

## VARIATIONS OF PHYTOPLANKTON ABUNDANCE AND SPECIES COMPOSITION IN KUDIDIFFI –KUBANNI STREAM, HANWA-MAKERA, ZARIA, NIGERIA: IMPLICATION FOR WATER QUALITY.

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### Abstract

Water samples were collected from 2006-2008 for the analysis of the phytoplankton abundance and population. Population of phytoplankton, abundance and species composition in Kudiddiffi- Kubanni stream, Nigeria, showed a marked difference between the lotic and lentic parts of the stream. Phytoplankton population and species composition showed both spatial and seasonal variations. Cyanophyta were the most abundant in station 2, which is the lentic part of the watercourse (40.28%) while stations 1, 3 - 6 had a range of % composition of 5.16 – 16.24%. Temporal variation showed 52.57% for Cyanophyta, 31.49% for Chlorophyta and 15.49% for Bacillariophyta. Blue-green algae and *Microcystis sp.* formed 90% of the Cyanophyta. Other members of the Cyanophyta present were *Oscillatoria sp.*, *Anabaena sp.*, *Nostoc sp.*, *Agmenellum sp.* and *Gomphosphaeria sp.* Chlorophyta and Bacillariophyta were represented by 13 and 7 taxa respectively. The presence of *Microcystis sp.*, known as a pollution index, showed the water to be highly impacted and this calls for urgent management of algal loading into the stream in order to stem further destruction of water quality and help in the restoration of the ecosystem. The high percentage of *Microcystis*(90%) could encourage accumulation of microcystins both in the stream and fish tissue thereby passing through the food chain which could pose significant threat to public health .The International Agency for Research on Cancer classified microcystins as ‘possible human carcinogens’based on the consideration of the accumulated toxicological data.It could also result in severe economic losses in aquaculture if they are implicated in the death of cultured animals or their consumers.Bloom of phytoplankton also leads to eutrophication of water bodies and death of fish and other important aquatic life.

**Keywords:** Kudiddiffi-Kubanni stream, Phytoplankton, Water quality, Cyanophyta, Chlorophyta, Bacillariophyta

### Introduction

The productivity of a given water body is determined by its physical, chemical and biological properties. The environmental properties of water need to be conducive for

aquaculture and especially for fish to grow well therefore, an ideal water condition is a necessity for the survival of fish since the entire life processes of the fish is wholly dependent on the quality of its environment. Water quality is determined by the physical and chemical state of the water body. These include all the physical, chemical and biological factors of water that influence the beneficial use of water. Water quality is important in drinking water supply, irrigation, fish production, recreation and other purposes to which the water must have been created (Moshood, 2008).

Plankton production and species composition of water bodies are mainly influenced by nutrient availability, environmental factors such as temperature, light and morphology of the water body (Kalff, 2002). Availability of light for Plankton growth in a Lake is determined by transparency, mixing depth and incident light (Gikuma *et al.*, 2005). Nutrients are normally present in different quantities from one water body to another and within the same system, may vary spatially or seasonally according to rainfall, temperature, wind and the nature of the Phytoplankton community (Maitland, 1978).

Chia (2009) reported that the physicochemical parameters that showed positive correlation with algal species clearly indicate that as the levels of these parameters increase or decrease, so does the level of biomass of algal species increase or decrease. Also in his work on Palladan pond, in Nigeria, he observed the pond has the highest alkalinity and water hardness values. The pond also was observed to contain blooms of *Microcystis sp.* as its most abundant flora. He explained that this goes a long way to confirm undesirable water quality conditions of the pond, which could have toxic effects on aquatic life.

This work seeks to know the phytoplankton composition and possible implications of the abundance of phytoplankton in Kudiddiffi stream, which is extensively utilized for farming, fishing, washing and other household chores.

### **Materials and Methods**

Kudiddiffi stream is found in Nigeria between Latitudes 4°N and 14°N and Longitudes 2°E and 15°E, in Zaria, found in the Northern part of Nigeria. The Study area lies within the Longitude 7°E and 42°E and Latitudes 6°N and 11°N in Northern Guinea Savannah belt, Zaria, Kaduna State (Fig.1). The watercourse is a stream, 5Km in length from the source to the confluence where it enters into Kubanni River at Km 136 along the Kaduna-Kano express road. The catchment falls within some of the most agriculturally productive areas in the town and rampant use of agro-chemicals.

