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Original Research Article

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

Industrialization and agricultural activities are the two major sources of water pollution. Kwadon stream has been known for its economic important. However, poor management was identified as the priority factor affecting the usability of that stream. The present study was conducted in order to study the effect of riparian land use on the phytoplankton distribution as well as variation of its physicochemical parameters. Five minute kicking technique was used for the collection of phytoplanktons at each sampling station. A total of about 18 phytoplankton species were surveyed of which most of the species belong to the four families of *Baciliariophyceae*, *Chlorophyceae, Chrysophyceae*, and *Myxophyceae*. The most abundant species found in the three sapling stations was *Ankistrodemus* sp 103 (55.67%). The physicochemical parameters measured in site A fall within the standard discharge limit which enable it to support highest species score than Site B and C. Result of this study will provides an important data that can be used as 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 low land 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 t~~he~~ contamination of water by ~~the~~ introduction of foreign matter such as micro-organisms, chemicals, industrial/municipal waste, and organic matter. These pollution sources deteriorates the quality of water and render it unfits for its intended uses [2]. ~~Water pollution is the contamination of water bodies which~~ affect the entire microbial communities as well as the water characteristics of the region [3]. The most affected microorganisms are ~~those~~ found at benthic zones.

~~The~~ benthic zone in freshwater environment is the ecological region at the lowest level of water body such as 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 [25]. Benthic microorganisms (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 water shed

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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 environmental condition has been reported to have considerable effect on the response of benthic community and it avails to measure the degree of pollution (Haruna et al., 2016). 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 [5,6,7,8]. 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, government is currently pooling resources in order to diversify the economic activities taking place in that region through re-structuring and expansion activities. This has led to the frequent remodeling 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 extinction of some beneficial benthic organisms. Therefore, this study was aimed at examining the riparian land use and how it affects the distribution and abundance of benthic microbial communities along the Kwadon stream. Result of his studies will provide based-line information on the effect of riparian land use on the plankton distribution, abundance and characteristics of the stream in relation to the riparian land use in Kwadon, Gombe State of Nigeria.

2. MATERIAL 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 around 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 (Up-stream) is mostly fishing while Site B (Mid-stream) and C (Downstream) are washing and irrigation respectively (Fig. 1).

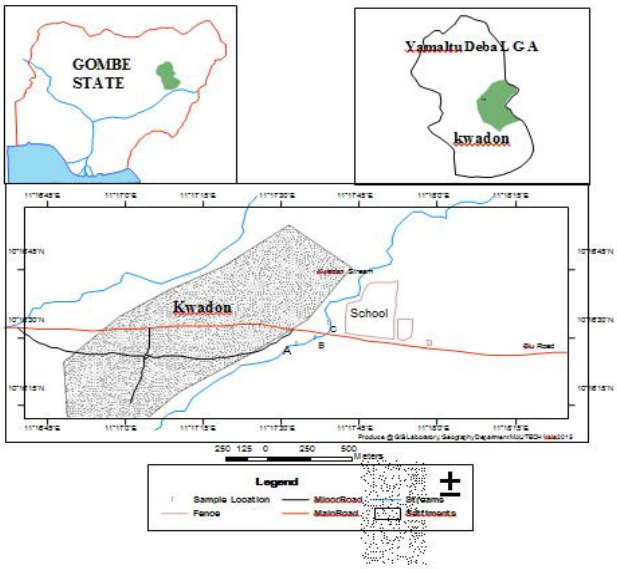

Fig. 1. Map of Yamaltu Deba Showing Kwadon as a Study Area

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2.2 Sample Collection and Preservation

Samples of water and planktons were ~~taken over~~ a period of six (6) months from 6am local time. Water samples for physicochemical studies were collected from the three (3) sites (A, B and C) below the water surface (**Fig. 1**). Water samples 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 labeled 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 (Saidu et al., 2016). [9]

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 drop of phenolphthalein indicator was 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;

Calculation; Free CO_2 (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 w~~hat-man~~ GF/C filter paper. Specifically, ammonia was determined using phenol hypo- chloride method. For total Nitrogen content of water, Sample collected were immediately filtered with pre-rinsed Whit-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 was observed. The total alkalinity was calculated from the equation below;

Alkalinity in mg/L = $\frac{n \times V_2 \times 1000}{V_1}$

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

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measurements were made at temperature other than 25°C. Conductivity of the water was determined using relation;

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

Where C = cell constant, R = Resistance.

