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ASSESSMENT OF PHYSICO-CHEMICAL QUALITY OF DRINKING WATER AND WATER QUALITY INDEX IN TRIBAL AREA OF DUMBRIGUDA MANDAL, OF VISAKHAPATNAM DISTRICT, ANDHRA PRADESH, INDIA

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ABSTRACT

The study was carried out in Dumbriguda Mandal by collecting and analysing the physic-chemical parameters of water samples (four open well, two bore and one spring) during April - October 2015. The results were compared with standards prescribed by WHO and ISO 10500-91. The parameters including pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), calcium (Ca2+) magnesium (Mg2+), Fluoride (F^-), Sulphate (SO_4^{2-}), chloride (Cl^-), nitrate (NO_3^-), phosphate (PO_4^{3-}) and BOD (Biological Oxygen Demand) were analyzed. The quality of water source of, each parameter was compared with the standard desirable limit of that parameter in drinking water as prescribed by Indian Standard 10500-91 and WHO. The comparison of different parameters spatially showed an increasing pattern in Electrical Conductivity, Total Dissolved Solids, Turbidity, Calcium and magnesium, DO, and Phosphates concentrations. Turbidity and TDs are highly correlated in pre monsoon, where as in post monsoon BOD and Do are strongly correlated in pre-monsoon season and in post-monsoon season, the influence of TH on EC, MgH, DO and CaH were also observed with significantly positive – correlation .The WQI has been calculated by using the standards of the drinking water quality recommended by the WHO. WQI was registered was 63.110 in the range of poor water quality category (WQI-76-100) in pre monsoon period and 94.98 under the category (76-100) of very poor water quality range for post-monsoon. The study shows very poor quality of water sample from all 07 locations across Dumbriguda Mandal for drinking purpose as per the water quality index.

INTRODUCTION

Poor water quality is responsible for the deaths of an estimated five million children annually (Watson 1996). Drinking water is generally considered to be of good quality due to modern water treatment facilities, including filtration and policies that protect catchments from human activities. The large water utilities also have the capacity to monitor for protozoan parasites and enteric viruses that are now recognized as the most significant causes of water-borne disease in developed countries. Many rural Indian cities, towns and villages do not have filtered drinking water and their catchments are generally not as completely protected as those supplying the major areas.

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Further the smaller utilities do not have the resources to monitor for protozoan pathogens and enteric viruses. Groundwater is generally considered to be much cleaner than surface water. However, several factors such as discharge of industrial, agricultural and domestic wastes, land use practices, geological formation, rainfall patterns and infiltration rate affects the groundwater quality and once contamination of groundwater in aquifers occurs, it persists for hundreds of years because of very slow movement in them (Jayalakshmi and Belagali 2006). It is used for drinking, irrigation, electricity generation, and many more. Water pollution are mainly due to contamination by foreign matter such as microorganism, chemicals, industrial or other wastes or sewage which deteriorate the quality of the water and cause to be unfit for its intended uses. Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. The science of hydrology has evolved to help us understand the complex water systems of the Earth and help solve water quality and quantity problems. Hydrology evaluates the location, distribution, movement and properties of water and its relationship with its environment. Around the world people have used groundwater as a source of drinking water, and even today more than half the world's population depends on groundwater for survival (UNESCO 1992). The value of groundwater lies not only in its wide spread occurrence and availability but also in its invariable good quality, which makes it an ideal supply of drinking water (UNESCO 2000).

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). Accumulated sewage can find its way into damaged water supply systems. Thus, improper maintenance is an additional factor of water pollution; 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). 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. Monitoring of drinking water quality is an important component of water management, while data analysis is necessary for the identification and characterization of water quality problems. Assessment is the process by which water quality data is transformed into information.

The information gained from monitoring is essential for assessing water quality. 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 this 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 drinking water analyses for bacteriological and physical-chemical properties are essential for public health studies. The bacteriological analysis determines the portability of water. The provision of potable drinking water for rural and urban areas is necessary to prevent the dangers of water diseases and public health prevention. Potable water has to comply with certain physical, chemical and microbiological standards (Okonko *et al*., 2008), which should not contain microorganisms and chemicals at harmful levels (Arunabh and Bhatt, 2008). 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.

In the tribal region of Visakhapatnam district the main sources of water are open wells, Bore wells, Natural Springs (Oota) and Kundi's available for drinking and utility purpose. In some remote habitations, even due to unacceptable quality of water, the water form natural springs are preferred. According to the survey in the villages, there have been facing severe scarcities of drinking water in spite of good rain fall over the region. Every year people die due to drinking of contaminated water which causes water borne diseases like malaria, dengue, typhoid, diarrhea and cholera in rainy season. But the villages could not effort for the replacement due to their economic problems and location in isolated areas. So far no studies have been conducted on the water quality with regard to its physical and chemical activity, and therefore there is a need to find out the status of water quality in this tribal area.

The main objectives of the study include

- To assess the quality of drinking water consumed by tribal Community by Physical, Chemical parameters.
- To determine the water quality index in pre and post monsoon seasons.

