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Spatio-Dynamics of Surface Water Characteristics in Delta State, Nigeria

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Abstract This study is anchored on the analytical determination of surface water characteristics in Delta State, Nigeria. It is a common place that most settlements situated along the river banks depend on the surface water for domestic purposes, source of domestic, agricultural, industrial wastes and sewage disposal, storm run of from urban landscape and other forms of waste that find their way from unidentified sources into the rivers. These various sources of wastes make it difficult for the rivers to maintain high level of hygienic water. It is on this premise that this study seeks to analysis the surface water characteristics of 8 major rivers in Delta State, Nigeria to determine the physico-chemical, heavy metals and microbiological parameters in line with WHO and FMENV standards. The sampling of the rivers were carried out during the rainy and dry seasons, with three samples from each river being collected at three different locations along the course of the river (the upstream, midstream and downstream) for both seasons and the analyzed results of the three samples for each river were averaged and used as basis of discussion. The results showed that E.Coli, Phytoplankton and Zooplankton that have been found to be present in some of the surface water being depended upon for source of drinking water have made the water from these surface water sources unfit for drinking and an indication that pathogens of intestinal origin of cholera, typhoid gastroenteritis etc are most likely to affect the health of those consuming the water from this sample point. The presence of Lead that could cause cancer, interfere with vitamin D metabolism, Copper that could cause gastrointestinal disorder, Nickel that could cause carcinogenic problems, Cadmium, Ammonia and Arsenic are a major concern to the health of those depending on these sources for domestic purpose.
Keywords *Surface Water; Characteristics; Pollution; Physico-Chemical; Heavy Metal; Microbial*

1. Introduction

Water is one of the most abundantly available resources in nature. It is an essential constituent of all living beings and occupies nearly 75% of matter of earth's crust. Water is a scarce and precious natural resource to be planned, developed, conserved and managed as such and an integrated and

environmentally sound basis, keeping in view the socio-economic aspects and needs of the people. It is a prime natural resource and a basic human need. Water acquires its salinity and other bacteriological compositions partly as it passes through the atmosphere by dissolving air-borne particulates and water soluble gases and also incorporating air-borne microbes. Its quality may further be degraded as it infiltrates the soil, causing leaching and weathering of the mineral constituents in the soil and enhances groundwater salinity (Olobaniyi and Efe, 2007).

Developments in science and technology have brought improved standard of living such as the use of borehole to get water but have also unwittingly introduced some pollution into our environment. Substances are regarded as pollutants if they are present in concentrations toxic to man, animals and plants, have an odour or in some other ways that irritate our sense (Ita et al., 1985).

The vulnerability of surface water and groundwater to quality degradation from human activities makes a periodic assessment of their qualities necessary (Ayoade, 1988).

Water is of fundamental importance to human life, animals and plants, it is of equal importance with the air we breathe in maintaining the vital processes to life and it makes up about 60% of body weight in human being.

Most Nigerian rivers are generally turbid with a high concentration of suspended silt, particularly during the rainy season (Ita et al., 1985). Nigerian freshwaters are also generally very productive at the primary (algae), secondary (zooplankton) and tertiary (fish and other aquatic vertebrates) levels. However, in industrial areas and urban centres there is some pollution with high levels of faecal coliforms (Ogbondeminu, 1986), heavy metals and industrial wastes which constitute public health hazards (Oluwande et al., 1983). This scenario is associated with the study area (Figure 1), hence the need for this study.

The impact of landfill leachate on the surface and groundwater has given rise to a number of studies in recent years (Abu-Rukah and Kofahi, 2001; Looser et al., 1999; Christensen et al., 1998; Flyhammar, 1995). Many approaches have been used to assess the contamination of underground and surface water. It can be assessed either by the experimental determination of the impurities or their estimation through mathematical modeling (Moo-Young et al., 2004). However, this study is based on the assessment of surface water characteristics derived from laboratory analysis of the various parameters studied.

