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RESEARCH ARTICLE

A STUDY ON PHYSICO - CHEMICAL QUALITY OF DRINKING WATER FROM DIFFERENT SOURCES IN PRE AND POST MONSOON BY USING WATER QUALITY INDEX METHOD IN ANANTHAGIRI MANDAL OF VISAKHAPATNAM DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT

Water samples were collected from bore wells, springs, tap and open wells of 07 different locations and analysed (June-July 2014) in pre and post-monsoon (December -January 2015) in Ananthagiri Mandal of Visakhapatnam district, Andhra Pradesh. The study was conducted to characterize the physicochemical parameters such as pH, Turbidity, Total Hardness, TDS, F, Cl, Mg, Ca, No_3, SO_4 etc. On comparing the results against the drinking water quality standards lead by BIS (ISO: 100500, 1995) and WHO. It was observed that the parameters, pH, Total dissolved solids, turbidity, Mg, Ca and DO was higher than the prescribed limits while other parameters were lower than the limits in pre and post monsoon periods. Water Quality Index (WQI) was also calculated for different sources individually in pre and post monsoon, it reflected that the WQI were found in the range of (82.86), Very poor water quality range and Unsuitable for Drinking water range (113.751) in pre and post monsoon periods respectively. Bore and tap water found to be in the range of very poor water quality **(93.458 to 93.538)**, and the well and spring water were in the range of unsuitable for drinking water **(110.757 – 112.866)**. It was resulted that the water is not suitable for drinking, and needed to be treated before it is consumed by local tribal community.

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INTRODUCTION

It is well known that clean water is absolutely essential for several purposes for healthy living (Mandalam *et al*., 2009). Water Quality is an important factor to judge environment changes, which are strongly associated with social and economic development. The World Health Organization (WHO) estimated that in developing countries about 80% of water pollution is a result of domestic waste. Moreover, the inadequate management of water systems can cause serious problems in the availability and quality of water (Krishnan *et al*., 2007). During the past decade, widespread reports of ground water contamination have increased public concern about drinking water quality (Yanggen and Born, 1990). Drinking water quality directly affects human health. The impacts reflect the level of contamination of the whole drinking water supply system (raw water, treatment facilities and the distribution network to consumers) (Magnuss, 2009).

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Drinking water is an essential environmental constituent and the quality of drinking water is an issue of primary interest for the residents of the European Union (Chirila *et al*., 2010). Failure to provide effective treatment of water sources and safe distribution can expose the community to the risk of disease outbreaks as well as other adverse health effects. Unfortunately in many countries across the world, drinking water supplies are contaminated and this has affected the health and the economic status of the population. Water borne diseases are the most dangerous ones in terms of public health, because they can easily spread (Ozdemir *et al*., 2010). According to the WHO, there were an estimated 4 billion cases of diarrhea and 2.2 million deaths annually. The consumption of unsafe water has been implicated as one of the major causes of this disease (Chan *et al*., 2007). Diarrhea is the major cause of death for more than 2 million people per year worldwide, mostly children under the age of five (Zamxaka *et al*., 2004), as a result of infection or the result of a combination of a variety of enteric pathogens. Chemical contamination of drinking water is often considered a lower priority than microbial contamination by regulators, because adverse health effects from chemical contaminations are generally associated with long-term exposures, whereas the effects from microbial contamination are usually immediate (WHO, 2007). There are some researches in the field of chemical and microbial contamination of the drinking water in our region (Dabevska-Kostoska *et al*., 2007). Nonetheless, chemical contamination can affect the taste and appearance of water, lead to community anger, detrimental economic impacts and in some cases serious morbidity (Thompson, 2006; Parvez *et al*., 2006). The evaluation of water in the developing countries has become a critical issue in recent years, especially due to the concern that fresh water will be scarce in near future. Water form a certain source may be good enough for drinking without any treatment but it may not be suitable as a coolant in an industry. The general WQI was developed by Brown *et al*. (1970) and improved by Deininger for the Scottish Development Department (1975). Horton (1965) suggested that the various water quality data could be aggregated into an overall index. Water quality index is well-known method as well as one of the most effective tools to expressing water quality that offers a simple, stable, reproducible unit of measure and communicate information of water quality to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of surface water. WQI is defined as a rating reflecting the composite influence of different water quality parameters.

The main objectives of the study was to analysis of a few quality parameters *viz*., pH, Total Hardness (TH), Calcium Hardness (CH), Total Dissolved Solids (TDS), Chloride (Cl), Sulphate (So_4^{-1}), Nitrate (NO_3) and Fluoride(F) as recommended by WHO to establish the nature of the relationship between the water quality parameters and assessment of the water quality using WQI. The study is for the assessment of the drinking water quality in the Mandal of Ananthagiri and surrounding villages. In this area the tribal people do not have access to public water supply and therefore they depend on Open well, spring and bore well waters for drinking and domestic use. Water borne diseases are identified to be the most dangerous ones in terms of public health. Thus there is a need to look for some useful indicators, both chemical and physical that can be used to monitor both drinking water operation and performance.

