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Seasonal Variations in Physico-Chemical Parameter of Groundwater in Bhimavaram, Andhra Pradesh India

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Abstract:- Physico-chemical analysis of open well water samples was carried out from 10 sampling locations in Bhimavaram town during three seasons namely summer, rainy and winter of 2012-'13 are presented. The quality analysis was made through the estimation of physico-chemical parameters such as pH, Turbidity, EC, TDS, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, D.O, TH, Ca^{2+}, Mg^{2+}, F^-, Na^+, K^+ and BOD. Each parameter was compared with its standard permissible limit as prescribed by World Health Organization (WHO) and BIS standard to assess the suitability of drinking and domestic purposes. The analytical results of groundwater samples shows that that certain parameters namely P^H, D.O and Fluoride were found within the desirable limits by BIS. However, Turbidity, EC, TH, TDS, BOD, Chloride, Sulphate, Phosphate, Nitrate, Sodium, Potassium, Calcium, were exceding the desirable limit throughout the investigation period in all locations.The results of analysis reveal that the ground water of the area was not suitable for human consumption and domestic use due to the influence saltwater intrusion, sewage, Industrial effluents and high urban concentration are the probable sources for the variation of water quality in the study area.

Keywords:- Physicochemical parameters, open well water, Industrial effluents.

I. INTRODUCTION

Half of the humanity now lives in cities and within two decades, it may cross 60 per cent. It may place heavy demand for basic needs among which water is the prime and essential resource. India has only 4 per cent of the global waters to meet the needs of its 1.25 billion human populations [25]. India is heading towards a freshwater crisis mainly due to improper management of water resources and environmental degradation, which has lead to lack of access to safe water supply to millions of people. Developing countries are witnessing changes in ground water which constitute another source of potable water Groundwater is a valuable natural resource for various human activities [18]. According to Egwari and Aboaba [7], natural processes and anthropogenic activities of man can contaminate groundwater, and such activities could be domestic, agricultural or industrial in nature. The usage of groundwater has increased substantially in Bhimavaram town of Andhra Pradesh, India. Hence it is necessary to undergo for quality analysis of groundwater in order to assess its suitability for consumption, irrigation and industrial activities. This study aims to investigate the current status of physico-chemical parameters in the ground water of Bhimavaram.

II. MATERIALS AND METHODS

2.1. Study area

Bhimavaram is located between 16º32¹00 northern latitude and 81º32¹00 eastern longitude and has a total population of 1, 42,317 as per 2001 censess (Source: Municipal Office and District Collector's office, 2011). Bhimavaram has a geographical area of 27 km^2. The study area, the town Bhimavaram with respect to state of Andhra Pradesh, India is shown in Fig. 1. In the town has some small scale industrial units like rice mills, prawn processing units, fish processing units and cement-pipes.

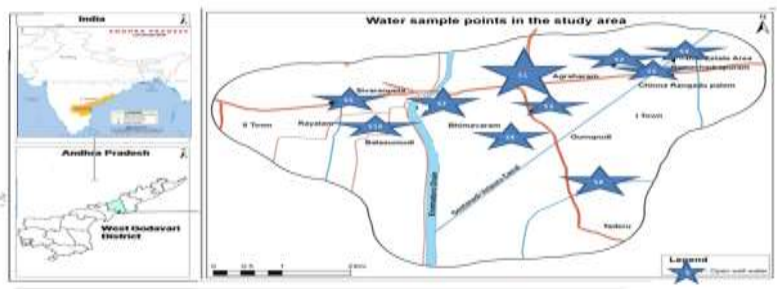

Fig.1 map showing the study area

Table 1: Studied wells locations with number, name, geographical coordinates and description of their surroundings

