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STUDY ON SPATIAL DISTRIBUTION OF GROUNDWATER QUALITY IN VIZIANAGARAM DISTRICT OF ANDHRA PRADESH, INDIA

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Abstract: Groundwater is one of the major sources of exploitation in semi-arid region of Andhra Pradesh. Thus for protecting Groundwater quality, data on spatial distribution are important. Analysis of groundwater quality is vital, because the physical and chemical characteristics of groundwater determine its suitability for agricultural and domestic usages. In the present study, various samples of groundwater collected from different areas in Vizianagaram district of Andhra Pradesh and analyzed for their physicochemical characteristics. The results of this analysis were compared with the quality standards of WHO and BIS. In this analysis the various physicochemical parameters such as p^H, T.D.S., Cl^-, F, No_3^-, Na^+, K^+, So_4^{-2}, Ca^{+2}, Mg^{+2}, T.H and HCO_3 etc. were determined using standard procedures. The quality of Groundwater samples were discussed with respect of these parameters and this is an attempt made to ascertain the quality of groundwater used for drinking and cooking purposes in the samples areas. Naturally, groundwater contains mineral ions. These ions slowly dissolve from soil particles, sediments and rocks as the water travels along mineral surfaces in the pores or fractures of unsaturated zone and the aquifer.
Keywords: Spatial distribution, Groundwater, physiochemical parameters, water quality, Geostatistics and Geographical Information System (GIS).

Introduction

Water is one of the principal natural resource for the survival of mankind. With the ever-increasing population and simultaneously decrease of surface water resources, groundwater resources have become more important. In our country, more than 60 percent of the irrigation requirements and 85 percent of the drinking water supplies are dependent on groundwater (Harender Raj Gautam and Rohitashav Kumar 2010). The constitution of India through the provisions of Article 47 guaranteed the states to provide clean drinking water improve public health. The constitutional jurisprudence of the country developed by the judiciary has placed drinking water as a derivative right within the purview of right to life under Article 21. Since independence various programmes have been undertaken by the government to provide water

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to the rural habitations. With over 700 million people living in around 1.60 million rural habitations. Provision of safe drinking water to such a huge population is a complex challenge (Anupam Hazra, 2010). Impure water is the root cause for many diseases especially in developing countries. Millions of people become sick each year from drinking contaminated water (Anumakonda Jagadeesh, 2010). The UN recommends that people need a minimum of 50 litres of water a day for drinking, washing, cooking and sanitation (Paramasivan and Karthravan 2010). Water has become the biggest problem of the 21st century. More than 2.2 million people die each year from diseases related to contaminated drinking water and poor living conditions, faced with water scarcity (Paramasivan and Karthravan 2010).

The present study is an attempt to analyses the spatial distribution of groundwater quality in vizianagaram district. Numbers of research papers were published relating to groundwater quality analysis. Physical and chemical parameters of groundwater such as EC, P^H, TDS, Na, K, Ca, Mg, Cl, HCO_3,CO_3, SO_4, NO_3, NH_3, PO_4, Fe and F were studied by Nosrat Aghazadeh and Asghasi Mogaddam (2010). In the most part of our country groundwater is a major source of drinking water, Groundwater in several parts of India is affected by arsenic and Fluoride pollution due to the geo-genic contamination and anthropogenic pollutions (CGWB, 2010). Aladejana and Talabi (2013) were studied groundwater quality in Abeokuta Soutwestern Nigeria. R.S.Negi et al. (2011) were analyzed the geo hydrological studies of springs and stream water of Takoli Gad watershed. Hydrological characterization and assessment of groundwater quality in shallow aquifers in vicinity of Najafgarh drain of NCT Delhi (Shashank Shekhar and Aditya Sarkar, 2013). Spatial distribution maps of groundwater for agricultural and a livestock & poultry purpose has been generated along with their areal statistics (Trapti Sharma et al. 2011). Total dissolved solids, total hardness, fluoride, chloride and chromium were beyond permissible limit in some samples of the Bhavanagar region (Deepti Mishra et al. 2009). The groundwater in rural areas can be polluted as a result of farming activities and an important source of pollution of the groundwater with nitrate is the excessive use of nitrate fertilizers (Cornelia Muntean et al., 2006). Adetunde et al. (2011) studied indicates that the hand-dug well water samples in the Ogbomoso North and South local government areas are general soft, most of the physicochemical parameters of the samples were within acceptable limits for drinking purposes. Drinking water is an important resource that needs to be protected from pollution and biological contamination studied by Tambekar (2012). The groundwater quality of the

