International Journal of Research in Agriculture and Forestry
Volume 6, Issue 8, 2019, PP 20-33
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Impact of Anthropogenic Activities on Some Physicochemical Parameters of Kiri Reservoir, Adamawa State, Nigeria

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ABSTRACT

Different anthropogenic activities were identified around Kiri Reservoir which ranged from the use of agricultural waste, chemical for fishing, open defecation, damming, runoff from the domestic waste, washing of plates, pots, clothing, hence the need to determine the impact of anthropogenic activities on water quality of Kiri Reservoir. Water samples were collected for water quality assessments for eighteen months (March, 2017- August, 2018) using standard methods. Some of the physicochemical parameters were measured at site (insitu). The Monthly mean of physicochemical parameters (Temperature, Conductivity, Transparency, pH, DO, BOD, Ammonia and phosphorus, Alkalinity, Free CO_2) for the period of this study ranged from 22^0c-30.33^0c, 124µS/cm-320µS/cm, 2.32cm-18.03cm, 6.45-8.06, 2.880mg/l-8.97mg/l, 1.82mg/l-7.07mg/l, 0.101mg/l-0.887mg/l, 0.073mg/l-0.896mg/l, 6.33mg/l-9.67mg/l, 0.000821mg/l-0.014373mg/l respectively. Phosphorus, Ammonia and BOD was outside the recommended range or safety limits for fish production in the tropics. This was an indication of the anthropogenic activities resulting from the agricultural and waste disposal into the water ways.

Keywords: *Anthropogenic, Impact, Kiri, Physicochemical, Reservoir*

INTRODUCTION

The quality of water plays a vital role in the productivity of aquatic habitats. It is described by its physical, chemical and microbiological characteristics (Rajeshwari and Saraswath, 2009). Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use such as drinking water or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish (Engelking, 2008). The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes. Pollution of aquatic environment by inorganic and organic chemicals is a factor posing serious threat to the survival of aquatic organisms including fish and planktons (Samir and Ibrahim, 2008). In the same vein, both the quantity and quality of water are affected by an increase in anthropogenic activities and any pollution either physical or chemical causes changes to the quality of the receiving water body (Aremu *et al*., 2011).Water quality is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. It also refers to the sum total of the physical, chemical and biological characteristics of water body.

This are the most common standard used to assess water quality relate to health of ecosystems, safety of human contact and drinking water. Guptaa *et al.* (2009) observed that the quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems. The recent research in Haryana

(India) concluded that it is the high rate of exploration then its recharging, inappropriate dumping of solid and liquid wastes, lack of strict enforcement of law and loose governance are the cause of deterioration of ground water quality.

Agarwal-Animesh (2011), reported that most of the rivers in the urban areas of the developing countries are the ends of effluents discharged from the industries. African countries and Asian countries experiencing rapid industrial growth and there are making environmental conservation a difficult task. David *et al.* (2010), reported that the environmental properties of water need to be conducive for fish to grow well; therefore an ideal water condition is necessity for the survival of fish since the entire life process of fish wholly depends on the quality of its environment. The increase use of chemical herbicides, pesticides, insecticides and fertilizer, improper disposal of sewage as well as global warming in Nigeria has created a growing awareness of the rational management of aquatic resources and control of waste discharge from the environment.

Water is an essential resource for sustainability of life on earth. It is the most vital requirement after oxygen, as its constant supply is needed to replenish the fluids lost through normal physiological activities such as respiration, perspiration and urination (Ahmed and Indabawa (2012). Water is inevitable for all living organism as it has a great social and economic value ultimately affecting man's health.

It is essentially required for industrial development fisheries, irrigation, hydro electrical generation, human life survival and domestic use (Keshere *et al.*, 2007). Water quality affects the abundance species composition, stability, productivity, and physiological condition of indigenous population of aquatic organisms (Ahmed and Indabawa, 2012). Water quality is indeed important in accessing the health of a watershed and could be used to make necessary management decision to control current and future pollution of receiving water bodies (Behbaniniaet *et al.*, 2009). Physicochemical parameters determine the productivity of a water body. Thus, a change in the physicochemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water (Adeyemi *et al.*, 2009). The physical, chemical and biological factor frequently affect the flora and fauna which lead to the altering of their diversity include pressure , density , buoyancy, temperature , light, oxygen content, carbon dioxide content, pH or hydrogen ion concentration (Achionye-Nzeh and Isimaikaiye, 2010).

Sulphates, phosphates, nitrate and ammonia also plays an important role in changing or altering the water quality of a given water body. It also helps for a better understanding of the ecological interrelationship amongst the population of the community.