The main objectives of the study include:

- To assess the Physical, Chemical parameters of drinking water consumed by Tribal Community.
- To evaluate the possible impacts of ground and surface water pollution.
- To determine the water quality index of different sources (well, spring, tap and open wells), individually in pre and post monsoons.

MATERIALS AND METHODS

Study Area

The study area is located in Ananthagiri Mandal which is on the north-eastern part of Araku Region of Visakhapatnam district, Andhra Pradesh India. The Araku division consists of the hilly regions covered by Eastern Ghats with an altitude of about 900 meters dotted by several peaks exceeding 1200 mts above the sea level. The area lies between longitude of E 18^o 10' 0" N and latitude E 83^o 0' 0" E. The climatic conditions are cool in this area on an account of green vegetation, elevation and thick forest. The temperature gets down on the onset of the south west monsoons and its tumbles to a mean minimum of 4ºc by January of every year, after which there is a reversal trend till the temperature reaches to mean maximum of 34ºC by the end of May, that is April to June are the warmest months. The area receives an average rainfall of 178.1cm in every year.

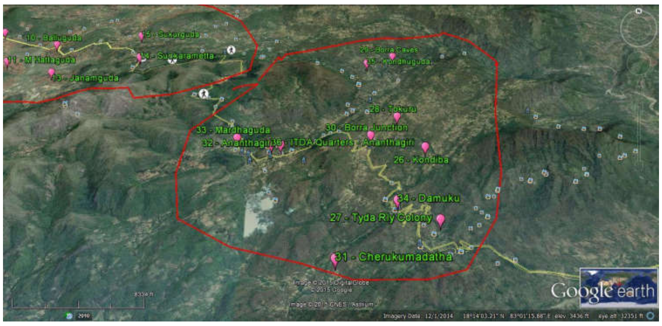


Figure 1. Sampling locations in Ananthagiri Mandal

Sample Collection and analysis

Water samples were collected from Open wells, bore wells and springs at different villages from Ananthagiri Mandal, Visakhapatnam district Andhra Pradesh, India in pre and post monsoon seasons - 2014. The sites are represented in Table 1& figure1. The samples are obtained by grab sampling method according to the consumption of local tribal community. Samples were collected in clean plastic cans of 2 lit capacities for physico- chemical analysis. The collected samples were transferred to the Environmental Science, Andhra University laboratory by following all the precautions laid by standard methods (APHA, 1995). pH, DO were determined within the felid of collection, the other parameters like TDS,Ca,Mg,NO_3,SO_4, chlorides, fluorides etc, were analyzed in the laboratory within the stipulated period. Physical and chemical parameters were analyzed as per the standard method of assessment of Ground water quality prescribed in standard method for the examination of water and waste water American public health association (APHA 1995) Each of the water samples was analyzed for 12 parameters *viz.,* pH, TDS, TH, CH, Cl, SO, NO, DO, turbidity and Fluoride using standard procedures recommended by APHA (Table 1). The experimental values were compared with standard values recommended by the WHO and ISO (100500). The calculation of WQI was done by Weighted Arithmetic Index (WAI) method, eleven water quality parameters were considered for calculation of water quality index.

Calculation of water quality index (WQI)

WQI is defined as a rating reflecting the composite influence of different water quality parameters (Ramakrishnalah *et al*., 2009) Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. In study for the calculation of water quality index (WQI), eleven important parameters were chosen. The WQI has been calculated by using the standards of the drinking water quality recommended by the WHO. The WAI method has been incorporated for the calculation of WQI of the water resource. Further quality rating or the sub index (q_n) was calculated by using the following expression.

$$q_n = 100 (V_n - V_{io}) / (S_n - V_{io}) \quad (1)$$

(Let there be n water quality parameters and quality rating or sub-index (q) corresponding to n the parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standards permissible value).

q_n = Quality rating for the n Water quality parameter

V_n = Estimated value of the n parameter at a given sampling station

S_n = Standard permissible value of the nth parameter

V_{io} = Ideal value of n parameter in pure water (i.e., 0 for all other parameters except the parameter pH, where it is 7.0).

Unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter

$$W_n = K/S_n \quad (2)$$

W_n = Unit weight for the nth parameters.

S_n= Standard value for nth parameter.

K = Constant for proportionality.

The overall water quality index was calculated by aggregating the quality rating with unit weight linearly.

$$WQI = \sum q_n W_n / \sum W_n \quad (3)$$

The maximum weight of 5 has been assigned to the parameters like NO3-, TDS, Cl-, F-and SO_{-4} due to their major importance in water quality assessment, (Srinivasamoorthy *et al*., 2007). In the second step, the relative weight (Wi) is computed from the following equation, where, Wi is the relative weight and Wi is the weight of each parameter and n is the number of parameters.

