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Physicochemical and Microbial Analysis of Surface Water Quality at Mbagule-Ipav, Gboko LGA Benue State, Nigeria for Drinking Purpose

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***Abstract*— *Surface water quality was accessed at Mbagule-Ipav, Gboko LGA Benue state, Nigeria, a community dominant with agricultural activities. Investigation showed that the community has one stream which serves as the only source of water to the community for domestic and agricultural purposes. This research was to ensure the use of clean and safe drinking water for the public health protection. On this regard, a physicochemical and Microbial analysis of the surface water was carried out for samples collected at two locations of the stream. A number of parameter: colour, temperature, pH, Dissolved Oxygen, Total Dissolved Solids, Salinity, electrical conductivity, Turbidity, Chemical Oxygen Demand, Biochemical Oxygen Demand, total hardness, Alkalinity, Cyanide, Ozone, Fluoride, nitrate, phosphate, sulphate, iron, lead, zinc, Chromium, Cadmium, Arsenic, Nickel, Vanadium, Calcium, Manganese, Magnesium, Aluminium, Total Bacteria Count, Total Fungi, Faecal Coliform, Samonella and Shigella specie were analyzed for each sample collected. The results obtained for each parameter were compared with the standard values set by Nigerian Industrial Standard (NIS) and Federal Ministry of Environment (FMEnv). The Analysis revealed the surface water showed evidence of surface water contamination in its present status as some parameters were in non-compliant with the Federal Ministry of Environment National Guidelines and Standards for Water Quality in Nigeria as well as the Nigerian Industrial Standard for drinking water quality, 2007. There is an urgent need for alternative sources of water supply such as the construction of boreholes, pipe borne water, etc., or the provision of water treatment plant and to educate the people on the causes, effects and prevention of surface water pollution as well as the impacts of pollution on human health.*

***Keywords*— *Benue state, Drinking water quality, FMEnv, Mbagule-Ipav, Gboko LGA, Microbial analysis, NIS, Physicochemical analysis, Surface Water.*

I. Introduction

Water is a finite resource that's veritably essential for the mortal actuality, farming, assiduity, etc. Without any mistrustfulness, shy volume and quality of water have serious impact on sustainable development. In developing countries, utmost of which have huge debt burdens, population explosion and moderate to rapid-fire urbanization, people have little or no option but to accept water sources of doubtful quality, due to lack of better indispensable sources or due to profitable and technological constraints to treat the available water adequately before use (Calamari and Naeve, 1994; Aina and Adedipe, 1996). The failure of clean water and pollution of fresh water has thus led to a situation in which one- fifth of the civic residers in developing countries and three quarters of their pastoral dwelling population don't have access to nicely safe water inventories(Lloyd and Helmer, 1992). Assessment of water isn't only for felicity for mortal consumption but also in relation to its agrarian, artificial, recreational, marketable uses and its capability to sustain submarine life. Water quality monitoring is thus a abecedarian tool in the operation of brackish coffers. To bolster its significance, World Health Organization (WHO), United Nations Environment Programme(UNEP), United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Meteorological Organization (WMO) launched in 1977, a water monitoring programme to collect detailed information on the quality of global ground and surface water.

On the premise of this, a study of the surface water portability was carried out by assaying the physico-chemical and Microbial characteristics to assess the quality of the surface water because it has been set up that the people of Mbagule- Ipav, Gboko LGA, Benue state, Nigeria principally make use of the water for all their domestic and agrarian purposes as the water body is observed to be the only source of water in the community and its environ. It has also been observed that children in this community generally urinate blood on the process of urinating, hence this exploration work to assess the quality of the surface water used by the community.

II. Literature Review

a. The Study Area

Mbagule- Ipav is a far- flung and off the grid community in Benue state. You can only visit the community with a motorcycle through narrow, undulating, bushy pathways framed by a large breadth of spreads and foliage (Vivian Chime, the string news, 20th December, 2021).