Among the various sources of water, groundwater is known to be more appropriate and often meets the criteria of quality of water. It is the most widely used source of water in most African countries, the study area inclusive and Nigeria at large. The quality of groundwater is the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies from place to place and with the depth of the water table (Looser et al., 1999). Ground waters have unique features, which render them suitable for public water supply (Abu-Rukah and Kofahi, 2001). They have excellent natural quality, usually free from pathogens, color and turbidity and can be consumed directly without treatment. It is widely distributed and can frequently develop incrementally at points near the water demand, thus avoiding the need for large-scale storage, treatment and distribution system (Abu-Rukah and Kofahi, 2001). Groundwater is particularly important as it accounts for about 88% safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist. Nevertheless, there are various ways groundwater may suffer pollution e.g., land disposal of solid wastes, sewage disposal on land, agricultural activities, urban runoff and polluted surface water (Abu-Rukah and Kofahi, 2001).

Although water quality is to some extent an index of water pollution, the indices presently used in Nigeria are inadequate to indicate the damage that is done by heavy metals, metalloids, organic and inorganic compounds and blue green algae. The common indicators for assessing water quality in Nigeria (Oluwande et al., 1983) are temperature, pH, biochemical oxygen demand, turbidity, dissolved oxygen, ammonia, nitrogen and coli form counts.

This study shall adopt these common indicators alongside lead, nickel, and chromium that should be absent from drinking water according WHO standard.

2. Research Methods

Samples of surface water were collected from 8 major rivers in the study area, Delta State, Nigeria (Figure 1 and Table 1). The samples from each of the rivers were collected for the rainy and dry seasons with three set of samples collected at the upstream, midstream and downstream of each river respectively and the averaged result of the three samples for each river was used as basis of discussion (Appendices 1 and 2).

The samples for the rainy season were collected in the months of June/July peak of the rainy season and the samples for the dry season were collected in the Months of December/January peak of the dry season. Special care was taken to ensure that samples were representative of water to be examined and that the samples were free of accidental contaminants during sampling. All samples were collected in clean plastic containers distinctively marked (to avoid mix up). The samples were subsequently kept in ice bags and immediately transferred to the laboratory.

Laboratory analysis of the samples included the physico-chemical, heavy metals and microbiological parameters. The concentrations of chemical components were analyzed using various techniques including; titrimetric, flame photometric and Atomic absorption spectrometric methods (APHA, 1992). The coli form counts were carried out by means of the standard plate count technique using MacConkey agar (APHA, 1992). The various sources of pollution were ascertained through direct field observations before and during the collection of water samples.

Table 1: *Names of Rivers where Samples were Collected*

S/N	Name of River Where Sample was Collected	Sample Code
1	River Niger by the bridge at Asaba	Location 1
2	River Niger by the bridge at Patani	Location 2
3	River Ase at Kwale	Location 3
4	River Ethiope by the bridge at Umutu	Location 4
5	River Niger by the bridge at Sapele	Location 5
6	River Warri by the bridge along refinery express way	Location 6
7	River Koko at Koko	Location 7
8	River Ogbe-Ijoh at Ogbe-Ijoh	Location 8