RESULTS AND DISCUSSION

The study reveals the drinking, water status at 07 different sites during the pre and post monsoon period is tabulated in Table, 3&4. The suitability of the ground and surface water from Ananthagiri Mandal for drinking and domestic was evaluated by comparing the values of different water quality parameters with those of the Bureau of Indian standards (BIS 1998, 100500) and WHO guideline for drinking water.

PH: pH is a numerical expression that indicates the degree, which water is acidic or alkaline, with the lower pH value tends to make water corrosive and higher pH provides taste complaint and negative impact on skin and eyes (Rao *et al*., 2010). The increase in pH values during the month of August to October is mainly related to the high bicarbonate content. The mean pH value of the water sample was 6.09 to 8.54 (pre monsoon) and 7.89 to 9.12 (post monsoon) respectively. The maximum permissible limit of WHO is 6.5- 8.5, the pH levels were slightly above the permissible limits in all the water samples, low pH (6.09) was recorded in spring water, high pH observed (9.12) in bore water. Though pH does not have direct effect on health, all biochemical reactions are sensitive to the variation of pH (Jeyakumar *et al*., 2003)

Total dissolved solids (TDS) : Total dissolved solids (TDS) mainly consists of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron etc. and small amount of organic matter **(Chandra *et al*., 2012).** The average concentration of total dissolved solid was 447.1 mgL-1 (pre monsoon); 507.81 mgL-1 (post monsoon) respectively. The maximum TDS 1470 mg/L was recorded in spring water and, the minimum 50 mg/lit was recorded in well water. The high TDS in post monsoon may be due to the soil particles found their way to the nearby spring sources in rainy seasons.

Dissolved oxygen (DO) Dissolved oxygen is the maximum concentration of oxygen that can dissolve in water. The oxygen content in water samples depends on a number of physical, chemical, biological and microbiological processes (**Nurchihan *et al.,* 2009).** As a function of water temperature, it may vary from place to place and time to time. It fluctuates seasonally (**Wavde *et al.,* 2010**). The average concentration of dissolved oxygen in the study area was 4.3 mgL-1 to 10.3 mgL-1 in pre monsoon; 2.0 mgL-1 to 12.3 mgL-1 in post monsoon period respectively. The maximum concentration of 12.3mgL-1 was noted at Ananthagiri Bore water, and the minimum concentration was noted at Damuku Tap water sample. However it was observed that there was increase of DO in all sources in post monsoon period; all the values were observed to be little above the permissible limits of the WHO standard which is 5mg\L.

Turbidity: The turbidity indicates clarity of water and is caused by living and nonliving suspended matter and colour producing substances. The turbidity readings of the samples were within the range of 6.9 to 18.9 NTU, in pre monsoon and 6.1 to 18.9 NTU in post monsoon period respectively. S_{11} and S14 (bore water) were below the limit of WHO and BIS standards and S_{10}, and S_{12} (spring and well water) were above the prescribed limit of WHO i.e. 05 NTU in pre and post monsoons respectively. The increase of turbidity in post monsoon period may be due to presence of suspended particles and other materials are usually responsible for high turbidity, similarly higher turbidity was reported by (**Medudhula *et al*., 2012)**. The soil particles may have found their way into the waters from the unstable sides thereby increasing turbidity of the water (**Garg *et al*., 2006).**

Total Alkalinity (TA): Alkalinity is a measure of the ability of water to neutralize acids.

Table 1. Analytical methods and equipment used in the study

S.No.	Parameter	Method	Instruments/Equipment
A.	Physico-chemical		
1.	pH	Electrometric	pH Meter
2.	TDS	Electrometric	Conductivity/TDS Meter
3.	Hardness	Titration by EDTA	-
4.	Chloride	Titration by $AgNO_3$	-
5.	Sulphate	Turbidimetric	Turbidity Meter
6.	Nitrate	Phenol disulphinic Method	UV-VIS Spectrophotometer
7.	Fluoride	SPADNS	UV-VIS Spectrophotometer
8.	Turbidity	Nephlometric method	Turbidity Nephlometer
9.	Calcium	Titration by EDTA	-
10.	Magnesium	Titration by EDTA	-
11.	DO	Titration by Sodium thiosulphate solution	-
12.	BOD	5 days incubation at 20ºC followed by titration	BOD Incubator

Table 2. Water Quality Index (WQI) and status of water quality (Chatterji and Raziuddin 2002)

Water quality index level		Water quality status
	0 - 25	Excellent water quality
16	**-50**	Good water quality
51	**-75**	Poor water quality
76	**- 100**	Very poor water quality
≥ 100		Un suitable for drinking