various areas around Kolleru Lake were studied by HariKrishna et al. (2013). The qualities of these water bodies vary widely depending on the location and environmental factors (Tay, 2007). The water quality of the various areas in GVMC clearly indicates that the water samples are highly polluted (Satyanarayana et al., 2013).

Study Area

Vizianagaram District covers geographical area of 6,539 Sq.kms. The district is a part of the Northern Coastal plains of Andhra Pradesh and lies between 17^{o} $15^{'}$ and 19^{o} $15^{'}$ of the Northern Latitudes and 83^{o} $0^{'}$ to 83^{o} $45^{'}$ of the Eastern Longitudes (Fig. 1). The normal annual rainfall of the district is 1131 mm. the district gets the benefit of both the South West and North East monsoons. For administrative convenience, the district is divided into 2 Revenue Divisions viz., Vizianagaram and Parvathipuram and 34 Revenue mandals.

Methodology

The water samples have been collected from 41 open wells in Vizianagaram distirct (Fig.2). The total water sample locations covered by Rural and Urban areas. In this present study, various physical and chemical parameters of water samples were determined and the results were compared with the values of various water quality standards such as World Health Organization (WHO, 2011) and Bureau of Indian Standards (BIS, 2003). The samples collected were analyzed for important physical and chemical parameters such as p^{H}, T.D.S, Cl^{-}, F, No_3^{-}, Na^{+}, K^{+}, So_4^{-2} , Ca^{+2}, Mg^{+2}, T.H and HCO_3 were determined using standard procedures. All the chemical constituents are expressed in mg/l (milligrams/liter) except pH.