2.8 Determination of Dissolved Oxygen

Dissolve 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-sulphate and alkaline reagents (potassium iodide plus potassium hydroxide). The stopper was re-placed and the bottle was shaken thoroughly. 2 mL of H_2SO_4 was added and shaken thoroughly to dissolve precipitate. 50 mL of content was transferred gently in a conical flask and about 4 drops of starch indicator was added. Titration was done against sodium thiosulphate solution and the end point was noted when initial blue color turns to colorless

2.9 Determination of Planktons Diversity

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

2.10 Data Analysis

All data obtained from this study was analyzed using Microsoft excel and SAS (Statistical Analysis System) version 15.0. Residuals of the data were tested for normality and equality of variance to fulfill the assumptions for 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.

3.0 RESULTS AND DISCUSSION

3.1 Planktons Diversity Assessment

A total of about 1289 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 belong to the four families of *Baciliariophyceae*, *Chlorophyceae, Chrysophyceae*, and *Myxophyceae*. Data in **Figure 1** showed that, there are abundance of species richness in site **A** than sites **B and C**. Generally high number of species scored were found in site **A**, followed by site **B** and **C** with a total of 15, 14 and 10 species respectively (Table 1). Shannon Weinner Index H' for various species was found to be 1.079, 1.054 and 0.90 for site 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 is used for the derivation of H' and 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 Physiochemical Parameters

The physicochemical parameters across the various sites (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) indicated insignificant difference between these parameters. This is because of water flow, less activities and evenly distribution of trees around the sites. Moreover, for the nutrient analysis there is also no significant difference in the following physiochemical parameters across sites (Dissolve 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). It is therefore evidently showed that, there was negligible effect of human activities on the physicochemical variation along the riparian zone of Kwandon (Table 2 and 3). Parameters such as Temperature, pH, and

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Turbidity, Dissolve 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.

Table1: Percentage Abundance of Phytoplankton species in Site A, B and C

S/N Species	(Site A)	%	Site B	%	Site C	%	Total No.
1. *Anabaena* sp.	71	48.63	13	8.9	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	61
5. *Closterium*sp	61	79.22	0	0	16	20.77	77
6. *Cyclotella* sp.	27	39.7	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.19	76	6	24	0	0	25	
10. *Nitzchia* sp.	7	36.84	12	63.15	0	0	19
11. *Oocystis* sp.	33	73.33	12	26.66	0	0	45
12. *Oscillatoria* sp.	13	56.52	0	0	10	43.47	23
13. *Ragilaria* sp.	22	100	0	0	0	0	22
14. *Tabellaria* sp.	33	100	0	0	0	0	33
15. *Ulothrix* sp.	15	33.33	10	22.22	20	44.44	45
16. *Enteromorpha* sp.	0	0	16	100	0	0	16
17. *Eudorina* sp.	0	0	10	47.61	11	52.38	21
18. *Zygnema* sp.	0	0	13	100	0	0	13

Site		Temp. (0 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	4.15	2.917	878.771	.000	.002	.000	23.964	19.874

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			7							
N	18	18	18	18	18	18	18	18	18	18