MATERIALS AND METHODS

Study Area

Kiri Reservoir is on coordinate's 9°40′47″N 12°00′51″E on the southern part of Adamawa State, Nigeria as shown in fig. I below. It is situated within Shelleng Local Government Area and about 20km from Numan Local Government. It is a 1.2 km long, 20m high zoned embankment with an internal clay blanket. The Reservoir fig. II was mainly completed in 1982. The reservoir has an area of 107.00 km2 and discharge/second capacity of 4000m3. It has a capacity of 690 million m^3 and it was built to provide irrigation for the Savannah Sugar Company (SSC), a large-scale sugar cane plantation and processing company set up as a joint venture between the Nigerian Federal Government and the Commonwealth Development Corporation, London.

Determinations of Physicochemical Parameters

Determination of Water Temperature

This were determined at the sampling site (in situ) using mercury-in glass thermometer (Glaswekwertein model) by dipping it into the water and allowing it to stabilize for two (2) minutes, removed and taking the reading immediately before recording same (APHA, 2005).

Determination of Conductivity

Conductivity was determined at the site (in situ) using conductivity meter (model: Large display conductivity pen-850037) with Serial Number; 152847. Electrolyte conductivity of the water body was determined as described by Wetzel, (2000). All measurement was taken at temperature other than 250C. The observed conductivity was corrected by multiplying by factor given in standard table of conversion.

Determination of Transparency

The transparency of the water was measured using Secchi disk as described by Stirling, (1985). Secchi disk was dipped into the water till the disk disappears and the depth was recorded (d1). It was then dipped further and then withdrawn carefully and the depth at which it became visible was recorded (d2). Actual measurement was obtained by taking the average of the two readings (d1+ d2/2) (APHA, 2005).

Determination of Hydrogen Ion Concentration (Ph)

The pH was determined directly at the sampling site (in situ) using pH meter (model: Pen type pH meter). The electrode of the meter was first standardized using buffer solution which was same temperature as the water. After calibration of the electrode in the solution, it was washed in distilled water before placing it deep into the water for about two minutes for equilibrium. The reading was standardized with buffer solution before measurement was determined (Ali, et al., 2000).

Determination of Dissolved Oxygen (DO)

Determination of dissolved oxygen (DO): A Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the dissolved oxygen. It was calibrated according to the instruction manual provided by the manufacturer. Sample of the water was collected in 100ml beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker that contains the sample water for about 2-3 minutes. The readings were recorded in mgl-1 (APHA, 1999; Mahar, 2003).

Determination of Dissolved Oxygen (DO)

Water sample was taken in a sampling bottle at each station by dipping and allowing the sample to overflow the bottle for two or three minutes to ensure the absence of air bubble are trap in the bottle and the initial DO was measured (D1). The sample was collected and tied in black polythene to prevent exposure to sun light and after five days, DO meter model (EXTECHIN STRUMENTS-407510A) was used to measure the final DO (D2). Biochemical oxygen demand (BOD) was calculated as (DO1-DO2) in mg/L, Where: DO1= dissolve oxygen (initial) and DO2=dissolved oxygen after five days (final). BOD is equal the difference in dissolve oxygen after 5days of incubation in dark cardboard (Higgins et al., 2008).

Determination of Total Ammonia

Ammonia was determined as described by Phillips, (1985). Sample of water collected was immediately filtered through pre-rinsed what man GF/C filter paper. The phenol-hypochloride method was adopted for freshwater samples. Phenol-nitropruside reagent was added to 25ml of sample. It was then mix and alkaline hypochloride reagent added. The flask was covered and the mixtures were left to stand in the dark for 1 hour at room temperature. The absorbance of standards of ammonia stock was serially diluted with the same procedure used for sample and reagent and calibration curve prepared. The result was recorded as milligram per liter (mg/l).

Determination of Total Phosphorus

Total Phosphorus was determined as described by AOAC (1990). Sample of water was measured into a test tube. Ammonium Molybdate solution was added and allowed to stand for 20 seconds. Hydroquinenone solution was added, and the flask was rotated to mix and 1ml of Na2SO4 solution will be added. 2ml of distilled water was added. The test tube was stopped by thumb and was shaking to mix thoroughly. The mixture was allowed to stand for 30 minutes and then measure with spectrophotometer set at 650nm, alongside blank. A calibration curve was prepared using standard phosphorus concentration.

Determination of Total Alkalinity

Total alkalinity was determined as described by Stirling (1985). Water sample was measured and transferred into a conical flask and 3 drop of methyl orange indicator was added. The sample was titrated with standard H2SO4 or HCL from a 10ml burette with continuous shaking until the colour change from blue to pale pink.

Determination of Free Carbon Dioxide

Free Carbon dioxide was determined by titration in the laboratory as described by Saxena, (1990). Water sample was put into a flask and 3 drop of phenolthalein indicator (reagent) was added. If the colour turned pink free CO2 is absent in the sample, but if the sample remains colourless, it was titrated against sodium hydroxide solution (reagent) until pink colour appeared (end point).