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In the absence of a sanitarium or primary health centre in Mbagule- Ipav, individualities have assumed the part of ‘unofficial community healthcare workers’. One of them who said he was trained by missionaries, told The Cable that he ran tests on some of the children in the village and discovered they've bilharzia also known as schistosomiasis, the complaint is caused by a parasitic worm that lives in freshwater. It's generally set up in tropical and tropical regions like Africa, Asia, and the Caribbean (Vivian Chime, theCable news, 20th December, 2021).

b. Importance of Fresh Surface Waters

Streams, Lakes, ponds, gutters, and aqueducts hold lower than one thousandth of a percent of the water on the earth, but they serve numerous critical functions for the terrain and for mortal life. These fresh surface waters sustain ecological systems and give niche for numerous factory and beast species. They also support a myriad of mortal uses, including drinking, irrigation, wastewater treatment, beast, artificial uses, hydropower, and recreation. Fresh surface waters also impact the extent and condition of other water coffers, including ground water, washes, and littoral systems downstream (EPA, 2020).

c. Extent and Condition

The state of fresh face waters can be covered using two broad orders of pointers extent pointers and condition pointers.

d. Sources of Surface Water Pollution

Surface water pollution is nearly entirely the result of mortal conditioning. Agriculture, mining, plant effluent, tips, mortal/ beast waste and localized pollution are just some of the most common sources of surface water pollution. Topography and geological conformations produce natural surface water runoff, but mortal manipulation of the land increases inflow rates and overall impurity (Hydroviv, 2020).

i. *Point* source pollution comes from a fluently identifiable source, like a plant or sewage treatment factory. Point source pollution is discharged through a channel, gutter, or any “separate vehicle” that directly or laterally enters a body of water. Point sources are generally regulated by National Pollutant Discharge Elimination System (NPDES) permits (Hydroviv, 2020).
ii. *Non-point* source pollution is much harder to regulate because the source isn't fluently identifiable. Agricultural and storm water runoff are the two most common types of nonpoint source pollution. Heavy rain events beget pollutants to runoff from roads and fields, collecting debris and pollution as it travels into a body of water (Hydroviv, 2020)
iii. *Air deposit:* Acidic aerosols, heavy essence, and other airborne pollutants may be deposited directly in water or may wash into water bodies after deposit on land. For illustration, mercury emitted to the air from combustion at power shops can be transported and deposited in lakes and budgets (EPA, 2020).
iv. *Invasive species:* Invasive arenon-indigenous factory and beast species that can harm the terrain, mortal health, or the frugality. Invasive species can crowd out native species and alter the physical and chemical condition of water bodies (EPA, 2020).
v. *Natural factors:* rush determines the timing and quantum of runoff and corrosion, while other aspects of rainfall and climate influence heating, cooling, and mixing in lakes — which affect the movement of pollutants and the cycling of nutrients. The mineral composition of bedrock and deposition helps determine whether a water body may be susceptible to acidification (EPA, 2020).
vi. *Extent:* The condition of fresh face waters also may be told by extent. Stream inflow patterns impact adulterant and deposition loads, while changes in the shape of water bodies —e.g., barring deep pools or creating shallow imprisonments- can change water temperature (EPA, 2020).

e. Extent as Habitat

The extent of face waters also represents the extent of niche — a crucial aspect of natural condition. Some factory and beast communities are sensitive to water position (e.g., riparian communities), while others may be acclimated to particular seasonal oscillations in inflow. Stressors that affect extent may eventually affect the condition of fresh face water niche — for illustration, hydromodifications that circumscribe the migration of certain fish species (EPA, 2020

III. Materials and Methodology

3.1. Materials

3.1.1. Apparatus and equipment

Oven, Desiccators, Forceps, Glassware, litmus paper, Filter papers, Steam bath, Centrifuge, Thermometer, Incubator, Colorimeter (HACH DR 6000) and Dissolved Oxygen meter. Hot plate or gas burner, Biochemical Oxygen Demand bottles, Filtration apparatus, Analytical balance, AAS (Buck Scientific 210VGP), multiparameter-meter (Bante 900P).

