Groundwater Quality Assessment In Eliozu Community, Port Harcourt, Niger Delta, Nigeria

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Abstract: Potable water is an essential ingredient for good health and the socio-economic development of man. Groundwater is an important natural resource for this. The majority of the Nigerian population depends on groundwater for drinking. Thus, availability of clean groundwater is of utmost importance. Hence, quality assessment was carried out to ascertain the groundwater quality in Eliozu Community in Obio/Apkor Local Government area of River State, Nigeria. The study assessed the level of contamination and quality of the groundwater of randomly selected boreholes. Water quality analysis was performed on samples collected from thirty (30) boreholes within Eliozu community for the following physicochemical parameters; pH, temperature, Electrical conductivity, total dissolved solids (TDS), total hardness, salinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, chloride, Cu, and Zn using standard methods. The result from the present study showed that the pH of groundwater samples ranges from 5.5 – 8.0, indicating slight acidity in some of the water samples. The values for electrical conductivity, salinity and total hardness were ranged between 10.1 – 25.4 uS/cm, 0.001 – 0.45 mg/L and 3.59 – 381.9 mg/L respectively and were all within the World health organisation (WHO), Department of petroleum resources and Federal environmental protection agency (FEPA maximum permissible limits. The COD, chloride, nitrate and heavy metal content of water samples were also within WHO, DPR and FEPA permissible limit. This indicates that most of the physicochemical properties of the tested water samples were within the WHO, DPR and FEPA permissible limits however, water samples from borehole points 5, 16, 22, 25, 28 and 30 were slightly acidic; those from borehole points 2, 17, 18 and 30 had DO levels below the WHO recommended limits of 6.0 mg/L while BOD was higher than the WHO recommended limits of 5.0 mg/L in most of the study locations. It was evident from this study that water samples from Eliozu community were possibly contaminated as a result of its DO and BOD values; it was therefore recommended that there should be regular monitoring of these physicochemical parameters from groundwater sources in Eliozu and other Niger Delta communities to ensure quality water supply for human health.

Index Terms: Water quality, groundwater, boreholes, Eliozu, heavy metal, physicochemical parameters.

1 Introduction

WAter is essential for life on earth; it covers about 70% of its surface, makes up about 70% of human mass. Water is the only substance that exists naturally on Earth in all three physical states of matter— gas, liquid, and solid—and it is always on the move among them. Human existence is threatened by inadequate quantity of good quality water. Water comprises of coastal water bodies and fresh water bodies (lakes, river and groundwater) [1].

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Groundwater resources is one of the most important resource available to humanity, therefore it is more than necessary to provide a tool that can assess its quality over space and time [2]. Groundwater exists below the surface of the ground in the spaces between particles of rock or soil, or in the crevices and cracks in rocks, usually within 100 meters of the surface of the Earth [3]. Groundwater plays a substantial role in water supply, in ecosystem functioning and human well-being. Worldwide, 2.5 billion people depend solely on groundwater resources to satisfy their basic daily water needs, and hundreds of millions of farmers rely on groundwater to sustain their livelihoods and contribute to the food security of so many others [4]. Groundwater reportedly provides drinking water to at least 50% of the global population and accounts for 43% of all water used for irrigation, and also sustains the base flows of rivers and important aquatic ecosystems. Uncertainty over the availability of groundwater resources and their replenishment rates pose a serious challenge to their management and in particular to their ability to serve as a buffer to offset periods of surface water scarcity [5]. Groundwater supplies are diminishing, with an estimated 20% of the world's aquifers being over-exploited [6], leading to serious consequences such as land subsidence and saltwater intrusion in coastal areas [7]. The major sources of pollution in streams, rivers and underground water arise from anthropogenic activities largely caused by the poor and uncultured living habit of people as well as the unhealthy practices of factories, industries and corporate bodies; resulting in the discharge of untreated effluents and waste [8-9]. Rivers state is a wetland in the Niger delta with likely serious problems of drinking water. Groundwater studies in some areas in Rivers State have shown increased levels in Total Dissolved Solids (TDS) (up to 2900 mg/L), high hydrocarbon content – oil and grease (71 mg/L in 2006 compared to 1.8 mg/L recorded seventeen years earlier) are reported to be some of the groundwater problems according to Ayotamuno and Kogbara [10]. Amajor [11] had reported iron and chloride elevation as groundwater issues and this was corroborated by Ophori *et al*. [12]. Similar problems as reflected in Bayelsa, Delta and Akwa Ibom States were also reported by Amangabara and Ejenma [13], Edet [14], and Amadi *et al.* [15]. The principal goal of groundwater monitoring and management in developing countries is to assess and manage the water resources that are available. Groundwater is an important source of drinking water for more than half of Nigeria's population and nearly all its rural population; it is generally a very good source of drinking water because of the self-purifying properties of the soil, therefore there is the need for regular monitoring and assessment of these drinking water sources. This is because monitoring provides data on groundwater quantity and quality and it is an integral aspect of groundwater management [16-17]. However, the quality assessment of groundwater samples in Eliozu community has not been reported, hence, this study is aimed at assessing the groundwater quality samples from this community; to provide baseline data which will be used as a guide for future monitoring and to determine the extent of contamination by comparing results with local and international standardized limits.