RESULTS AND DISCUSSION

The following values were recorded for the various parameters assessed for the period of this research. Table 1 presents the monthly mean variation of temperature. The highest (340C) value was recorded at site II in the month of March, 2017 and the lowest temperature (210C) was detected at site III in the month of January, 2018.The mean monthly value varied from 220C in the month of January, 2018 to 30.330C in the month of March, 2017 and April, 2018 showing significant differences in Months and seasons ($p<0.05$). Sites I, II, and III show no significant differences. The monthly mean water temperature varies between 220C - 30.330C for the period of this study. The current result agreed with the ranged of 230C - 33.50C reported by Akaahan, et al. (2015), in river Benue at Markudi. The lowest value observed in the month of January may be attributed to the usual seasonal change in air temperature resulting from dry cold wind from north-east trade wind called harmattan (Edward, 2017), while the highest water temperature in March may be due to characteristics of hot weather in north-east, while lower temperatures are likely to reduce metabolism and growth in organisms (Abowei, 2010), which is similar to the characteristic observed at Kiri Reservoir. The results of water temperature obtained from this study were higher and above safety limit of 80C - 300C set by WHO (2012), for tropical fish. The values were also higher than 24.70C - 290C reported for Lake Geriyo and 26.490C - 28.250C for Upper Benue River (Kefas, 2016; Edward, 2017) respectively. The normal range to which fish and other organisms is adapted in the tropics is between 80C and 300C (Mustapha, 2011).

The result slightly agreed with previous reports that the temperatures in tropics vary between 210C and 320C (Atobatele and Ugwumba, 2008). Temperature play an important role in the physical and chemical characteristics of water, it seem to have pronounced effect on the rate of CO_2 fixation by phytoplankton (primary productivity). The significance of bright sunlight and temperature helped in production of green algae.

It's also known to influence water chemistry, especially the parameters like dissolved oxygen, solubility, pH, conductivity. In addition, temperature affects the bacterial activities, which is responsible in the decomposition of organic matter for nutrient recycling, as well as solubility and liberation of dissolved gasses like O_2, CO_2, NH_3 and H_2S (Mohamed and Mostafa, 2009). The difference in temperature might be due to wet season weather condition that prevailed from the month of June to its peak in August when atmospheric temperature was low.

Table1. *Monthly Mean Water Temperature (0C) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	32	34	25	30.33	4.726
April	29	32	28	29.66	2.082
May	29	30	28	29.00	1.000
June	28.5	31.5	28	29.33	1.893
July	27.5	27.5	27	27.33	0.289
August	27	30.5	26.5	28.00	2.179
September	26	27	27	26.66	0.577
October	26.5	27.4	26	26.63	0.710
November	27	31	30	29.33	1.732
December	26	27	28	27.00	1.000
January, 2018	23	22	21	22.00	1.000
February	28	33	26	29.00	3.606
March	30	32	34	32.00	2.000
April	28	32	31	30.33	2.082
May	30	31	27	29.33	2.082
June	26	28	27	27.00	1.000
July	29	31	28	29.33	1.528
August	28	30	30	29.33	1.155
Mean	27.81	30.05	27.64		

Table 2 shows the result of monthly mean of conductivity for the period of the study (March, 2017-August, 2018). The highest value of conductivity (695µS/cm) was recorded at site III in the month of January, 2018, and the lowest of 116µS/cm was observed in November, 2017 at site III.

The monthly mean ranged between 124µS/cm in November, 2017 to 320µS/cm in January, 2018, showing significance differences in months and seasons and sites ($p<0.05$). Conductivity in natural waters is the normalized measure of the water's ability to conduct electric current. Variation in conductivity is an indication of the extent to which the reservoir circulates nutrients, especially in a nutrient rich reservoir (Olele and Ekelemu, 2008). The situation in the present study was such that increased conductivity during the dry season was enhanced by increased water evaporation and upwelling from wind, wave and tide. However, the conductivity value of 116µs/cm - 695µs/cm recorded shows that the conductivity level of the reservoir is high and this result varies with 18.68 - 32.64µs/cm obtained by Kefas (2016) from Lake Geriyo.

Conductivity levels below 50µs/cm are regarded as low; those between 50-600µs/cm are medium while those above 600µs/cm are high (Anago et al., 2013). High conductivity is an indication of the presence of large amounts of dissolved salts which may be detrimental to fish. The results of the current study fall within the recommended values of WHO (2012), maximum permissible limits of 8 - 10,000 µs/cm for drinking or freshwater.

