andhra Pradesh of India was assessed for the suitability of ground water for drinking, irrigation and industrial purposes. The groundwater nature is explained by Piper trilinear diagram which indicates that calcium and bicarbonate type of water class were dominant in the study area. The physical parameters fall within permissible limits as per WHO (2006). Major cations and anions are also present in desirable limits except for calcium (Ca^{2+}), Potassium (K^+), Magnesium (Mg^{2+}), Chloride (Cl-) and Nitrate (NO_3^-) due to anthropogenic activities and geological characteristics. The suitability of ground water for irrigation was evaluated based on SAR, RSC and TDS. Most of the samples of ground water in Nagavali area are suitable for irrigation purposes. The values of EC and SAR were plotted on U.S salinity diagram indicating high salinity and low sodium hazard and also low salinity & medium sodium. Only TH values were noted to be high indicating the quality of water if used causes incrustation and corrosion of pipes. Overall the ground water quality of the study area found to be suitable for drinking, irrigation and industrial purposes except in few areas.

ACKNOWLEDGEMENTS:

We would like to thank Head Department of Applied Geochemistry for providing immense facilities.

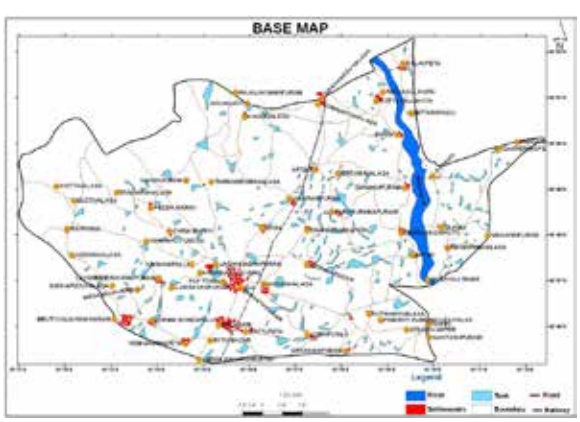

Fig .1 Base map of the study area.

