ANTHROPOGENIC WASTE EFFECTS ON AQUACULTURE IN RIVER BENUE AT MAKURDI, NIGERIA

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ABSTRACT

River Benue originates from Cameroonian mountains and flows westwards into Nigeria covering about 1,488km into Makurdi. River Benue divides Makurdi town into North and South banks, occupied throughout its embankment by houses, markets, industrial and commercial structures producing all manners of municipal wastes and disposing them into the river while the same river is use for fishing and fish culture as well as the major source of water supply for the inhabitants living along the embankment. The purpose of the study was to assess the water quality parameters of River Benue at Makurdi metropolis for Aquaculture. Five sampling sites were selected along the water course at areas considered full of possible activities that are capable of affecting the quality of the river water for aquaculture. Water samples were collected monthly for a period of six months, (August to January). Water quality characteristics considered vital for aquatic life were examined: physical parameters investigated were Colour, Temperature, Turbidity, Suspended solids (SS) and Total dissolve solids(TDS); chemical parameters were pH, Total alkalinity, Total hardness Magnesium, Calcium, Iron, Phosphate, Nitrate, electrical conductivity, Dissolved oxygen, Biochemical oxygen demand, Chemical oxygen demand and Feacal coliform. Amongthe18 parameters studied: Water colour averagely appeared brownish, temperature ranged from 270c to 34.40c, turbidity (25.2 to 67.1 NTU), Suspended solids (22.5 to 55.6 mg/l), Total dissolve solids (189to820mg/l), pH (6.2 to 7.6),Total alkalinity (51.0 to 98.0 mg/l), Total hardness (58.0 to 141 mg/l),Phosphate (6.35 to 10.20 mg/l),Nitrate (2.1 to5.15mg/l),Magnesium (21.6 - 38.6 mg/l), Calcium (34.6 - 48.2 mg/l),Iron (0.37 - 1.35 mg/l), electrical conductivity (89.6 to 565 µS/cm), Dissolved oxygen(14.4 to 18.4 mg/l), Biochemical oxygen demand(5.4 to 9.42 mg/l), Chemical oxygen demand(25.7 to 33. 0 mg/l) and Feacal coliform(34.1 to 87.2 MPN). Most of their mean values were within the limit of FAO for aquaculture, except Magnesium, Calcium, Iron and Phosphate which might not be suitable for some species of fishes and fish culture without some level of treatment.

Keywords: River Benue, Physico-chemical parameters, Water quality, Aquatic life, Makurdi.

1. INTRODUCTION

Water is universally accepted as one of the principal elements of life (Nwaogaze, 1990) and needs not to be chemically pure because complete absence of dissolved materials is not desirable but their presence to a certain range is permitted,(Mahajam, 1989).About 75% of the earth surface is covered with water in water bodies. These water bodies differ in size, from oceans and seas to the small ones like ponds. Rivers are large streams or water bodies that generally originate in mountainous areas or elevated areas and carry fresh water over land which usually end up in an ocean or sea, (Mocomi and Anibrain., 2016).

The quality and quantity of river water is influenced by both natural processes and anthropogenic interferences; the latter constitutes one of the major causes of environmental problems that alter the hydrochemistry in our river systems. Rivers are highly heterogeneous at spatial as well as temporal scales. Variation in the quality and quantity of river water is widely studied across the globe. Riedel *et al.* (2000) examined the spatio-temporal variation in trace elements inriver Patuxent, Maryland, while Gupta and Chakrapani (2005)studied temporal and spatial variations in water flow and sediment load in river Narmada Basin, India. Sileika, *et al (*2006) studied temporal and spatial variation of nutrient levels in river Nemunas.

Many scholars studied temporal and spatial trends in watershed, and constituents matter in river water like salt, organic substances, gases, disperse impurities, hydrobiology, bacteria and viruses; suspended clay, sand, gypsum and lime particles. Various organic substances, silicic acid, iron (III) hydroxyl, fulvic acid etc. Quadir *et al.*, 2006;Alber 2007;Kannel *et al.*, 2007;Kannel *et al*2007;)Kannel *et al* andNajafpour *et al.* (2008).Chemically, five principalcomposition of natural water groups according to (Nikolace*et al*; 1988) as: main ions which are present in appreciable concentration (Na, K, Ca, Mg, Sulphate, Carbonate, Chloride, Hydrocarbonate); dissolved gases (Nitrogen, Oxygen, Carbon (iv) oxide, hydrogen, sulphide, etc.); biogenic elements (compounds of phosphorus, nitrogen and Silicon); micro-elements (compound of all other chemical elements.) and organic substances are being studied.