Table2. *Monthly Mean Conductivity (µS/cm) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	154	169	173	165.3	10.017
April	177	186	252	205	40.951
May	182	177	183	180.7	3.215
June	190	204	190	194.7	8.083
July	178	181	209	189.3	17.098
August	140	157.5	235	177.5	50.559
September	139.5	453.5	204	265.7	165.83
October	117	267	224	202.7	77.242
November	121	135	116	124	9.849
December	135	143	147	141.7	6.110
January, 2018	129	136	695	320	324.78
February	141	165	146	150.7	12.662
March	143	157	168	156	12.530
April	155	181	161	165.7	13.614
May	161	168	181	170	10.149
June	156	208	182	182	26.000
July	145	146	172	154.3	15.308
August	133	132	132	132.3	0.577
Mean	149.81	187	209.44		

The monthly mean value of transparency is presented on Table 3. The value ranged from 1.70cm at site III in August, 2018to 21.90cm at site II in the month February, 2018. The monthly mean value ranged between 2.32cm in August, 2018 to 18.03cm in February, 2018,showing significance differences in months and seasons ($p<0.05$). The value of monthly mean across sites I, II, and III showed no significant differences.

Transparency is the measure of water clarity, the more the materials suspended in water the lesser the light can pass through water column. Water transparency of Kiri reservoir showed variations. Higher values were recorded during the dry season months and reduced during the rainy season, which can be attributed to increased input of organic matter from surface runoff while high transparency during the dry season may be due to sedimentation of suspended solid particles and absence of the input from the runoff.

Similar observation was made by Ehigiator and Obi (2015), on the interrelationships among Physical parameters of Ovia River. Similar observations were also made (Jidauna et al., 2009; Kefas, 2016; Edward, 2017). Low transparency lead to high turbidity or Total Suspend Solids which also affects the transparency or light scattering of the water and implies low photosynthetic activities and low productivity, and higher transparency implies high photosynthetic activities and high productivity.

From the results obtained for plankton's dynamics, it indicates that higher transparency correlated with the productivity of Kiri reservoir. Suspended and dissolved solids affect metabolism and physiology of fish and other aquatic organism (Lawson, 2011).

Many fish species are sensitive to prolonged exposure to transparency and monitoring of transparency is an important criterion for assessing the quality of water. Particles settle and can blanket the water bottom and smother fish eggs and benthic micro invertebrate.

Table3. *Monthly Mean Transparency (cm) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	16.00	14.00	14.00	14.67	1.155
April	17.50	15.50	14.00	15.67	1.756
May	12.00	13.33	14.80	13.38	1.401
June	11.50	11.50	9.95	10.98	0.924
July	7.00	8.50	7.65	7.72	0.751
August	6.40	7.00	6.50	6.63	0.322
September	6.25	4.25	11.80	7.43	3.884
October	8.25	6.40	7.30	7.32	0.950
November	14.30	9.70	8.90	10.97	2.914
December	14.40	10.20	9.10	11.23	2.797
January, 2018	14.75	18.90	11.70	15.12	3.612
February	12.50	21.9	19.70	18.03	4.917
March	14.50	20.40	18.6	17.83	3.024
April	15.20	16.95	11.90	14.68	2.587
May	17.25	12.30	12.85	14.13	2.730
June	9.65	10.60	8.40	9.55	1.106
July	5.25	6.25	4.25	5.25	1.000
August	3.00	2.25	1.70	2.32	0.651
Mean	11.43	11.67	10.73		

Table 4 shows the average monthly mean value of pH. The highest value (8.50) was recorded in June, July and August, 2018 at site II and III, and the lowest value (6.25) was recorded in September, 2017 at site III.

The monthly mean values ranged from 6.45-8.06 in April, 2018 and October, 2018 respectively showing significance differences in months and seasons ($p>0.05$).

The monthly mean value across Sites I, II and III showed no significant differences.

The hydrogen ion concentration (pH) of water is important because many biological activities can occur only within a narrow range of pH (Ahmed, 2015). Thus, any variation beyond acceptable range could be fatal to aquatic organisms.

Thus, the pH range of 6.25-8.50 obtained in this study is within the acceptable level of 6.0 to 8.5 for culturing tropical fish species and, for the recommended levels for drinking water (WHO, 2012). Federal Environmental Protection Agencies "FEPA" (1991), recommended 6.0-9.0 for fisheries and aquatic life as reported (Ibrahim et al., 2009; Akindele et al., (2013). This result also falls within the limits of the mentioned agencies or organization.

pH outside this range reduces the diversity in the aquatic environment because it stresses the physical system of most organisms and can reduce reproduction. Low pH also allows toxic elements and compounds to become mobile and available for uptake by aquatic plants and animals (Edward, 2017).

This can lead to condition that are toxic to aquatic life particularly to sensitive species. High mean value of pH recorded during wet season could be due to combined effects of run-off from agricultural lands (with high concentration of lime) and photosynthetic activity of macrophytes. Mustapha (2008), observed that there was increase in pH with photosynthesis. Low pH value in dry season could be attributed to decomposition of waste from the environment.