2 MATERIALS AND METHODOLOGY

2.1 Study Area

Eliozu (4.8619352N,7.0191502E), the study area is a fast growing suburban in Obio/Apkor Local Government Area, Port Harcourt, capital of Rivers state. Port Harcourt is located within the Niger Delta Basin of Southern Nigeria, within the eastern lower Niger Delta in the south eastern part of Rivers State of Nigeria. It is situated at the right bank of the Bonny River approximately 65km inland from the Bight of Bonny. The study adopted both field and laboratory based analytical procedures to generate the data required. Water samples were collected at thirty different borehole locations (residential houses) within the Eliozu community of Port Harcourt and where all geolocated.

Figure 1: *Showing River state, Niger Delta, Nigeria (Source: google map)*

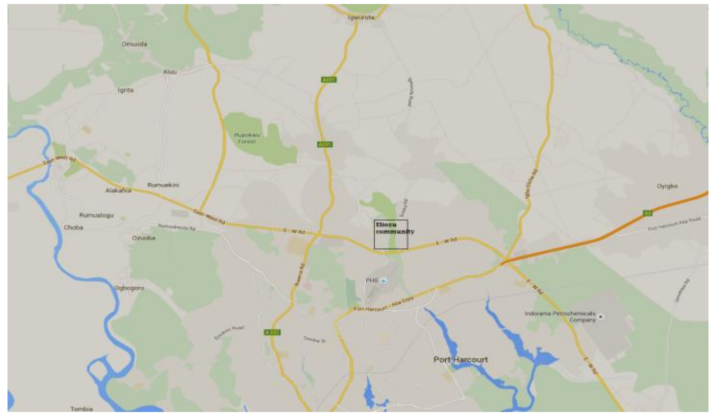

Figure 2: *showing the sampling area Eliozu in Obio/Akpor Local Govt Area, Port Harcourt, River state, Nigeria (Source: www.google.com/maps/@4.8619352,7.0191502,13.75z)*

2.2 Sampling procedures and Analyses

Water samples were collected from thirty (30) different already sunk private boreholes in the month of June, 2015. Water samples for Biochemical Oxygen Demand and COD were collected in two (2) separate 250ml sample bottles. The DO samples was fixed immediately after collection with Winkler I and II reagents while the BOD5 was stored after collection before they were taken to the laboratory for further analysis. Samples for other parameters such as; total hardness, nitrate, phosphate, chloride, copper, zinc and chromium was collected in a 500ml plastic bottle from each station, stored in an ice chest and transported to the laboratory. All analysis was done using Standard Methods. The physicochemical analyses of groundwater samples (pH, temperature, electrical conductivity and total dissolved solid) were determined on sites using a portable Hanna meter (HI991404-01 Model). Accuracy was ±0.5°Cfor temperature, ±0.1 for pH and ±2% F.S for EC/TDS. Sulphate, phosphate-phosphorus (PO_4^{3-} -P) and Chloride were determined according to APHA [18] methods in the laboratory. Chemical oxygen demand (COD) and Biological oxygen demand (BOD) were also determined following the procedure of De [19]. Heavy metal Analysis in water samples was done according to APHA/AWWA/WEF [20] standard Methods. Fifteen ml of HNO_3 were added to 250 ml of water samples then heated until 25 ml. The solution was transferred into 50 ml volumetric flask and made up to the mark with distilled water. Then, heavy metals were detected by Atomic Absorption Spectrophotometer (AAS). The data obtained from the laboratory analysis were used as variable inputs for the descriptive statistics such as mean, minimum, maximum and standard deviation. Data collected were also subjected to analysis of variance (ANOVA) and t-test. ANOVA was used to measure the variance between qualities of water from the boreholes.