Characterization of water is done for different parameters with classical and instrumental techniques to generate water quality data, effect of change in control measure on river quality, long-term planning and modeling need, determination of compliance with the water quality standard and warning of short term adverse changes in water quality requiring operational responses (Wishart *et al*, 1990; EAP, 2007).

Quality of water is done to agree with the standard values for the intended use (Ashton, 1995) and the protection of public health (McPherson and Livingstone, (1989). Physical parameters of (temperature, odour, taste, colour, dissolved solids, suspended solids, turbidity and electrical conductivity) are important as they affect other properties of contamination. High temperature increases the speed of chemical reactions and reduces gas solubility (Vairamani*et al*, 2003).Chemical parameters when present above certain limits may become toxic to man, animal and aquatic life. These include: acidic and alkaline chemicals, dissolved salts, hardness, dissolved oxygen, organic chemicals and radioactivity. Organic pollutants (bio-degradable and non-biodegradable) - biodegradable such as sugar, starch, fat, protein substance found in domestic and industrial wastes and synthetic substances are not toxic to micro-organism which carry out biological oxidation processes in water. Non-biodegradable chemicals like pesticides, herbicides and fungicide persist in the aquatic system longer (Oni, 1997). Microbiological Parameters (pathogenic organisms) render water unfit for human use (Davis, 1985 and Agunwamba, 2005).

Thus, in aquatic ecosystems of river water, a complex interaction of physical and biochemical cycles exists which may adversely affect many species of aquatic flora and fauna that are dependent on bothabiotic and biotic conditions. Water quality criteria for the protection of aquatic life maytake into account only physico-chemical parameters which tend to define a water quality that protects and maintains aquatic life, ideally in all its forms and life stages (Chapman, 2017).

Vol. 07, No. 04; 2022

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Water quality parameters of concern are traditionally dissolved oxygen (because it may cause fish kills at low concentrations); phosphates, ammonium and nitrate(may cause significant changes in community structure if released into aquatic ecosystems in excessive amounts). Heavy metals and synthetic chemicals can be ingested and absorbed by organisms and may bio-accumulate in the tissues of the organism causing carcinogenic, reproductive and developmental effects (Ute *et al.*, 1996).

River Benue originates from Cameroonian mountains and flows westwards into Nigeria. It is the second largest river in Nigeria and measures approximately 310,000 ha. It is about 1,488km in length with alluvia fertile flood plains on either banks (Welcomme, 1986). River Benue flows through Makurdi after being fed by many tributaries rivers in Nigeria such as: Okwa, Mada, Katsina-Ala, Menchum, Ankwe,Donga,Bantaji, Suntai river, Wase, Taraba, Kam, Pai, Gongola, Hawal, Faro and Gurara. River Benue confluence with River Niger at Lokoja the capital of Kogi state, Nigeria (Figure 1).

Makurdi town, the study area is drained principally by river Benue which divides it into Makurdi North and South banks (Ologunorisa and Tersoo, 2006). The two river banks are occupied throughout its embankment span within Makurdi town by houses, markets, industrial and commercial structures producing all manners of municipal wastes and disposing them into the river while the same river is use for fishing and fish culture as well as the major source of water supply for the inhabitants living along the embankment, Agro-allied industries and other related companies. The objective of this study was to assess the effects of anthropogenic waste on Physico-chemical parameters of river Benue water at Makurdi metropolis in order to analyze the variability and its suitability for aquatic life and compare with Permissible river water environmental standards.

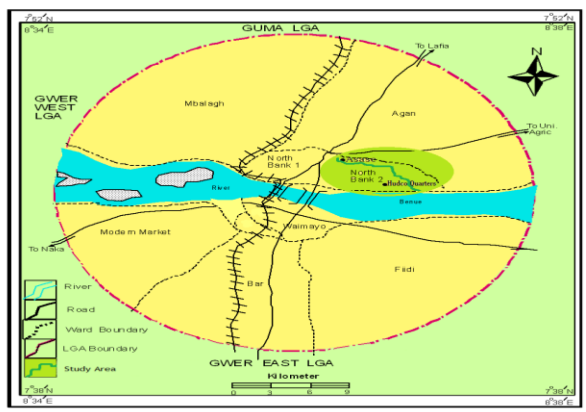

Figure 1: Rivers Benue and Niger in Nigeria Figure 2: River Benue at Makurdi

2.MATERIALS AND METHODS

2.1 The Study Area

Makurdi is the capital city of Benue state, Nigeria and located on latitude $7^0$41' N and longitude 8^0 28'E. The size of the River Benue within Makurdi town and major settlement runs through about 15km (Udo, 1981). The rainfall seasons at Makurdi produces a river regime of peak flows from August to early October and low flow from December to April. The rainy season last for seven months (April to October) with a mean annual rainfall ranging from 1200-2000mm (Nyagba, 1995). High temperature values averaging 28-33^{0}C are recorded in Makurdi throughout the year, most notable from March to April (NMI, 2017).