S.No.	**Sample Number**	**Sample name**	**Geographical Coordinates**	**Description of the sample location’s surroundings**
1	S1	Ramabhadra Badava	N16^{0}32’42 E 81‘32‘04	Situated adjacent to a seepage canal
2	S2	Industrial Estate Area	N 16^{0}32’59 E 81^{0}32’52	Situated adjacent to a pharmaceutical company
3	S3	Philips Colony	N16^{0}32’24 E 81^{0}32’14	Situated adjacent to a batteries work shop
4	S4	China Apparao Thota	N16^{0}32’05 E 81^{0}31’59	Situated near by an open field
5	S5	A.S.R.Nagar	N 16^{0}32’29 E 81^{0}30’39	Situated near by a prawn processing unit
6	S6	Maruthi Nagar	N 16^{0}32’51 E 81^{0}33’19	Situated near by rice mills
7	S7	Government Hospital	N16^{0}32’26 E 81^{0}31’20	Situated near by Eanamadurru drain
8	S8	Y.S.R. Nagar	N 16^{0}31’26 E 81^{0}32’34	Situated adjacent to a slum area
9	S9	Sanjeeva Nagar	N16^{0}32’10 E 81^{0}30’53	Situated near by a prawn tank
10	S10	Bhagath Singh Nagar	N16^{0}33’20 E 81^{0}33’21	Situated near by a prawn processing unit

2.2. Sample analysis

Open well with concrete apron around the well head were involved in the study. Water samples from 10 wells (Table 1), average depth 25-35m were collected into clean 500 ml plastic bottles. The sampling bottles were cleaned with 10% of nitric acid. After the collection of samples they were labeled and brought to Andhra university laboratory. The physico-chemical parameters were determined as described by APHA [1].

2.3. Statistical analysis

The samples were analyzed in triplicate, Graph pad prism version 6.0. To identify the seasonal variation among the different parameters were computed as well.

III. RESULT AND DISCUSSION

3.1. Water quality analysis of open well waters at Bhimavaram

Few people in Bhimavaram depend on groundwater sources for the purpose of drinking and domestic use. The quality of groundwater is mainly influenced by its physical, chemical and biological aspects which vary from place to place, with the depth of water table, and from season to season. So the comprehensive study of the 10 (S1-S10) groundwater samples qualities, covering the entire town was performed. In general, in the study area, the groundwater is available approximately 2-5 feet depth. The typical results of the analysis of the ground water in wells were presented in Tables 2 and Fig 2.

The ground water is generally clear with no colour during winter and summer seasons when viewed through normal eye but when compared with bottled water, there is some difference from turbidity point of view.

Water samples were collected from different wells in the town. The wells selected were mostly those that were being used by people for drinking and other domestic purposes. The pH values of all the samples at the entire study period were normal range within the BIS permissible limit of 6.5 – 8.5 (Table 2 and Fig 2) which indicates its suitability for various uses. But the concentration of turbidity, EC, TDS, Cl^-, SO_4^{2-}, NO_3^-, D.O, TH, Ca^{2+}, Mg^{2+}, Na^+, K^+ and BOD were higher than that of desirable limits mentioned by WHO [26]reports.

As per BIS, prescribed standard limit for turbidity in drinking water is 5 NTU. Highest turbidity values (Table 2) were found in sampling points S4 (8 NTU) and followed by sampling point S6 (7.17 NTU) in the rainy season.

BIS standard value for EC in drinking water is 300 uS/ho. The highest EC values (Table 2 and Fig.2) were found at open well water samples S2 (13400 µS/ho) and followed by S1 (1800 µS/ho) in the rainy season of the year 2012-'13. The highest value of conductivity was due to the maximum concentration of soluble salts present in the S1 and S2 during rainy season of the year 2012-'13.

TDS values were higher in S2 (8600 mg/L) and S1 (1090 mg/L) (Table 2and Fig.2). This may be due to leaching of various pollutants through sides and bottom of unlined drain. The similar results were also reported Bishnoi and Malik [4] and Ram *et al.,* [23] also observed high value of TDS in the groundwater.