This occurs as a result of anthropogenic activities, high CO_2, reduced volume and damming of the reservoir.

Table4. *Monthly Mean Hydrogen Ion Concentration (pH) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	7.35	7.27	6.33	6.98	0.567
April	7.05	7.04	6.35	6.81	0.401
May	7.04	7.14	6.52	6.90	0.333
June	7.26	7.82	6.99	7.36	0.423
July	7.45	7.95	7.35	7.58	0.322
August	8.05	7.25	7.01	7.44	0.545
September	6.85	6.75	6.25	6.62	0.322
October	8.47	8.50	7.20	8.06	0.742
November	8.30	7.25	6.57	7.37	0.872
December	8.01	7.04	6.81	7.29	0.637
January, 2018	8.02	8.05	6.94	7.67	0.632
February	7.77	7.37	7.81	7.65	0.243
March	7.46	7.32	7.32	7.37	0.081
April	6.57	6.49	6.30	6.45	0.139
May	7.30	7.50	8.40	7.73	0.586
June	7.40	7.60	8.50	7.83	0.586
July	7.60	8.50	7.70	7.93	0.493
August	7.90	8.50	7.50	7.97	0.503
Mean	7.55	7.52	7.10		

There was significant variation in dissolved oxygen (DO) during the period of this study. The highest value (12.70mg/L) was recorded at site I in the month of April, 2018, while the lowest value (1.70mg/L) was recorded at site II in the month of October, 2018. The monthly mean variation of dissolved oxygen (DO) ranged between 2.880mg/L in the month of May, 2017 and 8.97mg/L in April, 2018 (Table 5). Showing significance differences in months, seasons and sites ($p<0.05$).Dissolved Oxygen (DO) has primary importance in natural water as limiting factor because most organisms other than anaerobic microbes diminish rapidly when oxygen levels in waterfalls. Oxygen plays the most important role in determining the potential biological quality of water. The dissolved oxygen which ranged from 1.7mg/L - 12.7mg/L during the current study in the reservoir was significantly higher during the dry season than the rainy season. It was within the ranged of 3.51mg/L - 13.2mg/L reported by Kefas (2016), for Lake Geriyo. The high oxygen value for the dry season coincides with periods of lowest turbidity, temperature and higher concentration of zooplankton. Ibrahim et al. (2009), made similar observation on Kontagora reservoir. He also reported that, the cool harmattan wind which increases wave action, and decrease surface water temperature might have contributed to the increased oxygen concentration during the dry season, while the torrential rains, created increased turbidity and decreased oxygen concentration during the rainy season. Decomposition reduced the amount of oxygen, while increasing the amount of carbon dioxide in the affected environment. Photosynthetic activity and reduced turbidity enhanced Dissolved oxygen concentration (N'Diayeet al., 2013). Lack of DO can lead to anaerobic decomposition of organic matter, resulting in unpleasant odors that are indicative of formation of hydrogensulphide and ammoniums. As dissolved oxygen decreased, respiration, feeding and growth rate is reduced and the possibility of a disease attack is increased.

Table5. *Monthly Mean Dissolved Oxygen (DO) (Mg/L) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	9.21	2.02	7.83	6.35	3.816
April	11.26	2.04	9.06	7.45	4.815
May	2.58	1.94	4.11	2.88	1.115
June	3.67	3.86	2.80	3.44	0.565
July	3.00	3.20	2.50	2.90	0.361
August	4.90	3.80	3.35	4.02	0.797
September	3.50	3.30	3.00	3.27	0.252
October	8.25	1.70	6.23	5.39	3.354

November	3.20	7.05	3.50	4.58	2.142
December	3.50	6.52	3.70	4.57	1.689
January, 2018	5.80	2.10	10.4	6.10	4.158
February	9.60	4.00	9.60	7.73	3.233
March	10.23	3.11	7.21	6.85	3.574
April	12.70	5.40	8.80	8.97	3.653
May	3.90	3.30	6.30	4.50	1.588
June	7.30	7.20	3.80	6.10	1.993
July	8.10	9.70	8.80	8.87	0.802
August	6.40	8.80	9.70	8.30	1.706
Mean	6.51	4.39	6.15		