3.1.2. Reagents and procurement

All reagents used were of logical grade and were prepared in line with standard methodologies as described in the Manual for Standard Analytical Procedures (1999), except else Stated. Other procedures used are properly conceded.

3.2. Methodology

The criteria of selecting sampling points were based on the population density, proximity to area of anthropogenic activities and direction of flow of the surface water. Mbagule-Ipav is famous for its agricultural activities, therefore it was significant to see the water quality in such an area where there is runoff. Therefore, two (2) different points of surface water locations at the Mbagule-Ipav stream were chosen based on designed criteria. These locations were Mbagule-Ipav upstream (SW1) and Mbagule-Ipav Downstream (SW2). The two water samples were carefully collected to prevent the use of improper methodology or sampling techniques, insufficient sample preservation, inadequate identification, and transportation and to ensure it prove the validity of the data from field measurements. In-situ sample analysis for colour,

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temperature, pH, Dissolved Oxygen, Total Dissolved Solids, Salinity, electric conductivity and Turbidity was recorded at each sampling point. Thereafter, a waterproof ink label containing all required information such as name, location, date, time, and preservative was affixed to each of the samples collected before they were transported to Richflood laboratory, Abuja, Nigeria for ex-situ analysis. Laboratory analysis was conducted following standard protocols and methods of analysis by the American Public Health Association (APHA) standard procedure for the analysis of water and wastewater, 23rd Edition.

IV. Results and Discussions

4.1. Results

TABLE 4.1: Results of In-situ Analysis

SN	PARAMETER	UNIT	RESULT		DRINKING WATER STANDARD		FMEnv STD
			SW1 Mbagule-Ipav Upstream	SW2 Mbagule-Ipav Downstream	FMEnv	NIS	Aquatic Life
			IN-SITU ANALYSIS				
1	General Appearance	TCU	Not Clear	Not Clear	15 (Colourless)	15	NA
2	Odour	TN	Odourless	Odourless	3.5 (Odourless)	Unobjectionable	NA
3	Temperature	^0C	28.50	28.50	NA	Ambient	20-33
4	pH	-	7.22	7.14	6.50- 8.50	6.50- 8.50	6.0-9.0
5	Dissolved Oxygen	mg/L	4.82	5.05	7.50	NA	6.8
6	Total Dissolved Solids	mg/L	24.70	26.20	500	500	NA
7	Salinity	mg/L	0.03	0.03	NA	NA	NA
8	Electrical Conductivity	µS/cm	51.80	51.50	NA	1000	NA
9	Turbidity	NTU	50.00	50.00	1.0	5.00	NA

TN: Threshold Number, *TCU*: True Colour Unit, µS/cm: microsiemen per centimeter, NTU: Nephelometric Turbidity unit, ^0C: Degree Celsius, FMEnv: Federal Ministry of Environment, *NIS:* Nigerian Industrial Standard, *NA:* Not Available.
Source: Richflood Laboratory; September, 2021.
Limit Source: Federal Ministry of Environment National Guidelines and Standards for Water Quality in Nigeria and Nigerian Industrial Standard for drinking water quality, 2007.

TABLE 4.2: Results of Chemical Analysis.