3 RESULTS AND DISCUSSION

The results of this study as shown in Table 1 indicate that the variations observed in the physicochemical parameters assessed were mostly within the WHO, DPR and FEPA recommended standards. Water pH is considered an important parameter which determines the suitability of water for various purposes [21]. In the present study, pH ranged from 5.5 – 8.0 in the groundwater samples. Groundwater samples from most of the study sites where within the WHO and DPR and FEPA standards. However, water samples from borehole 5, 16, 22, 25, 28 and 30 had pH lower than the desirable limits of 6.5 – 8.5. Although statistical analysis revealed that these deviations from the set limits were not significant ($p > 0.05$), these results indicate that the groundwater from borehole 5, 16, 22, 25, 28 and 30 (figure 3) were slightly acidic. This may be attributed to the presence of organic materials in the soil which undergo decomposition under partially reducing conditions into organic acids [22] or it could be due to the anthropogenic activities associated with oil production that leads to pollution in the area [23]. The result of this study was in agreement with that of Egbai *et al.* [24] who reported that the pH of ground water in Okwuagbe community of Delta state Nigeria were low hence slightly acidic.

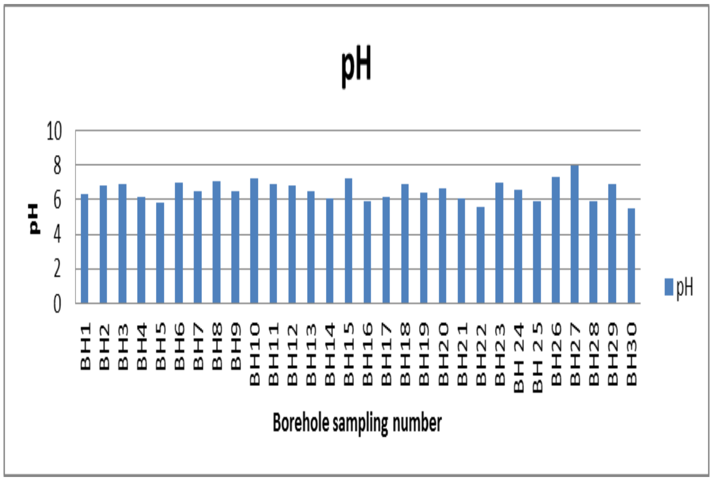

Figure 3: *showing pH of groundwater samples from all the sampling boreholes*

The temperature of water samples in this study ranged between 25.9 ^oC – 29.4 ^oC (figure 4). These were within the WHO and FEPA desirable standards of 25 ^oC – 30 ^oC. The level of electrical conductivity, salinity as well as TDS mostly goes together [13]. The values for electrical conductivity, salinity and total hardness were in the range 10.1 – 25.4 uS/cm (figure 5), 0.001 – 0.45 mg/L and 3.59 – 381.9 respectively. There were no significant differences between the electrical conductivity of the different groundwater sample ($p > 0.05$). However, the salinity of water samples from locations 21, 25, 28 and 29 were significantly higher than those from other sample points ($p < 0.05$). Similar observations were made for the TDS where groundwater samples from boreholes 6, 7, 11 and 12 were significantly higher than those from other boreholes ($p < 0.05$). A higher TDS means that there are more cations and anions in the water. With more ions in the water, the water become saline and increases the electrical conductivity. These results were similar to the findings of Agbalagba *et al.* [25], Amangabara and Ejenma [13] and Angaye and Yougha [26] on the quality of groundwater in some Niger Delta communities.