The lowest value of BOD (1.01mg/L) was recorded in the month of May, 2017 at site II, while the highest value (11.50mg/L) was recorded in the month of April, 2018, at site I (Figure 8). The monthly mean value of Biochemical Dissolved Oxygen (BOD) ranged between 1.82mg/L in the month of June, 2017to 7.07mg/L in the month of August, 2018 ((Table 6). Showing significance differences in months, seasons and sites ($p<0.05$).The BOD ranged between 1.01mg/L - 11.5mg/L obtained in the current study is higher than the 3.0 - 6.0mg/L recommended by EU, and is also higher than 3.26 - 3.56mg/L reported by Edward (2017), from Upper Benue River. The higher values were observed during the dry season months. High BOD experience during the dry season could attributed to the human activities ranging from damming of the water which doesn't allowed the follow of water, waste from the household which are dispose directly or indirectly into the water and organic and inorganic matter resulting from the rice farming. All these increased the rate of dissolved salt in the water. Usman et al. (2014), reported the coefficient of biological oxygen demand variation was higher in the dry season than in the rainy season in Lake Alau, North East Nigeria. The trend of seasonality in BOD followed that of DO concentration with higher values and variability during the dry season than in the rainy season. Biological oxygen demand (BOD) is the amount of oxygen required to biologically breakdown a contaminant. It is often used as a measurement of pollutants in natural and waste waters and to assess the strength of waste, such as sewage and industrial effluent (Zeb et al., 2011). BOD is a fair measure of cleanliness of any water on the bases that values of less than 2 mg/L are clean, 3 - 5mg/L, fairly clean and 10mg/L definitely bad and polluted (Idowu and Gadzama, 2011; Abolude et al., 2012). The results show that the Reservoir water may likely get polluted with time. BOD therefore is an important parameter of water, indicating the health scenario of freshwater bodies (Bhatti and Latif, 2011).

Table6. *Monthly Mean Biochemical Oxygen Demand (BOD) (Mg/L)*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	6.91	1.34	6.81	5.02	3.187
April	10.82	1.22	5.62	5.88	4.806
May	1.56	1.01	3.34	1.97	1.218
June	2.11	2.34	1.02	1.82	0.705
July	2.10	2.61	1.90	2.20	0.366
August	3.42	2.83	2.01	2.75	0.708
September	3.10	1.92	2.84	2.62	0.620
October	5.25	1.56	5.24	4.02	2.128
November	1.36	5.95	1.10	2.80	2.728
December	2.02	4.52	2.63	3.06	1.304
January, 2018	6.40	2.10	8.10	5.53	3.093
February	7.00	1.80	7.30	5.37	3.093
March	7.85	2.31	3.86	4.67	2.858
April	11.50	5.00	3.70	6.73	4.179
May	1.70	1.30	4.10	2.37	1.514
June	6.20	6.40	3.10	5.23	1.850
July	7.20	7.50	6.30	7.00	0.625
August	4.90	7.8	8.50	7.07	1.909
Mean	5.08	3.31	4.30		

The highest value of ammonia (1.131mg/L) was recorded in the month of January, 2018, at site II while the lowest value of ammonia (0.054mg/L) was recorded in the month of June, 2017 at site I ((Table7). The monthly mean value of ammonia ranged between 0.101mg/l in June, 2018 and 0.887mg/l in the month of November, 2017 at site. The monthly and site mean variation showed significant differences in seasons and sites ($p>0.05$). The monthly mean variation showed no significant differences across sites.

Ammonia is an important nutrient of phytoplankton and it is also the major end product of protein metabolism excreted by aquatic animals. The value of ammonia which ranged from 0.054mg/L - 1.131mg/L recorded in the current study is less than 0.53mg/L - 7.44mg/L reported by Kozak et al. (2014), in Lake Swarzêdzkie. But it was higher than 0.021mg/L - 0.108mg/L and 0.03mg/L - 0.11mg/L reported (Kefas, 2016; Edward, 2017), from Lake Geriyo and Upper Benue River. The highest values during the current study were observed during the dry season months. Higher concentrations correspond to pollution and can be toxic to aquatic organisms including fishes and other organisms in the water system.

Edward (2017), reported that highest value recorded during dry season could be as a result of high concentration of dissolved salts and other elements in water body due to reduced volume of water and also inorganic fertilizers which are used during the dry season farming. Increases in pollution loads during the summer season increase NO3, and this condition decreases NH4.

Table7. *Monthly Mean Ammonia (Mg/L) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	0.553	0.529	0.154	0.412	0.224
April	0.604	0.716	0.299	0.540	0.216
May	0.579	0.669	0.676	0.641	0.054
June	0.054	0.706	0.059	0.273	0.375
July	0.081	0.114	0.199	0.131	0.021
August	0.889	0.567	0.964	0.807	0.211
September	0.744	0.607	0.902	0.751	0.148
October	0.068	1.056	0.732	0.619	0.504
November	0.745	1.020	0.895	0.887	0.138
December	0.601	0.997	0.818	0.805	0.198
January, 2018	0.770	1.131	0.639	0.847	0.255
February	0.618	0.747	0.268	0.544	0.248
March	0.610	0.850	0.237	0.566	0.309
April	0.607	0.870	0.281	0.586	0.295
May	0.680	0.792	0.815	0.762	0.072
June	0.086	0.122	0.094	0.101	0.019
July	0.109	0.136	0.134	0.126	0.015
August	0.558	0.453	0.185	0.399	0.192
Mean	0.498	0.671	0.464		

The monthly mean value of phosphorus is presented on Table 8. The value ranged between 0.071mg/L at site II in March, 2017 to 1.169mg/L at site II in the month September, 2017. The monthly mean value of phosphorus ranged between 0.073mg/L in the month of March, 2017 to 0.896mg/L in the month of June, 2018.