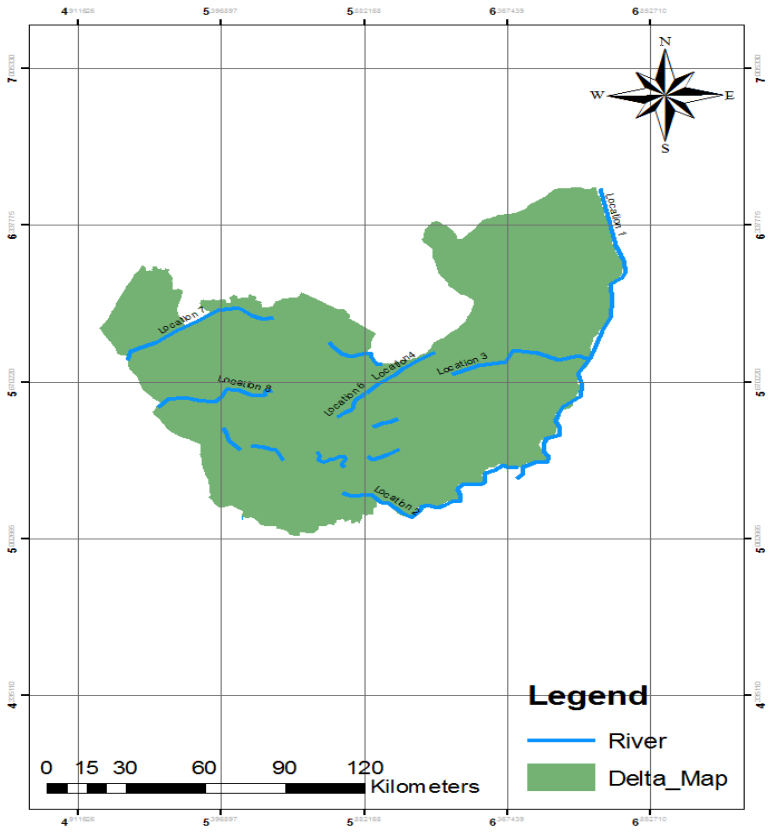

Figure 1: *Map of Study Area Showing Sample Locations*

3. Discussion of Results

3.1. River Niger by the Bridge at Asaba (Location 1)

The result of the analysis of the River Niger sample by the Bridge at Asaba for the rainy season shows (Appendix 1) that the heavy metals parameters are not within the set standard of FMENV and WHO are Ammonia (NH_3, 2.0 mg/l), Iron (Fe, 0.36 mg/l), Arsenic (As, 0.3 mg/l). The physico-chemical parameters that are not within the set limit of FMENV and WHO are; pH (5.20) Turbidity (14.35NTU), Dissolve oxygen (Do, 8.67) and BOD is 1.0. The microbiological parameter that is not within set standard is Total coli form count which 1.

The result of the analysis of the River Niger sample by the Bridge at Asaba for the dry season (Appendix 2) shows that pH (5.12), Iron (Fe, 6.81), Manganese (Mn, 0.90), BOD is 0.30 and the Total coli form count is 2.

3.2. River Niger by the Bridge at Patani (Location 2)

The result of the analysis of River Niger by the bridge at Patani; Location 2 for the rainy season (Appendix 1) shows that the microbiological parameter that is not within the set standard of FMENV and WHO Total coliform count which is 1. The parameters of heavy metals that are not within the set limit by FMENV and WHO is Manganese (Mn, 3.0 mg/l). The physico-chemical parameter that is not within the set standard are; pH (5.72) and BOD (0.05).

The results of the analysis of River Niger by the bridge at Patani; Location 2 for the dry season (Appendix 2) shows that the physico-chemical parameters that are not within the set standard are pH (4.21) and BOD (0.21). The parameters of heavy metals that are not within the set limit Nitrite (NO^-_2, 0.95 mg/l), and Cadmium (Cd, 0.02 mg/l). The microbiological parameter that is not within the set limit is Total coli form count (2).

3.3. River Ase at Kwale: Location 3

The result of the analysis of the River Ase water, location 3 for the rainy season (Appendix 1) shows that the microbiological parameters that are not within the set standard of FMENV/DPR and WHO Total coli form count (5) and Ecoli (2/100ml). The parameters of heavy metals that are not within the set limit of FMENV and WHO are Copper (Cu, 0.21 mg/l) and Manganese (Mn, 0.06 mg/l). The physico-chemical parameter that is not within the set standards is Turbidity (59.0NTU).