Spatially, Makurdi town is located within the floodplain of the lower river Benue valley and its physiography span between 73 – 167 m above sea level. Due to the general low relief, sizeable portions of Makurdi is waterlogged and flooded during heavy rainstorms.

2.2 Sample Point Sources

Period of sample collection was deliberately chosen to reflect parting away from rainy season to entering into dry season with less velocity of water flow current in order to monitor the pollution loads at the point sources. The point sources were restricted to particular areas perceived as flashpoints for generation of municipal, industrial and Agro-allied waste into the river. Five point sources were selected as shown in Table (1).

Table 1: Description of Sampling Sites

Sample Site (S)	Description
Benue brewery (S 1)	Brewery company by the river side, factory waste and fishery activities occur in this area.
Duku park (S 2)	A big interstates motor park, drainage canal conveying domestic waste and market dumping refuse in the canal which covey it down to the river.
Abattoir (S 3)	Abattoir (New bridge), an abattoir located by the river water side and local rice processing plant all dump their waste in the river.
Water board (S 4)	Water treatment plant and empty its effluents into the river
Wadata riverside (S5)	A large general market by the river with much canoe transportation services and dumping of anthropogenic waste into the river.

2.2.1 Sample Collection and Analysis

Water samples were taken monthly from the five point sources, 5m from the river embankment at a distance depth of 0.4m from the surface of the water (Chapman, 1996), for a period of 6 months, (August to January) in plastic laboratory bottles, placed in tight containers and taken to Benue State Environmental Sanitation (BENSESA) laboratory where the water was analyzed according to APHA/AWWA/ WEF (2012) standard methods. The parameters analyzed depended on the research objectives. Therefore, physical parameters investigated were Colour, Temperature, Turbidity, Total suspended solids(TSS) and Total dissolve solids(TDS); chemical parameters were pH, Total alkalinity(TA), Total hardness(TH),Magnesium(Mg), Calcium(Ca),Iron(Fe), Phosphate(PO_4), Nitrate(NO3), electrical conductivity(E.C), Dissolved oxygen(DO), Biochemical oxygen demand (BOD), Chemical oxygen demand(COD) and Feacal coliform (F. Coliform).

3.RESULTS AND DISCUSSION

3.1Result

Analyzed data from the 5 point sources of samples from Benue brewery, Duku park, Abattoir, Water board and Wadata riverside and mean concentrations of physico-chemical parametres from the study sites are presented in Table 2.

3.2 Discussion

3.2.1Physicalparametres

Variation in the physico-chemical parameters within sampling stations and across the seasons were analyzed respectively with time as discussed below.

Water colour: Colour, a physical characteristic of water that is not noticed unless it is very high, is measured by comparing a water sample to a colour standard. All the water samples (S1- S5) appeared brownish except (S3) point where the water appeared opaque throughout the study months. The brownish colour in the study sites was caused by chemical (tannin) formed from organic materials which are dumped at the water sides. Water sample from (S3) with opaque colour was taken from the river closer to an abattoir and rice processing plant that all dump their waste in the river.

According to Bhatnagar and Pooja (2013), pale colour, light greenish or greenish waters are suitable for fish culture; dark brown colour is lethal for fish/shrimp culture, light green colour- good for fish/shrimp culture, dark green colour is not ideal for fish/shrimp culture and clear water is unproductive for fish/shrimp culture. And the abundance of phytoplankton and zooplanktonisresponsibleforthedeterminationofcolourofanaquaticbody and Green, bluish green/brown greenish colour of water indicates good plankton population hence, good for fish health.