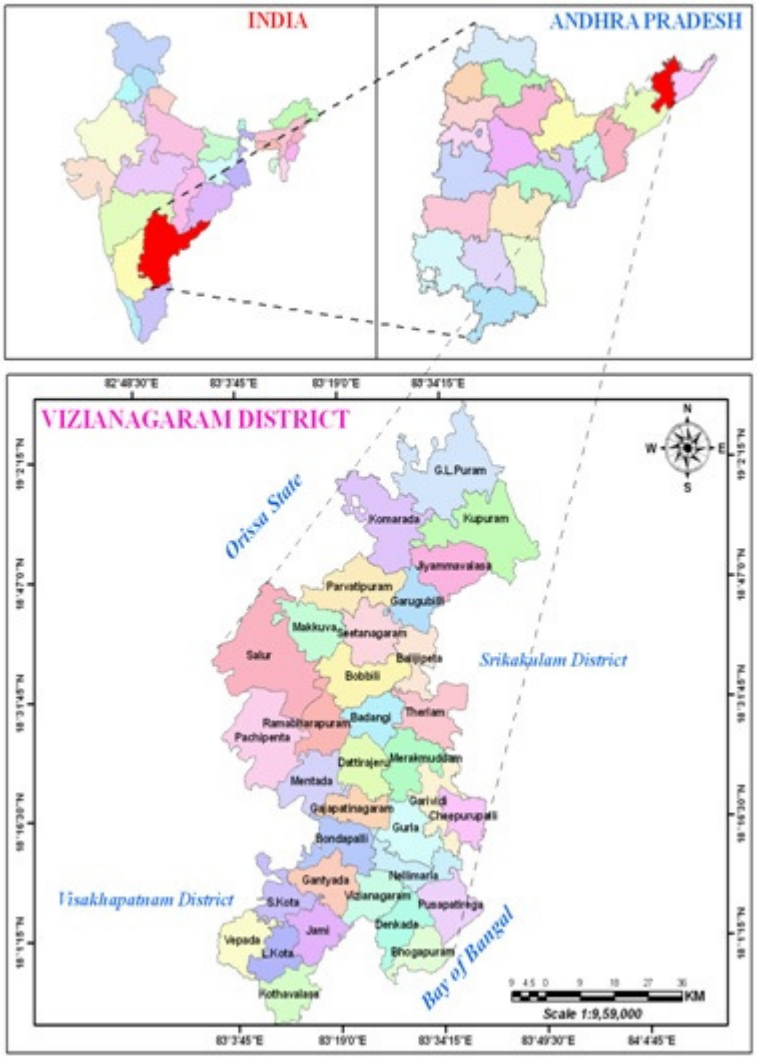

Fig.1: Location map of the study area

Results & Discussion

Water is indispensable for the existence and survival of life on earth. Groundwater is needed in almost every sphere of human activity. It required for direct consumption for washing, cleaning, cooling, waste disposal and transportation. Groundwater is essential for the irrigation, industries, livestock management, domestic requirements, and various human activities.