The result of the analysis of the River Ase water sample at Kwale, location 3 for the dry season (Appendix 2) shows that the physico-chemical parameters that are not within the set standard of FMENV and WHO are pH (4.21), DO (9.20 mg/l) and BOD (0.21 mg/l). The parameters of heavy metals that are not within the set limit of FMENV and WHO are Iron (Fe, 0.61 mg/l), Manganese (Mn, 0.13 mg/l), and Cadmium (0.02 mg/l). The microbiological parameter that is not within the set limit is Total coli form count which is 2.

3.4. River Ethiope by the Bridge at Umutu: Location 4

The result of the analysis of the River Ethiope sampled by the Bridge at Umutu for the rainy season (Appendix 1) shows that the microbiological parameters are within the set standard of FMENV and WHO. The parameters of heavy metals that are not within the set limit by FMENV and WHO are Lead (Pb, 0.01 mg/l), which is negligible, and Manganese (Mn, 0.32 mg/l). The physico-chemical parameters that are not within the set standard are pH (4.34) and BOD (0.90).

The result of the analysis of the River Ethiope sampled by the Bridge at Umutu for the dry season (Appendix 2) shows that the parameters of heavy metals that are not within the set standard of FMENV and WHO are Cupper (Cu, 9.09 mg/l) and Iron (Fe, 7.08 mg/l). The physico-chemical parameters that are not within the set standards of FMENV and WHO are pH (6.34), DO, (9.36) and BOD (0.31). The microbiological parameter that is not within the set standard of FMENV and WHO is Total coli form count which is 1/100ml.

3.5. River Niger by the bridge at Sapele (Location 5)

The result of the analysis of River Niger by the bridge at Sapele; Location 5 for the rainy season (Appendix 1) shows that the microbiological parameters are within the set standard of FMENV and WHO. The parameters of heavy metal that was not within the set limit by FMENV and WHO are Ammonia (NH_3, 2.32 mg/l), Iron (Fe, 9.32 mg/l), Cupper (Cu, 10.59 mg/l), Manganese (Mn, 0.09 mg/l) and Nickel (Ni, 0.21 mg/l). The physico-chemical parameters that are not within the set standard are pH (6.34) and BOD (0.01).

The result of the analysis of River Niger by the bridge at Sapele; Location 5 for the dry season (Appendix 2) shows that the physico-chemical parameters that are not Turbidity (16.10 NTU), BOD (0.93). The microbiological parameters are not within the set standard of FMENV and WHO Total coli form count (5) and E.coli (1/100ml). The parameter of heavy metal that is not within the set limit is Cupper (Cu, 0.06 mg/l).

3.6. River Warri by the Bridge along Refinery Express Way (Location 6)

The result of the analysis of the River Warri by the bridge along refinery express way, for the rainy season(Appendix 1) shows that the microbiological parameters are not within the set standard of FMENV and WHO are E.Coli (1/100ml), Zooplankton that contains Amoeba and Proteus spp and Phytoplankton that contains Synedra spp. The parameter of heavy metal is not within the set limit by FMENV and WHO is Iron is (Fe, 0.31mg/l). The physico-chemical parameters that are not within the set standard are pH (6.19) and Turbidity (48.71NTU) and BOD (0.30).

The result of the analysis of the River Warri by the bridge along refinery express way for the dry season (Appendix 2) shows that the microbiological parameters are not within the set standard of FMENV and WHO are E.Coli (1/100ml), Zooplankton that contains Amoeba and Proteus spp and Phytoplankton that contains Synedra spp. The parameter of heavy metal is not within the set limit by FMENV and WHO are Iron (Fe, 1.21mg/l) and Manganese (Mn, 0.08 mg/l). The physico-chemical parameters that are not within the set standards are pH (6.45) BOD (0.09).