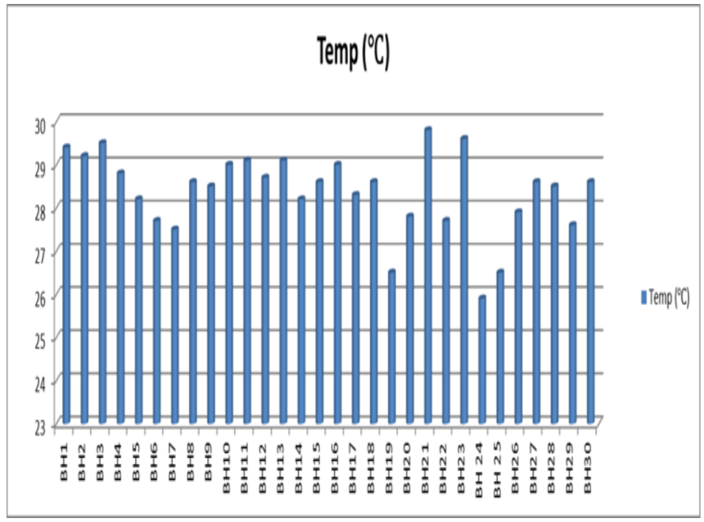

Figure 4: *showing Temperature of groundwater samples from all the sampling boreholes*

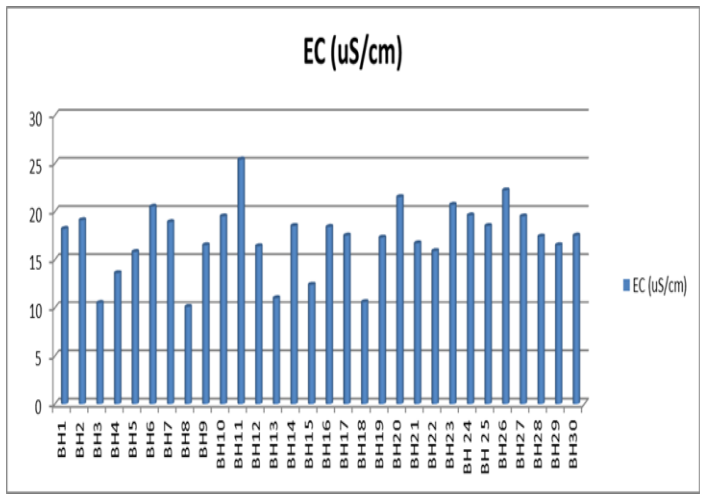

Figure 5: *showing Electrical conductivity of groundwater samples from all the sampling boreholes.*

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution [27]. Dissolved oxygen (DO) is one of the most important parameters for assessing the suitability of portable water systems. This is because DO significantly affects the activities of other chemicals in the water; it oxidizes both organic and inorganic substance thus altering their chemical and physical states and capacity for causing harm to the consumer [28]. Further, DO affect the proliferation of microorganism in water systems. The current study revealed that the mean DO (5.51±0.62 mg/L) of groundwater samples from Eliozu community did not exceed the WHO maximum desirable limit of 8 mg/L however, ground water from borehole 2, 17, 18 and 30 were significantly lower than the WHO minimum desirable limit of 6 mg/L ($p < 0.05$). This finding was in agreement with that of Etim *et al.,* [27] but was in contrast with those of Efe *et al.* [29] and Nduka *et al.* [28].

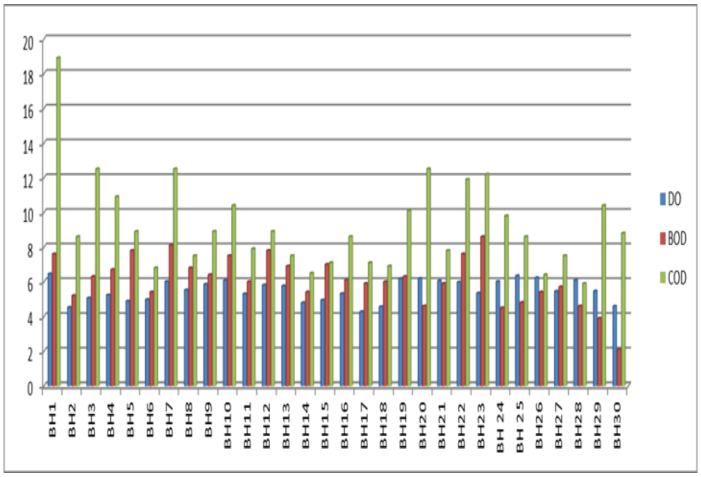

Figure 6: *showing DO, BOD and COD of groundwater samples from all the sampling boreholes*