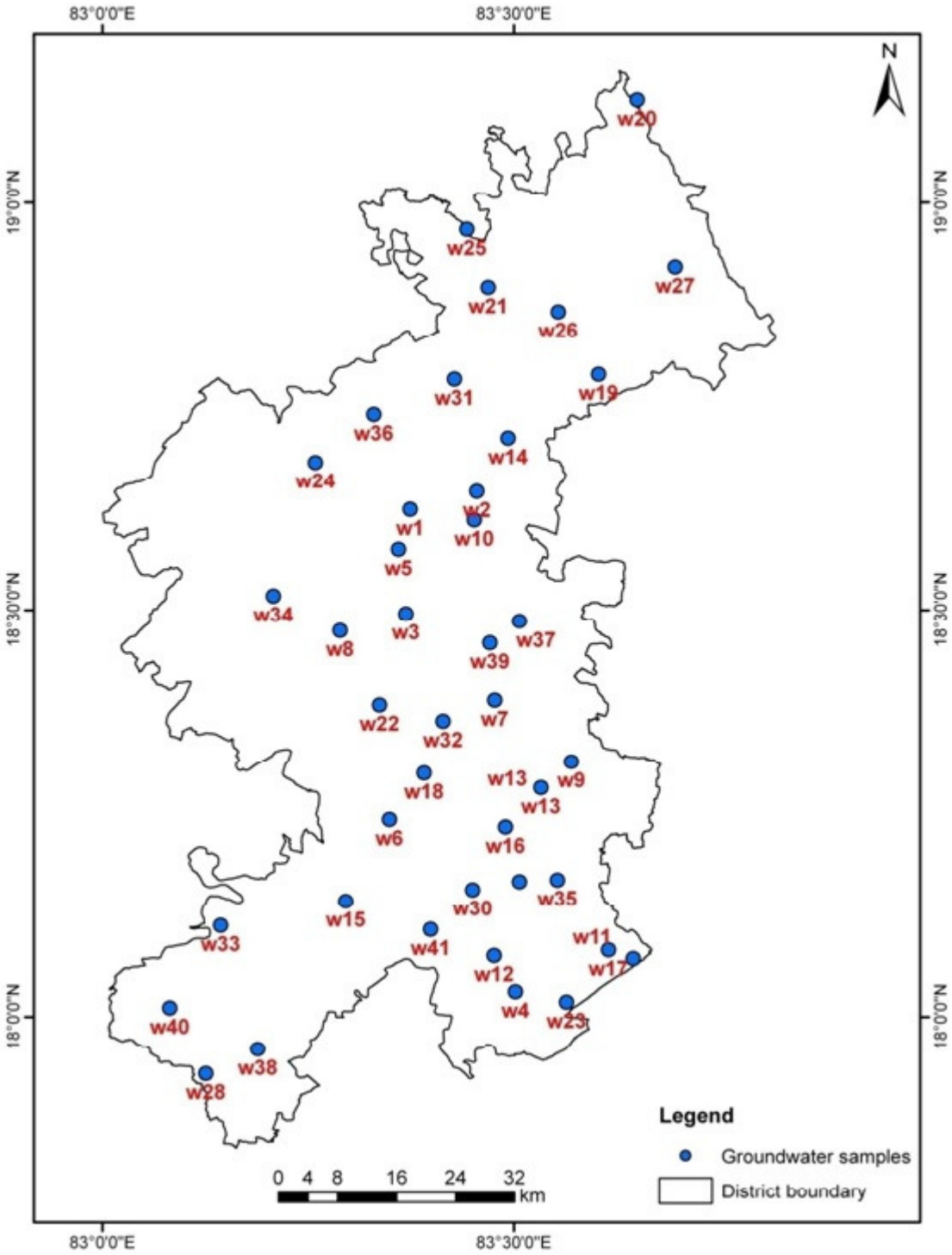

Fig. 2: Groundwater samples location map

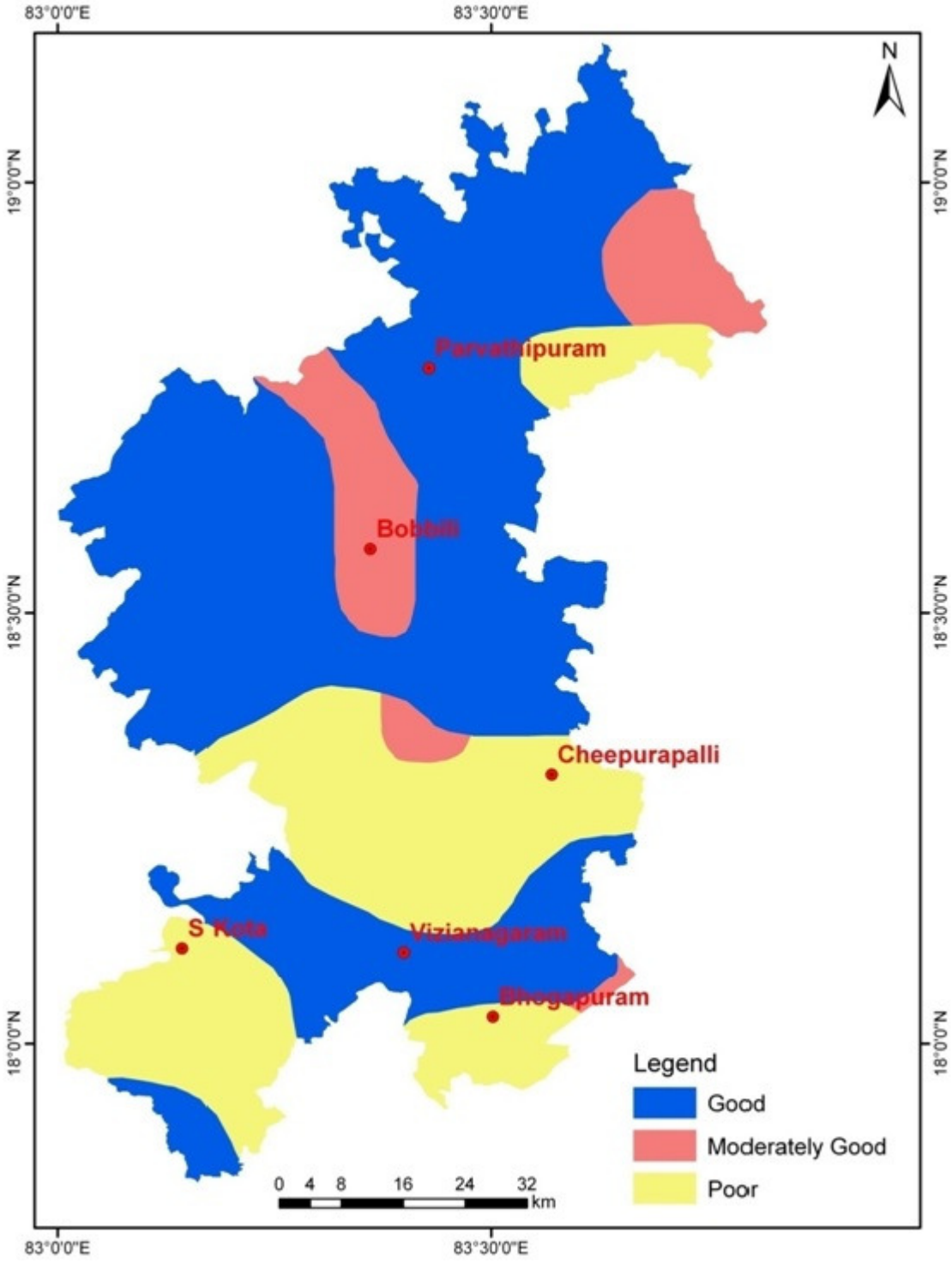

Fig. 3: Spatial distribution of groundwater quality

Table 1: Physico – Chemical characteristics of groundwater samples in Vizianagaram District

S.No	Name of the Locations	pH	T.D.S (Mg/l)	Cl (Mg/l)	F (Mg/ l)	No_3 (Mg/l)	Na (Mg/ l)	K (Mg/l)	So_4 (Mg/l)	Ca (Mg/l)	Mg (Mg/l)	T.H (Mg/l)	HCO_3 (Mg/l)
W1	Anitpeta	7.0	1139	114	1.5	15	315	5	144	16	39	200	523
W2	B.D.Valasa	8.8	464	86	0.3	20	29	3.5	36	56	39	300	95
W3	Badangi	8.6	636	114	0.8	28	46	2	35	24	83	400	162
W4	Bhogapuram	7.4	3578	1482	0.8	77	350	7	232	176	389	2040	181
W5	Bobbili	7.9	618	143	0.4	28	38	2.5	92	104	34	400	86
W6	Bondapalli	7.7	1024	352	0.6	10	204	64	115	48	44	300	171
W7	Budarayavalasa	7.6	470	48	0.6	36	50	1.75	48	48	34	260	124
W8	Busayyavalasa	8.0	416	38	0.6	10	59	1.25	34	32	29	200	119