Table 3. Physico-chemical parameters of pre monsoon

S.No	CODE		Source	pH	TDS	Cl	TH	CaH	MgH	TA	F	Nitra	Sulp	DO	turbid
1	S1	Kondiba	Well	8.67	50	28	90	35	55	260	0.1	4	15	6.5	18.9
2	S2	Tyda	Well	8.26	52	36	35	45	10	280	0.3	6	12	6.1	8.5
3	S3	Tokuru	Bore	8.14	58	85	135	30	105	220	0.3	5	13	6.1	6.1
4	S4	Borra caves	Bore	8.31	148	43	170	110	60	57	0.6	5	15	5.3	6.5
5	S5	Borra junction	Well	7.98	1248	21	120	15	50	350	0.2	5.5	22	6.2	9.2
6	S6	Cherukumadatha	Tap	8.12	1152	89	165	60	105	209	0.4	7	11	10.3	6.9
7	S7	Ananthagiri	Bore	8.56	1145	36	141	52	89	35	0.3	5	20	6.8	8.6
8	S8	Mardhaguda	Bore	7.89	203	45	122	72	50	56	0.2	4	12	9.1	6.5
9	S9	Damuku	tap	8.23	389	134	165	69	96	48	0.2	6	11	4.3	8.6
10	S10	Kondhuguda	spring	8.45	1256	39	203	59	144	71	0.3	8	23	6.2	14.1
11	S11	ITDA quarters Ananthagiri	Bore	9.12	135	59	111	68	43	76	0.4	5	20	7.1	6.6
		Mean		8.33	507.81	55.90	132.45	55.90	73.36	151.09	0.3	5.5	15.18	6.72	18.49

Table 3&4 Physico-chemical parameters of post monsoon

S.No	CODE	Location	Source	pH	TDS	Cl	TH	CaH	MgH	TA	F	Nitra	Sulp	DO	ttur bid
1	S12	Kondiba	Well	8.42	102	63.8	308	149	159	39	0.2	3	14	7.6	18.9
2	S13	Tyda	Well	8.53	558	33.2	93	48	45	251	0.2	5	16	5.3	7.8
3	S14	Tokuru	Bore	8.14	265	36.2	68	57	11	263	0.2	10	17	6.2	6.2
4	S15	Borra caves	Bore	8.13	148	91.2	140	41	99	223	0.3	9	19	6.3	6.7
5	S16	Borra junction	Well	7.8	152	45.9	152	112	40	52	0.4	7	15	4.3	8.9
6	S17	Cherukumadatha	Tap	8.01	450	89	78	162	78	84	0.4	0.51	12	2.6	8.5
7	S18	Ananthagiri	Bore	7.06	420	49	252	166	86	140	0.08	0.9	11	12.3	9.2
8	S19	Mardhaguda	Bore	8.02	629	66	89	46	40	66	0.21	1.3	13.2	5.3	7.63
9	S20	Damuku	tap	7.03	389	52	98	60	38	84	0.52	1.7	7.1	2.0	10.1
10	S21	Kondhuguda	spring	6.09	1470	56	128	78	50	60	0.23	2.3	13.6	4.7	18.9
11	S22	ITDAquarters Ananthagiri	Bore	7.08	336	172	290	52	238	172	0.09	1.5	4.1	6.5	6.9
		Mean		7.66	447.1	58.23	154.18	88.27	64.4	130.3	0.27	3.83	12.90	5.73	10.41

Table 5. Calculation of Water Quality Index in pre monsoon

S.No.	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	7.66	6.5-8.5	0.2190	44.0	9.63
2	TDS mg/L	447.1	500 mg/L	0.0037	89.42	0.3308
3	Chlorides mg/L	58.23	250 mg/l	0.0074	23.292	0.1723
4	Total hardness mg/L	154.18	300 mg/L	0.0062	51.393	0.3186
5	Turbidity , NTU	10.41	05 NTU	0.08	208.2	16.65
6	Calcium mg/L	64.4	75 mg/l	0.066	85.866	5.667
7	Total alkalinity mg/L	130.3	120 mg/L	0.0155	108.58	1.682
8	Sulphates mg/L	12.90	250 mg/L	0.01236	5.16	0.0634
9	Nitrates mg/L	3.83	45mg/L	0.0412	8.511	0.350
10	Fluorides mg/L	0.27	01 mg/L	0.166	27	4.482
11	Dissolved oxygen mg/L	5.73	5.0 mg/L	0.3723	114.6	42.66
				∑Wn=0.989	**∑qn=766.02**	**∑Wn qn= 82.006**

Water quality index =∑ Wn qn / ∑ Wn= 82.86 (Very poor water quality Range).