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

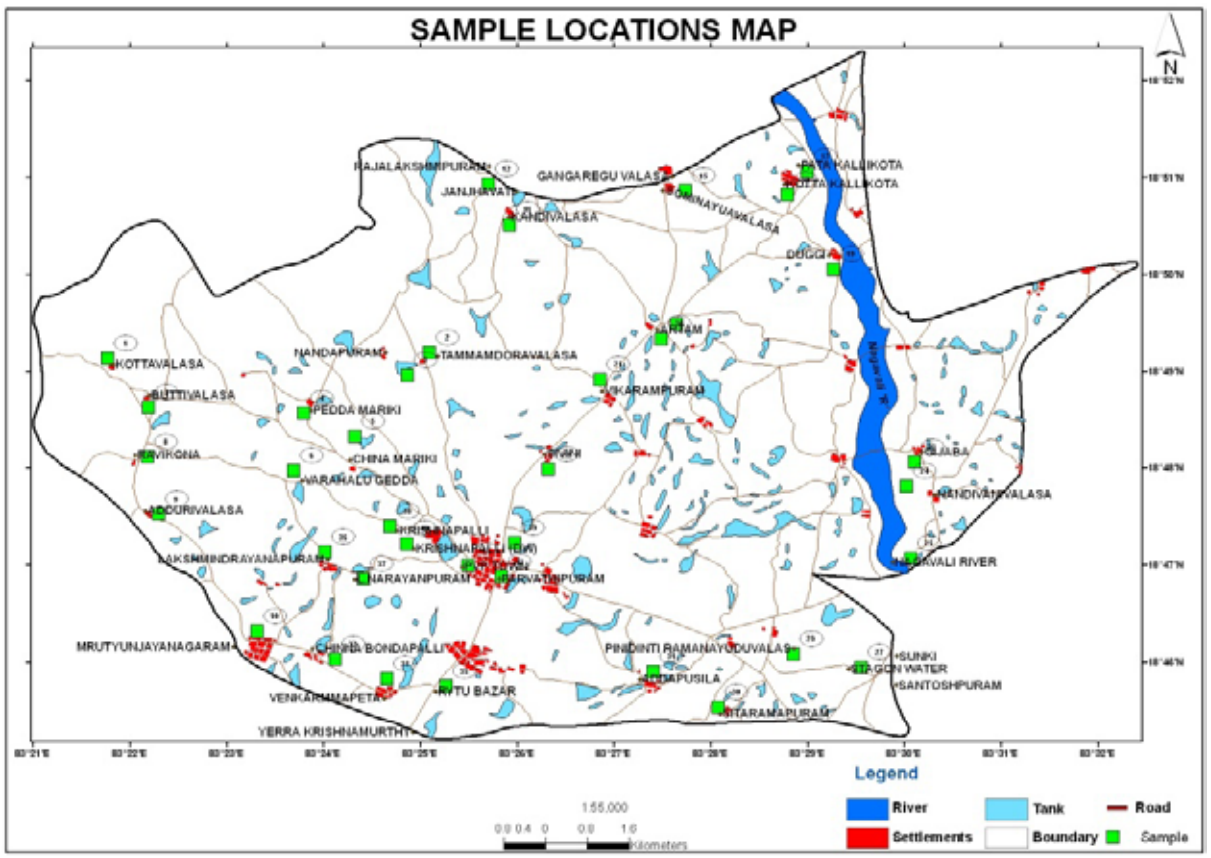

Fig .2 Sample Location map.

s.no	type	PH	EC	TH	TDS	Ca^{+}	Mg^{+}	Na^{+}	K^{+}	Co_3^{-}	Hco_3^{-}	So_4^{-}	No_3^{-}	Cl^{-}	F^{-}
1	B.W	6.89	600	96	390	66.1	37.2	56.8	10	21.6	329.4	39	20	29	0.3
2	B.W	7	930	129.3	606	110	55.8	22	22	10.8	274.5	9	10	121	0.6
3	P.W	8.5	580	73.9	377	139	37.2	2.8	55	21.6	285	8	8	40	0.4
4	B.W	6.99	1240	160.6	806	139	65.1	4.25	63	0	395.2	8	70	121	0.3
5	B.W	6.85	896	123.9	582.4	22	65.1	3.74	53	0	120.7	133	40	172	0.2
6	R.W	8	410	79.3	267	51.4	27.9	3.91	444	21.6	214.1	23	10	8	0.3
7	B.W	6.93	480	57.3	312	66	27.9	3.07	0.7	16.2	197.6	78	30	24	0.2
8	B.W	6.85	630	73.9	409.5	88	37.2	2.95	46	0	356.8	117	20	21	0.4
9	B.W	7.74	562	88.6	365.3	66	37.2	1	41	32.4	279.9	21	10	21	0.4
10	B.W	6.7	1870	309.7	1216	264	148	2.6	40	16.2	334.8	20	100	596	0.2
11	B.W	7.06	1890	225	1229	29	93	2.7	16	0	472.1	151	100	299	0.2
12	W.W	7.25	1780	250	1157	36.7	111	2.44	45	16.2	312.9	112	80	269	0.3
13	B.W	7.28	740	92.5	481	73.5	55.8	1.3	47	27	345.8	115	10	16	0.5