MATERIALS AND METHODS

Study Area

The study area is located in Dumbriguda mandal which is on the north-eastern part of Visakhapatnam district, Andhra Pradesh India. The Dumbriguda mandal is 15 km from Araku valley division which consist of the hilly regions covered by Eastern Ghats with an altitude of about 900 meters dotted by several peaks exceeding 1200 meters above the sea level. The area lies between 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.

Sample Collection and Analysis

Water samples were collected by random sampling method from Open wells, bore wells, and spring from different villages of Dumbriguda Mandal, Visakhapatnam district Andhra Pradesh, India in pre and post monsoon seasons 2015. The samples were obtained 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 laboratory of

Department of Environmental Sciences Andhra University, by following 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 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 15 water quality parameters in replicates viz., pH, TDS, TH, CH, turbidity, EC, DO, BOD, PO_4 Cl , SO_4 , NO_3 and F^{-1} [Table 2&03]. The experimental values were compared with standard values recommended by the WHO. The calculation of WQI was done by Weighted Arithmetic Index (WAI) method. Eleven water quality parameters were considered for calculation of water quality index. The statistical analysis such as mean, correlation of obtained data were carried out using Microsoft offices excel 2007.The mean values were calculated to know the chemical parameters which are deviating from WHO standard. The correlation analysis was done to understand the closeness of the relationship between chosen variables.

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 the 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.

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

(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.

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

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.

$$WQI = \sum qn\, Wn / \sum Wn \qquad (3)$$

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, K. *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.

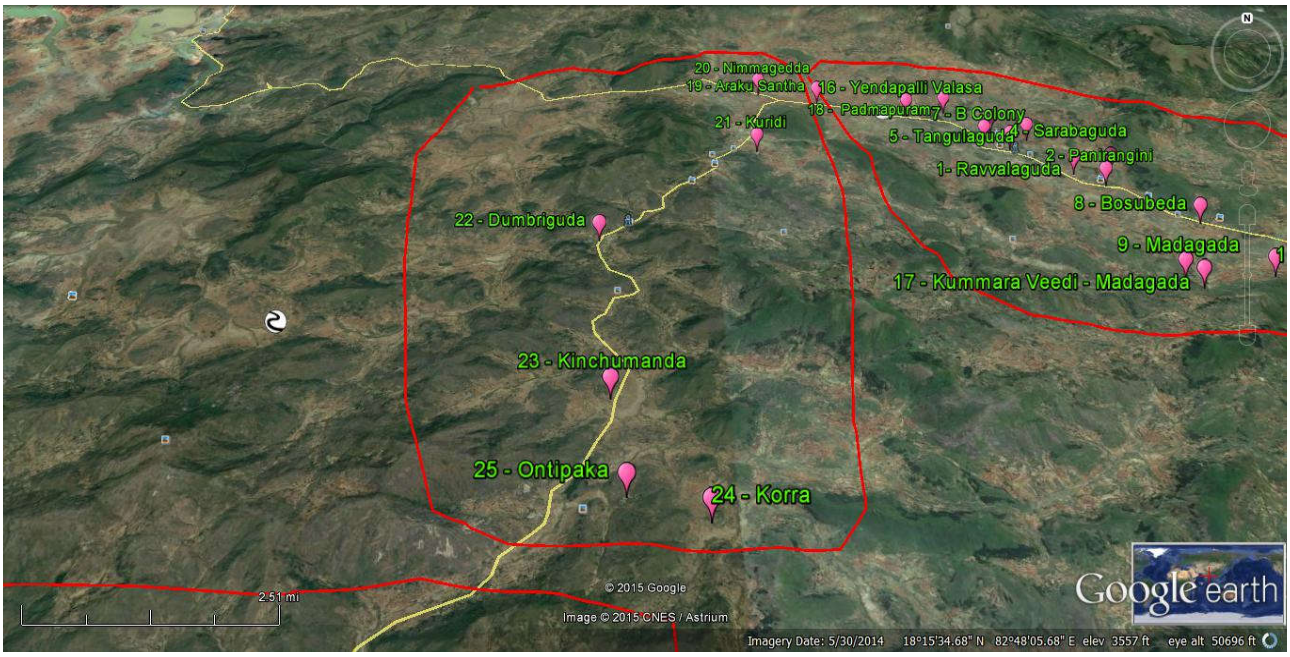

Fig.1. Sampling Locations in Dumbriguda Mandal

RESULT AND DISCUSSION

The potable nature of groundwater is mainly based on the physico-chemical characteristics of the water sample of season-wise analysis of 07 water samples of Dumbriguda Mandal was done for both pre and post monsoon and is presented in (Table 2 and 3)

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	Turbidometric	Turbidity Meter
6.	Nitrate	Phenol disulphonic 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 20^oC followed by titration	BOD Incubator

PH: pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The mean values of the pH in the water samples were 5.5 to7.4 and 7.47 to 8.58 for pre-monsoon and post-monsoon seasons respectively. This approves that the nature of groundwater samples vary from slightly acidic to slightly alkaline, and neutral to slightly alkaline in pre and post monsoon. This may be due to the presence if high dissolved carbon dioxide and organic acids (fulvic and humic acids), which are derived from the decay and subsequent leaching of plant materials (Ho Langmuir 1987). However, all the 07 samples were registered with the pH values between 5.5 and 8.58 which were not in the range of 6.5-8.5 (WHO, 1994) the permissible limit as per WHO standard in pre monsoon period.