3.7. River Koko at Koko (Location 7)

The result of the analysis of the River Koko at Koko, for the rainy season (Appendix 1) shows that the microbiological parameters that are not within the set standard of FMENV and WHO are E.Coli (6/100ml), Zooplankton that contains Cyclotell spp and Phytoplankton that contains Cholorella. The parameters of heavy metal are not within the set limit by FMENV and WHO are Iron (Fe, 2.50mg/l), Copper (Cu, 2.32 mg/l), Manganese (Mn, 10.65 mg/l), Nickel (Ni, 0.10 mg/l), Lead (Pb, 1.01 mg/l), and Cadmium (Cd, 0.03 mg/l). The physico-chemical parameters that are not within the set standard are pH (5.13) and BOD (6.20).

The result of the analysis of the River Koko at Koko for the dry season (Appendix 2) shows that the microbiological parameters are not within the set standard of FMENV and WHO are Total coliform count (1), E.Coli (5/100ml), and Phytoplankton that contains Closterium spp. The parameters of heavy metal that are not within the set limit by FMENV and WHO are Iron (Fe, 3.68mg/l), Copper (Cu, 2.50 mg/l), Manganese (Mn, 10.80mg/l) and Lead (Pb, 1.08 mg/l). The physico-chemical parameters that are not within the set standards are pH (4.45), Turbidity (6.21 NTU) and BOD (6.23).

3.8. River Ogbe-Ijoh at Ogbe-Ijoh (Location 8)

The result of the analysis of the River Ogbe-Ijoh at Ogbe-Ijoh, for the rainy season(Appendix 1) shows that the microbiological parameters that are not within the set standard of FMENV and WHO are E.Coli (2/100ml) and Total coli form count (1). The parameters of heavy metal are not within the set limit by FMENV and WHO are Iron (Fe, 2.25mg/l), Copper (Cu, 39.80 mg/l), Manganese (Mn, 15.45 mg/l) and Nickel (Ni, 0.16 mg/l). The physico-chemical parameters that are not within the set standard are Turbidity (12.10 NTU) and BOD (9.53).

The result of the analysis of the River Ogbe-Ijoh at Ogbe-Ijoh for the dry season (Appendix 2) shows that the microbiological parameters are not within the set standard of FMENV and WHO are Total coliform count (1), E.Coli (3/100ml), Zooplankton that contains Amoeba and Proteins spp and Phytoplankton that contains Synedra spp. The parameters of heavy metal that are not within the set limit by FMENV and WHO are Iron (Fe, 5.50mg/l), Copper (Cu, 17.33 mg/l), Manganese (Mn, 3.21mg/l). The physico-chemical parameters that are not within the set standards are pH (4.36), and BOD (6.10).

4. Conclusion

E.Coli, Phytoplankton and Zooplankton that have been found to be present in some of the surface water being depended upon for sources of drinking water have made the water from these surface water sources unfit for drinking and an indication that pathogens of intestinal origin of cholera, typhoid gastroenteritis etc are most likely to affect the health of those consuming the water from this sample point. The presence of Lead that could cause cancer, interfere with vitamin D metabolism, Copper that could gastrointestinal disorder, Nickel that could cause carcinogenic problems, Cadmium, Ammonia and Arsenic are a major concern to the health of those depending on these sources for domestic purpose.

To improve the quality of these surface water, this study strongly recommends the use of Phytoremediation in the decontamination of polluted surface water contaminated with inorganic pollutants that can find their way as surface runoff or seepage to pollute ground water.