Showing significance differences in the monthly variation of phosphorus ($p<0.05$). The value of mean across sites I, II, and III showed no significant differences. Phosphorus is an essential element for plant growth and agricultural productivity. The seasonal variations of phosphorus in Kiri reservoir varied between 0.071mg/L and 1.169mg/L in March and September respectively. This is less than 3.80 - 6.30mg/L, 14.5-31mg/L and 20 – 51mg/L reported from Prairie Lake, Delimi River and most African Rivers and Lakes, but is higher than 0.002mg/L and 0.37mg/L observed by Usman et al. (2014), from Lake Alau.

The higher phosphorus concentration during the rainy season could be due to surface run-offs as well as the decomposition of organic matter. This agreed with the work of Osimen et al. (2015), who reported higher value during the rainy season in Ojirami reservoir, but varied with the observations (Usman et al., 2014; Ibrahim et al., 2009), in Lake Alau and Kontagora reservoir, who reported higher value during the dry season.

The source of phosphorus can be from arable agriculture. It was also observed during the study period that the intensive agricultural activities involved the use of fertilizers and pesticides to produce dry season crop like vegetables.

Some villages were using the water for domestic use, washing of vehicles, which could increase the phosphorus level of the water. Phosphorus values obtained in the current study were higher than the tolerable range of 1mg/L (USEPA, 1991). High phosphorus may result into excessive algal growth and other aquatic forms of life are endangered. Algae blooms limit recreational use by reducing water clarity and aesthetic qualities. Factors that limit algal growth include available forms of phosphorus, sunlight, and temperature. In most temperate waters, Phosphorus is usually reported as the principal limiting factor of production.

Table8. *Monthly Mean Phosphorus (Mg/L) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	0.076	0.071	0.073	0.073	0.003
April	0.187	0.105	0.088	0.127	0.053
May	0.165	0.167	0.155	0.162	0.006
June	0.068	0.080	0.083	0.077	0.008
July	0.084	0.093	0.170	0.116	0.047
August	0.657	1.166	0.580	0.801	0.138
September	0.585	1.169	0.632	0.795	0.325
October	0.620	0.547	0.155	0.441	0.250
November	0.621	0.592	0.592	0.602	0.017
December	0.167	0.637	0.564	0.456	0.253
January, 2018	0.275	0.206	0.149	0.21	0.063
February	0.180	0.239	0.192	0.204	0.031
March	0.201	0.240	0.210	0.217	0.020
April	0.216	0.246	0.274	0.245	0.029
May	0.308	0.373	0.389	0.357	0.043
June	1.107	0.705	0.875	0.896	0.202
July	0.257	0.194	0.243	0.231	0.033
August	0.326	0.339	0.337	0.334	0.007
Mean	0.339	0.398	0.320		

The highest value of alkalinity (17.3mg/L) was recorded in the month of January, 2018 at site II while the lowest value (5.70mg/L) was recorded in the month of January, 2018 at site I (Appendix II). The monthly mean value of alkalinity ranged between 6.33mg/L in November, 2017and 9.67mg/l in the month of January, 2018 ((Table 9). Showing significance differences in the monthly variation of alkalinity ($p<0.05$).

The value of mean across sites I, II, and III showed no significant difference. Alkalinity of surface water is primarily a function of carbonate, hydroxide content and also includes the contributions from borates, phosphates, silicates and other bases.

The value of the alkalinity of the Kiri Reservoir was found to be between 5.70mg/L - 17.30mg/L which falls within the range of 6.0 - 57mg/L reported (Osimen et al., (2015). The value being within the maximum permissible limit of WHO (2012), this is higher than the result obtained by Agbaire and Obi (2009) for River Ethiopein Abraka, Nigeria. The current results were less than 226.67mg/L - 440mg/L, 35.0 ±0.49 - 46.8 ± 0.89mg/L reported for river Yobe and Alau Dam respectively(Binta et al., 2017; Ja'afaru and Wakil, 2015). The alkalinity is higher in the dry season when the reservoir had low water level.

The high alkalinity recorded at site II could be attributed to the high dissolved gas (CO2) obtained at same site. High alkalinity results in physiological stress on aquatic organism and may lead to loss of biodiversity. The high value during the dry season could be due to low water levels with its attendant concentration of salts and the lower value in the rainy season could be due to dilution.