Electrical Conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts (Dahiya *et al*., 1999). The EC values range from 35 µS /cm to 423 µS /cm with mean value of 188 us/cm in pre monsoon period and 100us/cm to 888 µS /cm in post monsoon season. High value of EC was observed in two sources spring and well water sources in post and pre monsoons respectively. The recommended permissible limits for electrical conductivity are 300µS/cm to 400µs/S/cm (ISO 10500:2004). The Electric conductivity is higher than the permissible limits in post monsoon when compared to pre-monsoon in all the samples; the high Electric conductivity may be due to the silt carried by the surface runoffs during rainy season in the hilly areas. (Kuchekar *et al*., 2008) observed that the Electrical conductivity of water samples was high in monsoon.

TDS(Total dissolved solids): No health based guideline is proposed by WHO for TDS. Since TDS higher than 1000 mg/L impart taste to the water, therefore, a desirable value of 1000 mg/L is proposed by WHO. Furthermore, a value higher than 1000 mg/L results in excessive scales in water pipes, heaters, boilers and household appliances (WHO), Geneva, (2004). The concentration of TDS was found to be in the ranges of 98 to 745 mg/L and 104 to 1152 mg/L in pre and post monsoon respectively. The mean concentration of water samples was 251 mg/L and 266.71 mg/L in pre and post monsoon respectively, it can be further pointed out that TDS in the drinking water samples consistently increased at all the sampling points after monsoon; this may be due to the dilution of underground aquifer after the monsoon season. TDS at some sampling sources (springs) increased as compared to the other sources in post monsoon may be due to unhygienic practices or may due to dilution of surface water sources(streams) from upper hilly areas.

Turbidity: In most waters, turbidity is due to colloidal and extremely fine dispersions. The turbidity indicates clarity of water and which is caused by living and nonliving suspended matter and also colour producing substances. The turbidity readings of the samples range from 5.8 to 17.5 NTU, 5.9 to 48.2 NTU in pre and post monsoon with mean of 8.45 NTU, 13.31 NTU in pre and post monsoon period respectively. Sampling points showed turbidity above the limits prescribed by ISI 10500- 91 and WHO as shown in table 3&4. The consumption of highly turbid water may constitute a health risk as excessive turbidity can protect pathogenic microorganisms from the effects of disinfectants, and also stimulate the growth of bacteria during storage (Zvikomborero, 2005). Deterioration in drinking water quality in distribution networks is probably due to an increase in microbial numbers, an elevated concentration of iron or increased turbidity, all of which affect taste, odour, and colour in the drinking water. Turbidity can provide shelter for opportunistic microorganisms and pathogens (Aulicino *et al*., 2004).

Chloride: The chloride content in the water samples of Dumbriguda Mandal is quite low and varies from 3.91 to 59.1 mg/L during the pre-monsoon season and 28 to 78 mg/L during the post-monsoon season. No sample in the study area crosses the desirable limit of 250 mg/L. The limits of chloride have been laid down primarily for taste considerations. A limit of 250 mg/L chloride has been recommended as desirable limit for drinking water supplies (BIS 1991; WHO 1996). However, no adverse health effects on humans have been reported from intake of water containing an even higher content of chloride. The most important source of chlorides in the waters is the discharge of domestic sewage (Patil and Patil, 2011). In the present analysis, chloride concentration was found in the range of 3.91mg/L to 78 mg/L. The chloride concentration was within the prescribed limits of WHO and BIS.

Total Alkalinity: Alkalinity itself is not harmful to human health though the still water supplies with less than 100 mg/L are desirable for domestic use, (Trivedi and Goel, 1984). (Ramaswamy and Rangaraju 1991) reported higher alkalinity value in the ground water of Tirrupur, Tamilnadu that may be due to the contamination of these resources with domestic and industrial wastes. In the study, the alkalinity of water sample ranges from 11.5 to 52 mg/L, 39 to 57 mg/L with mean of 21.24 mg/L and 50.85 mg/L during pre and post monsoon respectively. The alkalinity was higher in well and bore water, than the WHO prescribed limits of 200 mg/L. The value of alkalinity in water provides an idea of natural salts present in water. The standard desirable limits of alkalinity in portable water is recommended to be 120 mg/L (WHO, 1984) but, the water samples had not exceeded the alkalinity value prescribed by WHO.

the values of calcium and magnesium range from 16.5 to 118.2mg/L and 55 to 155 mg/L respectively, during the pre-monsoon season. Slightly higher values of calcium and magnesium were observed in spring water during the post-monsoon season may be due to dilution effect of rain water. In ground water, the calcium content generally exceeds the magnesium content in accordance with their relative abundance in rocks. The increase of magnesium is quite proportionate with calcium in both the seasons. About 40% of the samples of the study area fall within the desirable limit of 75 and 30 mg/L for calcium and magnesium in both pre- and post-monsoon seasons and the remaining 60% of the samples exceed the desirable limit prescribed for drinking water. The concentration of Calcium and magnesium were above the limits in post monsoon may be due to dilution effect of underground aquifers.