The chemical oxygen demand is a measure of the organic matter in water that is susceptible to oxidation under test conditions [30]. The COD of groundwater samples in this study (5.9 – 18.9 mg/L) were within the WHO permissible limit of 40 mg/L. This is similar to the findings of Amangabara and Ejenma [13]. Biochemical oxygen demand (BOD) is the parameter used to assess the pollution of surface water and ground water [31]. BOD is an indication of the concentration of bacterial facilitated decomposable organic material in the water. The values obtained for BOD () in this study are within the FEPA [41] recommended standards for all the water samples analysed. However, according to the WHO [38] standards, a sample with a 5 day BOD between 1.0 and 2.0 mg/L indicates very clean water, 3.0 to 5.0 mg/L indicates moderately clean water and > 5 mg/l indicates a nearby pollution source. This indicates that, the groundwater sample from borehole 30 which had a BOD of 2.1 mg/L was very clean; those from borehole 20, 24, 25, 28 and 29 were moderately clean while the other majority with BOD above 5.0 mg/L can be said to be polluted. Total hardness measures the ability of water to cause insoluble calcium and magnesium salts of higher fatty acids present in soap to precipitate [32]. The total hardness values of the present study were found to range between 8.9 mg/L – 38.8 mg/L. This was within the WHO maximum permissible limit of 500 mg/L and was in conformity with other studies from the Niger Delta region of Nigeria [27]. Chloride ions are among the most important anions in water as they help maintain acid-base balances as such excess of it may cause edema [34]. Chloride contamination can originate from sewage and industrial effluents and saline intrusion [33]. The values obtained for chloride in this study ranged from 3.28 mg/L to 34.5 mg/L. These values were well below the WHO maximum permissible limit of 250 mg/L., this is in conformity with several findings on water quality in the Niger Delta region [34 - 37]. According to World Health Organization [38], chloride in excess of 250 mg/L gives rise to detectable taste in water because pure water should not have taste [33].

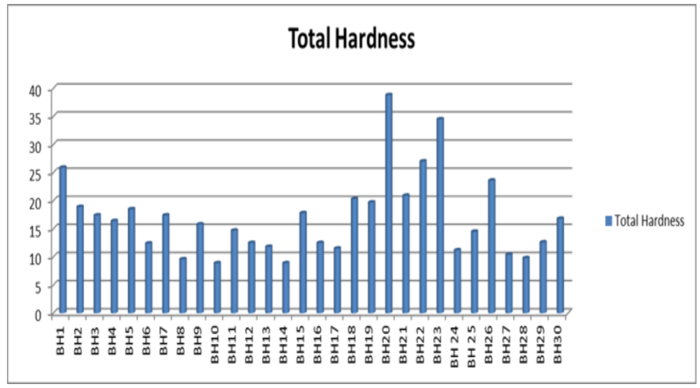

Figure 7: *showing the Total hardness of groundwater samples from all the sampling boreholes*

Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. Nitrate can also get into shallow groundwater from leaking of wastewater (where latrines and septic tanks are poorly sited) or other organic wastes (from animals livestock, fish and birds) into groundwater. Nitrate values in the samples ranged from 0.003 mg/L to 1.65 mg/L. These values were below the WHO recommended limit of 45.0 mg/L. This is similar to the findings of Nwala *et al.* [35] and, Manilla and Tamuno-Adoki [36]. Increased nitrate content in drinking water can cause large-scale health effects through drinking-water exposure. The primary health concern regarding nitrate is the formation of methamoglobinaemia [33]. It has been reported by Nwala *et al.* [35] in earlier research that nitrate above 44 mg/L in drinking water causes methamoglobinaemia in children.

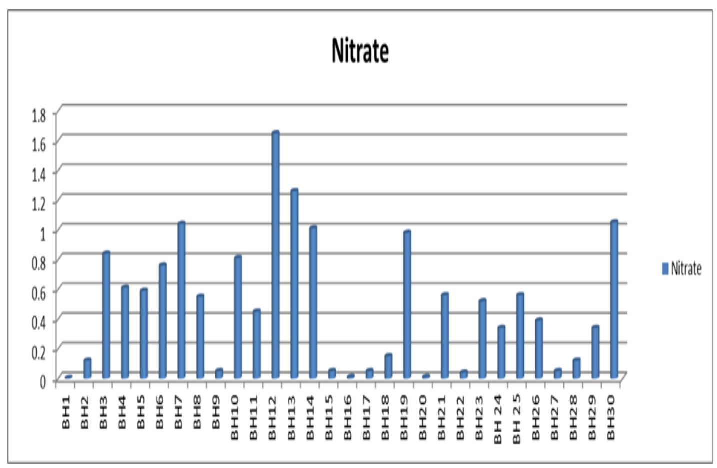

Figure 8: *showing the nitrate level of groundwater samples from all the sampling boreholes*