SN	PARAMETER	UNIT	RESULT		DRINKING WATER STANDARD		FMEnv STANDARD
			SW1 Mbagule-Ipav Upstream	SW2 Mbagule-Ipav Downstream	FMEnv	NIS	Aquatic Life
			CHEMICAL ANALYSIS				
1	Total Suspended Solids	mg/L	59.00	60.00	NA	NA	NA
2	Chemical Oxygen Demand	mg/L	60.00	39.00	NA	NA	NA
3	Biochemical Oxygen Demand	mg/L	23.00	19.00	NA	NA	4.00
4	Total Hardness	mg/$CaCO_3$	70.00	90.00	200	150	NA
5	Total Alkalinity	mg/L	50.00	48.00	NA	NA	NA
6	Flouride (F^-)	mg/L	1.40	1.30	1.50	1.50	NA
7	Nitrate (NO_3^-)	mg/L	2.37	4.50	10.00	50	NA
8	Phosphate (PO_4^{2-})	mg/L	0.49	0.47	<5	NA	<5
9	Sulphate (SO_4^{2-})	mg/L	3.12	2.07	500	100	500
10	Cyanide (CN)	mg/L	0.063	0.011	0.1	NA	0.005
11	Ozone(O_3)	mg/L	0.01	0.02	NA	NA	NA

Source: Richflood Laboratory; September, 2021.
Limit Source: Federal Ministry of Environment National Guidelines and Standards for Water Quality in Nigeria and Nigerian Industrial Standard for drinking water quality, 2007

TABLE 4.3: Results of metal/heavy metal Analysis

SN	PARAMETER	UNIT	RESULT		DRINKING WATER STANDARD		FMEnv STD
			SW1 Mbagule-Ipav Upstream	SW2 Mbagule-Ipav Downstream	FMEnv	NIS	Aquatic Life
			METAL/HEAVY METAL ANALYSIS				
1	Potassium (K)	mg/L	0.11	0.14	NA	NA	NA
2	Magnesium(Mg)	mg/L	0.19	0.20	1.0	0.20	NA
3	Calcium(Ca)	mg/L	0.63	0.58	NA	NA	NA
4	Manganese(Mn)	mg/L	0.05	0.02	0.05	NA	NA
5	Iron (Fe)	mg/L	3.50	4.40	1.00	1.00	0.30
6	Zinc(Zn)	mg/L	6.50	8.60	5.00	5.00	3.00
7	Copper(Cu)	mg/L	0.20	0.11	0.10	5.00	1.00
8	Vanadium(V)	mg/L	0.01	0.01	0.01	NA	0.10
9	Lead (Pb)	mg/L	<0.001	<0.001	0.05	0.01	0.0017
10	Nickel(Ni)	mg/L	1.543	0.942	0.05	0.02	0.0025- 0.015
11	Chromium(Cr)	mg/L	0.358	1.098	0.05	0.05	0.02-2.00
12	Cadmium(Cd)	mg/L	0.187	0.075	0.01	0.003	0.0002- 0.0018
13	Arsenic (As)	mg/L	<0.001	<0.001	0.20	0.01	0.50
14	Aluminium(Al)	mg/L	<0.001	<0.001	1.00	NA	NA

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Source: Richflood Laboratory; September, 2021.
Limit Source: Federal Ministry of Environment National Guidelines and Standards for Water Quality in Nigeria and Nigerian Industrial Standard for drinking water quality, 2007.

TABLE 4.4: Results of microbial Analysis

SN	PARAMETER	UNIT	RESULT		DRINKING WATER STANDARD		FMEnv STD
			SW_1 Mbagule-Ipav Upstream	SW_2 Mbagule-Ipav Downstream	FMEnv	NIS	Aquatic Life
			MICROBIAL ANALYSIS				
1	Total Bacteria Count	CFU/ml	146.00	99.00	0	NA	0
2	Total Fungi Count	CFU/ml	45.00	76.00	0	0	0
3	Salmonella and Shigella spp	CFU/ml	5.00	6.00	NA	NA	NA
4	Fecal Coliform	CFU/ml	22.00	26.00	0	NA	0

CFU=Colony forming unit.
Source: Richflood Laboratory; September, 2021.
Limit Source: Federal Ministry of Environment National Guidelines and Standards for Water Quality in Nigeria and Nigerian Industrial Standard for drinking water quality, 2007

4.2. Discussions

4.2.1 Colour and odour

The surface water samples collected represents a typical surface water quality in the parameters of colour and odour; The colour of the samples weren't clear but odourless. The colour was against the limits of drinking water quality as quested by both NIS and FMEnv while the odour complied with the colorful nonsupervisory limits of drinking water quality in Nigeria. The pale unheroic colouration may be attributed to dissolved natural organic matters similar as tannins.