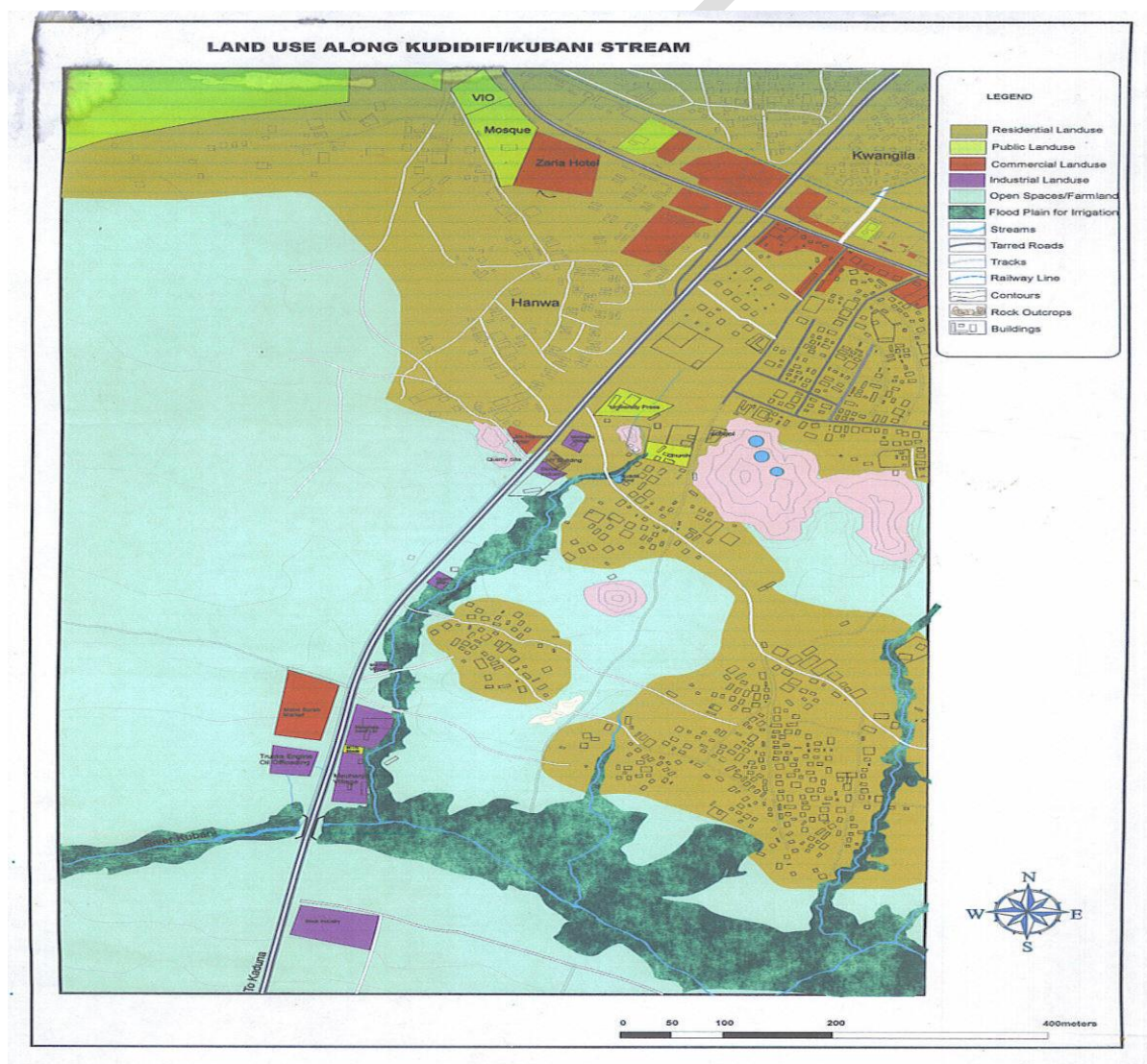
Samples for the analyses of Phytoplankton abundance, species composition and nutrients were collected between 2006 and 2008 in Six Sampling Stations along the watercourse. Water samples were collected using Plankton net of 70 meshes/cm with a radius of 25cm. This was dragged just below the water surface to a distance of 1 metre. The collected volume of water was concentrated in a 50ml collection bottle attached to the net and preserved with Lugol's solution. Differential count, identification and photomicrograph of identified organisms were carried out in the laboratory according to APHA (1995). Sample water for physicochemical analysis was collected in a 2-liter Polyethylene bottles in duplicates at mid-stream at 0.25m below the surface of the water. pH, TDS, temperature, water depth and Secchi transparency were determined *in situ* by a