The BIS desirable limit for nitrate in drinking water is 45mg/L. High concentration of nitrates was found in several wells i.e. S4 (75 mg/L), S4 (56 mg/L) in the rainy season of the year 2012-'13 (Table 2 and Fig. 2). This was attributed to seepage of waste water from the surroundings of the wells and may be due to contamination from a septic system, sewage and agricultural runoff that can leach and enter into the groundwater. The surrounding of the well is not cemented and mostly earthern. The majority of residents use the water from nearby wells. There is likely stagnation of waste water in the close surroundings of the wells. Similar results were reported by Rengaraj *et al.,* [24] on groundwater at Madras city. and also Nageswara Rao [12] in their study on groundwater at Jeedimetla Industrial Estate in Hyderabad city, Achyuthan Nair *et al.,* [2] in Northest Libya. It can be seen that higher values of nitrate resulted lower D.O values than the recommended limit of 5 mg/L [26] throughout the study period in open well water samples (Table 2). This may be due to seepage of waste water from the surroundings of the wells.

D.O affects the solubility and availability of many nutrients and thereby affecting the productivity of aquatic system [16]. D.O content was low in summer because of enhanced utilization by micro-organisms in the decomposition of organic matter. In summer the D.O depletion was due to high temperature.

The waste water might contain leachates of liquids from solid organic wastes dumped in the surroundings of wells, improperly lined septic tanks near the wells, the aquifers of the wells and seepage of fertilizers like urea, ammonia, salts, nitrates and phosphates. Major part of the fertilizers might add in the groundwater aquifers and increase the concentration of NO_3^-, SO_4^{2-} and PO_4^{3-} in the groundwater of the wells. The seepage of NO^{3-} is fast as it does not precipitate with any other metal ions unlike SO_4^{2-}or PO_4^{3-}. If the cations in soil were considered Cl^- also is not precipitated except with Pb and so, it can seep through the soil. This may be the reason for higher concentration of these ions (Cl^-, NO_3^-) in groundwater.

Standard limit of chlorides for drinking purpose is 250 mg/L given by WHO. Seasonal data showed that during the study period the chloride content was found to be high during summer season 2012-'13 in S2 (4372 mg/L) (Table 2 and Fig. 2). This might be due to decrease in amount of water and also high temperature which increase the decaying process as also reported by Zafar and Sultana [28]. A similar observation was made by Chaturvedi and Pandey [6] in their study. The present observations were contrary to the earlier reported by Rai and Srivastava *et al.,* [20] in their study.

Maximum values of sulphates were observed in the summer compared to other seasons. As per WHO, prescribed standard limit for sulphate is 250 mg/L. The highest sulphate content was found (Table 2 and Fig. 2) in S6with 390 mg/L followed by S9 (375 mg/L). This might be due to seepage of agricultural fertilizers. A similar observation was made by Nwala *et al.,* [14] and Bolaji and Tse [5] in their study. The source for the presence of sulphate in the water samples was contamination of domestic sewage [9][22].

In the present investigation, it was noted that the fluoride values were maximum in the summer than other seasons, none of the sampling sources crossed the maximum permissible limit of 1ppm set by WHO. Fluoride is more commonly found in ground water than the surface waters due to weathering of fluoride bearing rocks, primary silicates and associated accessory minerals [17][11][15].

The WHO, (2005) desirable limit for sodium in drinking water is 250 mg/L. It was found that open well water samples S2 (1878) contain more sodium than other samples (Table 34 and Fig. 21). Similar results were reported by Yusuf [27] in Lagos city.

Total hardness was found in S2 (2232 mg/L) followed by sampling point S4 (687 mg/L). These values exceeded the BIS prescribed limit of 300 mg/L drinking water. This might be due to industrial effluents directly entering into the groundwater and may be due to decay of organic matter and weathering of rocks and minerals [3]. The high values in these locations were attributed to the effluents from the pharmaceutical and drug industries which reach these points due to the westerly slope of the area.

The hardness of water is not a pollution parameter, but it indicates water quality mainly in terms of calcium and magnesium. Water containing excess hardness is not desirable for potable purposes, as it forms scales on water heaters and utensils when used for cooking and consumes more soap during washing clothes [8]. Similar results were reported by Nair [13] in his study on groundwater from Northeast Libya.

During the study period, it was observed that the alkali metals (Na^+ and K^+) levels were more compared to alkaline earth metals (Ca^{++} and Mg^{++}).

The residential area of the town is surrounded by agricultural area where agricultural activity and usage of fertilizers is very high throughout the year and also by aquaculture area. The open well water is available at shallow depth of 4-5 feet. So seepage of the fertilizers especially NO_3^-, PO_4^{3-} from agricultural field to the aquifer is possible resulting in the contamination of the well water.