Table 2: Mean Distribution of Physiochemical Parameters across Sites

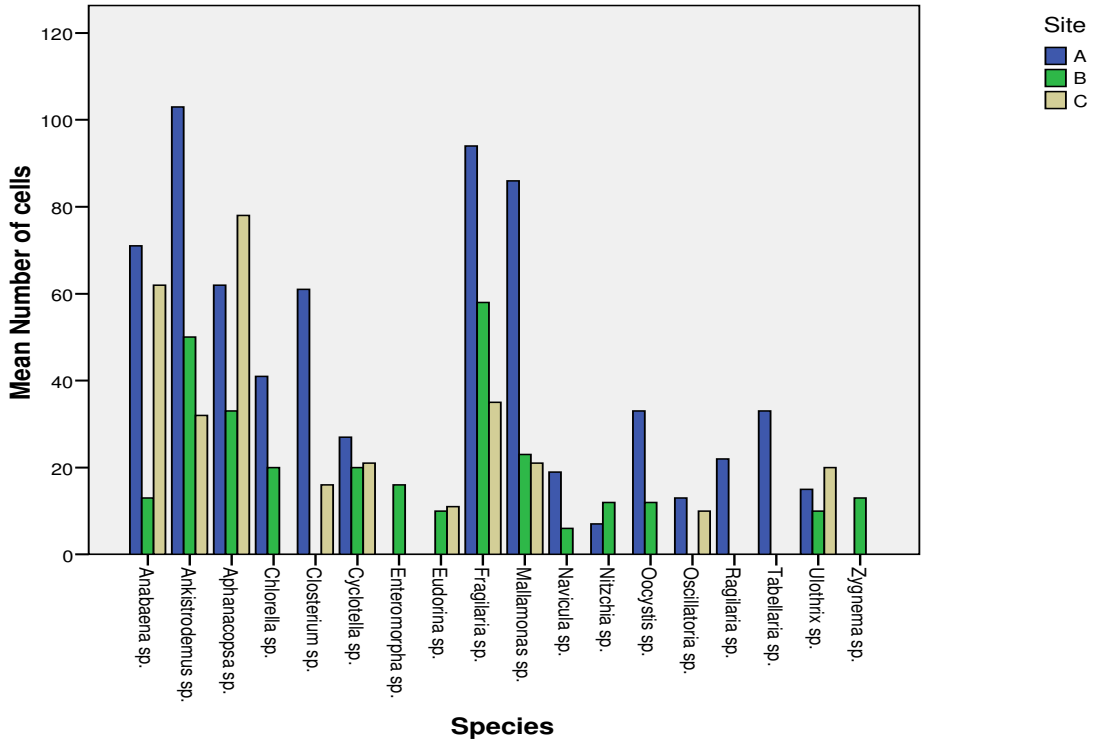

Fig. 2: Mean distribution of phytoplankton species across various site

Table 3: Table of Values of Physiochemical Parameters Found in the Study Area

	N	Mean	Std. Deviation
Parameter (units)	18	2015.00	000
Temperature (^oC)	18	25.78	2.510
Turbidity (cm)	18	3.67	1.455
pH	18	9.33	2.039
Dissolve O_2(mg/L)	18	6.48	1.708
Conductivity (µmhos/cm)	18	79.11	29.644
Ammonia (mg/L)	18	04578	019398
Nitrogen (mg/L)	18	13861	049082
Phosphorus (mg/L)	18	04550	011708

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Alkalinity (mg/L)	18	15.536	4.8953
Free CO_2 (mg/L)	18	11.117	4.4580

3.2.0 DISCUSSION

3.2.1 Distribution and Abundance of Planktons

A total number of 33 species of planktons were identified in sites A, B, C in this study. Generally, the species score determined at each Site 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 rank as the most diversed species in Kwadon stream (Fig. 2). Such percentage abundance were comparable with the one reported by [15]. The species abundance of *Chlorophyceae* observed might be due to their high adaptation to wide range of physio-chemical parameters. Similar study was also conducted in wetlands valley of Cameroon by [16] to compare species abundant found in different sampling sites.

The most abundant species was found to be *Ankistrodemus* sp followed closely by *Flagilaria* species. Interestingly these two species has 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 (dissolve oxygen and pH) values of site 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 Site B and C are not quite favorability, some species appear to be more tolerant such as *Ulothrix* species and *Aphanacopia* been the most abundant in site C than A and B and these trend is most likely a coincidence but we have no prove for where it goes.

3.2.2 Physicochemical and Planktons Parameters

The significance variations different parameters observed in the sampling sites could be attributed to the flow variability and changes in water shed condition. 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 run off) and catchments activities which prevailed during the raining and dry season period respectively.

The monthly mean water temperature of the stream, fluctuate between 23.14^{o}C and 28.33^{o}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 dry season as the year advances towards the dry harmattan period occurring within the month of November and December. These findings are in accordance with the findings of [19] which reported that a 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 ranged of temperature recorded during the period of this study was 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 universal parameters that determine other parameters. Increase in temperature increases the rate of physical reactions such as increase in evaporation and volatilization of substances. Increased in temperature also decreases the solubility of gases such as O_2, CO_2, N_2 and CH_4. The metabolic rate of aquatic organism is also related to temperature which increases the respiration rates leading to increased oxygen consumption and increased decomposition of organic matter.

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 water runoff and suspended organic matter found during the

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rainy season from July - October. However, as the rainy season come to an end, the turbidity get reduced. These findings contradict the research of Kolo and Tukura [18] where the highest range of turbidity recorded was attributed 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 pH ranges of 7.67- 11.55 was recorded in the month of July to December which was within the normal range for aquatic life [18]. This thus indicated that various anthropogenic activities inputs did not alter the ambient pH. High water pH can affect production, causing death to many aquatic organisms.

A monthly mean dissolved oxygen range 5.36 mg/L 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 hold higher dissolved oxygen at lower temperature than at higher temperature. The lower dissolved oxygen recorded in the month of January to May was 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 that said most biologist accept 6ppm as the minimum concernment for fish. Many species of fish can survive under varying concentrations below 6pmm [16].