Temperature concentrations: Surface water temperature is an indispensable ecological factor that regulates the physiological behaviour and distribution of aquatic organisms. Lower temperatures are reported to likely reduced metabolism and growth of aquatic animals (Abowei, 2010). All the temperatures from (S1- S5) ranged between 27^0c and 34.4^0c with mean variation ranged between 29.9 – 31.4^0c (Table 2)(Figure 3). It showed little variations across the seasons within the months of study. The lowest temperature (27^0c) was recorded in the month of December while the highest (34.4^0c) was in October (Figure 3). WHO specify aqua cultural water temperature to be < 40^0c while FAO specification varied according to environmental temperatures in a particular region (Ftsum *et al.,* 2012) (Table 2).

Table 2: Mean Concentrations of Physico-chemical Parameters' of River Benue at Makurdi

Study Sites							**WHO , FAO Standards**	
Parameters	**Units**	**S1**	**S2**	**S3**	**S4**	**S5**	**WHO (2018)**	**FAO (2012)**
Colour	TCU	Brownish	Brownish	Opaque	Brownish	Brownish	-	-
Temperature	o^c	31	29.9	31 .4	32.2	31.4	<40	Varied

Turbidity	NTU	41.7	34.2	41.9	60.3	60.2	5	Varied
SS	mg/l	25.9	28.9	37.1	44.4	47.6	Unsuspected	Unsuspected
TDS	mg/l	531	533.3	496	464	517.2	1000	2000
pH	-	7.00	6.84	7.03	6.87	6.74	6.5-8.5	6.0-8.5
TA	mg/l	78.2	73.1	74.8	73.8	74.4	50-300	5-500
TH	mg/l	80.5	91.0	84.1	92.2	97.1	50 -100	Varied
Magnesium	mg/l	31.4	30.7	32.7	33.0	35.5	0 -5	> 5
Calcium	mg/l	39.8	41.9	39.7	40.1	41.1	0-20	> 21
Iron	mg/l	0.74	0.78	1.14	0.97	1.21	0.3	0.5
Phosphate	mg/l	7.6	7.38	7.36	7.60	7.94	0.1	2
Nitrate	mg/l	3.6	3.22	3.57	3.93	4.36	45	50
E.C	µs/cm	208.3	235	345	319.7	373	750	3000
DO	mg/l	16.6	16.7	16.3	16.6	15.9	5.0 - 7.0	> 40
BOD	mg/l	7.00	7.21	8.3	7.23	7.28	2.0 – 5.0	> 30
COD	mg/l	27.4	27.3	29.7	27.7	28.4	-	200
F. Coliform	mg/l	55	68.7	57.6	56.0	58.0	Not specify (NS)	NS

Turbidity concentrations: Turbidity in water may be due to organic and or inorganic constituents. It is often determined and used as surrogate measure of total suspended solids (Bilotta and Brazier, 2008). The turbidity of the river water increases steadily from August to October with slight reduction as the dry season intensified. The turbidity ranged from 25.2 to 67.1 NTU, with mean range from 34.2 – 60.3 NTU(Figure 3). The highest was recorded at S4 and S5, followed by S1 and S3. This was caused by constant deposition of effluent at the study sites. The result is within the recommended standard value of turbidity by FAO which depends on individual country recommendations. These ranges from < 20 - < 40 (ANZECC, 2000) (PHILMINAQ, 2017). Turbidity induced changes in the water body may change the composition of an aquatic community. Gupta and Gupta (2006) reported that warm water fishes did not show

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any behavioural reaction until the turbidity get to 20,000 mg/l, hence the values of turbidity obtained in this study may not affect the fish community in River Benue.