Fluoride: The presence of fluoride in drinking water is essential and WHO (1984) prescribed 1.5 mg/L fluoride as desirable limits in drinking water. In this study fluoride concentration observed from 0.22 to 0.78 mg/L, and 0.1 to 0.4 mg/L with the mean of 0.53mg/L and 0.25 mg/L in pre and post monsoon respectively, The concentration of fluoride ions in drinking water of study area is observed to be within the permissible limits of WHO and BIS standards. Small concentration of fluoride in drinking water has beneficial effect on human health for preventing dental carries. Higher concentration of fluoride than that of 1.5 mg/L carry an increasing risk of dental fluorosis and much higher concentration lead to skeletal fluorosis, (Vyas *et al.,* 2008).

Table 2. Physico - chemical parameters of water samples in the pre-monsoon. All values are expressed in mg/L except pH, Conductivity in (µmS/cm), turbidity in NTU

S.No.	Location	Source	pH	EC	TDS	Cl	TH	CaH	MgH	TA	F	Nitra	Phosp	Sulp	DO	BOD	turbid
1	Araku santha	Well	6.32	331	310	59.1	148	68	80	16.6	0.78	2.5	4.2	21	5.0	2.0	7.5
2	Nimmagedda	Bore	5.5	164	98	33.5	89	63	26	11.5	0.3	5	3.7	28	2.6	0.5	6.3
3	Kurdi	Spring	7.4	35	745	9.78	71.2	35.2	36	18.3	0.63	2.21	2.2	84	5.6	2.6	17.5
4	Dumbriguda	Bore	7.12	157	110	7.82	148	41.6	99.2	16.6	0.74	2.0	3.7	32	5.9	2.8	5.8
5	Kinchumanda	Well	6.90	423	128	9.78	240.	16.5	124	18.5	0.31	4.1	6.2	26	5.4	2.1	6.3
6	Korra	Well	6.0	113	203	3.91	140	118.2	21.27	15.2	0.74	BDL	4.2	28	5.5	3.5	9.9
7	Ontipaka	Well	6.7	93	163	5.8	142	82	60	18.2	0.22	3.2	3.4	18.2	3.2	1.5	5.9
	mean		6.56	188	251	18.52	139.74	60.64	63.78	21.24	0.53	2.71	3.94	33.88	4.74	2.14	8.45

Table 3. Physico-chemical parameters of water samples in the post-monsoon. All values are expressed in mg/L except pH, Conductivity in (µmS/cm), turbidity in NTU

S.No.	Location	Source	pH	EC	TDS	Cl	TH	CaH	MgH	TA	F	Nitra	Phosp	Sulp	DO	BOD	turbidi
1	Araku santha	Well	8.58	240	124	36	85	70	15	56	0.4	6.5	4.5	27	1.5	0.8	9.8
2	Nimmagedda	Bore	7.89	216	108	29	79	62	18	56	0.3	7.9	4.8	25	1.8	0.6	6.5
3	Kurdi	Spring	8.48	888	1152	28	100	55	45	56	0.1	6.5	4.3	24	8.1	2.1	10.2
4	Dumbriguda	Bore	8.45	212	115	43	185	155	30	39	0.4	6.5	4.7	27	5.1	2.0	12.1
5	Kinchumanda	Well	8.39	196	104	78	80	65	15	40	0.2	8.0	4.2	33	6.3	1.8	5.9
6	Korra	Well	7.47	264	142	36	35	75	40	57	0.3	5.0	4.8	18	6.3	1.5	42.8
7	Ontipaka	Well	8.49	100	122	57	335	125	210	52	0.1	0.4	4.8	19	9.2	2.8	9.8
	mean		8.25	302.28	266.71	43.85	128.42	86.71	53.28	50.85	0.257	5.82	4.58	24.71	5.47	1.8	13.3

Calcium and magnesium (Ca2+ and Mg2+): Calcium and magnesium, along with their carbonates, sulphates, and chlorides make the water hard. A limit of 300 mg/L has been recommended for potable water (BIS 1991). The total hardness values in the study area range from 71.2 to 240 mg/L during pre-monsoon season and 65 to 335 mg/L during post-monsoon season. In general, the hardness values are low in spring water samples in both the seasons. As evident from the results, about 98% of the samples fall within the desirable limit of 300 mg/L. The remaining 2% of the samples exceeds the desirable limit of 300mg/L but is well within the maximum permissible limit of 600 mg/L. The desirable limit for calcium and magnesium for drinking water are 75 and 30 mg/L, respectively (BIS 1991). In drinking water of the study area,