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

14	B.W	7.34	800	120	520	66.1	46.5	2.34	78	21.6	400.7	172	20	35	0.6
15	B.W	7.33	910	120	591.5	73.5	46.5	2	38	32.4	406.2	20	20	59	0.5
16	B.W	6.87	510	79.3	331.5	51.4	27.9	1.42	18	0	274.5	6	10	26	0.3
17	B.W	7.18	1183	121.9	769	66.1	55.8	2.35	93	43.2	159.2	8	30	97	0.6
18	B.W	6.96	1930	371.2	1255	21.3	158.2	0.99	15	16.2	351.3	215	100	741	0.7
19	B.W	7.12	840	112.6	546	66.1	46.5	2.36	23	32.4	455.6	226	30	64	0.4
20	B.W	6.9	987	162.6	641.6	88.2	74.4	2.5	68	0	587.4	8	50	91	0.4
21	B.W	7.06	1479	207.7	961.4	124	83.7	2.25	50	5.4	417.2	136	60	188	0.2
22	B.W	6.87	1800	234	1170	132	102	4.5	10	0	450.1	54	70	272	0.4
23	B.W	7.3	739	96	480.4	58.8	37.2	1.32	30	0	455.6	8	20	24	0.6
24	B.W	7.2	1201	96	780.7	58.8	37.2	0.54	32	0	505	35	20	107	0.9
25	W.W	7.18	1010	114.6	656.5	58.8	55.8	0.56	20	0	516	4	20	62	1
26	R.W	7.59	211	40.6	137.2	22	18.6	11.25	20	0	104.3	164	8	16	0.2
27	B.W	7.2	614	96	399.1	58.8	37.2	1.2	24	0	378.8	21	10	16	0.5
28	S.W	7.68	365	57.3	237.3	29.4	27.9	0.12	15	0	186.6	14	10	35	0.4
29	B.W	6.98	1009	140.5	655.9	66.1	74.4	0.13	12	0	389.7	16	30	83	0.7
30	B.W	6.8	1889	184.4	1228	110	74.4	35	26	0	505	181	60	221	0.5
31	B.W	6.85	1834	278	1192	139	139	0.49	24	0	505	230	30	280	0.5
32	B.W	7.12	1987	250	1292	139	110	1.13	23	0	839.9	22	20	299	0.3
33	T.W	7.44	290	40.6	188.5	22	18.6	1.45	24	0	148.2	133	8	24	0.2
34	W.W	6.96	601	97.9	390.7	51.4	46.5	1	61	0	225	127	10	70	0.4
35	B.W	7.04	734	121.8	477.1	66	55.8	1	35	0	406.2	23	6	51	0.5
36	B.W	7.08	985	153.1	640.3	88	65.1	3.22	45	0	400.7	156	20	102	1
37	B.W	6.47	776	112.5	504.4	66	46.5	1.4	40	0	148.2	13	60	97	0.4
38	B.W	6.85	1981	478	1288	264	214	1.6	19	0	494.1	6	90	706.	0.1
39	P.W	7.03	385	56.9	250.3	29	27.9	2.9	18	0	137.2	47	20	40	0.5
40	P.W	6.97	689	394.9	447.9	36.7	27.9	2.18	18	0	301.9	58	10	62	0.5
41	B.W	7.29	1150	110.7	745.5	73.5	37.2	2.3	25	0	570.9	73	9	94	0.9
42	W.W	7.46	716	121.9	765.5	66.1	55.8	2.5	96	10	373.3	25	7	32	0.4

Table 1 Analytical result of various Pysico-chemical parameters of water samples in study area (mg/l)

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

B.W=Bore Water, R.W=River Water, P.W=Pure Water, T.P=Tap Water, W.W=Well Water, S.W=Stagnant Water.

Parameters	Minimum	Maximum	Mean	WHO(2006)	% of Samples exceeding
PH	6.47	8.5	7.1	6.5 - 8.5	-------
Conductivity(µs/cm)	211	1987	1005	1400	23.3%
Total hardness(mg/l)	40.6	478	150.73	500	--------
Total Dissolved Solids (mg/l)	137.15	1291.55	660.48	1000	21.4%
Sodium(mg/l)	0.13	56.89	4.99	200	-------
Potassium(mg/l)	0.77	96.64	36.93	55	19.04%
Calcium(mg/l)	21.3	264	75.264	75	28.57%
Magnesium(mg/l)	18.6	214	63.02	50	
Carbonate(mg/l)	0	43.2	8.228	varies	-------
Bicarbonate(mg/l)	104.3	839.9	357.44	1000	---------
Sulphate(mg/l)	4	230	72.26	400	---------
Nitrate(mg/l)	6	100	32.523	50	23.08%
Chloride(mg/l)	8.09	741.95	136.88	250	19.04%
Fluoride(mg/l)	0.1	1.0	0.45	1.5	----------

Table 2 Comparison of Physico-chemical parameters of water samples with WHO (2006) Standards

Parameters	Range	Water class	% of samples exceed
SAR	10	Excellent	All
	18	Good	Nil
	18-26	Doubtful	Nil
	26	Unsuitable	Nil
RSC	>1.25	Good	All
	1.25-2.50	Doubtful	Nil
	2.5	Unsuitable	Nil
TDS	0-1000	Fresh	80.95%
	1000-10,000	Brackish	19.04%
	10,000-1,00,000	Saline	Nil
	>1,00,000	Brine	Nil