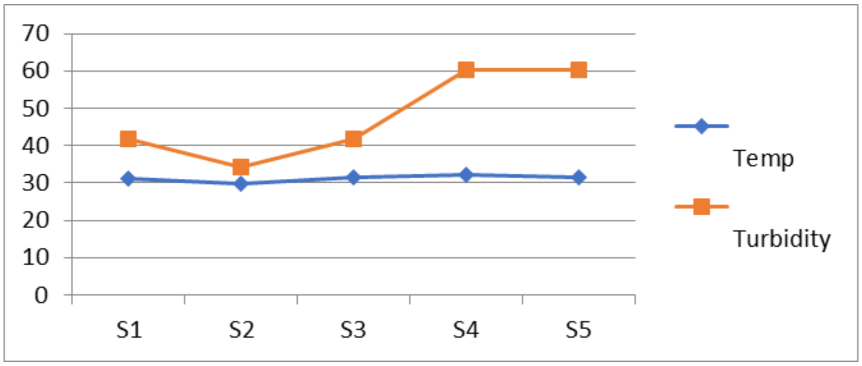

Figure 3: Mean concentrations of Temperatures and Turbidity of the Study Areas

Concentration of Suspended Solids (SS): The SS concentration from the five study sites increases during rainy season with decline in concentration during dry season. The concentrations ranged from 22.5 to 55.6 mg/l with a mean range between25.9- 44.6mg/l. Towards dry season water flow becomes steady and the effluents discharged from industrial activities around the areas accounted for the concentrations and steady state flow into the study sites which experiences laminar flow devoid of rainfall. FAO does not recommend definite values for SS, because levels in river waters are highly variable and depend on many factors but this result from river Benue water falls within the acceptable standard range of 25 – 150 mg/l,(ANZECC,2000). **Concentration of Total Dissolved Solids (TDS):**
Total solids refer to any matter either suspended or dissolved in water. Everything that retained by a filter is considered a suspended solid, while those that passed through are classified as dissolved solids, i.e. usually 0.45µ in size (APHA *et al*, 2017). The levels of total dissolved solids from the study sites fluctuate from 189to820mg/l. The highest concentration was observed at point S3 (September, rainy season), while the least value was from S1 (January, dry season).The significant variation in concentration values might be due to variations in agricultural activities and waste transport within the study area into the river. The total dissolved solids consist mainly of carbonates, bicarbonates, chlorides, sulfates, phosphates and possibly nitrates of calcium, magnesium, sodium, potassium, with traces of iron, manganese and other substances. The chemical content of water may below were artificially by dilution or raised by the addition of chemical wastes, dissolved salts, acids, alkalis, gas or drainage waters from irrigated land. Excessive TDS can reduce water clarity, hinder photosynthesis, and lead to increased water temperatures (Chang, 2005; Cotman *et al.*, 2001).
TDS values from the entire study sites of the river were within stipulated standards by WHO guideline of 1000mg/l and that of FAO of 200 mg/l, (Table 2), for the protection of fisheries and aquatic life. High concentrations of TDS in water decreases the amount of light that can penetrate the water, slows photosynthetic processes, lowers the production of dissolved oxygen; high absorption of heat from sunlight, increases the temperature which can result to lower

Vol. 07, No. 04; 2022

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oxygen level; low visibility which will affect the fish' ability to hunt for food; clog fish' gills; and prevent development of egg and larva. Figure 4 showed (S2) had the highest TDS in December. This may be due to waste from rice processing area and slaughtered animals. Since there was no rain fall to evacuate the waste, its effluents accumulation dumped in the river resulted into the high concentration.

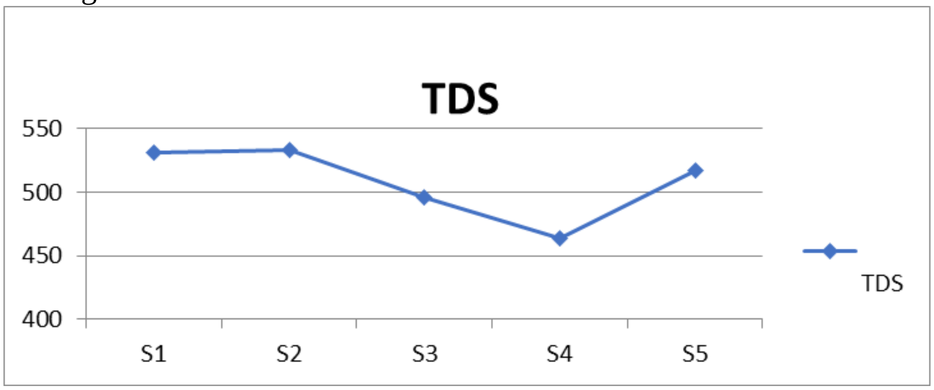

Figure 4:Highest values of TDS Recorded from Site S2.

3.2.2 Chemical properties

pH concentrations: pH concentrations within the study period varied from 6.2 to 7.6. pH appeared slightly acidic in the months of August and September,(6.2 - 6.9). This is expected because August/ September is the peak of rainy season and a peak of water flow into the river from the catchment tributaries which washes many minerals into the river. Highest pH range of alkalinity, (7.16 – 7.60) was recorded at S3 (Abattoir) and S5 (market)(Figure 5). This could be as a result of heavy concentration of effluents deposits and anthropogenic waste being dumping into the river. Generally, the study showed that pH of the river water increases with increase in alkalinity from October to December (dry season). The pH is interdependent with other water quality parameters, such as carbon dioxide, alkalinity, and hardness which also influence the toxicity as well as hydrogen sulfide, cyanides, heavy metals, and ammonia (Klontz, 1993).

