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Effect of Riparian Land Use on Phytoplankton Characteristics of Kwadon Stream, Gombe State of Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Industrialization and agricultural activities are the two major sources of water pollution. Kwadon stream has long been known for its economic importance such as the provision of water for agricultural and domestic usage. However, poor management was identified as the priority factor affecting the usability of that stream thereby causing water crises in the region. This research was conducted in order to study the effect of the riparian land use on the phytoplankton distribution as well as the variation of its physicochemical parameters. Three sampling sites were selected for this study which includes; Sites A, B and C. Five-minute kicking technique was used for the collection of phytoplankton species. A total of 18 phytoplankton species were surveyed belonging to the families of *Bacillariophyceae*, *Chlorophyceae, Chrysophyceae*, and *Myxophyceae*. Shannon-weaver

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diversity index showed that a total of 1289 cells were quantified in all the sampling sites. The most diverse phytoplankton taxa were *Chlorophyceae* (431 cells), followed by *Bacillariophyceae* (377 cells), *Myxophyceae* (266 cells) and then *Chrysophyceae* (156 cells). In all the phytoplankton taxa, *Ankistrodemus* sp 103 (55.67%) was most abundance species. The physicochemical parameters measured in site A fell within the water quality standard for freshwater and marine aquaculture which enables it to support highest species score than Sites B and C. Results of this study is important in providing information on how phytoplankton respond to environmental change which can be used as a baseline for pollution control and ways to improve the economic activities in the region.

Keywords: Pollution; phytoplankton; physicochemical parameters; species.

1. INTRODUCTION

Worldwide, stream communities have been subjected to varying degrees of degradation as a result of changing land uses; particularly the degradation of lowland rivers by prolonged agricultural activity is receiving increasing recognition as a global problem. The conversion of land from one use to another affects stream ecosystems in a number of ways, including changes to nutrient loadings. This link between terrestrial and freshwater ecosystems can also result in freshwater systems being vulnerable to human-induced stresses on either ecosystem. Major changes to the rates of ecosystem processes, through excessive nutrient loading or disruption of essential nutrient cycles, can cause water pollution thereby affecting freshwaters fauna [1].

Water pollution is the contamination of water by the introduction of foreign matter such as micro-organisms, chemicals, industrial/municipal waste, and organic matter. It also affects the entire microbial communities as well as the water characteristics of the region [2]. These pollution sources deteriorates the quality of water and render it unfits for its intended uses [3]. The most affected microorganisms are those found at benthic zones.

The benthic zone in the freshwater environment is the ecological region at the lowest level of water bodies such as the ocean, streams, sediment surface and some sub-surface layers. Organisms such as crustaceans, fishes and polychaetes are dominantly found thriving at this zone. They often live on rocks, logs, sediment, debris and aquatic plants during some period in their life cycle. This is the most important part of the stream communities where the riparian effect can be observed [3]. Benthic organisms (Crayfish, Clams, Snails, aquatic worms, Stoneflies, and Mayflies) at this zone undergo symbiotic relationship with the substrate bottom thereby exhibiting their sessile nature. The benthic boundary layer is an integral part of the benthic community that can be affected by the change in physicochemical parameters of the water bodies due to agricultural and industrial activities.

The riparian zone is the green ribbon of life alongside a stream. This ribbon is a mixture of vegetation types, which varies greatly from place to place. It connects the upland zone (the area of watershed that does not receive regular flooding) to the aquatic zone (the area of the stream channel covered by water controlling the flow of water and sediment.

The variation of the environmental condition has been reported to have a considerable effect on the response of the benthic community and it avails to measure the degree of pollution [4]. Water quality is defined in terms of its chemical, physical and biological contents. The quality of the streams and lakes changes with seasons and geographical areas, that is why pollution guidelines have been set up to provide basic scientific information about water parameters and ecological relevant toxicological threshold values for specific water usage [4].

Several studies have been carried out on the effects of riparian land use on stream benthic communities [5-8]. The riparian land use along Kwadon stream, Gombe State of Nigeria is of economic important. It serves as the major sources of both food and income to the low socio-economic group of individuals within Kwadon community. As a result, the government is currently pooling resources in order to diversify the economic activities taking place in that region through restructuring and expansion activities. This has led to the frequent remodelling of the riparian zone in the region thereby threatening the life of the benthic microbial communities as

well as water characteristic that defined their survival. All these may lead to the extinction of some beneficial benthic organisms. Therefore, this study is aimed at examining the riparian land use and how it affects the distribution and abundance of benthic microbial communities along the Kwadon stream. The result of this study will provide based-line information on the effect of riparian land use on the phytoplankton distribution, abundance and characteristics of the stream in relation to the riparian land use in Kwadon.

2. MATERIALS AND METHODS

2.1 Study Area

The stream was located in Kwadon, Yamaltu Deba Local Government Area of Gombe State. The area lies between latitude 10° 16' 15'N to 10°17' 7"N and longitude 11°16' 44"E to 11° 18' 28"E. The types of activities carried out by the stream include farming, washing, bathing, and fishing. Three sampling sites were pointed out as A, B and C. Activities taking place in Site A (Upstream) is mostly fishing while Site B (Midstream) and C (Downstream) are washing and irrigation respectively (Fig. 1).

2.2 Sample Collection and Preservation

Samples of water and phytoplankton were collected over a period of six (6) months from 6 am local time. Water samples for physicochemical studies were collected from the three (3) sites (A, B, and C) below the water surface (Fig. 1). They were taken in triplicates at each sampling sites using sample bottles. The bottles were rinsed with the water before being filled with the samples. Sample bottle of 300 mL was dipped below the water surface. The bottle was filled to the brim and covered immediately to avoid air bubbles inside. Water samples were preserved using ethanol before being transported to the laboratory for processing. Water samples were collected in labelled sampling bottles. Physicochemical parameters were determined as follows;

2.3 Determination of Temperature and pH

Temperature and pH readings were taken in-situ using mercury bulb thermometer (GlaswekwerTein model) and pH meter (model: Hanna instruments model No H18915ATC) as described by [9].