conductivity/TDS/pH probe (HANNA Instruments Model HI 98311) and Mercury-in-glass thermometer

. Other parameters like Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) were analyzed in the laboratory using Winkler's method.

### \ **Statistical analysis**

Two-way analysis of variance(ANOVA)and Duncan's Multiple Range Test were Carried out to determine significant differences in all the parameters with seasons and months at 0.01 and 0.05 levels of significance respectively using Stastical Application for Sciences (SAS) Computer



**FIG 1: LAND USE ALONG KUDIDIFFI/KUBANNI STREAM ,ZARIA, KADUNA STATE, NIGERIA.**

## Results

The results show degradation in the stream water quality especially at Sample Station 2, which is the lentic part of the stream (pool), and at Stations 4 and 6, which are Kubanni River's extension of the Kudiddiffi stream.

NO<sub>3</sub>-N was of higher concentration in the water body than PO<sub>4</sub>-P. This could be due to the application of NPK fertilizers through water run-offs into the stream. Dissolved Oxygen was high except in Sample Station 2. BOD was low generally except in Station 2 with a value of 14.79mg/L, which is higher than the regulatory limit for aquatic habitat. (Table 1).

Algae taxa found in Kiddidiffi-kubanni stream Hanwa Makera, Zaria, Kaduna State, Nigeria included Cyanophyta, Chlorophyta, Bacillariophyta and Chrysophyta. Cyanophyta taxa were the most abundant. The highest percentage of cyanophyta found were *Microcystis* in sampling station 2 which was highest of the water course. *Microcystis* formed 90% of the phytoplankton Table 2.

Phytoplankton observed were found in the following order of abundance; Cyanophyta > Chlorophyta > Bacillariophyta > Chrysophyta. *Microcystis sp.* was of the highest abundance (90.01%) (Table 2). The high abundance of the Cyanophyta indicated highly polluted water. This was further confirmed by MacroInvertebrate Index (MBI) of the water body which were 1.34, 7.86, 8.00, 8.00, 8.00 and 8.09 from Station 1 through 6 respectively (Table 2).

Kuddiffi-Kubanni confluence i.e. station 5 has high density of Bacillariophyta. Chlorophyta has the highest abundance in station 1 (Table 2) which might indicate clean water part of the stream. Station 1 has the highest density of Chlorophyta (37.88%) and the least was in station 6 (8.86%). Station 2 had 19.16% and stations 3, 4 and 5 had 13.98%, and 10.65% respectively (Table 2).

Temporally, at the onset of the raining season, Chlorophyta taxa was observed scarce (June) but as the rain progressed, a bloom was observed. Chlorophyta taxa observed in the water course included *Euglena sp.*, *spirogyra sp.*, *Chlamydomonas sp.*, *Scleractisium*, *Scenedesmus*, *Pediastrum*, *Coeleostrum spp.*, *Protococcus sp.*, *Volvox sp.*, *Ankistrodesmus sp.* etc in descending order of abundance (Table 3).

Bacillariophyta found in the water course included *Navicula sp.*, *Actinocyclus sp.*, *Gomphonema sp.*, *Diatoma sp.*, *Synedra sp.*, *Biddulphia sp.*, and *Cyclotella sp.* in terms of species diversity and abundance, *Actinocyclus sp.* was the most abundant. Temporally, there was no significant differences between the rainy and dry season abundance, however, Cyanophytes exhibited a significant difference spatially and temporally ( $P \leq 0.05$ ).