In the study area the groundwater aquifer is likely to be recharged by rain water and canal water and contaminated by seepage of waste water from paddy field and prawn tanks which contain cations like K^+ , NH_4^+, and Ca^{2+} and anions like Cl^-, PO_4^{3-}, sO_4^{2-} and NO_3^-.

The soluble salts of the soil may reach the groundwater during slow seepage of rain or canal water. The geological conditions in that area may also contribute to different salts content.

(a) Major part of the ions may be utilized by plants through the roots, a small part of the above salts may seep through the soil which is known as cation exchange reaction in the following manner

$$\underset{\text{solid}}{Ca^{2+}\,\text{soil}} + \underset{\text{solution}}{K^+ + Cl^-} \rightarrow \underset{\text{solid}}{K^+\,\text{soil}} + \underset{\text{solution}}{Ca^{2+} + Cl^-}$$

$$\underset{\text{solid}}{Ca^{2+}\,\text{soil}} + \underset{\text{solution}}{NH_4^+ + NO_3^-} \rightarrow \underset{\text{solid}}{NH_4^+\,\text{soil}} + \underset{\text{solution}}{Ca^{2+} + NO_3^-}$$

and similarly other cations also follow the same pattern, resulting in increasing the salt content of the groundwater.

(b) The very small amount of soluble leachates of organic compounds may also reach the groundwater aquifer whereas major portions of it may get absorbed by the soil during seepage.

Thus, the groundwater aquifers were likely to be contaminated by the use of fertilizers. This may be due to increased hardness of the groundwater as explained above. Similar observations were reported in earlier studies, (Prem Singh [19]; Raja [21] ; Kiran Mehata [10], which stated the impact of agricultural activity on groundwater quality.

IV. CONCLUSION

It revealed from the analysis results of groundwater samples indicate that certain parameters namely P^H, D.O and Fluoride were found within the desirable limits by BIS. However, Turbidity, EC, TH, TDS, BOD, Chloride, Sulphate, Phosphate, Nitrate, Sodium, Potassium, Calcium, were exceding the desirable limit throughout the investigation period in all locations. This may be due to the percolation of contaminated water into the groundwater. The quality of wells in Bhimavaram region is not reliable for human consumption, therefore continuous monitoring will be required to prevent contamination of groundwater resources. Hence there is a need for continuous monitoring studies on ground water quality and portability.

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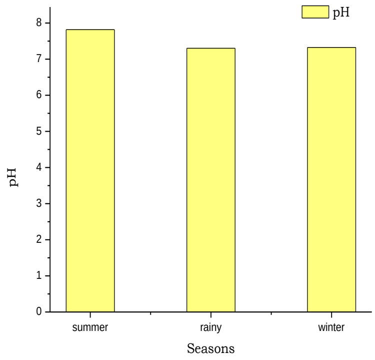
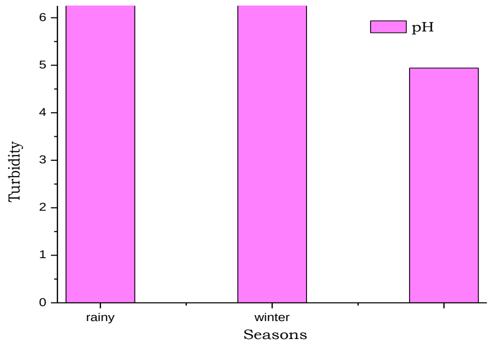
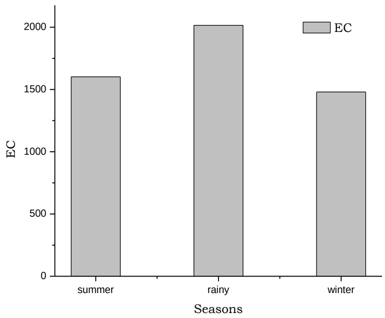
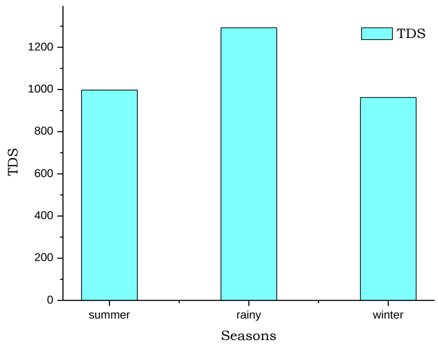
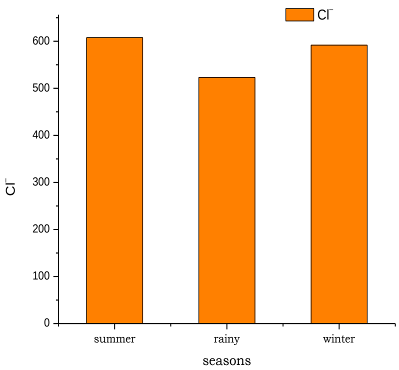
Fig. 2: The following Graphs showing the concentrations of physicochemical parameters (pH, Turbidity, EC, TDS, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, D.O, TH, Ca^{2+}, Mg^{2+}, F^-, Na^+, K^+ and BOD) during the summer, the rainy and winter seasons of 2012-'13