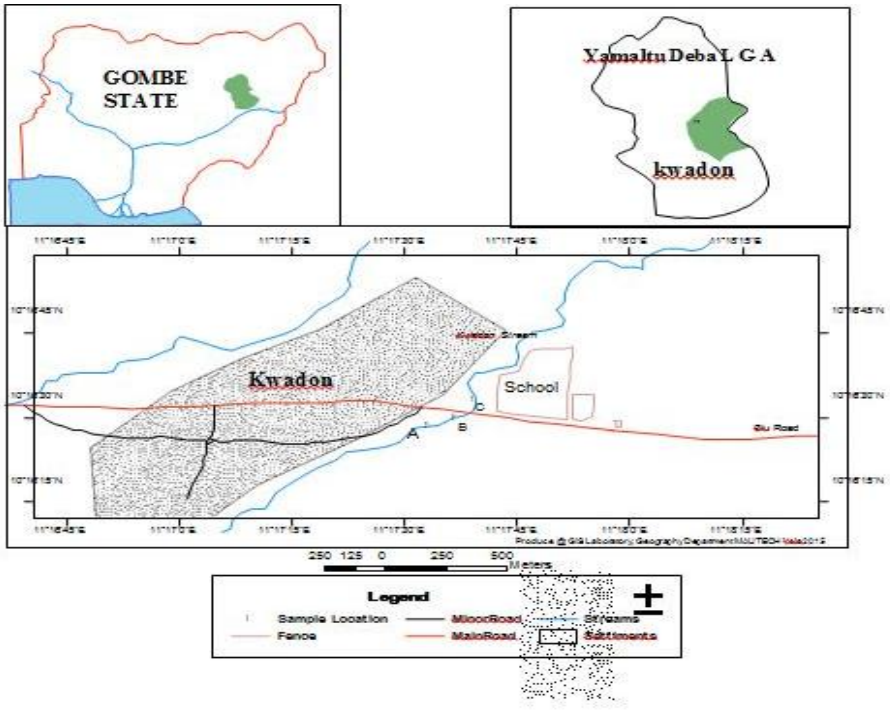

Fig. 1. Map of Yamaltu Deba showing Kwadon as a study area

2.4 Determination of Free Carbon Dioxide

Free carbon dioxide was determined according to the method described by [10]. 50 mL of water was placed in the flask and two drops of phenolphthalein indicator were added. It was then titrated against sodium hydroxide solution (reagent) until pink color appeared (end point). The total amount of free oxygen determined was computed as follows;

$$\text{Free } CO_2 \text{ (mg/L)} = \frac{Vt \times 100}{Vs}$$

Where V_T = volume of titrant (mL), V_s = volume of the sample (mL)

2.5 Determination of Total Nitrogen and Phosphorus

The total nitrogen content of water (ammonia and nitrogen) was determined according to the method described by [11]. The samples of the water were filtered through pre-rinsed what-man GF/C filter paper. Specifically, ammonia was determined using phenol hypo- chloride method. For total nitrogen content of water, the sample collected were immediately filtered with pre-rinsed what-man GF/C filter paper and fixed with 1mL concentration H_2SO_4 and a dozen anti-bumping granules were added. The final reading was taking using spectrophotometer. For each of the analysis, water was used as blank. Total phosphorus was determined by the method of AOAC [12]. 5 mL of the sample was mixed with 1 mL ammonium molybdate solution and allowed to stand for 20 seconds. 1 mL of hydroquinone solution was added, the flask was mix and about 1 mL of Na_2SO_3 was added. Reading was made using spectrophotometer.

2.6 Determination of Total Alkalinity

Total alkalinity was determined as described by [13]. 50 mL of water samples was measured and transferred into conical flask; 3 drops of methyl orange indicator were added. The sample was titrated with standard 0.01MH_2SO_4/ HCL from a 10 mL burette with continuous shaking until the color changes from blue to pale pink were observed. The total alkalinity was calculated from the equation below;

$$\text{Alkalinity in mg/L} = \frac{n \times V2 \times 1000}{V1}$$

Where n = normality of standard H_2SO_4, v_1 = volume of the samples, v_2 = volume of acids used.

2.7 Determination of Conductivity

Electrolyte conductivity of the water body was determined at the side using conductivity meter (Model: PHYTE 65667.00). The unit of measurement was expressed in µs/cm which is the SI units. All measurements were made at a temperature other than 25°C. Conductivity of the water was determined using relationship;

$$\text{Conductivity (K)} = \frac{C \times 1}{R}$$

Where C = cell constant, R = Resistance.

2.8 Determination of Dissolved Oxygen

Dissolved oxygen was determined as described by [10]. Glass stoppered of 100 mL was used for sample collection. The sample was fixed with 1 mL of each manganous sulfate and alkaline reagents (potassium iodide plus potassium hydroxide). The stopper was replaced and the bottle was shaken thoroughly. 2 mL of H_2SO_4 was added and shaken thoroughly to dissolve the precipitate. 50 mL of content was transferred gently in a conical flask and about 4 drops of the starch indicator was added. Titration was done against sodium thiosulphate solution and the end point was noted when initial blue color turned to colorless.

2.9 Determination of Phytoplanktons Diversity

Samples of phytoplankton were collected in a plastic bottle at about 10 cm below the water surface. The sample was preserved at 4°C in dark glass bottles under 1:1000 ratio lugols iodine to facilitate sedimentation. A sample of phytoplankton was counted and identified according to the standard method of APHA [14]. Counting was done specifically using a compound microscope and was counted in counting chambers.

2.10 Data Analysis

All data obtained from this study was analysed using Microsoft excel and Statistical Analysis System (SAS) version 15.0. Residuals of the data were tested for normality and equality of variance to fulfil the assumptions for the parametric test. Shannon-Weiner Diversity index H' was used to determine

diversity amongst sites. All experimental data were taken in triplicate and the average values were taken.