Table 3 Classification of ground water on the basis of SAR, RSC and TDS

Parameters	Study area values	Industrial standards (Subba rao, et, al 2005)	Affects
PH	7.1	<7	SAFE
TH	478mg/l	>300 mg/l	Incrustation
TDS	660.48mg/l	>1000mg/l	SAFE
SO_4	72.26mg/l	100mg/l	SAFE
HCO_3	357mg/l	400mg/l	SAFE
Cl	136mg/l	>500mg/l	SAFE

Table.4 Classification of ground water for the suitability in industrial purposes (Subbarao, et, al 2005)

Volume : 4 | Issue : 8 | August 2014 | ISSN - 2249-555X

REFERENCE

Ahmad, A. and Alam, M. 2003. Physico-chemical and Toxicological Studies of Industrial Effluents in and Around Delhi and Ground water quality of some Area in Delhi City. Chemical and Environmental Research.Vol.12, No.1&2. | Ahmed. S.S, Mazunder..Q.H, Jahan. C.S, Ahmed.H and Islam.I. .2002. Hydrogeochemistry and classification of ground water Rajshahi City corporation Area, Bangladesh. Journal of the geological society of India.,vol.60 pp.411-418. | | APHA. 1998. Standard method for the examination of water and wastewater (20th Edition). American Public Health Association, Washington, USA | | Babu.M.N., and Sankara pitchaiah, P.2000. Chemical facies in ground water of Bandlamettu-Agnigundala area, Guntur district, Andhra Pradesh, India. Environmental Geochemistry, vol.3.No1&2, pp.11-18. | Back. W.1966. Hydrochemical Facies and ground water flow in Northern part of Atlantic coastal plain, USGS. Proc. Paper, 498-A, A-442p. | Carroll, D. 1962. Rainwater as a chemical agent of geological processes – A review, US Geological Survey Water Supply paper 1535-G, pp.18. | Davis, S.N., and Dewist, R.J.M.1996. Hydrogeology, John Wiley and Sons, Inc., Newyork. | Eaton, F.M. 1950. Significance of carbonates in irrigation waters. Soils Science, vol.69, pp.122-133. | Feth, J.H.1981. Chloride in natural continental water- a review: U.S.Geological Survey water supply paper 2176. 30p. | Gibbs, R.J.1970 Mechanisms Controlling world water chemistry science, vol.170, pp1088-1090. | Gupta, S.C. 1981. Evaluation of quality of well waters in Udaipur district, Indian J.Environ. HIth, vol.23, No.3, pp.195-202. | Karanth, K.R.1987. Groundwater Assessment, Development and Management, Tata Mc Graw Hills Publication company Limited. New Delhi. | Madhusudhana Reddy P, Rajashekhar Reddy S.V. and Sakram G (2014), Groundwater suitability studies in Andhra Pradesh: A Study in Tandur area of Ranga Reddy District. IJRD, Vol 1, pp. 27 ISSN:2321-3434. | Piper A.M (1944).A Graphical procedure in the Geochemical Interpretation of water analysis. Transaction American Geophysical Union, 25-914-928 | Piper A.M (1953).A Graphical procedure in the Geochemical Interpretation of water analyses. U.S.Geological Survey, Groundwater Note No.12. | Sakram G. Sundaraiah R, Vishnu Bhoopathi and Praveen Raj Saxena (2013). The impact of agricultural activity on the chemical quality of groundwater, Karanja vagu watershed, Medak District, Andhra Pradesh, International Journal of Advanced Scientific and Technical Research , p.p.769-786. | SubbaRao, N., I. Saroja, Nirmala and K. Suryanarayana, 2005. Groundwater quality in a coastal area: a casestudy from Andhra Pradesh, India, Environ. Geol.,48: 543-550. | Todd, D.K. 1980. Groundwater, Hydrology, 2nd edition, John Wiley and Sons, pp.267-315. | US Sanlinity Laboratory Staff, 1954. Diagnosis and improvement of saline and alkaline soils:US department Agriculture Handbook 60, pp.160. | Walton, W.C.1970. Groundwater resources evaluation, New York, Mc Graw Hill Book Co. | WHO (World Health Organization) (2006). Guideline for drinking water quality recommendation. | Zaparozec, A. 1972. Graphical interpretation of water quality data, groundwater, vol.10, No.2, pp.32-43. |