W9	Cheepurupalli	7.7	781	200	0.5	54	55	14	50	96	58	480	76
W10	Chintada	8.3	365	76	0.8	5	35	1	39	40	29	220	105
W11	Chintapalli	8.3	832	200	0.1	41	170	4.5	80	40	49	300	124
W12	Denkada	8.4	557	76	0.5	4	90	5	52	16	49	240	219
W13	Garividi	7.9	826	276	0.3	12	160	17.5	73	56	34	280	133
W14	Garugubilli	8.2	704	162	0.3	24	46	1	43	24	97	460	190
W15	Gantyda	8.1	481	114	0.5	12	45	2.5	48	48	39	280	124
W16	Gujjanagivalasa	7.7	1050	190	0.4	109	120	23	104	88	78	540	48
W17	Gulivindada	7.9	794	143	0.5	43	94	5.5	89	48	73	420	171
W18	Jinnam	7.5	1402	523	0.5	21	230	47	158	136	49	540	114
W19	Jiyyammavalasa	7.9	2074	836	0.6	65	203	4	100	104	224	1180	105
W20	Kedripuram	8.4	160	14	0.4	3	13	2	1	24	10	100	76
W21	Komarada	8.0	467	86	0.5	28	60	1	35	32	39	240	105
W22	Komatipalli	7.7	722	646	0.6	22	240	23	134	88	141	800	219
W23	Konada	7.7	2496	969	0.4	17	550	90	250	112	97	680	285
W24	Kondabutchanna peta	8.4	198	10	1	1	18	1.5	1	16	19	120	124