3. RESULTS AND DISCUSSION

3.1 Phytoplanktons Abundance and Diversity

A total of 1364 species of phytoplankton were surveyed for a period of six (6) months. A total number of 18 phytoplankton species were found of which most of them belonged to the four families of *Bacillariophyceae*, *Chlorophyceae, Chrysophyceae*, and *Myxophyceae*. Data in Fig. 1 showed that there are an abundance of species in sites A than sites B and C. Generally a high number of species scores were found in site A, followed by sites B and C with a total of 15, 14 and 10 species respectively (Table 1). Shannon-Weiner Index H' for various species was found to be 1.079, 1.054 and 0.90 for sites A, B, and C respectively. The effective numbers of species for these sites were (2.94, 2.86, and 2.47) for A, B and C which were used for the derivation of H' and an effective number of species (Appendix 1). Data in Appendix 1 showed that the closer the effective number of species the higher the species richness and the more evenly distributed species are in a given population.

3.2 Physicochemical Parameters and their Statistical Comparison

The statistical analysis of the physicochemical parameters across the various sites showed in Appendix 2. The data obtained includes; Temperature ($F_{2, 15}$ = 22.3, p = 0.000), Turbidity ($F_{2, 15}$ = 15.6, p = 0.000); pH ($F_{2, 15}$ = 15.8, p = 0.000), and conductivity ($F_{2, 15}$ = 45.2, p = 0.000). This indicates a significant difference between these parameters since the calculated values are greater than the tabulated values. This difference could be due to water flow, fewer activities and evenly distribution of trees around the sites. Moreover, for the nutrient analysis, there was also a significant difference in the following physiochemical parameters across sites except for ammonium and alkalinity where the tabulated values are greater than the calculated values (Appendix 2). The statistical data are presented as follows; (Dissolved Oxygen ($F_{2, 15}$ = 2.7, p = 0.10), Ammonia ($F_{2, 15}$ = 0.24, p = 0.78); Nitrogen ($F_{2, 15}$ = 0.86, p = 0.44); Phosphorus ($F_{2, 15}$ = 1.31, p = 0.29), and Alkalinity ($F_{2, 15}$ = 0.03, p = 0.97). The calculated values for dissolved oxygen, ammonium, nitrogen, phosphorus and alkalinity were 2.7, 0.24, 0.86, 1.31 and 0.03 respectively while the tabulated value were 0,10, 0.78, 0.44, 0.29, 0.97 respectively. It is therefore evidently showed that there was the negligible effect of human activities on the physicochemical variation along the riparian zone of Kwandon stream (Table 3). Parameters such as Temperature, pH, and Turbidity, Dissolved Oxygen and conductivity were found to be positively correlated. There was also a significant positive correlation between Free CO_2 with Alkalinity and with Phosphorus.

3.3 Discussion

3.3.1 Distribution and abundance of planktons

A total number of 18 species of phytoplankton were identified in sites A, B, C in this study. Generally, the species score determined at each sites A, B, and C are found to be 103(55.7%) of *Ankistrodemus* sp, 58 (33.01%) of *Fragilaria* sp and 78 (45.08%) of *Aphanacopsa* sp. (Table 1). Therefore, *Ankistrodemus* sp was ranked as the most diverse species in Kwadon stream (Fig. 2). Such percentage abundance was comparable with 26.42% reported by [15]. Four families of *Bacillariophyceae*, *Chlorophyceae, Chrysophyceae*, and *Myxophyceae* were encountered during the study. Based on the result in Appendix 1, Shannon-weaver diversity index showed that a total of 1289 cells were quantified in all the sampling sites. The most diverse taxa were *Chlorophyceae* with a total of 431 cells, followed by *Bacillariophyceae* with a total of 377 cells, *Myxophyceae* with a total of 266 cells and then the least taxa; *Chrysophyceae* with a total of 156 cells (Appendix 1). The highest species abundance of *Chlorophyceae* observed might be due to their high adaptation to a wide range of physicochemical parameters. A similar study was also conducted in wetlands valley of Cameroon; an area characterized by low salinity due to high rainfall and a dense river network, which supplies freshwater. The various species of phytoplankton identified were *Phormidium, Heterocapsa, Rivularia, Trichodesmium*, and *Lyngbya* which are different from the species surveyed in his study despite the high amount of rainfall received during the rainy season [16]. The variation of the species occurrence was due to the high salinity content of 12 which favor the survival of certain species of microalgae. This is a strong indication that the nature of the chemistry of water body determined the types of species, their

distribution, tolerability and their ability to function as indicator species.

The most abundant species was found to be *Ankistrodemus* sp followed closely by *Flagilaria* species. Interestingly these two species have their highest individual number in site A. This is a strong indication that site A is more suitable for phytoplankton wellbeing. This assertion was confirmed by the physicochemical parameters (dissolved oxygen and pH) values of sites A, and B and C. These agree with another study conducted by [17], where high dissolve oxygen level favors the survival of aquatic biota. Furthermore, despite that the physicochemical parameters in sites B and C are not quite favorable, some species appear to be more tolerant such as *Ulothrix* species and *Aphanacopia* been the most abundant in sites C than A and B and this trend is most likely a coincidence but we have no prove for where it goes.