Heavy metals are considered highly toxic in nature due to their complex bioaccumulation properties [39]; they have also been reported to be carcinogenic [40]. The current study assessed the level of heavy metals copper, zinc and chromium in groundwater samples from Eliozu community. FEPA [41] has reported that Copper can potentially cause severe health effects such as gastrointestinal disturbance including nausea and vomiting. Use of water that exceeds the set standard for many years could cause liver or kidney damage. The amount of copper in water samples in this study ranged between 0.001

and 0.18 mg/L, zinc ranged between 0.03 and 1.89 mg/L while chromium content were between 0.00 mg/L and 0.015mg/L. The one way ANOVA analysis revealed that, the heavy metal contents from all the study locations were not significantly different in each other ($p > 0.05$). The contents of heavy metals copper, zinc and chromium in the ground water samples from Eliozu community were also within the WHO [38] and FEPA [41] maximum permissible limits of 1.5 mg/L, 3.0 mg/L and 0.05 mg/L respectively. These observations were in conformity with some other studies conducted in Niger Delta region [42 - 46].

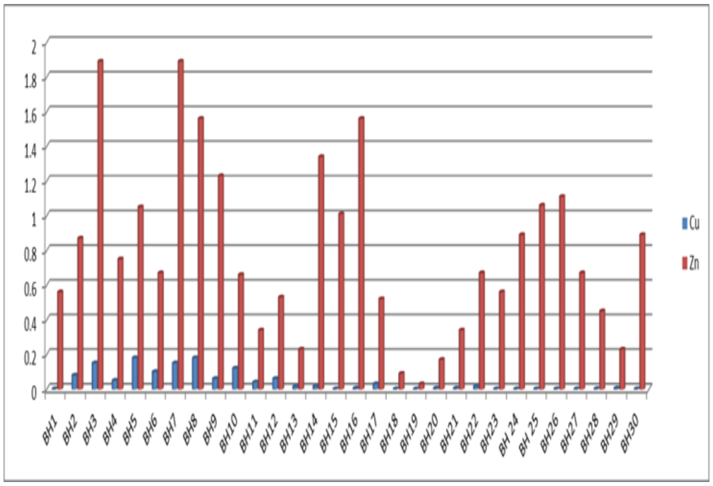

Figure 8: *showing the Cu and Zn level of groundwater samples from all the sampling boreholes*

4 CONCLUSION

Groundwater in most communities serves as an important natural resource and is often considered an appropriate alternative to surface water supply sources that are prone to easy contamination. The findings of this study showed that most of the physicochemical parameters assessed in groundwater samples from Eliozu community were within set limits. However, an elevated biochemical oxygen demand observed in most of the study locations as well as slightly acidic pH in some groundwater samples indicate that, there are possibility that the water samples are contaminated. Although significantly high BOD levels detected in this study may not be as a result of anthropogenic activities since other parameters were within range, it is recommended that all the ground water resources in Eliozu community is treated appropriately in order to ensure that they are safe for consumption

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Table 2: *Physicochemical and heavy metal analyses*