Nitrate: Presence of nitrate in water leads to organic pollution. The water samples had nitrite level range from 2 to 5 mg/L and 0.4 to 8 mg/L with mean of 2.71 mg/L and 5.82 mg/L present in pre and post monsoon respectively. The nitrate concentration in spring and well water sample is found be high in both seasons, this might be due to the activity of microorganisms from sewage and contamination of water by sewage and other waste that are rich in nitrate and spring water sources connected to the agricultural fields which may use fertilizers. The nitrates concentrations in all the samples were were low generally and below the prescribed standard of WHO. The WHO standard for nitrate is 50mg/L and above this limits may cause cyanosis disease or blue baby syndrome in infants less than 3months (WHO, 2006). Nitrate is an effective plant nutrient and is moderately toxic. A limit of 45 mg/L has been prescribed by WHO (1996) and BIS (1991) for drinking water supplies.

Sulphate (SO_4^{-2}): Sulphates are a naturally occurring anion found almost in all types of water. It gets leached into the ground water by many processes. One of those may be the breakdown of organic substance in the soil as mentioned by (Alexander 1961). In the study the SO_4^{-2} concentration varies from 18.2 to 84 mg/L, 18 to 33 mg/L during pre and post monsoon respectively. The spring and well water sample found to be in slightly more concentration when compared to the bore water sample. No sample from the different sources has exceeded the BIS and WHO prescribed standards i.e. (200mg/L) and as such, the overall concentration of sulphate in the study area is within the safe limit and ground water appears suitable for drinking purposes in respect of SO_4. The concentration of sulphates were below the limit of standard prescribed by WHO i.e. 500mg/L.

Phosphate (PO_4):-There are number of ways by which phosphates contaminate to ground water. These include anthropogenic input like chemical fertilizers household detergents, human and animal wastes while the major geological source is appetite, a principal rock mineral in which phosphorous is a chief component (Stednick, 1991). The phosphate ion, in drinking water is important since it indicates the degree of pollution. In the present study the phosphate concentration analyzed ranges from 2.2 to 6.2 mg/L , 4.2 to 4.8 mg/ L and mean value of 3.94 mg/L and 4.5 mg/L in pre and post monsoon period. As 1mg/L is the recommended standard of phosphate for the drinking water, all the water samples are slightly above the prescribed limits. No amount of phosphate in water is believed to have effects on human health (EPA, 1995).

Dissolved Oxygen(DO):- It is one of the most important aspect in evaluating water quality and signifies physical and biological process dealing with the water supply. A good water should have solubility of oxygen in 7.0 to 7.6 mg/L at 35^0C to 36^0C respectively (Kudesia, 1995), oxygen saturated water have pleasant taste. In the study, the DO found to be in the range of 2.6 to 5.9 mg/L and 1.5 to 9.2 mg/L with mean of 4.7 mg/Land 5.4 mg/L in pre and post monsoon period respectively. The sampling points showed DO values above 5.0mg/L, indicating borderline contamination by organic matter according to ISI 10500-91 Standards.

BOD (Biological oxygen Demand): BOD is the most important parameter which is used to assess the quality of water regarding organic matter present in both suspended and dissolved form. Biochemical oxygen demand (BOD) is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions (Sawyer *et al*., 1978) Usually drinking water has a BOD of less than 1mg/L and water is considered to be fairly pure if BOD is of 3mg/L and doubtful purity is at BOD value of 5mg/L (Rao, 1997.) In the study BOD values range from 0.5 to 3.5 mg/L and 0.6 to 2.8 mg/L with mean of 2.14 mg/L and 1.8 mg/L respectively in pre and post seasons.

Correlations

The Karl Pearson correlation matrix was calculated for the water quality parameters for pre and post monsoon season are displayed in Table 4&5. The parameters that are highly positively interrelated with each other are TH and EC: 0.801349 **;** MgH and EC,TH (Total Hardness) : 0.740796, 0.811395 **;** TA (Total Alkalinity) and Cl (chlorides): 0.668644 ; PO_4 (phosphate) and EC (Electrical Conductivity) with MgH: 0.879406, 0.639038**;** while moderate correlation was found in DO (Dissolved Oxygen) and pH with F(Flouride): 0.610608, 0.724281 **;** BOD and TDS (Total dissolved solids) with F and DO:0.70183,0.718897,0.879103**;** turbidity and TDS correlated highly with CaH(Calcium Hardness):0.955923, 0.65912, in pre monsoon season. In post monsoon season the strong correlation was found in MgH with TH:0.882756 **;** PO_4 with TDS:0.617041**;** SO_4 and NO_3:0.723202**;** DO with TH and MgH:0.509048, 0.656471 ; BOD and TH with MgH, DO: 0.727879, 0.726745 and 0.933411.The values account for greater corelations are DO and BOD in both the seasons.

Turbidity and TDs were highly correlated in pre monsoon, and in post monsoon BOD and Do are strongly correlated. In pre-monsoon season and in post-monsoon season the influence of TH on EC and MgH, DO and CaH were also observed with significantly positive - correlation. The correlation of NO_3 with SO_4 in post monsoon has been found with higher positive *r* value (0.723202) and in post-monsoon (-0.17047) it is negatively correlated.