Table 1. Percentage abundance of phytoplankton species in sites A, B, and C

S/N	Species	Site A	%	Site B	%	Site C	%	Total
1	*Anabaena* sp.	71	48.63	13	8.90	62	42.46	146
2	*Ankistrodemus* sp	103	55.67	50	27.02	32	17.29	185
3	*Aphanacopsa* sp	62	35.83	33	19.07	78	45.08	173
4	*Chlorella* sp	41	67.21	20	32.78	0	0.00	61
5	*Closterium*sp	61	79.22	0	0.00	16	20.77	77
6	*Cyclotella* sp	27	39.70	20	29.41	21	30.88	68
7	*Fragilaria* sp	94	50.26	58	31.01	35	18.71	187
8	*Mallamonas* sp.	86	66.15	23	17.69	21	16.15	130
9	*Navicula* sp.	76	6.00	24	0.00	0	25.00	100
10	*Nitzchia* sp	7	36.84	12	63.15	0	0.00	19
11	*Oocystis* sp.	33	73.33	12	26.66	0	0.00	45
12	*Oscillatoria* sp.	13	56.52	0	0.00	10	43.47	23
13	*Ragilaria* sp.	22	100.00	0	0.00	0	0.00	22
14	*Tabellaria* sp	33	100.00	0	0.00	0	0.00	33
15	*Ulothrix* sp.	15	33.33	10	22.22	20	44.44	45
16	*Enteromorpha* sp.	0	0.00	16	100.00	0	0.00	16
17	*Eudorina* sp.	0	0.00	10	47.61	11	52.38	21
18	*Zygnema* sp.	0	0.00	13	100.00	0	0.00	13

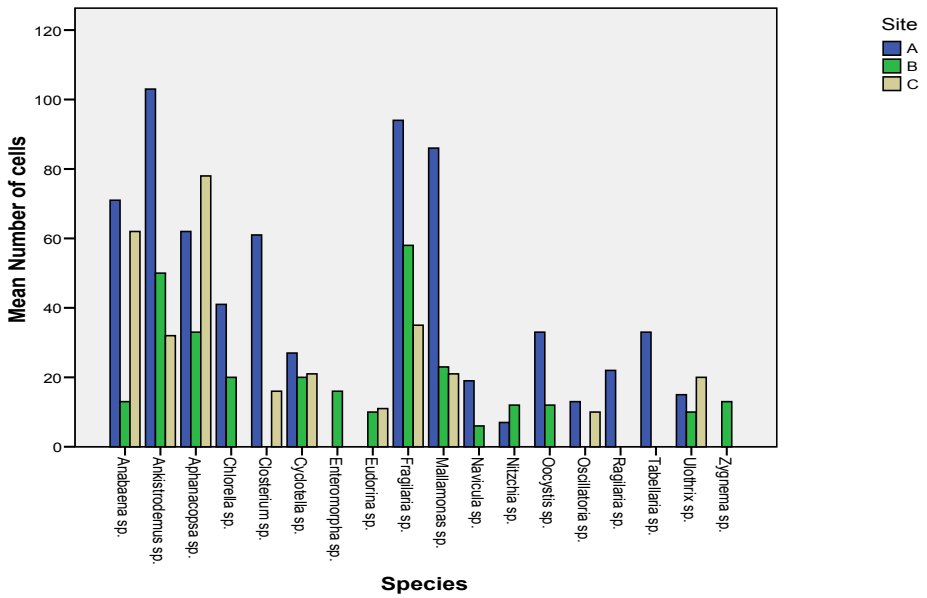

Fig. 2. Mean distribution of phytoplankton species across various sites

Table 2. Mean distribution of physiochemical parameters across sites

Site		Temp. (°C)	Turbidity	pH	Dissolved O_2	Conductivity	Ammonia	Nitrogen	Phosphorus	Alkalinity	Free CO_2
A	Mean	23.17	2.33	7.67	7.42	111.83	.04183	.14817	.04917	15.970	11.475
	Std. deviation	1.835	.516	.644	1.617	12.914	.022956	.065356	.011907	5.3892	5.3139
	Variance	3.367	.267	.415	2.616	166.779	.001	.004	.000	29.043	28.238
	N	6	6	6	6	6	6	6	6	6	6
B	Mean	25.83	3.50	8.77	6.66	79.03	.04550	.11700	.04800	15.233	10.483
	Std. deviation	1.169	.837	1.460	.873	13.896	.010232	.007642	.014832	5.1310	4.3823
	Variance	1.367	.700	2.131	.762	193.100	.000	.000	.000	26.327	19.205
	N	6	6	6	6	6	6	6	6	6	6
C	Mean	28.33	5.17	11.55	5.36	46.48	.05000	.15067	.03933	15.403	11.392
	Std. deviation	.816	1.169	1.419	1.983	8.072	.024650	.054924	.005922	5.0746	4.4049
	Variance	.667	1.367	2.013	3.931	65.164	.001	.003	.000	25.751	19.403
	N	6	6	6	6	6	6	6	6	6	6
Total	Mean	25.78	3.67	9.33	6.48	79.11	.04578	.13861	.04550	15.536	11.117
	Std. deviation	2.510	1.455	2.039	1.708	29.644	.019398	.049082	.011708	4.8953	4.4580
	Variance	6.301	2.118	4.157	2.917	878.771	.000	.002	.000	23.964	19.874
	N	18	18	18	18	18	18	18	18	18	18

Table 3. Overall physiochemical parameters found in the study area

Parameter (units)	N	Mean	Std. deviation	Reference [28]
Temperature (°C)[a]	18	25.78	2.510	27-29
Turbidity (cm)[a]	18	3.67	1.455	5.0
pH[a]	18	9.33	2.039	6.5-8.5
Dissolves O_2(mg/L)[a]	18	6.48	1.708	3-7 mg/L
Conductivity (µmhos/cm)[a]	18	79.11	29.644	1000
Ammonia (mg/L)[b]	18	.04578	.019398	<0.05
Nitrogen (mg/L)[a]	18	.13861	.049082	<0.5 mg/L
Phosphorus (mg/L)[a]	18	.04550	.011708	0.02-20 mg/L
Alkalinity (mg/L)[b]	18	15.536	4.8953	5-500 mg/L
Free CO_2 (mg/L)[a]	18	11.117	4.4580	-

(a) Denote a significance difference. (b) Denote insignificance difference.

3.3.2 Physicochemical and phytoplanktons parameters

The significant variations of the different parameters observed in the sampling sites could be attributed to the flow variability and changes in watershed conditions. This agrees with the observation of [9,18] who reported that the high variability in water quality may be due to the impact of extrinsic factors (rainfall and surface runoff) and catchments activities which prevailed during the raining and dry seasons period respectively.