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Appendix

Appendix 1: Parameters of water characteristics for the rainy season

S/N	Parameters	L 1	L2	L3	L4	L5	L6	L7	L8	FMENV	WHO
1	pH (%)	5.20	5.72	7.80	4.34	6.34	6.19	5.13	6.51	6.5-8.5	6.5-8.5
2	Turbidity (NTU)	14.35	0.49	59	1.42	3.46	48.71	2.01	12.10	5.0	5.00
3	Conductivity (µS/cm)	142	103.00	087	190	67.00	87.00	358	68.00	NA	NA
4	TDS (mg/L)	065	55.00	023	68.01	32.00	25.00	135	27.00	500	500
5	Alkalinity($caco_3$) (mg/L)	171	7.00	125	49.76	80.01	50.00	140	132	NA	NA
6	Calcium (mg/L)	15.47	1.00	13.73	12.29	16.98	10.21	3.69	13.06	NA	NA
7	Chloride(Cl^-) (mg/L)	3.08	23.00	0.02	13.20	14.28	0.48	60.05	220	250	250
8	Sulphate(So_4^{-2}) (mg/L)	6.08	0.00	4.90	11.26	11.20	3.20	21.00	11.00	500	400
9	Nitrite LR(No^{-2}) (mg/L)	0.04	0.01	0.06	0.20	0.20	0.15	0.05	0.19	1.0	1.0
10	Nitrate LR(No_3^2) (mg/L)	2.81	0.51	3.10	0.36	2.12	4.21	0.05	0.16	10	10
11	Ammonia (NH_3) (mg/L)	2.00	0.62	0.51	0.04	2.32	0.08	0.03	0.01	<1.0	NA
12	Silica (Sio_2) (mg/L)	0.02	0.01	0.56	0.08	3.60	2.10	0.01	0.02	NA	NA
13	Potassium (K) (mg/L)	2.05	6.00	11.32	2.23	0.04	7.05	4.32	2.32	NA	NA
14	Phosphate(po_4^3) (mg/L)	0.37	2.08	1.28	0.06	2.34	0.04	0.02	0.01	5	NA
15	Iron (Fe) (mg/L)	0.36	0.003	0.04	0.07	9.32	2.33	2.50	2.25	1.0	0.3
16	Magnesium (Mg) (mg/L)	11.02	16.00	0.32	9.11	0.03	2.59	6.81	0.02	NA	50
17	Copper (Cu) (mg/L)	0.01	0.00	0.21	0.06	10.59	0.04	2.32	39.80	0.1	0.05
18	Sodium (Na) (mg/L)	0.03	12.80	5.56	10.40	0.31	16.01	0.14	1.00	200	200
19	Manganese (Mn) (mg/L)	0.04	3.00	0.06	0.32	0.09	0.03	10.65	15.45	0.05	0.05
20	Nickel (Ni) (mg/L)	0.01	0.016	0.02	0.01	0.21	0.01	0.10	0.16	0.05	NA
21	Zinc (Zn) (mg/L)	0.05	0.30	0.6	0.26	0.01	0.39	0.00	0.00	5.0	5.0
22	Lead (Pb) (mg/L)	0.03	ND	0.01	0.01	0.00	0.02	1.01	0.01	0.05	NA
23	Arsenic (As) (mg/L)	0.3	ND	0.1	0.2	0.01	0.01	0.001	0.01	0.2	0.05
24	Cadmium (Cd) (mg/L)	0.01	ND	0.000	0.001	0.01	0.00	0.03	0.001	0.01	NA
25	Dissolve oxygen (mg/L)	8.67	7.51	6.90	7.23	7.09	6.21	0.02	0.01	7.5	8.0
26	BOD (mg/L)	1.00	0.05	0.02	0.90	0.01	0.30	6.20	9.53	0	0
27	Total coli forms count (Cfu/ml)	1	1	5	0	0	1	2	1	0	0
28	E.Coli (Cfu/ml)	0	0	2	0	0	1	6	2	0	0
29	Zooplankton	NIL	NIL	Amoeba Proteus	NIL	NIL	Amoeba, Protens	Cyclotella	NIL		
30	Phytoplankton	NIL	NIL	Synedra Survivella Diatoma Ulothix	NIL	NIL	Synedra	Cholorella,Effapsoidea	NIL		