Table 6. Calculation of Water Quality Index in post monsoon

S.no	Parameter	Observed value	Standard value (Sn) WHO, ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	8.33	6.5-8.5	0.2190	88.66	19.416
2	TDS mg/L	507.81	500 mg/L	0.0037	101.56	0.3757
3	Chlorides mg/L	155.90	250 mg/l	0.0074	62.63	0.4634
4	Total hardness mg/L	132.5	300 mg/L	0.0062	44.166	0.2552
5	Turbidity , NTU	18.49	05 NTU	0.08	369.8	29.584
6	Calcium mg/L	55.90	75 mg/l	0.066	74.533	4.919
7	Total alkalinity mg/L	151.09	120 mg/L	0.0155	125.90	1.951
8	Sulphates mg/L	15.18	250 mg/L	0.01236	6.072	0.0750
9	Nitrates mg/L	5.5	50mg/L	0.0412	11	0.453
10	Fluorides mg/L	0.3	01 mg/L	0.166	30	4.98
11	Dissolved oxygen mg/L	6.72	5.0 mg/L	0.3723	134.4	50.037
				∑Wn=0.989	**∑qn=1048.7**	**∑Wn qn= 112.509**

Water quality index =∑ Wn qn / ∑ Wn= 113.751 (Un suitable for Drinking Range)

Table 7. Calculation of Water Quality Index in well water samples

S.No.	Parameter	Observed value	Standard value (Sn) WHO, ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	8.27	6.5-8.5	0.2190	84.66	18.540
2	TDS mg/L	360.33	500 mg/L	0.00165	72.06	0.1188
3	Chlorides mg/L	37.98	250 mg/l	0.0074	15.19	0.1124
4	Total hardness mg/L	133	300 mg/L	0.0062	44.33	0.2748
5	Turbidity , NTU	10.36	05 NTU	0.1653	207.2	34.250
6	Calcium mg/L	67.33	75 mg/l	0.066	89.77	5.924
7	Total alkalinity mg/L	205.33	120 mg/L	0.0155	171.10	2.652
8	Sulphates mg/L	15.66	250 mg/L	0.01236	6.264	0.0774
9	Nitrates mg/L	5.08	50mg/L	0.0412	10.16	0.4185
10	Fluorides mg/L	0.233	01 mg/L	0.166	23.3	3.867
11	Dissolved oxygen mg/L	5.816	5.0 mg/L	0.3723	116.32	43.305
				∑ = 0.989	**∑= 840.354**	**∑Wn*qn= 109.539**

Water quality index =∑ Wn qn / ∑ Wn=110.757 (Un suitable for Drinking Range)

Table 8. Calculation of Water Quality Index in bore water

S.No.	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	7.44	6.5-8.5	0.2190	29.33	6.423
2	TDS mg/L	269.88	500 mg/L	0.00165	53.97	0.0890
3	Chlorides mg/L	68.24	250 mg/l	0.0074	27.29	0.2019
4	Total hardness mg/L	151.8	300 mg/L	0.0062	50.60	0.3137
5	Turbidity , NTU	6.093	05 NTU	0.1653	121.86	20.143
6	Calcium mg/L	69.4	75 mg/l	0.066	92.53	6.1069
7	Total alkalinity mg/L	130.8	120 mg/L	0.0155	109.0	1.6895
8	Sulphates mg/L	14.43	250 mg/L	0.01236	5.77	0.07131
9	Nitrates mg/L	4.61	50mg/L	0.0412	9.22	0.3798
10	Fluorides mg/L	0.25	01 mg/L	0.166	25	4.150
11	Dissolved oxygen mg/L	7.1	5.0 mg/L	0.3723	142	52.866
				∑ = 0.989	**∑ = 666.57**	**∑ qn* Wn = 92.434**

Water quality index =∑ Wn qn / ∑ Wn=93.458 (Very poor water quality Range)

Table 9. Calculation of Water Quality Index in spring water

S.No.	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	7.27	6.5-8.5	0.2190	18	3.942
2	TDS mg/L	863	500 mg/L	0.00165	172.6	0.2849
3	Chlorides mg/L	47.5	250 mg/l	0.0074	19.0	0.1406
4	Total hardness mg/L	165.5	300 mg/L	0.0062	55.166	0.3420
5	Turbidity , NTU	16.5	05 NTU	0.1653	330.0	54.549
6	Calcium mg/L	68.5	75 mg/l	0.066	91.33	6.0277
7	Total alkalinity mg/L	65.5	120 mg/L	0.0155	54.583	0.8460
8	Sulphates mg/L	18.3	250 mg/L	0.01236	7.320	0.0904
9	Nitrates mg/L	5.15	50mg/L	0.0412	10.30	0.4243
10	Fluorides mg/L	0.265	01 mg/L	0.166	26.50	4.399
11	Dissolved oxygen mg/L	5.45	5.0 mg/L	0.3723	109	40.580
				∑ = 0.989	**∑= 893.799**	**∑Wn qn= 111.625**
Water quality index =∑ Wn qn / ∑ Wn=112.866 (Un suitable for Drinking Range)						