Water bodies undergo seasonal and daily changes in temperature which affects all kinds of the physical, chemical and biological process [9]. It affects the solubility of gasses in waters, gas solubility decreases with increased in temperature. In warmer waters the respiration rate of aquatic organisms' increases, as does the decomposition of organic matter, both of which consume oxygen. The monthly mean water temperature of the stream, fluctuate between 23.14°C and 28.33°C in sites (A and C) during the period of the study (Table 2). This might be due to the rainy season condition experience between July-September; which may stop as a result of the dry season as the year advances towards the dry harmattan period occurring within the months of November and December. These findings are in accordance with the findings of [19] which reported the seasonal variations of the physicochemical characteristics of Tagwai dam, Minna, Niger State in relation to their potential for fish production over twelve months. They reported that the low temperature of 23°C to 27°C recorded in all the stations within the months of December – January might be attributed to cold weather conditions of that period because of severe harmattan. The ranges of temperature recorded during the period of this study were lower than 31 – 34°C obtained at Balanga Dam, Gombe State of Nigeria [9]. They concluded that the high temperature observed in this lake could be due to the shallow nature of the lake, which could be favorable to fish growth and other economic development [20]. Water temperature is a universal parameter that determines other parameters. The increase in temperature increases the rate of physical reactions such as an increase in evaporation and volatilization of substances. Increased in temperature also decreases the solubility of gasses such as dioxygen (O_2), carbon dioxide (CO_2), nitrogen gas (N_2) and methane (CH_4). The metabolic rate of an aquatic organism is also related to a temperature which increases the respiration rate leading to increased oxygen consumption and increased decomposition of organic matter. The temperature obtained from this study were found to be within acceptable limit for aquatic life (Table 3).

Transparency is a measure of turbidity of the water body and is an indication of availability of light in the water column to support photosynthesis by phytoplankton. Turbidity is a measure of water clarity; the more availability of free suspended material in the water, the less light can pass through the water column [9]. The highest mean turbidity reported from this study was 2.33 cm - 5.17 cm in the month of July to December. This could be due to the increased water runoff and suspended organic matter observed during the rainy season from July - October. However, as the rainy season comes to an end, turbidity gets reduced which could be due to the absence of flood water, surface runoff and settling effect of the suspended solids after the seizure of rain and also human and agricultural activities. The turbidity value of this study does not exceed the standard range of 5

cm for aquatic life. This implies that phytoplankton species thrive by manufacturing energy using light which is the reason the sampling stations support a number of species diversity as described in the previous chapter [21]. Pointed out that suspended and dissolved solids affect metabolism and physiology of fish and other aquatic organism by increasing the rainfall and thus have adverse effects on dissolved oxygen and carbon dioxide. Dissolved solids could directly influence water conductivity, the higher the dissolved solid the higher the conductivity.

Hydrogen ions concentration (pH) of water measured the concentration of hydrogen ions that causes acidity and alkalinity on a scale of 0-14 with 7 as a neutral state. A very low pH signifies acidity while high pH level indicates alkalinity. Increase or decrease in both the two conditions may reduce production in fish and other aquatic organisms and may even cause death. The pH ranges of 6.5-9.0 were observed to be the most suitable for fish production [22]. Increase in pH has also been shown to affect metabolism, physiology, and growth of aquatic organisms [9]. pH is influenced by the acidity of the bottom sediment and biological activities. High pH may result from a high rate of photosynthesis by dense phytoplankton blooms. The pH ranges of 7.67- 11.55 were recorded in the month of July to December which was within the normal ranges for aquatic life [18]. This thus indicated that various anthropogenic activities did not alter the normal pH of the water. High water pH can affect production, causing death to many aquatic organisms. However, the mean pH value has exceeded 8.5 maximum standards for aquatic life. Probably, the phytoplankton at that region had acquired the adaptive features that will enable them to grow under high pH.

Dissolved carbon dioxide in the aquatic environment, increases with a decrease in dissolved oxygen. It is an important parameter in primary production and phytoplankton biomass. High rates of dissolved carbon dioxide are detrimental to survival, physiology and metabolic activities of aquatic biota. A monthly mean dissolved oxygen range 5.36 to 7.46 mg/L recorded in the month of July- December was attributed to greater and frequent rate of wind current which does not encourage or enhance decay of organic matter, exhaustion of the dissolved oxygen while [18] reported that water holds higher dissolved oxygen at lower temperatures than at higher temperatures. The lower dissolved oxygen values recorded in the months of January to May were attributed to higher temperature characteristics of these periods. The 6.0 mg/L recorded in some months during the study period was in line with recommendations of some researchers who said most biologists accept 6ppm as the minimum concernment for fish. Many species of fish can survive under varying concentrations below 6 pmm [16].

Conductivity is a measure of the ability of water to conduct electrical current, where conductance increases with increasing total salt concentration in the water [23-25]. It is measured in micro Siemens per centimeter (µs/cm) and is affected by the electrical change of the dissolved solids, usually, salts within the water. The mean electrical conductivity (EC) recorded during raining season was 46.46-111.83 µmhos/cm. This could be attributed to high concentration of pH in the water body. This result is higher than EC values of ranges from < 10 to 40 µS/cm observed in the stream of central Brazil, possibly indicating the good quality of water in these environments [26].

The alkalinity of the water body is a measure of the concentration of anions in water. The dissolved anions according to [9] may be sourced from bicarbonates, carbonates, hydroxides, phosphates borates or silicates which may be derived from industrial waste, dissolved rocks, salts, soil or bottom sediments. The increase in alkalinity above the standard water criteria can have an advance effect on the metabolism and reproduction of phytoplankton. The monthly mean variation of total alkalinity from 15.232 to 15.970 mg/L observed could be due to the presence of much limestone (carbonate of Mg and Ca) deposit in the surrounding soils and along the course of tributaries that enter the water. Therefore it may have lower buffer capacity and respond poorly to fertilizers which may both be determined by rainy season mostly from July- December. This is contrary to the findings of [18] who reported that the alkalinity range of 4.05 to 8.10 mg/L obtained from their research falls below the recommended value of 5 to 500 mg/L for freshwater fish culture. Furthermore, [12] suggested that this could be due limestone deposit in the surrounding soil and along the water course.