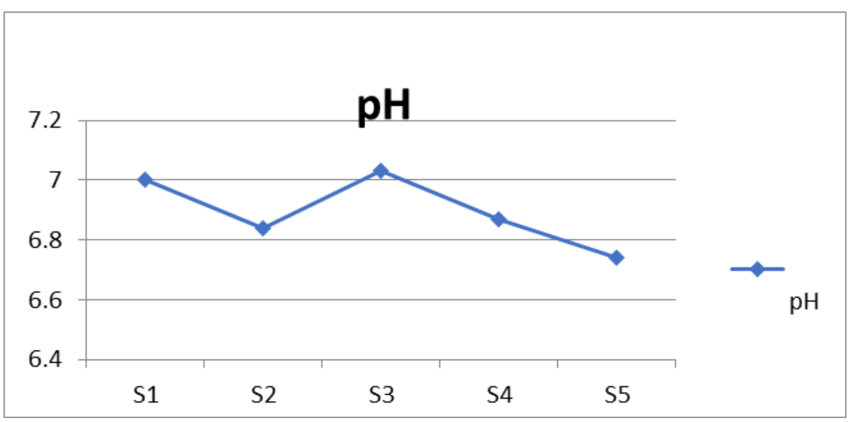

Figure 5: Highest values of pH Occurred at S3 Point.

pH can also affect fish health especially most fresh water species. A pH range between 6.5-9.0 is ideal, but most marine animals cannot tolerate wide range pH as freshwater animals, thus the optimum pH is usually between pH 7.5 and 8.5 (Mosummath *et al.*, 2016). Below pH 6.5 some species experiences low growth (Lloyd, 1992). At lower pH, the organism' stability to maintain its salt balance is affected and reproduction ceases (Lloyd, 1992).At approximately pH 4.0 or below and pH 11 or above, most species die (Lawson, 1995). The general result from this study indicates that the pH is within the desirable range for aquaculture life (Table 3).

Table 3. pH Tolerance Levels and its Effect on Aquaculture

pH levels	Effectson warm waterpond fish
< 4.0	Acid death point
4.0 – 5.0	No production
6.5 - 9.0	Desirable range for fish production
9.0 - 11.0	Slow growth
>11.0	Alkaline death point

Source: (PHILMINAQ 2017).

Alkalinity is the total measure of substances in water that have acid neutralizing ability (Hoko,2008; Virendra, *et al*,2013).Total alkalinity concentration from this study ranged from 51.0 to 98.0 mg/l as $Caco_3$, with a mean ranged between 73.1- 78.2mg/l. The concentration decreases from the rainy season downward into the dry season. It level showed closer variation at all sites. The highest mean alkalinity (78. 2 mg/l) was found from study site (S1) during dry season because it is an area where heavy anthropogenic waste are generated and dumped into the river.Similarly, the lowest mean alkalinity (73.1mg/l) was found at (S2).The waste generated from this site flows into a watershed before discharging into the river course. These results therefore agreed with Virendra *et al.*,(2013) that amount of alkalinity is dependent on the nature of materials discharged into the water bodies. The total alkalinity from the river was below the recommended value which is a range from 5-500 mg/l, (Table 2), hence very much suitable for aquatic life.

Hardness is the measure of alkaline earth elements such as calcium and magnesium in water. The total hardness from the five sites was found to range from 58.0 to 141 mg/l. The highest mean value (97.1mg/l) was found in (S5) site with heavy human waste downstream and the lowest (80.5mg/l) at (S1) site with minimum human waste upstream.

In an aquatic water body, hardness is essential of fish for metabolic reactions such as bone and scale formation (Chatterjee and Raziuddin, 2002). The recommended ideal values of hardness for fish culture are in ranges. At least a water body should contain20mg/l; 30-180 mg/l are optimum for some species. The desirable range is 50-150mg/l as $CaCO_3$. Hardness values less than 20mg/l) causes stress,75-150mg/l is optimum for fish culture and >300mg/l is lethal to fish life as it increases pH, resulting in non-availability of nutrients, but some euryhaline species may tolerate high limits of hardness (Ronald *et al*, 1999; Bhatnagar and Pooja, 2013).