The mean Electrical conductivity recorded during raining season was 46.46-111.83µmhos/cm. This could be attributed to high concentration of pH in the water body. This result is contrary to the findings of [18] who recorded a highest electrical conductivity of $10.2x10^{-2}$ to $13.6x10^{-2}$ during dry season from November to June. This was attributed to concentration effect of the water as a result of low volume of water in the reservoir while a lower electrical conductivity was recorded at the peak of the rainy season between July and October ($5.1x10^{-2}$ to $9.7\ x10^{-2}$) and was attributed to neutralization effects as a result of runoff into the reservoir, rain water, erosion and increase in water volume in the reservoir [16].

The monthly mean variation of total alkalinity from 15.232 mg/L 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 with the findings of [18] who reported that the alkalinity range of 4.05 mg/L to 8.10 mg/L obtained from this research falls below the recommended value of 50 mg/L to 300 mg/L for freshwater fish culture. Furthermore, [12] suggested that this could be due limestone deposit in the surrounding soil and along the course.

The monthly mean total ammonia variation ranges from 0.500- 0.418 mg/L which is higher than 0.025 mg/L and 0.06- 0.07 mg/L reported by [21]. It is also lower than 0.3 mg/L to 1.9 mg/L reported by [2]. 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 excretory product of some aquatic animals [10].

The monthly mean total nitrogen fluctuate between 0.15067 and 0.1170 mg/L which is lower than 0.25 to 0.34 mg/L reported by [2] in River Ilagil. But, it is higher than 0.02 mg/L to 2.0 mg/L recommended by [22]. This may not be unconnected with the amount of rainfall in the area. The increase in rainy 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 [22].

The mean monthly variation of phosphorus ranges from 0.03733 to 0.04917 mg/L. The values observed is lower than 0.04 to 0.05 mg/L obtained by in river Suka but higher than 0.021-0.046 mg/L reported by Kefas and Abubakar (2010) [2] in river Ilagil. The high values observed could be as a result of anthropogenic activities and waste sedimentation associated with the sites. This agrees with ACTFER [23] that artificial sources of phosphorus include fertilizers, detergents, waste water, Industrial affluent and animals excreta among others.

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The mean monthly variation of free CO_2 ranged from 0.88 mg/L to 1.82 mg/L, which is lower than 6.0 mg/L to 7.9 mg/L reported in Lughu reservoir and 2.6 to 4.17 mg/L as reported by [2] in River of Ilagil Ngurore. However, the value falls within the 10 mg/L safety limit reported by [19].

The physico-chemical parameters observed are almost all within the safety limit which make it variation in the distribution of planktons in all the sites while the impact of riparian land use in the study area helped in structuring the larval *Ephemeropteran* communities in the stream.

3.2.3 Effects of the Riparian Land Use on the Physico-chemical parameters and Planktons

The results show that riparian land use has a direct impact on abundance and diversity of planktons. Sites A shows higher diversity of planktons than the other sites, this could be as result of less effects of fishing on the planktons, could also be result 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 implies that domestic use and irrigation may have negative impact on plankton's diversity with fewer species likely to survive in irrigation site and domestic site. Variation of phytoplankton diversity at the riparian zone could also be as a result of the changes in physico-chemical parameters across the sites because of the riparian activities [24].

Conclusion

The study of the effect of riparian land use on the characteristics of Kwadon stream was conducted for a period of six month.

- The phytoplanktons species identified in all the three sampling site was found to belong to the following family; *Baciliariophyceae, Chlorophyceae, Chrysophyceae, and Myxophyceaean.*
- Highest diversity of phytoplankton score was found during rainy season than the dry season.
- This study showed that the physiochemical parameters obtained at site B and C were not within the recommended safety limit which obviously was what led to the low species abundance in that site. The different kind of activities carried out at the sampling stations contributed to the changes in the physical chemistry of the water which affect the species diversity. This study therefore suggested that riparian land use has a direct impact on abundance and diversity of plankton of Kwadon stream which can be consider of high crucial in order to identify the potential risk factors threatening the life of aquatic biota in the region for conservation purpose.
- It is therefore important to prohibit dumping of waste at the stream area. Also, farmers should be enlighten on the dangers associated with the used of inorganic fertilizers, insecticide and herbicides (agrochemicals) on the stream and aquatic life

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APPENDICES

Appendix I: Calculation of Shannon Weiner Diversity Index and effective number of species for entire riparian habitat surveyed.

Species	Plankton 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
Aphanacopsasp	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
Chiorella 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

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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**