4.2.2 Temperature

Temperature Water temperature is a physical property expressing how hot or cold water is. As hot and cold are both arbitrary terms, temperature can further be defined as a dimension of the average thermal energy of a substance (Brown,W. 1999). Thermal energy is the kinetic energy of tittles and motes, so temperature in turn measures the average kinetic energy of the tittles and motes (Brown,W. 1999). This energy can be transferred between substances as the inflow of heat. Heat transfer, whether from the air, sun, another water source or thermal pollution can change the temperature of water. Temperature is an important factor to consider when assessing water quality. In addition to its own goods, temperature influences several other parameters and can alter the physical and chemical parcels of water. In this regard, water temperature should be reckoned for when testing (Wilde,F. 2006). The temperature of the representative samples collected at the two points were all 28.50 °C. The temperature was within the range of 20- 33 °C for submarine life as needed by FMEnv. This could be attributed to the season of slice which was the stormy season and also foliage covers around the sluice area.

4.2.3 pH

pH is codified as one of the most important water quality parameters. dimension of pH relates to the acidity or alkalinity of the water. A sample is considered to be acidic if the pH is below7.0. Meanwhile, it's alkaline if the pH is advanced than 7.0. The normal drinking water pH range mentioned by NIS and FMEnv guidelines is between 6.50 and 8.50 (Table 4.1). The pH values of the surface water samples were recorded as 7.22 and 7.14 for SW1 and SW2 independently as presented in Figure 4.1

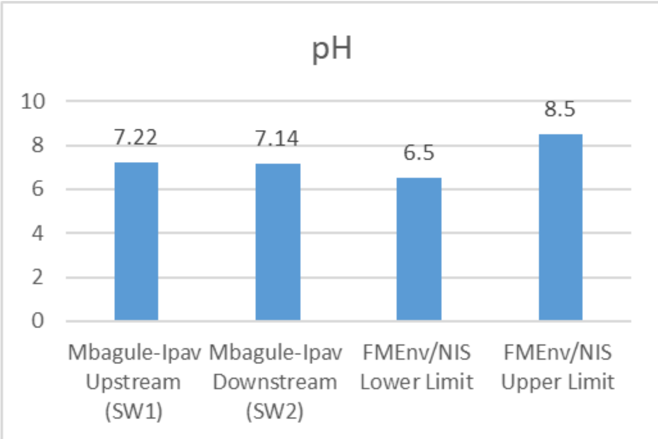

Figure 4.1: Distribution of pH in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.4 Total Dissolved Solid (TDS)

Total Dissolved Solid (TDS) of water is the difference between the Total Solid (TS) and the Suspended Solid (SS). The results showed that the Total Dissolved Solid of the sampled surface water was relatively low with the values recorded as 24.70mg/L and 26.20mg/L for SW1 and SW2 when compared with the FMEnv and NIS standards of 500 mg/l for drinking water. This condition is an indication that the surface water body was not inundated with substances emanating from land areas and farming activities going on within the community as presented in *figure 4.2.*

4.2.5 Electrical Conductivity (EC)

Conductivity is the ability of a solution to permit the flow of electrical current. It varies with the number and type of ions in the solution. The conductivity in water is proportional to the concentration of dissolved solids, which in most cases are commonly inorganic salts. The higher the salinity of water, the higher its conductivity (Kiely, 1998). The conductivity of the surface water analyzed was 51.80 µS/cm to 51.50 µS/cm. This values shows that the surface water had less ionized particles and was in complaint with the NIS standard of 1000 µS/cm for drinking water quality as presented in *figure 4.2*.