Water quality index (WQI): Water quality index (WQI) was also assessed based on the WQI Level by (Chatterji and Raziuddin 2002) (Table 5&6). The WQI registered was 63.110 in the range of poor water quality (WQI-76-100) (Table 8) in pre monsoon period and 94.98 in the range (76-100) of very poor water quality range in post-monsoon. The study showed a very poor quality of water from all 07 locations across Dumbriguda mandal for drinking purpose as per the water quality index. The water quality index in post monsoon found to be more worse than the pre monsoon water quality index this may be due to mixing of silt and rain water in to open wells and springs in rainy season. However, this water can be used for drinking purpose only after treatment followed by disinfection and needed to be protected from the perils and contaminations. A very poor category of water quality index (WQI) was recorded during post monsoon season may be due to unhygienic practices and excessive flow of agricultural and domestic waste) into spring and well water.

Table 4. Karl Pearson correlation matrix during pre-monsoon season

	pH	*EC*	*TDS*	*Cl*	*TH*	*CaH*	*MgH*	*TA*	*F*	*Nitra*	*Phosp*	*Sulp*	*DO*	*BOD*	*turbid*
pH	1														
EC	-0.08353	1													
TDS	-0.04762	-0.43432	1												
Cl	-0.43531	0.432534	-0.27334	1											
TH	0.15394	0.801349	-0.29612	-0.12422	1										
CaH	-0.60072	-0.40187	0.554369	0.008045	-0.26036	1									
MgH	0.490359	0.740796	-0.6001	0.020605	0.811395	-0.64959	1								
TA	0.239214	-0.25764	-0.21972	-0.31823	0.09253	0.193084	0.05748	1							
F	0.153569	-0.09126	0.522091	0.212535	-0.17813	0.201456	-0.06283	-0.51495	1						
Nitra	-0.17693	0.371024	-0.80517	0.298146	0.096377	-0.544	0.253903	0.083213	-0.76479	1					
Phosp	-0.17872	0.879406	-0.26269	0.0545	0.917125	-0.19014	0.639038	-0.1713	-0.21525	0.224484	1				
Sulp	0.54203	-0.49168	0.402234	-0.24325	-0.55902	-0.3673	-0.30429	-0.23962	0.245033	-0.17047	-0.61117	1			
DO	0.610608	0.153161	0.42209	-0.24279	0.295594	-0.24951	0.379383	-0.39204	0.724281	-0.64607	0.141645	0.367431	1		
BOD	0.431141	-0.15174	0.70183	-0.44359	0.162431	0.190556	0.055021	-0.19501	0.718897	-0.90707	0.001023	0.271712	0.879103	1	
turbid	-0.21551	-0.37022	0.955923	-0.33955	-0.16956	0.65912	-0.57775	-0.23737	0.449097	-0.79087	-0.09579	0.18189	0.351435	0.682855	1

Table 5. Karl Pearson correlation matrix during post-monsoon season

	pH	*EC*	*TDS*	*Cl*	*TH*	*CaH*	*MgH*	*TA*	*F*	*Nitra*	*Phosp*	*Sulp*	*DO*	*BOD*	*turbid*
pH	1														
EC	0.143865	1													
TDS	-0.53172	-0.44123	1												
Cl	0.293061	-0.4731	-0.145	1											
TH	0.493125	-0.29767	-0.0185	0.298669	1										
CaH	0.267121	-0.443	0.21056	0.194934	0.724221	1									
MgH	0.208451	-0.22051	0.196062	0.242562	0.882756	0.4492	1								
TA	-0.37697	0.319884	0.33127	-0.69345	-0.22877	-0.54236	0.110411	1							
F	-0.17498	-0.40439	0.3671	-0.27301	-0.3795	0.207676	-0.5978	-0.1393	1						
Nitra	-0.0916	0.246234	-0.45864	-0.13562	-0.7956	-0.47875	-0.95354	-0.20452	0.43782	1					
Phosp	-0.50586	-0.50073	0.617041	-0.36887	0.326057	0.467395	0.382127	0.296314	0.286765	-0.48067	1				
Sulp	0.471815	-0.03205	-0.64092	0.448833	-0.29368	-0.16003	-0.58836	-0.63753	0.233795	0.723202	-0.70686	1			
DO	0.125098	0.272655	-0.04	0.364589	0.509048	0.244939	0.656471	-0.15084	-0.79907	-0.61001	-0.1302	-0.36465	1		
BOD	0.362189	0.109665	-0.07226	0.439515	0.727879	0.529764	0.726745	-0.35276	-0.65499	-0.6703	-0.0721	-0.25863	0.933411	1	
turbid	0.029372	0.385402	0.220864	-0.54053	-0.22735	0.283593	-0.38656	-0.03124	0.509119	0.196411	0.034695	-0.0875	-0.12321	-0.05052	1