Table 10. Calculation of Water Quality Index in tap water

S.No.	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	7.84	6.5-8.5	0.2190	56	12.265
2	TDS mg/L	345	500 mg/L	0.00165	69.0	0.1138
3	Chlorides mg/L	91	250 mg/l	0.0074	36.4	0.269
4	Total hardness mg/L	126.5	300 mg/L	0.0062	42.166	0.261
5	Turbidity , NTU	8.52	05 NTU	0.1653	170.40	28.167
6	Calcium mg/L	87.75	75 mg/l	0.066	117	7.722
7	Total alkalinity mg/L	106.25	120 mg/L	0.0155	88.541	1.372
8	Sulphates mg/L	10.27	250 mg/L	0.01236	4.108	0.0507
9	Nitrates mg/L	3.80	50mg/L	0.0412	7.6	0.313
10	Fluorides mg/L	0.38	01 mg/L	0.166	38	6.308
11	Dissolved oxygen mg/L	4.8	5.0 mg/L	0.3723	96	35.740
				∑ = 0.989	**∑= 725.21**	**∑Wn qn= 92.51**

Water quality index =∑ Wn qn / ∑ Wn=93.538 (Very poor water quality Range)

It is due to the presence of bicarbonates, carbonates and hydroxide of calcium, magnesium, sodium, potassium and salts of weak acids and strong bases as borates, silicates, phosphates, etc. Large amount of alkalinity imparts a bitter taste, harmful for irrigation as it damages soil and hence reduces crop yields (Sundar *et al*., 2008). The average concentration of total alkalinity in pre and post monsoon was 130.3mgL-1 and 151.09 mgL-1 respectively. The maximum value was noted in Well water and minimum value was noted in bore water, and concentration was slightly increased in post monsoon period.

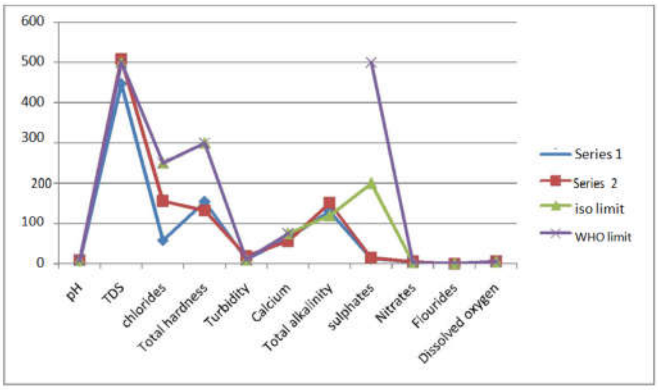
Calcium and magnesium (Ca2+ and Mg2+): The distribution of calcium and magnesium concentrations in the water samples were highly fluctuations during different periods. The average concentration of calcium was 88.27mgL-1 in pre monsoon and 55.9mgL-1 in post monsoon period respectively. The average concentration of magnesium was 64.4mgL-1 and 73.36mgL-1 in pre and post monsoon period respectively. Calcium hardness and magnesium hardness were found to be slightly above the permissible limits similar observations were recorded by **(Geeta 2012).** Maximum concentration of Calcium were observed in well, spring and bore water and minimum was in tap water, where as in magnesium concentration the low value was found in bore sample and high value was observed in spring and well water.

Chloride (Cl-) Chloride occurs in all types of natural waters. The high concentration of chloride is considered to be an indication of pollution **(Venkatasubramanian *et al*., 2007).** The sewage water and industrial effluent are rich in chloride and hence the discharge of these wastes results in high chloride level in surface water **(Haslan *et al*., 1991).** In the study chlorides ranged from 33.2 mgL-1 to 172 mgL-1 in pre monsoon period and 21 mgL-1 to 134 mgL-1 in post monsoon respectively. The chloride content are found to be below the permissible limit of 250mg/l (BIS 1991), though chlorides below the permissible limits its presence denotes pollution hence required treatment before use**.**

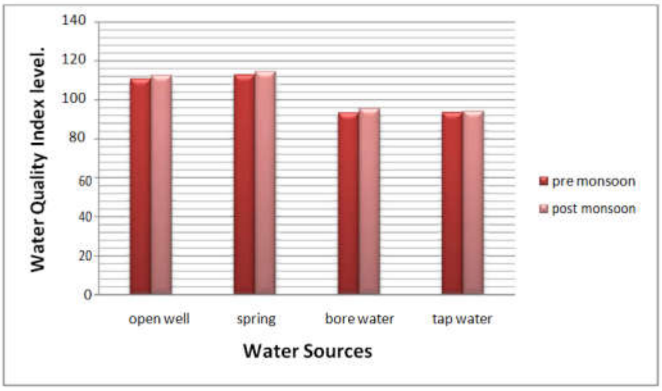
Total hardness (TH) as ($CaCo_3$): Total hardness, a measure of the quality of water supplies, is governed by the content of calcium and magnesium salts combine with carbonate and bicarbonate and with sulphate, chlorides and other anions of mineral acids. However total hardness is used to classify water as soft or hard. The average concentration of total hardness was 154.18 mgL-1in pre monsoon period and 132.45 mg L-1in post monsoon period respectively. The mean values of hardness in the water samples at all the locations have been shown in graph,11.The maximum persisted limits of **(WHO)** is 300-600 mg/l, Hard water chokes water pipes deposits incrustation on utensils and increase soap consumption

(**Nabanita Haloi *et al*., 2011**). Maximum hardness was observed after monsoon may be due to surface runoffs mixing with sources in rainy season and minimum values were observed in pre monsoon due to disinfection of water sources, well water found to be harder than the spring, bore and tap water samples.