**Table 1 Statistical Analysis for 24 months sampling on Physico-chemical Analysis for Each Sampling Point (the First Line Represents Mean  $\pm$  Standard error, the Second Line Represents Minimum and Maximum Concentrations)**

Sampling Stations	Ph	Air Temperature °C	Water Temperature °C	E.C Umhos/cm	TDS mg/L	O <sub>2</sub> mg/L	BOD mg/L	COD mg/L
1	7.58 $\pm$ 1.55 7.12-8.95	24 $\pm$ 0.17 18-30	21.92 $\pm$ 0.66 15.5-27	251 $\pm$ 30.79 140-900	121 $\pm$ 16 70-450	6.14 $\pm$ 0.27 4.05-8.90	4.8 $\pm$ 0.10 0.2-4.93	370 $\pm$ 31 100-900
2	7.23 $\pm$ 0.07 8.3-8.10	24.98 $\pm$ 0.71 17-32	23.29 $\pm$ 0.91 11-28.2	264 $\pm$ 14 168-430	122 $\pm$ 5.4 80-135	2.68 $\pm$ 0.35 0.5-9.25	14.79 $\pm$ 0.93 0.15-92	368 $\pm$ 27 80-630
3	7.38 $\pm$ 0.12 6.05-8.60	23.38 $\pm$ 0.69 15-27.50	21.27 $\pm$ 1.24 15-36.5	263.54 $\pm$ 10 160-359	134 $\pm$ 5.47 80-150	5.52 $\pm$ -0.3 2.65-9.10	10.12 $\pm$ 0.8 0.21-89.5	344 $\pm$ 23 140-550
4	7.24 $\pm$ 0.09 6.30-8.10	24.38 $\pm$ 0.74 19-30	23.52 $\pm$ 0.71 17-30	174 $\pm$ 26.07 80-740	92.21 $\pm$ 13 40-370	5.30 $\pm$ 0.38 2.60-9.05	12.018 $\pm$ 1.3 0.40-95.25	363 $\pm$ 32 100-590
5	7.31 $\pm$ 1.49 6.67-8.30	24.84 $\pm$ 0.75 19-30	22.07 $\pm$ 0.77 11-29	238 $\pm$ 19 70-325	113 $\pm$ 9.30 50-230	5.59 $\pm$ 0.3 2.6-9.18	9.60 $\pm$ 0.68 0.20-54.60	408 $\pm$ 27 110-500
6	7.27 $\pm$ 1.49 6.85-8.87	24.15 $\pm$ 0.87 19-30	22.25 $\pm$ 0.82 14-30	178 $\pm$ 20 100-440	89.75 $\pm$ 8 55-220	5.22 $\pm$ 0.44 1.6-9.40	10.26 $\pm$ 0.86 0.13-83.25	355 $\pm$ 26 82-650

**Table 2 ABUNDANCE ,M.E.I AND M.B.I INDICES OF KUDIDIFFI STREAM, HANWA-MAKERA, ZARIA NIGERIA**

SAMPLING STATIONS	1	2	3	4	5	6	% Total
Cyanophyta (%)	13.24	40.28	16.34	10.00	14.91	5.16	52.57
Chlorophyta (%)	37.88	19.16	13.98	13.63	10.65	8.56	31.49
Bacillariophyta (%)	4.83	5.06	4.43	28.26	52.53	4.83	15.94
M.B.I index (pollution)	1.34	7.86	8.00	8.00	8.00	8.09	--
M.E.I Index (Productivity)	302.50	158.44	670	249.22	245.22	245.65	99.72