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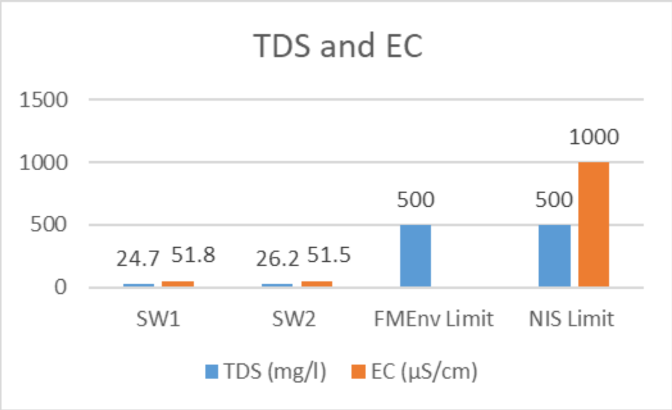

Figure 4.2: Distribution of TDS and EC in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.6 Turbidity

The turbidity of the surface water samples collected were analyzed to be 50.00 NTU for both SW1 and SW2 respectively. This values were in non-compliant with the FMEnv standard of 1.00 NTU as well as 5.00 NTU for NIS limits for drinking water quality. This could as a result of the presence of fine silt particles in the sample collected as presented in *figure 4.3.*

4.2.7 Total Suspended Solid (TSS)

The results showed that the Total Suspended Solids of the sampled surface water were relatively high with values recorded as 59.00 mg/L and 60.00mg/L for SW1 and SW2 as presented in *figure 4.3*.

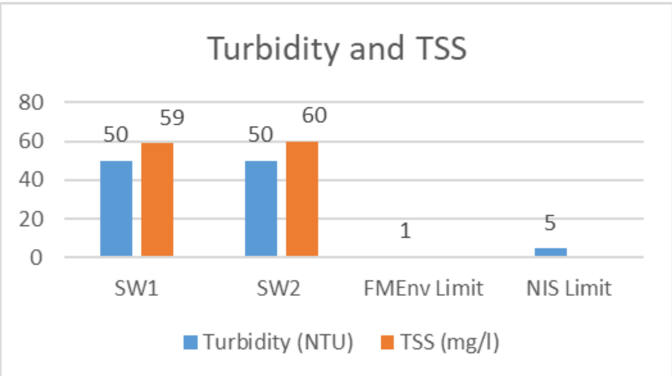

Figure 4.3: Distribution of Turbidity and TSS in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.8 Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD)

The COD and BOD in the face water sample were fairly high as the values recorded were 60.00 mg/l and3 9.00 mg/l for COD, 23.00 mg/l and 19.00 mg/l for BOD independently. The recorded values for BOD exceeded the FMEnv limit of 4.00 mg/l for submarine life at both locations. BOD measures the quantum of oxygen consumed by microorganisms in putrefying organic matter in sluice water. BOD also measures the chemical oxidation of inorganic matter (i.e., the birth of oxygen from water via chemical response). The rate of oxygen consumption in a sluice is affected by a number of variables; temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. BOD directly affects the quantum of dissolved oxygen in gutters and aqueducts. The lesser the BOD, the more fleetly oxygen is depleted in the sluice. This means lower oxygen is available to advanced forms of submarine life. The consequences of high BOD are the same as those for low dissolved oxygen because submarine organisms come stressed-out, suffocate, and die. Sources of BOD include leaves and woody debris; dead plants and creatures; beast ordure; backwaters from pulp and paper manufactories, wastewater treatment plant, ranches, and food-processing shops; failing septic systems; and civic storm water runoff as presented in *figure 4.4*

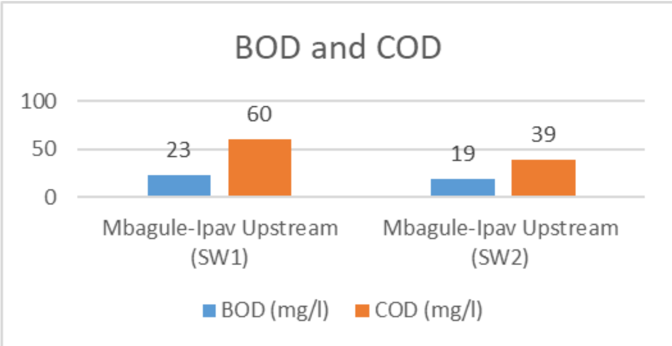

Figure 4.4: Distribution of Turbidity and TSS in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.9 Total Hardness