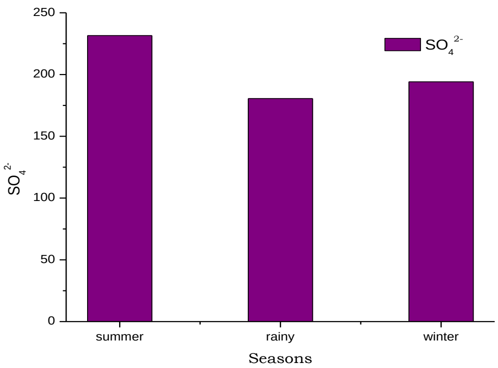


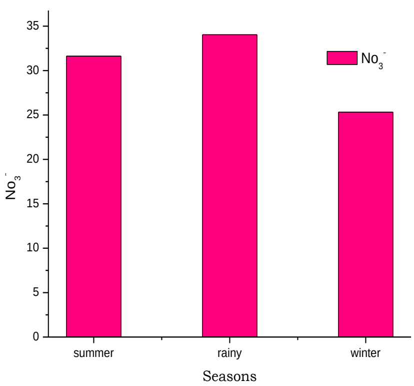


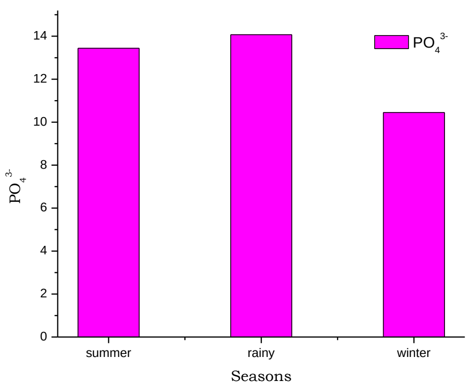


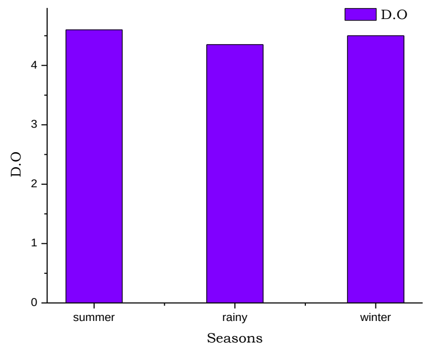








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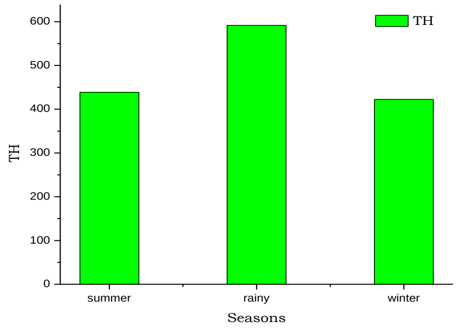
TH
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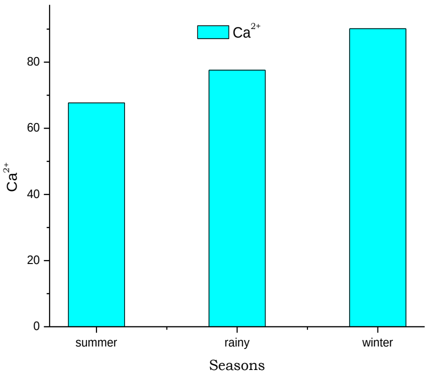
400
500
600
TH
summer
rainy
winter
Seasons