W25	Kuneru	8.4	570	76	0.4	5	78	5	106	24	53	280	190
W26	Kurupam	8.2	371	76	0.3	17	38	13.7	36	40	24	200	86
W27	Mondemkhallu	7.8	710	133	0.4	46	80	85	80	48	39	280	124
W28	Musiram	8.0	230	29	0.2	8	19	1.5	18	40	10	140	95
W29	Neliwada	8.2	646	133	0.7	9	110	13	67	24	49	260	219
W30	Nellimarla	7.7	541	105	0.2	48	48	5	18	80	29	320	86
W31	Parvathipuram	7.7	518	171	0.2	20	60	3	43	88	15	280	48
W32	Porali	7.5	909	181	0.8	61	74	11.5	56	16	122	540	181
W33	S.Kota	8.6	934	238	1.6	16	210	1	98	16	58	280	238
W34	Saluru	8.3	640	105	0.2	2	85	3	5	24	68	340	314
W35	Sathiwada	7.8	589	95	0.8	17	68	20	53	32	53	300	209
W36	Tallaburidi	7.6	669	162	0.3	5	88	3	64	80	34	340	209
W37	Therlam	7.9	541	124	0.8	33	68	1	34	40	44	280	95
W38	Uttarapalli	7.8	1190	333	0.6	78	200	3	110	96	63	500	67
W39	Uttaravalli	7.9	896	238	0.9	24	73	6.5	59	48	102	540	209
W40	Vepada	7.7	1280	380	0.2	70	125	60	132	160	63	660	76
W41	Vizianagaram	7.6	456	95	0.5	14	65	1	68	40	29	220	105

Note: P^H, TDS- Total Dissolved solids, Cl- Chloride, F- Fluoride, No_3- Nitrate, Na- Sodium, K- Potassium, So_4-Sulphate, Ca- Calcium, Mg- Magnesium, T.H- Total Hardness and HCo_3-bicarbonate

Table.2: The Minimum, Maximum, Mean concentration and Standard Deviation of chemical parameters with water quality standard.

Chemical Parameters	Observed Concentration				Water Quality Standard	
	Min.	Max.	Mean	Std. Dev.	WHO	BIS
P^H	7	8.8	7.94	0.3715	6.5-8.5	6.5-8.5
TDS	160	3578	827.90	630.25	500	500
Cl	10	1482	233.46	287.36	75	250
F	00.1	1.6	0.55	0.31	1.5	1.0
No3	1.0	109	28.24	24.89	100	45
Na	13	550	114.85	106.84	10	100
K	1.0	90	13.7	22.48	250	--
So4	1.0	250	74.14	54.58	200	200
Ca	16	176	57.75	40.14	45	75
Mg	10	389	64.17	65.24	50	30
T.H	100	2040	408.29	330.36	--	30
HCo3	48	523	151.95	86.92	--	--

Note: WHO- World Health Organization and BIS- Bureau of Indian Standards.

The pH values of groundwater ranged from 7.0 to 8.8 with an average value 7.9 and Standard deviation value 0.37. High values of 8.8 and 8.6 were observed at B.D.Valasa (W2) and Badangi (W3) (Tables 1&2). This shows that the groundwater of the study area is mainly alkaline in Nature. The total solids in a liquid sample consist of total dissolved solids (TDS) and total suspended solids. The total dissolved solids indicate the general nature of salinity of water. The TDS value ranged from 160 to 3578 mg/l. In the present study, Very high concentration of TDS values of 3578 mg/l and 2496 mg/l were observed at Bhogapuram (W4) and Konada (W23) locations which are nearby Sea coast and low concentration of 160 mg/l and 198 mg/l were observed at Kedripuram (W20) and Kondabutchannapeta (W24) locations which are nearby hilly area. The BIS specifies a desirable total dissolved solids limit of 500 mg/l and study area shows 51 percent of the samples were exceeding permissible limit as prescribed by WHO and BIS (2011&2003). Chlorides are readily soluble and are found in almost all types of waters. Chlorides of sodium and magnesium have highest degree of solubility in water. Washing out of salts from soil may be a reason for the presence of chlorides in groundwater. Chlorides are also reported with sulfates in water which can enter

the water bodies in the form of solutions of stratified sedimentary rocks (Drever, 1982). The Chloride (Cl) ion concentration varied between 10 and 1482 mg/l with a mean values of 233.4 mg/l and Standard deviation value is 287.36 mg/l. Very high concentration of 1482 mg/l, 969 mg/l and 836 mg/l were observed at Bhogapuram (W4), Konada (W23) and Jiyyammavalasa (W19) samples were exceeding desirable permissible limit prescribed by WHO&BIS. Low concentration of 10 mg/l, 14 Mg/l and 29 mg/l were found out at Kondabutchannapeta (W24), Kerdipuram (W20) and Musiram (W28) (Table.1, Table.2 & Fig.2).