Water hardness is the total calcium and magnesium ion attention in a water sample and is expressed as the attention of calcium carbonate. The measure and posterior control of water hardness is essential to help scaling and clogging in water pipes. The samples were in compliant with FMEnv standard of 200 mg/$CaCO_3$L and 150 mg/$CaCO_3$L for NIS limit of drinking water quality. The values recorded were 70.00 and 90.00 mg/$CaCO_3$L as presented in *figure 4.5*

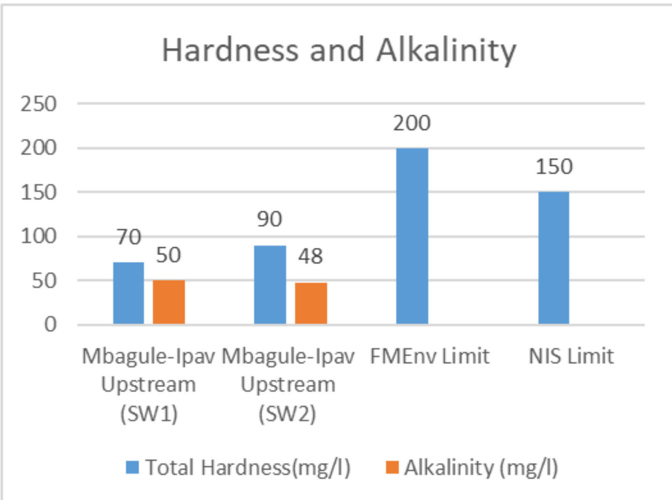

Figure 4.5: Distribution of Hardness and TSS in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.10 Anions

The anions analyzed were Nitrate, Phosphate, Sulphate, Flouride and Cyanide. redundant of these nutrients in drinking water can beget adverse goods in human and animal health. The result of nutrients shows that the parameters tested for anions were within the FMEnv standard as well as the NIS limits for drinking water quality as indicated in *figure 4.6*.

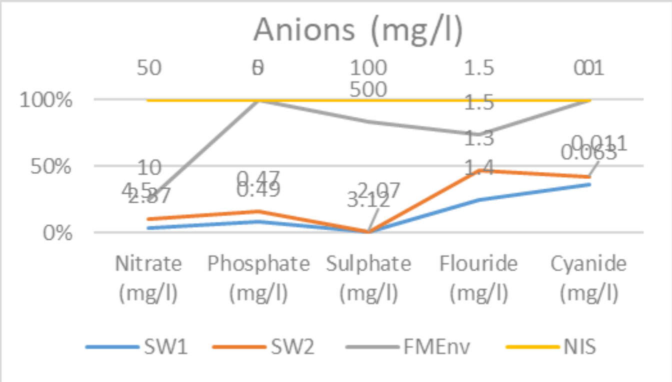

Figure 4.6: Distribution of Anions in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.11 Heavy/Trace Metals

The presence of heavy essence in drinking water advanced than a certain absorption can bring about mischievous impacts on human health. thus, it's important to analysis heavy essence in drinking water, and utmost of the studies on drinking water quality involve disquisition of heavy essence. In this exploration, the heavy/ trace essence anatomized were K, Mg, Ca, Mn, Fe, Zn, Cu, V, Pb, Ni, Cr, Cd, As and Al. The results of heavy/ trace essence similar as Fe, Zn, Ni, Cr and Cd and Pb anatomized were above the FMEnv and NIS nonsupervisory limits and were in non-compliance with their separate nonsupervisory limits of drinking water quality. This could be as a result from chemical filtering of bedrock, water drainage, and runoff from banks, the discharge of civic artificial and pastoral agrarian wastewater. This is presented in figure4.7