Sulphate ($SO4^{2}$-): Sulphate is the most common ion present in water; it can produce a bitter taste at high concentration. One of the occurrences of Sulphates in natural waters may be the breakdown of Organic substances in the soil **(Alexander 1961**). The high concentration of sulphate induces diarrhea **(Shah *et al*., 2011).** The average concentration of sulphate was 4.1mgL-1 to 19.0mgL-1 in pre monsoon period 11.0mgL-1 to 23.0mgL-1 in post monsoon periods. Minimum concentration of sulphate were observed in bore water and maximum concentration were observed in spring water and slightly the concentration was increased after rainy season may be due to rain water mixing with the water source. sulphate values in all the sources were found to be below the permissible limit of 200mg/L **(BIS, 1991)**



Graph 1. Comparison of physic-chemical parameters with ISO-100500 & WHO standards



GRAPH 2. WQI in pre and post monsoon period of different sources

Nitrate (NO_{3-}): Nitrates generally occur in trace level in surface waters, but may attain high levels in some ground waters one of the reasons may be application of fertilizers to lands also contribute nitrate to ground water (**Peavy *et al*., 1986**). The higher concentration of nitrate causes Methaemoglobinemia in infants (**Vijay Kumar *et al*., 2005).** The average concentration of nitrate water was 0.51mgL-1 to 10. 0 mgL-1 in pre monsoon period and 1.0 mgL-1 to 8.0 mgL-1 in post monsoon period. Maximum value was observed in bore water sample and minimum value was observed in tap water source and the nitrates concentration in all the samples were below the desirable limits (BDL).

Fluoride (F-): The recommended limit of fluorides as per **WHO** are 1.5 mg/L and 1-1.5 as per **ISO (10500:2004)**. Values over 1.5mg/L may cause dental fluorosis or mottling of permanent teeth in children between the ages of birth to 13 years **(Chandra *et al*., 2012).** The average concentration of fluoride was 0.08 mgL-1 to 0.52 mgL-1 in pre season and 0.1 mgL-1 to 0.6 mgL-1 in post monsoon period respectively. Maximum concentration of fluoride was observed in bore water sample and the least value was observed in Well water sample, almost all the water samples were below the desirable limit of WHO and BIS standards.

Water quality index (WQI): The water quality index is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public/lay men in a consistent manner. Water quality index (WQI) was assessed based on the WQI Level by **(Chatterji and Raziuddin 2002**), (Table 1 & 2, 5 & 6). The study shows very poor quality of water sample from all 11 locations across, Anathagiri, Mandal for drinking purpose as per the water quality index. The water quality index, (WQI) assessed was **82.86** (Very poor water quality Range) in pre monsoon period and **113.751** (Un suitable for Drinking Range) in post monsoon season respectively, when comparing the WQI of the pre and post monsoon the WQI after the monsoon was found to be more worse, in the range of unsuitable for drinking water than the pre monsoon period, even though of its poor quality range. The average water quality index (WQI) was **93.458** **(**Very poor water quality Range) in bore water, **110.757 (**Un suitable for Drinking Range) in well water, **112.866 (**Un suitable for Drinking Range) in spring water and **93.538** (Very poor water quality Range) in tap water respectively in different sources. Hence, the analysis suggest that the water from bore well found to be little safer than the spring, open well and tap water in pre and post monsoon and the water in pre monsoon is better than the post monsoon period, the water needed to some degree of treatment before usage.

Conclusion

The study elevated that the water in the tribal areas of Visakhaptnam, District, Ananthagiri Mandal was found to be below the permissible limits, in parameters like, chlorides, Total hardness, Fluorides, Sulphates and Nitrates, pH, Turbidity, Calcium, Magnesium, Total solids, Electrical conductivity and In some extent dissolved oxygen found to be above the range of permissible limit of the WHO and BIS standards. From this study it is evident that, the concentrations of physical, chemical content in spring and well found to be higher than the bore water. Hence the bore water is faintly preferred for drinking for the local tribal community than the spring and well, in the absence of other alternative sources. The particular water from its sources with high value in some parameters like turbidity and Total solids may be due to mixing of surface runoffs and the silts carried, in rainy season, and this water is recommended to be treated or filtered before it is utilized for drinking. The Water quality index (WQI) indicates that the groundwater (bore) of a few locations are in the range of very poor quality and the well and spring water found in the range of un suitable range for drinking, thus it is suggested that the bore water found safer in some extent than the spring and well, and tap sources. Over all it is concluded that the water from all sources need some degree of treatment/filtration before consumption and also needed to be protected from the perils of the prevailing and reducing disaster

REFERENCES

Abdel-Satar, A.M. 2005. *J. Egypt Acad. Soc. Environ. Develep*, 49-73

Alexander, D.C. 1961. Introduction to soil Microbiology. Wiley, New York-London.