Conductivity is a measure of the ability of water to conduct electrical current, where conductance increases with increasing total salt concentration

in the water. It is affected by the electrical change of the dissolved solids, usually, salts within the water. The monthly mean total ammonia variation ranges from 0.418 - 0.500 mg/L in this study which is higher than 0.025 mg/L and 0.06- 0.07 mg/L reported by [21] in freshwater streams was observed in this study. It is also lower than 0.3 to 1.9 mg/L reported by [2] in Lake Geriyo. The high values observed could be as a result of decomposition of organic matter. Ammonia in water is released as an end product of decomposition of organic matter and also as an excretory product of some aquatic animals [10]. Obviously, cattle rearing could the major cause of the increase in ammonium concentration > 0.05.

Nitrogen is found in several forms in the aquatic ecosystem [22,26]. It occurs in form of ionized ammonium, nitrates (NO_3) and nitrites (NO_2). Nitrogen can be accumulated in water body through wastewater treatment plans, run off fertilized areas, runoff from the animal manure storage area and industrial discharge that contain corrosion. The monthly mean total nitrogen fluctuates between 0.1170 and 0.15067 mg/L which is higher than 0.25 to 0.34 mg/L reported by [23] in river Ilagil Ngurore, Yola-south L.G.A Adamawa State of Nigeria, But, it is lower than 0.02 to 2.0 mg/L recommended by [22]. This may not be unconnected with the amount of rainfall in the area. The increase in rain and runoffs from farmlands increase the concentration of total nitrogen in the water body. The concentration is however within the tolerable limit of 1 mg/L for the aquatic organism.

The mean monthly variation of phosphorus ranges from 0.03733 to 0.04917 mg/L was observed in this study. These values are higher than 0.021-0.046 mg/L reported by [23] in River Ilagil Ngurore, Yola-south L.G.A Adamawa State. The high values observed could be as a result of anthropogenic activities and waste sedimentation associated with the sites. This agrees with Australian Centre for Tropical. Freshwater Research (ACTFER) [27] that artificial sources of phosphorus include fertilizers, detergents, waste water, and industrial affluent and animals excreta among others. The concentration of phosphorus fell within the acceptable range of 0.02 - 20 mg/L for aquatic life [23].

The mean monthly variation of free CO_2 ranged from 0.88 to 1.82 mg/L, which is lower than 6.0 to 7.9 mg/L reported in Lughu reservoir and 2.6 to 4.17 mg/L as reported by [27] in River of Ilagil Ngurore. However, the value fell within the 10 mg/L safety limit for aquatic life reported by [19].

The physicochemical parameters observed are almost all within the safety limit which makes its variation in the distribution of phytoplankton in all the sites while the impact of riparian land use in the study area helped in structuring their communities in the stream.

3.3.3 Effects of the Riparian Land use on the physicochemical parameters and phytoplankton

The results of this study showed that riparian land use has a direct impact on abundance and diversity of phytoplankton. Sites A shows a higher diversity of phytoplankton than the other sites, this could be as a result of fewer effects of fishing activities on the phytoplankton, could also result in low temperature, and decreased in fishes species at fishing area. While at sites B and C when compared to Site A, this could be as result of low turbidity, domestic effluent and agrochemical used in irrigation farming reduced the distribution at the sites. This means that the two major sources of stream pollution are domestic and irrigational activities which also affect the phytoplankton diversity. Variation of phytoplankton diversity at the riparian zone could also be as a result of the changes in physicochemical parameters across the sites because of the riparian activities [28, 29, 30].

The riparian zone is critical to the health of every stream and its surrounding environment. It connects the upland zone (the area of watershed that does not receive regular flooding by a stream) to the aquatic zone (the area of the stream channel covered by water controlling the flow of water). Land use activities are not a Nigerian issue but a global one. This is because of its identification a priority cause of the contamination of many stream environments. Other factors that can cause gradual degradation of streams are prolonged agricultural activity, which has been shown to affect stream ecosystems in various ways including changes to nutrient loadings and sediment inputs [5].

4. CONCLUSION

The study of the effect of the riparian land use on the characteristics of Kwadon stream was conducted.

- The phytoplankton species identified in all the three sampling sites were found to

belong to the following families; *Bacillariophyceae, Chlorophyceae, Chrysophyceae, and Myxophyceae.*