Phosphate concentrations: Typical phosphate concentrations in surface waters are more in nutrient enriched waters, and are considered to be largely non-toxic, although certain man- made organophosphates do have toxic effects (Oyhakilome *et al*, 2011). Concentration from the five study sites ranged from 6.35 to 10.20 mg/l, with mean concentration ranges of 7.36 – 7.94 mg/l (Table 2).High total phosphate value was due to agricultural discharge by runoff from major tributaries rivers and farms into the river (Ademoroti,1996). Phosphate applied as fertilizers in agriculture contains elevated concentrations of phosphate (Cotman *et al*, 2001).

Nitrate Concentrations: Nitrate ion usually originates from anthropogenic activities including agricultural activities, domestic sewage and other effluents containing nitrogenous compounds (Joseph *et al*, 2012).The nitrate concentration from this study range from 2.1to5.15mg/l with a mean range of 3.22 - 4.36 mg/l.The small amount of nitrate found in natural waters is of mineral origin, coming from organic and in organic sources, including waste discharges and artificial fertilizers. By this result, nitrate concentration from river Benue fall far below the recommended standard of FAO's values of 50mg/l for aquatic animals, and therefore within the standard limits.

In aquaculture, nitrate is considered a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms, but stimulates the growth of plankton and water weeds that provide food for fish. This may increase the fish population, but when concentrations become excessive, and other essential nutrient factors are present, eutrophication and associated algal blooms can become a problem. Nitrate- nitrogen levels below90mg/l have been reported to have no effect on warm-water fish (Anon,1992).

Metals Concentrations: The concentrations of heavy metals analyzed in the river water showed mean values ranged as Follows: Fe(0.74 - 1.21mg/l), Mg (30.7- 35.5mg/l), Ca (39.7- 41.9 mg/l).Similar observations were reported on the study of heavy metals on surface water (Chapman, 1993).The concentrations of the analyzed metals were significant in the water and are all above the recommended values by FAO standard(Table 2)(Figure 6). Their presence in natural waters is a combination of contribution from weathering of rocks and minerals, dumpsite leachates, sewage effluents and farming activities (Chapman, 1993). The high level content in the water has no identifiable point source, though, it has been reported that iron occurs at high levels in Nigeria soils (Joseph *et al*, 2012), especially Benue trough (Middle belt) of Nigeria referred to as " home of solid minerals in Nigeria", and could manifest in surface waters that flow over them.

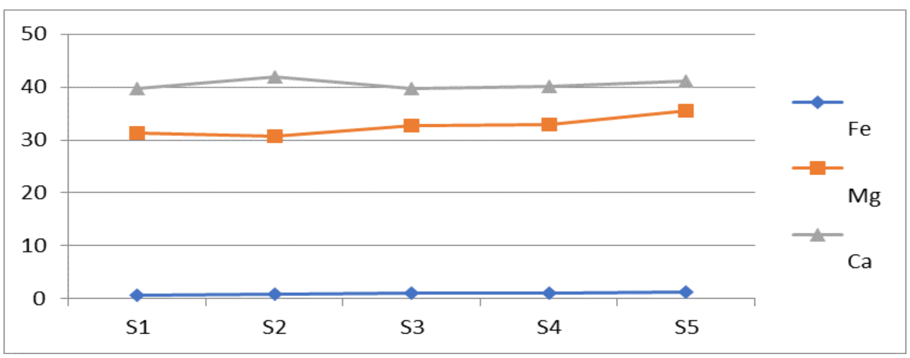

Figure 5: Concentrations of some Metals are all above Limits.

Water electrical conductivity (EC_w): Water electrical conductivity values from the study sites ranged from 89.6 to 565µS/cm. Water conductivity values were higher during rainy season and reduced drastically into the dry season because the highest values (565µS/cm) was in August, while the lowest was in January . This is attributable to excessive washing of dissolved metals by rain fall and transported through the tributaries into the river. All the values from this study fall within the recommended values by WHO and FAO (Table 3).

Dissolved Oxygen (DO): The dissolved oxygen (DO) from the study sights varied from 14.4 to 18.4 mg/l, and mean range of 15.9- 16.7mg/l. The result showed relative fluctuations throughout the rainy season and during early months of dry season. These might be due to dumping of effluents at sample sites which usually mix with water weed in the river course leading to increased progressive growth of submerged macrophytes (Hacioglu and Heinken, 2005). Numerous scientific studies suggest that 4-5 mg/l of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0mg/L, but when it drops below3.0mg/l, even the rough fish dies, while high DO concentrations (>20mg/l) are toxic to fish and cause physiological dysfunctions and developmental abnormalities in fertilized eggs and larvae. Hence, the dissolved oxygen (DO) levels (14.4 to 18.4mg/l) measured in the river is considered high for all intent but fall within the acceptable limits of 40mg/l by FAO (Ftsum 2012).