BIS. 1992 Specification for drinking water IS 10500:1991. Edition 2.2 Bureau of Indian Standards, New Delhi.

Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. 1970. A water quality index: Do we dare? *Water & Sewage Works, 117*, 339– 343.

Chandra S., Singh A., Tomer P.K. 2012. *Chem Sci Trans*, 1 (3), 508-515

Chirila, E., T. Bari and L. Barbes, 2010. Drinking water quality assessment in Constanta town. *Ovidius Univ. Ann. Chem*., 21: 87-90.

Dabevska-Kostoska, M., Dj. Fejzuli, M. Srbinovski, M. Ismaili and S. Aliu, 2007. Quality of drinking water in Dolni Polog region. Macedonian Ecol. Soc.

Garg RK, Saksena DN. and Rao RJ. 2006. Assessment of Physico-chemical water quality of Harsi reservoir district Gwalior, Madhya Pradesh, *Journal of Ecophyiology and Occupational Health*, 6,pp 33-40

Geeta, 2012. "A physico chemical and microbial Analysis of Drinking Water in some Parts of Chinthapalli Mandal Visakhapatnam Andhra Pradesh India". Ph.D Thesis Andhra University Visakhapatnam.

Haslan S.M. 1991. River Pollution, Belhaven Press, Great Britain.

Horton, R. K. 1965. An index number system for rating water quality. *Journal–Water Pollution Control Federation,* 37, 300–305.

Jeyakumar, T., Indira, S. and THILLAI Arasu, P. 2003. Status of ground water quality and public health around Tiruchendur Indian, *J.Env.Prot*., 23(3):256-260.

Krishnan, R.R., K. Dharmaraj and B.D.R. Kumari, 2007. A comparative study on the physicochemical and bacterial analysis of drinking, bore well and sewage water in the three different places of Sivakasi. J. En. Biol. January, 28: 105-108.

Li, L., P. Byleveld, A. Leask and W. Smith, 2009. Assessment of chemical quality of drinking water in regional New South Wales, Australia. Proceedings of the 18th World IMACS/MODSIM Congress, Jul. 13-17, Cairns, Australia, pp: 4326-4332.

Magnuss, V., 2009. Chemical composition and assessment of drinking water quality: Latvia case study. *Proc. ECOpole*, 3: 267-272.

Mandalm P., Upadhyay, R., Hasan, A. 2009. Seasonal and spatial variation of Yamuna.

Nabanita Haloi and Sharma H.P. 2011. "Seasonal distribution of physico-chemical parameters of ground water of Barpeta district, Assam, India". *Archives of Applied Science Research*, Vol 3(6):107-113.

Ozdemir, C., E. Kalipci and S. Sahinkaya, 2010. Evaluation of bacteriological and chemical analysis of drinking water used in konya. Balwois 2010- Ohrid, Republic Macedonia, Ohrid.

Parvez, F., Y. Chen, M. Argos, A. Z. M. I. Hussain and H. Momotaj, 2006. Prevalence of arsenic exposure from drinking water and awareness of its health risks in a Bangladeshi population, results large population-based study. *Eng. Health Perspectives*, 114: 355-59. DOI: 10.1289/ehp.7903

Peavy, H.S., Rowl, D.R. and Techobunoglons, G. 1986. Envl.Eng. 3rd Ed., Mc Grew Hill Cook Company, NewDelhi, 11-39.

River water quality in Delhi, India. *Environ Monit Assess*, DOI 10.1007/s10661-009-1265-2. Shah D.G., Patel P.S., 2(5) (2011), 8-11

Sundar M L, Saseetharan M K. 2008. *J Environ Sci Eng* 50(3), 187-190,

Venkatasubramani R. and Meenambal, T. 2007. *Nat, Environ, Poll Tech*., 6, 307-313

Vijaykumara, J. Narayana, E.T. Puttaiah and K. Harishbabu, 2005. *J. Eco. Taxicol. Environ Monit*, 15,3, 253- 261.

Wavde P N, Arjun B. 2010. *J Environ Sci Eng*, 52(1), 57-60.

WHO, 2007. Chemical safety of drinking-water: Assessing priorities for risk management. *Int. J. Environ. Stud*., DOI: 10.1080/00207233.2011.565947

Yanggen, D.A. and S.M. Born, 1990. Protecting groundwater quality by managing local land use. *J. Soil Water Conser*., 45: 207-210.

Zamxaka, M., G. Pironcheva and N. Muyima, 2004. Microbiological and physico-chemical assessment of the quality of domestic water sources in selected rural communities of the Eastern Cape Province, South Africa. Water SA, 30: 333-340.

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