- The highest diversity of phytoplankton score was observed during the rainy season than the dry season.
- This study showed that the physicochemical parameters obtained at site B and C were not within the recommended safety limit for aquatic life which obviously was what led to the low species abundance in that sites. The different kinds of activities carried out at the sampling stations contributed to the changes in the physical and chemistry of the water which affects the species diversity. This study, therefore, suggests that riparian land use has a direct impact on abundance and diversity of phytoplankton of Kwadon stream which can be considered of high crucial in order to identify the potential risk factors threatening the life of aquatic biota in the region for conservation purpose.
- Therefore, it is important to prohibit dumping of waste at the stream area. Also, farmers should be enlightened on the dangers associated with the used of inorganic fertilizers, insecticide and herbicides (agrochemicals) on the stream.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Umar DM, Harding JS, Chapman HM. Tropical land use and its effects on stream communities. Journal of Environmental and Policy Evaluation. 2014;4(2):165-196.
2. Kefas M, Abubakar KA, Ali J. The assessment of water quality via physicochemical parameters and macro invertebrates in Lake Geriyo, Yola, Adamawa State, Nigeria. The International Journal of Science and Technoledge. 2015;3(3):284.
3. Ekubo AT, Abowei JFN. Aspects of aquatic pollution in Nigeria. Research Journal of Environmental and Earth Science. 2011; 3(6):673-693.
4. Lawson EO. Physicochemical parameters and heavy metal contents of water from the mangrove swamps of Lagos Lagoon, Lagos, Nigeria. Advanced in Biological Research. 2011;5(1):8-21.
5. Umar DM. The effects of land use on stream communities in highland tropical Nigeria. PhD thesis University of Canterbury, Christchurch, New Zealand; 2013.
6. Kominoski JS, Marczak LB, Richardson JS. Riparian forest composition affects stream litter decomposition despite similar microbial and invertebrate communities. Ecology. 2011;92(1):151-159.
7. Findlay S, Quinn JM, Hickey CW, Burrell G, Downes M. Effects of land use and riparian flowpath on delivery of dissolved organic carbon to streams. Limnology and Oceanography. 2001;46(2):345-355.
8. Quinn JM, Cooper AB, Davies-Colley RJ, Rutherford JC, Williamson RB. Land use effects on habitat, water quality, periphyton and benthic invertebrates in Waikato, New Zealand, hill-country streams. New Zealand Journal of Marine and Freshwater Research. 1997;31(5): 579-597.
9. Saidu H, Usman B, Umar D. Studies of species distribution for phytoplankton in Balanga dam. Journal of Advanced Research in Applied Sciences and Engineering Technology. 2016;3(1):1-9.
10. Sexana MM. Environmental analysis: Water, soil and air. Agro-Botanical Publisher India. 1990;32-35.
11. Philips MJ. Analysis of nutrients. *In* Stirling H. P (ed) chemical and biological methods of water analysis for agriculture. First edition institute of aqua. The university of Stirling, printed and made in great Britain. 1985;110.
12. AOAC. The Official methods of analysis association of official analytical chemists, 17th edition Washington DC. 1990;2:13–14.
13. Stirling HP. Chemical and biological methods of water analysis for aqua. The University of Stirling. Printed and made in Great Britain. 1985;119.
14. American Public Health Association (APHA). The standard method for the examination of water and wastewater.15th edition. Washington DC, American public Health Association. 1980;1134.
15. Fonge BA, Tenning AS, Egbe EA, Yinda GS, Fongod AN, Achu RM. Phytoplankton diversity and abundance in Ndop wetlands plains, Cameroon. African Journal of Environmental Science and Technology. 2012;6(6):247-257.

16. Oben PM, Oben BO, Fonge BA. High incidence of cyanobacteria blooms along the coast of Cameroon Gulf of guinea and their effect on human health and amenities. Tropical, Fresh Water Biology. 2006;15:33-45.
17. Koloanda RJ, Oladimeji AA. Water quality and some nutrient levels in Shiroro Lake, Niger State, Nigeria. Journal of Aquatic Sciences. 2004;19(2):99-106.
18. Akpan AW. A survey of the functional feeding groups in the Delima River in Jos, Plateau state Nigeria. Nigerian Journal of Applied Fisheries and Hydrobiology. 1990; 1:25-31.
19. Kolo RJ, Tukura MD. Aspects of limnological studies of Tagwai dam, Minna, Niger state, Nigeria. Journal of Aquatic Sciences. 2007;22(1):11-26.
20. Haruna AB. Aquaculture in the tropics: Theory and practice. Al-Hassana Publisher Abuja. Kaduna, Kano Nig. 2003;253-271.
21. Alabaster JS. Lloyd R. Water quality criteria for freshwater fish FAO and Butterworths London. 1992;297.
22. USEPA. Risk assessment technical backgr ound In-formation; 2002. Available:http://www.epa.gov./reg3hwmd/risk.
23. Kefas M, Abubakar KA. Physico-chemical Quality of river Ilagil Ngurore, Yola-south L.G.A Adamawa State. Biological and Environmental Science Journal for the Tropics. 2010;7(4):35-39.
24. Haruna S, Danladi U, Bashir MA, Mohammed I, Abdulkarim AD. The impact of aquati environmenta. International Journal of Biological Sciences. 2015;2(2): 39-50.
25. Soulé M, Bassirou ID, Matalabi AA, Mahamane S. Systematic composition, life forms and chorology of Parklands of Commune of Mayahi, Niger West Africa. Asian Journal of Biology. 2016;1(1):1-11.
26. Bispo PC, Oliveira LG, Bini LM, Sousa KG. Ephemeroptera, plecoptera and trichoptera assemblages from riffles in mountain streams of central Brazil: Environmental factors influencing the distribution and abundance of immatures. Brazilian Journal of Biology. 2006;66(2B):611-622.
27. Australian Center for Tropical Freshwater Research (ACTFA). Water quality for sustainable agriculture. NRM Wet Tropics Australian Centre for Tropical Freshwater Research. 2002;34–36.
28. Philminaq. Water quality criteria and standards for freshwater and marine aquaculture. The mitigating impact from aquaculture from Philippine; 2004. Available:http://aquaculture.asia/files/PMNQ%20WQ%20standard%202.pdf
29. Lawson EO. Physicochemical parameters and heavy metal contents of water from the mangrove swamps of Lagos Lagoon, Lagos, Nigeria. Advanced in Biological Research. 2011;5(1):8-21.
30. Soulé M, Bassirou ID, Matalabi AA, Mahamane S. Systematic composition, life forms and chorology of parklands of commune of Mayahi, Niger West Africa. Asian Journal of Biology. 2016;1(1):1-11. Article no.AJOB.30473.