ND= Not detected: NA= Not applicable

Appendix 2: Parameters of water characteristics for the dry season

S/N	Parameters	L 1	L2	L3	L4	L5	L6	L7	L8	FMENV/DPR	WHO
1	pH (%)	5.12	4.21	4.21	6.34	6.87	6.45	4.45	4.36	6.5-8.5	6.5-8.5
2	Turbidity (NTU)	0.75	0.92	0.83	0.08	16.10	1.82	6.21	0.25	5.0	5.00
3	Conductivity (µS/cm)	88.03	131	131	420	83.20	172	72.00	113	NA	NA
4	TDS (mg/L)	36.04	57.00	57.00	221	34.20	75	20.00	45	500	500
5	Alkalinity($caco_3$) (mg/L)	40.12	41.00	41.00	57.00	21.10	82	150	40.04	NA	NA
6	Calcium (mg/L)	10.15	13.12	13.12	11.80	12.27	0.32	2.68	29.51	NA	NA
7	Chloride(Cl^-) (mg/L)	3.32	4.40	4.40	110	6.04	87.03	150	1.83	250	250
8	Sulphate(So_4^{-2}) (mg/L)	90.06	9.12	9.12	40	6.11	91.00	30.00	6.03	500	400
9	Nitrite LR(No^{-2}) (mg/L)	0.08	0.95	0.95	0.17	0.04	0.06	0.06	0.01	1.0	1.0
10	Nitrate LR(No_3^2) (mg/L)	0.04	1.82	1.82	0.26	4.31	16.00	0.06	1.52	10	10
11	Ammonia (NH_3) (mg/L)	0.06	0.01	0.01	0.02	0.51	0.02	0.04	0.03	<1.0	NA
12	Silica (Sio_2) (mg/L)	0.04	2.30	2.30	0.02	0.72	0.01	0.05	0.02	NA	NA
13	Potassium (K) (mg/L)	3.12	0.02	0.02	1.20	9.52	2.30	0.03	3.02	NA	NA
14	Phosphate(po_4^3) (mg/L)	0.05	1.02	1.02	1.26	2.16	0.05	0.02	0.1	5	NA
15	Iron (Fe) (mg/L)	6.81	0.61	0.61	7.08	0.04	0.01	3.60	5.50	1.0	0.3
16	Magnesium (Mg) (mg/L)	14.60	37.80	37.80	0.01	0.32	42.06	0.03	0.06	NA	50
17	Copper (Cu) (mg/L)	0.03	ND	ND	9.09	0.06	0.02	2.50	17.33	0.1	0.05
18	Sodium (Na) (mg/L)	90.90	45.90	45.90	0.12	2.40	92.09	0.45	0.60	200	200
19	Manganese (Mn) (mg/L)	0.90	0.13	0.13	0.01	0.01	0.08	10.80	3.21	0.05	0.05
20	Nickel (Ni) (mg/L)	0.01	ND	ND	0.00	ND	0.01	0.02	0.12	0.05	NA
21	Zinc (Zn) (mg/L)	0.01	ND	ND	0.01	0.42	ND	ND	0.02	5.0	5.0
22	Lead (Pb) (mg/L)	0.00	0.00	0.00	0.00	0.002	0.00	1.08	0.01	0.05	NA
23	Arsenic (As) (mg/L)	0.01	0.01	0.03	0.00	0.001	0.01	0.002	0.01	0.2	0.05
24	Cadmium (Cd) (mg/L)	0.00	0.02	0.02	0.01	ND	0.02	ND	0.00	0.01	NA
25	Dissolve oxygen (mg/L)	7.50	7.40	9.20	9.36	6.08	7.31	ND	0.00	7.5	8.0
26	BOD (mg/L)	0.30	0.21	0.21	0.31	0.93	0.09	6.23	6.10	0	0
27	Total coli forms count (Cfu/ml)	2	2	2	1	5	1	1	1	0	0
28	E.Coli (Cfu/ml)	NIL	NIL	NIL	NIL	1	NIL	5	3	0	0
29	Zooplankton	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Amoeba, Protens		
30	Phytoplankton	NIL	NIL	NIL	NIL	NIL	NIL	Closterium	Synedra		

ND= Not detected: NA= Not applicable