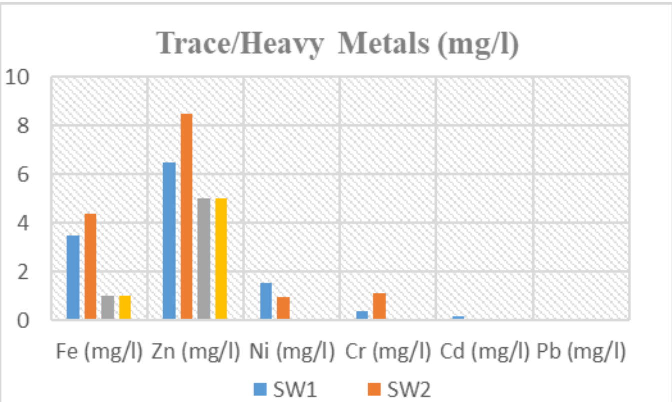

Figure 4.7: Distribution of Trace/Heavy Metals in the surface water samples.
Source: Richflood Laboratory, Sept 2021

4.2.12 Microbial Analysis

A total of two (2) surface water samples were analyzed for microbiological contamination and the indicator parameters were Total Bacteria Count, Total Fungi Count, Faecal Coliform, Salmonella and Shigella specie. Microbiological parameters tested were in non-compliance with FMEnv and NIS regulatory limit of no growth as growths were observed in all the microbiological parameters analyzed as presented in *Figure 4.8.*

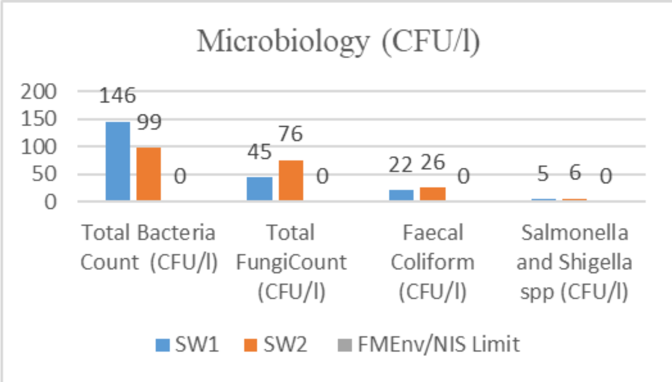

Figure 4.8: Distribution of microorganisms in the surface water samples.
Source: Richflood Laboratory, Sept 2021

V. Conclusion and Recommendations

5.1. Conclusion

Surface water contamination is one of the major environmental problems, resulting out of improved living standards, growing population and interference with natural eco-system. The results of the surface water analyzed for drinking quality at Mbagule-Ipav, Gboko LGA, Benue state, Nigeria described above generally recorded some evidence of surface water contamination in its present status with some parameters especially Turbidity, BOD, heavy metals and microbiological elements tested indicating non-compliance with the NIS and FMEnv Standard limits for drinking water and aquatic life. Hence, the surface water quality was not safe for domestic (drinking), agricultural and Industrial purpose unless treated.

5.2. Recommendations

- Alternative sources of quality water are strongly advised to the community such as bore holes, pipe borne water and tap water supply.
- Boiling of the water is encouraged before use.
- Construction water treatment plant from the surface water and distribution to the community.
- Regular monitoring of surface water quality is required to assess pollution activity from time to time for taking necessary measures to mitigate the intensity of pollution activities within the community.
- Proper environment management plan may be adopted to check potential pollution activities.
- There is an urgent need to educate people and bring awareness about the causes, affects and prevention of surface water pollution and also the consequences of impacts of pollution on human health.
- However, it is also important to investigate other potential water contaminants such as chemicals and microbial and radiological materials for a longer period of time,

including human body fluids, in order to assess the overall water quality of Mbagule-Ipav community.

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