APPENDICES

Appendix 1. Calculation of Shannon-weiner diversity index and an effective number of species for entire riparian habitat surveyed

Species	Phytoplankton Taxa	Site	Number of cells	Pi	lnpi	pi(lnpi)
Anabaena sp.	MYXOPHYCEAE	A	71	0.055081458	-1.25899	-0.06935
Ankistrodemus sp.	CHLOROPHYCEAE	A	103	0.079906905	-1.09742	-0.08769
Aphanacopsa sp.	MYXOPHYCEAE	A	62	0.048099302	-1.31786	-0.06339
Chlorella sp.	CHLOROPHYCEAE	A	41	0.031807603	-1.49747	-0.04763
Closterium sp.	CHLOROPHYCEAE	A	61	0.047323507	-1.32492	-0.0627
Cyclotella sp.	BACILIARIOPHYCEAE	A	27	0.02094647	-1.67889	-0.03517
Fragilaria sp.	BACILIARIOPHYCEAE	A	94	0.072924748	-1.13713	-0.08292
Mallamonas sp.	CHRYSOPHYCEAE	A	86	0.066718386	-1.17575	-0.07844
Navicula sp.	BACILIARIOPHYCEAE	A	19	0.014740109	-1.8315	-0.027
Nitzchia sp.	BACILIARIOPHYCEAE	A	7	0.005430566	-2.26515	-0.0123
Oocystis sp.	CHLOROPHYCEAE	A	33	0.025601241	-1.59174	-0.04075
Oscillatoria sp.	MYXOPHYCEAE	A	13	0.010085337	-1.99631	-0.02013
Ragilaria sp.	BACILIARIOPHYCEAE	A	22	0.017067494	-1.76783	-0.03017
Tabellaria sp.	BACILIARIOPHYCEAE	A	33	0.025601241	-1.59174	-0.04075
Ulothrix sp.	CHLOROPHYCEAE	A	15	0.011636928	-1.93416	-0.02251
Anabaena sp.	MYXOPHYCEAE	B	13	0.010085337	-1.99631	-0.02013
Ankistrodemus sp.	CHLOROPHYCEAE	B	50	0.03878976	-1.41128	-0.05474
Aphanacopsa sp.	MYXOPHYCEAE	B	33	0.025601241	-1.59174	-0.04075
Chlorella sp.	CHLOROPHYCEAE	B	20	0.015515904	-1.80922	-0.02807
Cyclotella sp.	BACILIARIOPHYCEAE	B	20	0.015515904	-1.80922	-0.02807
Enteromorpha sp.	CHLOROPHYCEAE	B	16	0.012412723	-1.90613	-0.02366
Eudorina sp.	CHLOROPHYCEAE	B	10	0.007757952	-2.11025	-0.01637
Fragilaria sp.	BACILIARIOPHYCEAE	B	58	0.044996121	-1.34682	-0.0606
Mallamonas sp.	CHRYSOPHYCEAE	B	23	0.017843289	-1.74853	-0.0312
Navicula sp.	BACILIARIOPHYCEAE	B	6	0.004654771	-2.3321	-0.01086
Nitzchia sp.	BACILIARIOPHYCEAE	B	12	0.009309542	-2.03107	-0.01891
Oocystis sp.	CHLOROPHYCEAE	B	12	0.009309542	-2.03107	-
Ulothrix sp.	CHLOROPHYCEAE	B	10	0.007757952	-2.11025	-0.01637
Zygnema sp.	CHLOROPHYCEAE	B	13	0.010085337	-1.99631	-0.02013
Anabaena sp.	MYXOPHYCEAE	C	62	0.048099302	-1.31786	-0.06339
Ankistrodemus sp.	CHLOROPHYCEAE	C	32	0.024825446	-1.6051	-0.03985
Aphanacopsa sp.	MYXOPHYCEAE	C	78	0.060512025	-1.21816	-0.07371
Closterium sp.	CHLOROPHYCEAE	C	16	0.012412723	-1.90613	-0.02366
Cyclotella sp.	BACILIARIOPHYCEAE	C	21	0.016291699	-1.78803	-0.02913
Eudorina sp.	CHLOROPHYCEAE	C	11	0.008533747	-2.06886	-0.01766
Fragilaria sp.	BACILIARIOPHYCEAE	C	35	0.027152832	-1.56618	-0.04253
Mallamonas sp.	CHRYSOPHYCEAE	C	21	0.016291699	-1.78803	-0.02913
Oscillatoria sp.	MYXOPHYCEAE	C	10	0.007757952	-2.11025	-0.01637
Ulothrix sp.	CHLOROPHYCEAE	C	20	0.015515904	-1.80922	-0.02807
		3 Site	**Total = 1289**		**H =**	**1,473**
				Effective Number of Species		**4.362302**

Appendix 2. ANOVA tables showing a variation of physiochemical parameters across the various sites

			Sum of squares	df	Mean square	F	Sig.
Temperature * Site	Between Groups	(Combined)	80.111	2	40.056	22.253	.000
	Within Groups		27.000	15	1.800		
	Total		107.111	17			
Turbidity * Site	Between Groups	(Combined)	24.333	2	12.167	15.643	.000
	Within Groups		11.667	15	.778		
	Total		36.000	17			
pH * Site	Between Groups	(Combined)	47.875	2	23.937	15.753	.000
	Within Groups		22.794	15	1.520		
	Total		70.669	17			
Dslv O_2 * Site	Between Groups	(Combined)	13.048	2	6.524	2.678	.101
	Within Groups		36.543	15	2.436		
	Total		49.591	17			
Conductivity * Site	Between Groups	(Combined)	12813.893	2	6406.947	45.221	.000
	Within Groups		2125.214	15	141.681		
	Total		14939.107	17			
Ammonia * Site	Between Groups	(Combined)	.000	2	.000	.243	.787
	Within Groups		.006	15	.000		
	Total		.006	17			
Nitrogen * Site	Between Groups	(Combined)	.004	2	.002	.862	.442
	Within Groups		.037	15	.002		
	Total		.041	17			
Phosphorus * Site	Between Groups	(Combined)	.000	2	.000	1.309	.299
	Within Groups		.002	15	.000		
	Total		.002	17			
Alkalnity * Site	Between Groups	(Combined)	1.785	2	.893	.033	.968
	Within Groups		405.604	15	27.040		
	Total		407.390	17			
Free CO_2 * Site	Between Groups	(Combined)	3.631	2	1.815	.081	.922
	Within Groups		334.229	15	22.282		
	Total		337.860	17			

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