BoreHole No	pH	Temp (°C)	EC (uS/cm)	Salinity	TDS	DO	BOD	COD	Hard	Nitrate	Cl^-	Cu	Zn
BH1	6.3	29.4	18.2	0.003	3.59	6.45	7.6	18.9	25.9	0.003	5.01	0.001	0.56
BH2	6.8	29.2	19.1	0.001	7.28	4.52	5.2	8.6	18.9	0.12	12.3	0.08	0.87
BH3	6.9	29.5	10.5	0.05	6.06	5.06	6.3	12.5	17.4	0.84	15.8	0.15	1.89
BH4	6.2	28.8	13.6	0.01	13.55	5.23	6.7	10.9	16.4	0.61	6.87	0.05	0.75
BH5	5.8	28.2	15.8	0.00	45.9	4.88	7.8	8.9	18.5	0.59	12.4	0.18	1.05
BH6	7	27.7	20.5	0.003	156.9	4.97	5.4	6.8	12.4	0.76	7.67	0.1	0.67
BH7	6.5	27.5	18.9	0.001	205.8	6.01	8.1	12.5	17.4	1.04	4.23	0.15	1.89
BH8	7.1	28.6	10.1	0.05	89.9	5.52	6.8	7.5	9.6	0.55	3.68	0.18	1.56
BH9	6.5	28.5	16.5	0.00	75.05	5.86	6.4	8.9	15.8	0.05	13.8	0.06	1.23
BH10	7.2	29	19.5	0.01	381.9	6.08	7.5	10.4	8.9	0.81	20.5	0.12	0.66
BH11	6.9	29.1	25.4	0.003	342	5.3	6	7.9	14.7	0.45	21.8	0.04	0.34
BH12	6.8	28.7	16.4	0.002	167.9	5.81	7.8	8.9	12.5	1.65	18.5	0.06	0.53
BH13	6.5	29.1	11	0.00	34.8	5.76	6.9	7.5	11.8	1.26	16.8	0.015	0.23
BH14	6.1	28.2	18.5	0.001	15.6	4.79	5.4	6.5	8.9	1.01	17.3	0.015	1.34
BH15	7.2	28.6	12.4	0.008	3.91	4.94	7	7.1	17.8	0.05	6.86	0.001	1.01
BH16	5.9	29	18.4	0.01	9.65	5.31	6.1	8.6	12.5	0.01	5.25	0.005	1.56
BH17	6.2	28.3	17.5	0.002	24.8	4.27	5.9	7.1	11.5	0.05	4.08	0.03	0.52
BH18	6.9	28.6	10.6	0.004	19.7	4.56	6	6.9	20.3	0.15	3.99	0.001	0.09
BH19	6.4	26.5	17.3	0.00	21.9	6.18	6.3	10.1	19.7	0.98	5.95	0.001	0.03
BH20	6.7	27.8	21.5	0.04	6.89	6.19	4.6	12.5	38.8	0.01	7.56	0.005	0.17
BH21	6.1	29.8	16.7	0.23	22.9	6.05	5.9	7.8	20.9	0.56	5.2	0.005	0.34
BH22	5.6	27.7	15.9	0.05	12.8	5.98	7.6	11.9	27.0	0.04	18.7	0.015	0.67
BH23	7	29.6	20.7	0.10	23.6	5.34	8.6	12.2	34.5	0.52	11.9	0.001	0.56
BH 24	6.6	25.9	19.6	0.45	28.8	6.01	4.5	9.8	11.2	0.34	9.78	0.001	0.89
BH 25	5.9	26.5	18.5	0.23	15.7	6.34	4.8	8.6	14.5	0.56	19.5	0.001	1.06
BH26	7.3	27.9	22.2	0.01	19.5	6.23	5.4	6.4	23.6	0.39	34.5	0.001	1.11
BH27	8	28.6	19.5	0.004	44.5	5.45	5.7	7.5	10.4	0.05	13.9	0.001	0.67
BH28	5.9	28.5	17.4	0.45	34.7	6.09	4.6	5.9	9.8	0.12	18.9	0.002	0.45
BH29	6.9	27.6	16.5	0.34	28.4	5.46	3.9	10.4	12.6	0.34	27.8	0.005	0.23
BH30	5.5	28.6	17.5	0.03	15.9	4.59	2.1	8.8	16.8	1.05	12.9	0.001	0.89
Mean	6.56	28.37	17.21	0.07	62.66	5.51	6.1	9.28	17.03	0.5	12.78	0.04	0.79
SD	0.57	0.93	3.63	0.13	95.83	0.62	1.4	2.69	7.22	0.44	7.66	0.06	0.5

Table 2: *WHO and DPR permissible limits*

Parameters	WHO Accepted Limits	WHO Max Permissible Limits	DPR limits	FEPA Desirable Limit	FEPA Maximum Limit
pH	6.5	8.5	6.5 - 8.5	7-8.9	6.5-9.5
Temp	28	-	35	25-30	25-30
EC	0 – 40	-	-	3000	4000
Salinity	400	-	600	-	-
TDS	500	-	800	400	-
DO	6	8	-	>5	7.5
BOD5	0.002	0.05	-	10	10
COD	40	-	-	-	-
Total Hardness	500	-	800	-	-
Nitrate	45	0	-	10	35
Chloride	250	-	-		
Copper	1.5	0.05	1.5		
Zinc	3.0	15	1	3	5
Chromium	0.001	0.05	-		