Similar result was obtained by Qureshimatvaet al. (2015), for Chandlodia Lake, India. Measurement of alkalinity is important in determining of water body ability to neutralized acid pollution from rainfall or waste water. An average fresh water alkalinity values is 150mg/L.

According to the Lawson (2011), alkalinity between 30 and 500mg/L is generally acceptable for fish and shrimp production. High alkalinity results in physiological stress on aquatic organism and may lead to loss of biodiversity.

Table9. *Monthly Mean Alkalinity (Mg/L) of Kiri Reservoir*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	7.10	9.20	8.40	8.23	1.060
April	7.80	8.60	8.20	8.20	0.400
May	6.40	6.50	6.40	6.43	0.058
June	8.70	9.20	10.0	9.30	0.656
July	9.80	6.80	10.2	8.93	1.858
August	6.90	8.40	9.60	8.30	1.353
September	7.30	6.50	7.1	6.97	0.416
October	7.00	8.50	6.8	7.43	0.929
November	6.40	6.20	6.4	6.33	0.116
December	6.20	7.30	6.5	6.67	0.569
January, 2018	5.70	17.3	6.00	9.67	6.612
February	7.40	9.80	9.40	8.87	1.286
March	7.50	10.1	8.80	8.80	1.300
April	7.20	9.50	10.0	8.90	1.493
May	7.40	8.60	9.80	8.60	1.200
June	9.80	8.90	9.70	9.47	0.493
July	10.0	6.70	9.90	8.87	1.877
August	7.50	6.30	6.50	6.77	0.643
Mean	7.56	8.58	8.32		

The monthly mean value of free carbon dioxide is presented on Table 10. The value ranged between 0.000352mg/L at site I and II in the month of May, 2017 to 0.032736mg/L at site II in the month April, 2018.

The monthly mean variation of free carbon dioxide ranged between 0.000821mg/L in the month of November, 2017 and 0.014373mg/L in the month of April, 2018. Showing significance differences in the monthly variation of free CO2 in months and seasons ($p<0.05$).

The values of mean across sites showed no significant differences. Free CO2 is the most important greenhouse gas on Earth. Its fluxes across the air-water or sediment-water interface are among the most important concerns in global change studies and are often a measure of the net ecosystem production/metabolism of the aquatic system (Patil et al., 2012).

The value of CO2 in the current study of Kiri reservoir ranged from 0.000352mg/L - 0.03273mg/L, which was within the maximum permissible limit (6.0mg/L) as defined by WHO (2012) guidelines. A good fishery is correlated with low free carbon dioxide and at high concentration it is vice versa.

However, maximum free carbon dioxide was observe during dry season and this could be due to reduced water volume, high temperature, dry season farming which washed organic and inorganic waste into the water body and increase in the biological activities in the reservoir than during the rainy season which experience an increase in the volume of water and thereby disturb the biological activities of the reservoir due the increase runoff (dilution).

Similar observation was made by Kefas (2017), for Lake Geriyo. Free CO2 is an important parameter in primary production and phytoplankton biomass. Water acidity increases with increased dissolved CO2.High rates of CO2 are detrimental to survival, physiology and metabolic activities of aquatic animals including fish (Lawson, 2011).

Table10. *Monthly Mean Free Carbon Dioxide (CO_2) (Mg/L)*

Months	Site I	Site II	Site III	Mean	STD
March, 2017	0.002112	0.0044	0.002288	0.002933	0.00127
April	0.003872	0.017072	0.004928	0.008624	0.00734
May	0.000352	0.001056	0.000352	0.000587	0.00041
June	0.002288	0.002112	0.00264	0.002347	0.00027

July	0.003344	0.001232	0.003696	0.002757	0.00133
August	0.001408	0.001936	0.002816	0.002053	0.00071
September	0.002112	0.000704	0.00176	0.001525	0.00073
October	0.001408	0.001936	0.001056	0.001467	0.00044
November	0.000352	0.00088	0.001232	0.000821	0.00044
December	0.00176	0.002288	0.001232	0.00176	0.00053
January, 2018	0.002112	0.002816	0.003696	0.002875	0.00079
February	0.002112	0.004048	0.003344	0.003168	0.00098
March	0.00264	0.004224	0.003696	0.00352	0.00081
April	0.004224	0.032736	0.00616	0.014373	0.0159
May	0.001211	0.002112	0.003696	0.001936	0.00185
June	0.00264	0.00176	0.002992	0.002464	0.00063
July	0.003696	0.001408	0.003872	0.002992	0.00137
August	0.001584	0.00176	0.003696	0.002347	0.00117
Mean	0.002179	0.004693	0.002953		

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Citation: *ZIRA, J.D., Kotos A.A., Isa, et al "Impact of Anthropogenic Activities on Some Physicochemical Parameters of Kiri Reservoir, Adamawa State, Nigeria", International Journal of Research in Agriculture and Forestry, 6(8), 2019, pp 20-33.*