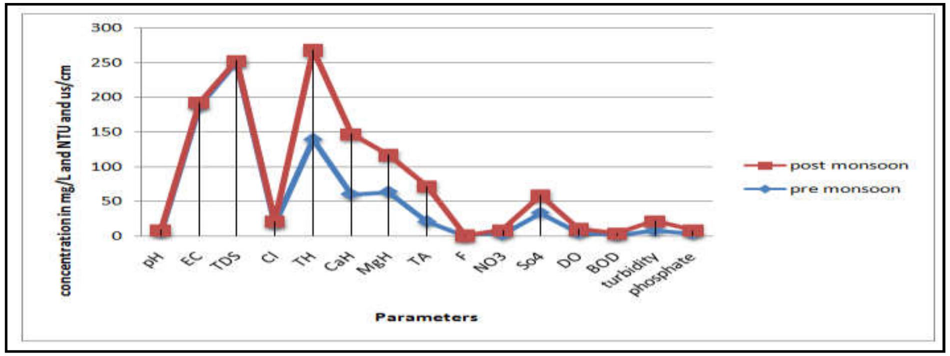

Figure 2. Graphical representation of Concentration of parameters in pre and post monsoon. All units are in mg/L except pH, turbidity in NTU and EC in us/cm

Table 6. Calculation of Water Quality Index during Pre monsoon season

S.no	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	6.56	6.5-8.5	0.2190	04	0.876
2	TDS mg/L	251	500 mg/L	0.0037	50.2	0.185
3	Chlorides mg/L	0.757	250 mg/l	0.0074	0.302	0.0022
4	Total hardness mg/L	139.74	300 mg/L	0.0062	46.58	0.288
5	Turbidity , NTU	8.54	05 NTU	0.08	170.8	13.664
6	Calcium mg/L	60.64	75 mg/l	0.066	40.85	2.696
7	Total alkalinity mg/L	21.24	120 mg/L	0.0155	17.7	0.274
8	Sulphates mg/L	33.88	250 mg/L	0.01236	13.55	0.167
9	Nitrates mg/L	2.71	45mg/L	0.0412	6.02	0.248
10	Fluorides mg/L	0.53	01 mg/L	0.166	53.0	8.798
11	Dissolved oxygen mg/L	4.74	5.0 mg/L	0.3723	94.8	35.26

Water quality index =∑ Wn qn / ∑ Wn= 63.110 (Poor water quality), ∑Wn=0.98966 ∑qn = 497.802 ∑Wn*qn =62.4582

Table 7. Calculation of Water Quality Index during Post monsoon season

S.no	Parameter	Observed value	Standard value (Sn) WHO,ISO 100500:04	Unit Weight (Wn)	Quality rating (qn)	qn* Wn
1	pH	8.25	6.5-8.5	0.2190	83.33	18.249
2	TDS mg/L	266.7	500 mg/L	0.0037	53.34	0.197
3	Chlorides mg/L	43.85	250 mg/l	0.0074	17.54	0.129
4	Total hardness mg/L	128.42	300 mg/L	0.0062	42.806	0.265
5	Turbidity , NTU	13.31	05 NTU	0.08	266.2	21.29
6	Calcium mg/L	86.71	75 mg/L	0.066	115.61	7.630
7	Total alkalinity mg/L	50.85	120 mg/L	0.0155	42.37	0.656
8	Sulphates mg/L	24.71	250 mg/L	0.01236	9.884	0.1221
9	Nitrates mg/L	5.82	45mg/L	0.0412	12.933	0.532
10	Fluorides mg/L	0.25	01 mg/L	0.166	25	4.15
11	Dissolved oxygen mg/L	5.47	5.0 mg/L	0.3723	109.4	40.72

Water quality index =∑ Wn qn / ∑ Wn= 94.984(very poor water quality), ∑Wn = 0.9896 ∑qn= 778.413 ∑Wn*qn =93.940

Table 8. 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
26 - 50	Good water quality
51 - 75	Poor water quality
76 - 100	Very poor water quality
≥ 100	Un suitable for drinking

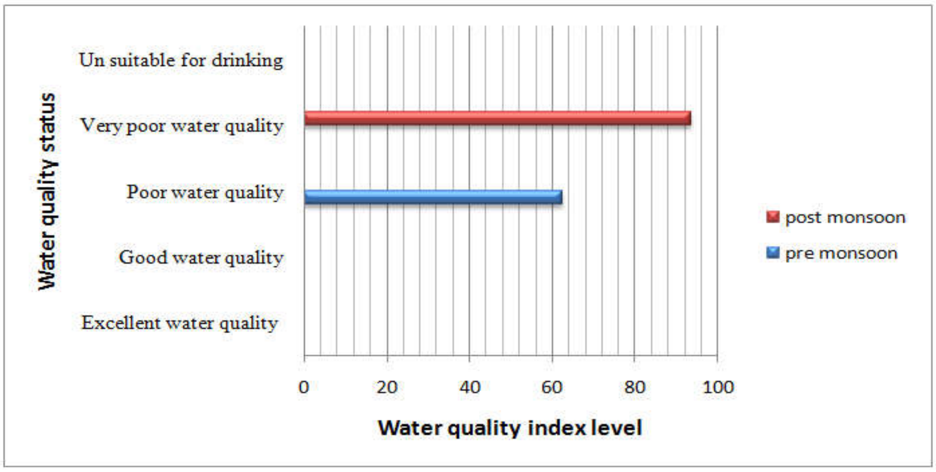

Figure 03. Water Quality Index (WQI) and status of water quality in pre and post monsoon seasons

Conclusion

From the study it was observed that some physico – chemical parameters and Water quality index (WQI) were determined from different sources were above the limits of WHO.