Ca^{2+}
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20
40
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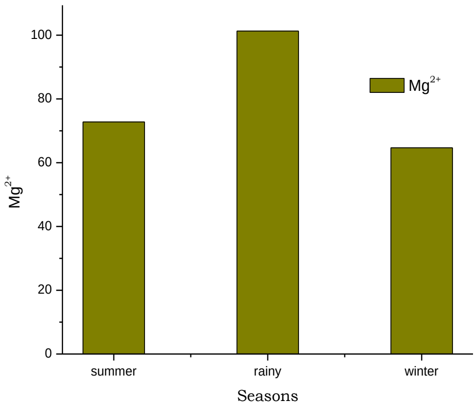
80
Ca^{2+}
summer
rainy
winter
Seasons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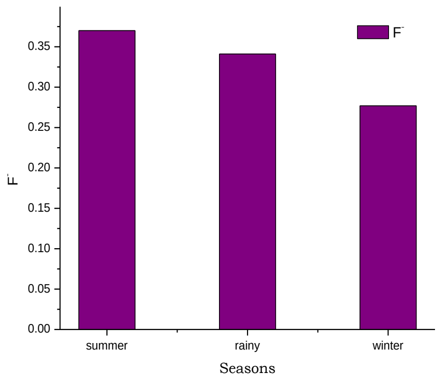
Seasons


F^-
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F^-
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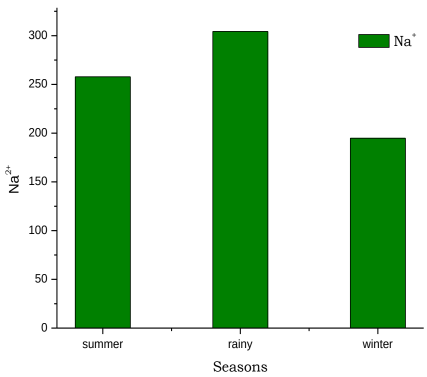
Seasons


Na^+
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250
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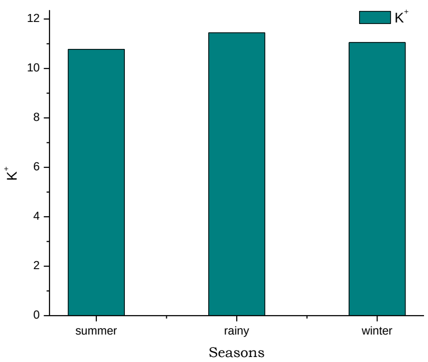
Na^{2+}
summer
rainy
winter
Seasons


K^+
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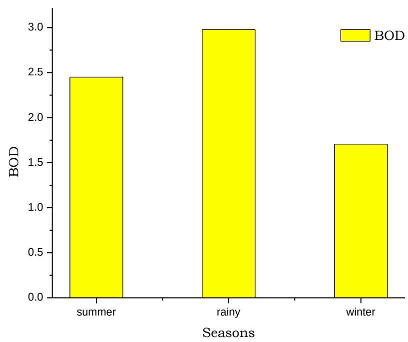
12
K^+
summer
rainy
winter
Seasons


BOD
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0.5
1.0
1.5
2.0
2.5
3.0
BOD
summer
rainy
winter
Seasons

Table 2: Physico-chemical analysis of open well water samples in the study area during summer 2012-'13