Concentration of Biological oxygen demand BOD: Biochemical Oxygen Demand is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. Natural sources of organic matter include plant decay and leaf fall. Oxygen consumed in the decomposition process robs other aquatic organisms of the adequate oxygen they need for survival, (Priyanka and Sujata, 2014).

Values from study area varied from 5.4 to 9.42mg/l and mean range of 7.00 -8.3mg/l. Higher values were recorded during peak of rainy season but significantly reduced towards dry season period. The BOD value in rivers often increases during periods of heavy rain and high River flows as organic matter is washed in from the land and farmyards (Joseph *et al.*, 2012).Therefore variations in the levels of BOD between the five sampling point might be due to the run-off from agricultural activities in to the study area.

The BOD levels recorded in the entire sampling points were higher than the WHO guidelines of 2.0 to5.0 mg/l for drinking water but within FAO limits (Table 2) for the protection of fisheries and aquatic life and for domestic water supply (Chapman, 1993). When BOD levels are high, dissolved oxygen (DO) levels decrease because the bacteria are consuming the oxygen that is available in the water. Therefore, increased is an indication of waste material discharges from settlements and tributaries along the river Benue courses and within Makurdi town particularly the study sites which are flash points for effluents.

Concentration of Chemical Oxygen Demand (COD): COD is the amount of oxygen consumed to chemically oxidize organic water constituents to in organic products. It is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution, commonly expressed in mass of oxygen consumed over volume used to easily quantify the amount of organics in water. It is commonly applied in quantifying the amount of oxidizable pollutants found in surface water and useful in terms of water quality by providing a metric to determine the effect an effluent have on the receiving body of water*(Lenore et al, 2010)*.Concentrations from the five sample sites varied from 25.7 to 33. 0 mg/l and mean range from 27.3 – 28.4 mg/l. The higher values from this study were obtained during the months of rainy season while the lowest values were obtained during dry season. The values are all within the WHO limit of 200mg/l (Table2). The increasing trend in COD concentration in the rainy season is an indication of waste discharges into the river course.

Faecal coliform (F. coliform): Faecal coliform (Coliform bacteria) originate in the intestines of warm-blooded animals and are capable of growth in the presence of bile salts or similar surface agents, to produce acid and gas. Large quantities of faecal coliform bacteria in water are not harmful according to some authorities, but may indicate a higher risk of pathogens being present in the water (Doyle and Erickson, 2006).The results varied from 34.1 to 87.2 MPN. The highest value (87.2MPN) was from S5 and during rainy season (August), while the lowest value (38.1MPN) was from S1, in January (dry season). Higher values recorded during rainy season could be due to influx of the coliform into the river through runoff from vegetation decay, municipal sewage, garbage, domestic and feacal waste from the environment (CPCB,2000). Increased levels of faecal coliforms provide a warning of possible contamination with pathogens. When levels are high, an elevated risk of waterborne gastroenteritis may result (Fresno, 2009).The presence of faecal coliform in aquatic environments may indicate that the water has been contaminated with the fecal material of humans or other animals. Faecal coliform bacteria can enter rivers through direct discharge of waste from mammals and birds,
from agricultural and storm runoff and from human sewage; plant material, and pulp or paper mill effluent, (Doyle and Erickson, 2006). Faecal coliform can be harmful to the environment, while its Aerobic decomposition can reduce dissolved oxygen levels if discharged into rivers or waterways kill fish and other aquatic life (US-EPA, 2008).

4. CONCLUSION

Assessment of water quality parameters of River Benue at Makurdi metropolis for Aquaculture was carried out by taking sampling from sites considered to be full activities that are capable of affecting the quality of the river water for aquaculture.

All the physical parameters were found to be within the safe limit. pH was slightly acidic in the months of August and September,(6.2 - 6.9),peak of rainy seasons, but appeared alkaline at some points (7.16 – 7.60) in the dry season. Total alkalinity and Total hardness was a bit higher on range values(51.0 to 98.0 mg/l) for all study sites, but standards limits ranged from 50- 300, 5-500 for WHO(2018) and FAO(2012) respectively. All the analyzed metals were above the recommended values. Electrical conductivity and COD are within the limits, while DO and BOD had higher concentration above the limits, but DO falls within the recommended limits of FAO (2012).

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