The water samples collected from hand-pumps, well and spring showed deviations from water quality standards indicating that the drinking water was contaminated mostly in post monsoon period. The comparison of different parameters spatially showed an increasing pattern of Electricity

Conductivity, Total Dissolved Solids, Turbidity, Calcium and magnesium, DO, and Phosphates concentrations. Water quality index (WQI) was found to be in the range of poor water quality in pre monsoon season and in the range very poor water quality in post monsoon seasons. This refers that the water quality in post monsoon found to be worse than the pre monsoon. The tribal people living in these areas are therefore at higher potential risk of contracting water-borne and sanitation related diseases, and water from these sites is unfit for drinking purpose. In conclusion it is necessary to apply strong preventions immediately to save water from deterioration in the study area. Thus high priority should be given to water quality monitoring and advanced technologies should be adopted to make water fit for domestic and drinking purpose, after treatment as such condition if prevails would make water unfit causing various health hazards.

REFERENCES

Alexander, M. M., P. Longabucco & D. M. Philips, 1981. The impacts of oil on marsh communities in the St. Lawrence River: Oil Spill Conference, American Petroleum Institute, Washington D.C, pp. 333-340.

American Public Health Association, 1989. Standard methods for the examination of water and waste water, 17th Ed., Washington, DC.

Arunabh, M. and V. Bhatt, 2008. Physico-chemical and microbiological analysis of underground water in V.V Nagar and Nearby Places of Anand District, Gujarat, India. E-J. Chem., 5: 487-492.

Aulicino F.A. and Pastoni F. 2004. Microorganisms surviving in drinking water systems and related problems, *Annali d'igiene* 16 (1–2), 265–272.

BIS, 1991. Specifications for Drinking Water, IS:10500: 1991, Bureau of Indian Standards, New Delhi, India.

Chan, C.L., M.K. Zalifah and A.S. Norrakiah, 2007. Microbiological and physicochemical quality of drinking water. Malaysian J. Anal. Sci., 11: 414-420.

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.

Dahiya S. and Kaur A., physic chemical characteristics of underground water in rural areas of Tosham subdivisions, Bhiwani district, Haryana, *J. Environ Poll.,* 6 (4), 281 (1999)

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

Kuchekar S.R, Kamble P.N, Kokate S.J, Aher H.R, (2008), Seasonal variation in Physico- Chemical parameters of Khadakwasala Reservoir. *Rasayam Journal of Chemistry* Vol1, No1, 63—67.

Langmuir, D., 1987. Aqueous environmental chemistry, Prentice-Hall, Inc., New Jersey, pp: 600. 23.

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.

Manivaskam N., 2005. Physicochemical examination of water sewage and industrial effluent. 5th Edition, Pragati Prakashan, Meerut.

Okonko, I., O. Adejoye, O. Damilola, O. Tolulope and A. Fajobi *et al*., 2008. Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Gojota, Lagos state, Nigeria. *Afr. J. Biotechnol*., 7: 617-621.

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

Patil, V.T. and Patil, P.R. 2010. Physicochemical Analysis of Selected Groundwater Samples of Amalner Town in Jalgaon District, Maharashtra, India. *E-J. of Chem.* 7(1): 111-116.

Ramaswamy V. and Rajaguru, P.1991. Ground Water quality of Tirrupur, *Indian J.Envl. Hlth.* Vol 33 (2,) 187-191

Sawyer, C N, McCarthy, P. L. 1978. Chemistry for environmental engineering, 3rd edn. McGraw- Hill Book Company, New York.

Thompson, T., 2007. Chemical safety of DrinkingWater: Assessing Priorities for Risk Assessment. 1st Edn., World Health Organization, Geneva, ISBN: 924154676X, pp: 142.

Trivedy R K and Goel P K 1986 Chemical and Biological methods for water pollution studies Environmental Publication, Karad.

UNESCO, 1992. Groundwater UNESCO Environmental and development, briefs no. 2, p 14. 9.

UNESCO, 2000. Groundwater pollution, International Hydrological Programme.

Vyas, H. V. and Sawant, V. A., 2008. Seasonal variations in drinking water quality of some bore well waters in urban area of Kolhapur city, Nature environment and pollution technology, 7 (2), pp 261-266.

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

Yalakshmi Devi, O. and Belagali, S. L. 2006. Nature, Environment and pollution Technology (2006), 5(4), p 553.

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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