Name of the sample	pH	Turbidity	EC	TDS	Cl^-	SO_4^{2-}	NO_3^-	PO_4^{3-}	D.O	TH	Ca^{2+}	Mg^{2+}	F^-	Na^+	K^+	BOD
						during summer season										
S1	7.89	6	1120	687	155	375	47	8.1	4.2	299	120	29.36	0.21	122	55	3.4
S2	8	7	10023	6078	4518	191.9	48	24	2.1	1601	256	249.6	0.68	1587	21	4.45
S3	7.65	4.22	867	554	248	156	41	29	3.4	598	12	120.32	0.5	112	6.2	2.2
S4	7.89	6	823	526	152	275	62	22	2.6	618	78	116.88	0.8	86	3.15	1.6
S5	7.76	5.4	887	542	144	260	44	21	1.3	438	70	77.12	0.55	112	5.94	3.3
S6	7.94	3.2	646	461	122	390	66	27	2.5	328	80	41.68	0.22	129	3.1	4.1
S7	7.54	3.2	245	154	30.12	29.15	1.2	1	4.6	39	16	6.4	0.1	20.01	3.23	1.2
S8	7.87	4	239	134	356.24	29.11	1.87	0.89	4.7	146	19	41.92	0.22	187	3.59	1.4
S9	7.76	4.1	845	601	322	375	4	0.4	3.4	156	14	21.28	0.2	102	3.3	1.2
S10	7.87	4.1	324	234	30.23	234	1.2	1	2.1	165	12	23.2	0.22	121	3.25	1.65

During rainy season

S1	**7.03**	**7.9**	**1800**	**1090**	**102**	**272**	**52**	**7.7**	**5.3**	**387**	**92**	**56.32**	**0.21**	**142**	**61**	**2.97**
S2	7.74	6.2	13400	8600	4372	170	50.1	20	4.7	2232	280	400.16	0.2	1878	22.4	7.8
S3	7.2	5.8	923	605	125	119	67	28	3.2	657	24	148.32	0.6	112	6.3	2.9
S4	7.44	8	844	544	112	254	75	28	3	687	141	105.36	0.5	85	0.4	1.8
S5	7.44	5.9	897	568	125	242	32	29	2	577	76	108.56	0.3	125	6.1	2.22
S6	7.24	7.17	677	458	104	332	54	24	3.4	433	81	71.28	0.2	101	3.89	4.9
S7	7.23	4.1	248	159	27	27.99	2.3	1	5.8	77	19.9	5.48	0.2	20.1	3.78	1.56
S8	7.25	4.1	254	168	117	28.17	2.34	1	6.1	256	20	45.76	0.6	212	3.6	1.99
S9	7.12	4.3	890	602	124	231	2.33	1	6.2	223	22	26.8	0.4	158	3.59	1.88
S10	7.32	4.4	223	134	24.44	129	3.32	1	6.3	388	19.99	44.8	0.2	210	3.4	1.77

During winter season

S1	**7.18**	**7.2**	**1045**	**644**	**158**	**371**	**49.1**	**8**	**4.5**	**322**	**126**	**30.88**	**0.21**	**149**	**59**	**3.2**
S2	7.12	6.8	9080	6022	4500	178	48.4	18	3.2	1589	288	270.8	0.1	1000	20	3.21
S3	7.24	4.5	869	523	262	143	34	12	3	512	27	110.72	0.46	82	5.2	1.21
S4	7.23	6	819	523	180	254	44	22	3.4	534	187	53.36	0.7	67	3.2	1.2
S5	7.16	5.7	824	545	190	185	18	21	1.2	437	99	69.28	0.21	122	6	2.21
S6	7.56	3.5	660	432	132	335	51	23	3.2	288	88	37.12	0.21	96	3.3	1.34
S7	7.18	3.4	238	143	25	29.14	2.22	0.1	6.2	52	21	4.86	0.22	21	3.33	1.19
S8	7.67	4	232	138	129.99	29.11	2.21	0.2	6.2	154	22	26.22	0.22	142	3.6	1.1
S9	7.56	4.3	807	520	312	217	2.11	0.1	6.2	112	23.1	24.79	0.21	147	3.49	1.2
S10	7.33	4	223	132	29.21	200	2.2	0.1	6.4	223	20.22	18.78	0.23	122	3.38	1.2

Concentration of all parameters are expressed in mg/L except pH, Turbidity (NTU) and EC (µS/ho).