The Fluoride (F) concentration varied between 0.1 to 1.6 mg/l with a mean values 0.55 mg/l and Standard deviation (S.D) value 0.31 mg/l. All samples are not exceeding the permissible limits except S.Kota (W33) and Antipeta (W1) (Fig.2). Sodium and Potassium are present in a number of minerals. The increasing pollution of groundwater has resulted in a substantial increase in the sodium content of drinking water. Sodium (Na) and Potassium (K) values ranged from 13 to 550 mg/l and 1 to 90 mg/l with an average value of 114.85 mg/l and 13.7 mg/l, S.D values 106.84 & 22.48 respectively (Table.1&2).

The Nitrate (No3) concentration varied between 1.0 to 109 mg/l with a mean values 28.24 mg/l and Standard deviation value 24.89 mg/l. Nitrate concentration only one sample are exceeding the permissible limits that is Gujjingivalasa (W16). Sulphate content in groundwater is made possible through oxidation, precipitation, solution and concentration, as the water traverses through rocks (Karanth 1987). The Sulphate (So4) values of groundwater ranged from 1 to 250 mg/l with an average value of 74.14 mg/l and S.D is 54.58 (Table.2) this shows at Konada (W23) and Bhogapuram (W4) were exceeding the maximum desirable limit prescribed by BIS (2003).The presence of calcium in drinking water is natural geological source, industrial waste, mining by products and agricultural wastes (Deshpande, 2002). Calcium compound in water are responsible for hardness of water. Groundwater contains these ions mainly from the dissolution of salts present in bed rocks and top soils (Drever, 1982). Calcium (Ca) values ranged from 16 to 176 mg/l with an average value of 57.75 mg/l and S.D 40.14 mg/l. The desirable limit of Calcium (Ca) for drinking water is specified by BIS (1991) as 75 mg/l and a maximum permissible limit of 200 mg/l. It is observed that Bhogapuram (W4), Vepada (W40) and Jinnam (W18) were exceeding maximum permissible limit (Table.1&2).

Magnesium (Mg) concentration varies from 10 mg/l to 389 mg/l with mean values of 64.17 mg/l and S.D is 65.24 mg/l. Very high concentration of 389 mg/l, 224 mg/l and 122 mg/l

were observed at Bhogapuram (W4), Jiyyammavalasa (W19) and Porali (W32) shows in the Fig.2. According to BIS (2003) the desirable values of Mg is 50 mg/l and a maximum permissible limit of 150 mg/l. Hardness is generally defined as the calcium carbonate equivalent of calcium and magnesium ions expressed in ppm or mg/l. The hardness of water reflects the composition of the geological formation with which it has been in contact. A total hardness value varies from 100 to 2040 mg/l with a mean values 408.29 mg/l and S.D Value 330.36. The desirable limit of total hardness (TH) for drinking water is specified by BIS as 300 mg/l and a maximum permissible limit of 600 mg/l. Very high concentration of 2040 mg/l, 1180 mg/l and 800 mg/l were observed at Bhogapuram (W4), Jiyyammavalasa (W19) and Komatipalli (W22) (Table.1&2 and Fig.2). The Bicarbonate (HCo3) concentration varies from 48 to 523 mg/l with mean values of 151.95 mg/l and S.D value 86.92. Very high concentration of 523 mg/l, 285 mg/l and 314 mg/l were observed at Antipeta (W1), Konada (W23) and Saluru (W34) (Table.1&2).

Conclusion

The groundwater which is existed in most of the northern part of Vizianagaram district is good, except Jiyyammavalasa and Mondemkhallu mandals. One linear patch starting from Badangi to towards Tallaburidi is moderately good and the area between Bondapalli and Cheepurapalli mandals are contains poor groundwater because manganese ores are deposited in this region. The area between Gantyada and Gulivindada existed good groundwater because excellent drainage network is available which recharge the potable groundwater. The most of the southern part of this district existed poor groundwater quality because many major and minor industries were existed which causes pollute the groundwater.

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