Table 3: SPECIES DIVERSITY (%) OF BIOTA IN KUDIDIFFI STREAM, HANWA-MAKERA, ZARIA, NIGERIA

Cyanophyta	(%)	Chlorophyta and Chrysophyta	(%)	Bacillariophyta	(%)
<i>Microcystis</i>	90.46	<i>Chlamydomonas</i>	29.47	<i>Navicula</i>	57.00
<i>Oscillatoria</i>	7.89	<i>Euglena</i>	20.00	<i>Amoeba</i>	34.13
<i>Nostoc</i>	1.02	<i>Spirogyra</i>	13.15	<i>Cladocera</i>	5.12
<i>Anabaena</i>	0.39	<i>Scenedesmus</i>	2.17	<i>Diffusia</i>	3.07
<i>Gomphosphaeria</i>	0.19	<i>Volvox</i>	1.52	<i>Euplotes</i>	2.73
<i>Agmenellum</i>	0.06	<i>Encystment</i>	0.81	<i>Stylonychia</i>	2.05
		<i>Ankistrodesmus</i>	0.76		
		<i>Pediastrum</i>	0.43		
		<i>Coeleostrum</i>	0.22		
		<i>Oedogonium</i>	0.22		
		<i>Protococcus</i>	0.11		
		<i>Selerastrum</i>	0.11		
		<i>Tribonama</i>	0.11		

## Discussion

The results of this work showed a higher concentration of  $\text{NO}_3\text{-N}$  in comparison with  $\text{PO}_4\text{-P}$  with the order of the concentration of anions in Kudiddiffi stream being  $\text{NO}_3\text{-N} > \text{Cl} > \text{PO}_4\text{-P}$ . This shows that the stream is phosphorus limited. According to Guildford and Hecky (2000), the ratio between N and P can be used to indicate the Phytoplankton nutrient status in a water body. For TN:TP ratio  $< 20$ , Phytoplankton is normally nitrogen limited but in cases where the ratio is  $> 50$ , Phytoplankton will most likely be phosphorus limited.. Gikuma *et al.* (2005) explained that the TN:TP ratio in Nyanza Gulf, Kenya shows that the Lake is consistently Phosphorus limited and that the Lake can be either nitrogen or phosphorus limited depending on the prevailing physicochemical nutrient status. Under nitrogen limited condition, Phytoplankton species with the ability to form dinitrogen from the atmosphere normally have advantage over the other species and thus predominate (Guildford *et al.*, 2003). This is in line with the current status of Kudiddiffi stream, where nitrogen fixing *Microcysts* sp. and other Cyanophyta occurred in greatest abundance. Since the stream is Phosphorus limited, increase in nitrogen-fixing algal bloom will persist hence increased eutrophication resulting in negative effects on the water quality.

Phytoplankton community in lakes has been a good indication of the health of the ecosystem. Chia *et al.* (2009) explained that the communities of algae are tools of ecological water index analysis. The negative correlation of Cyanophyta population with DO and high correlation it has with BOD in Kudiddiffi-Kubanni stream might be attributed to the impairment of water by the Cyanophytes and further confirms Cyanophytes as index of pollution.

Hummert *et al.* (2001) explained that the dominance of Cyanophyta in Lakes pose a water quality challenge as this algal group produce Phycotoxins which can destroy drinking water quality. Cyanobacteria produce a wide range of bioactive substances or secondary metabolites. International Agency for Research on Cancer classified microcystins as 'possible human carcinogens'. Toxins produced by cyanobacteria are of several types comprising neurotoxins, hepatotoxins etc (Carmichael, 1997). Landsberg (2002) and Hudnell (2008) explained that toxins from cyanophytes pose a significant threat to public health because of their ability to bioaccumulate and thus passing through the food chain, high fishkill and severe economic losses. Babatunde (2009) in the work on Kudiddiffi stream discovered also that algal bloom consisting of Cyanophyta is detrimental to the water quality of the stream because of the low fish productivity observed. There are reports of losses amounting to about one billion US dollars per decades (Landsberg, 2002; Hudnell, 2008). Among the toxins are the microcystins which present the most concern to public health (Chen *et al.*, 2009a). Microcystins are known to inhibit growth of fishes. Environmental level toxicity has been reported for several fishes such as salmon (Anderson *et al.*, 1993), carp (Xie *et al.*, 2004), zebrafish (Oberemm *et al.*, 1999) and catfish (Zimba *et al.*, 2001). High phytoplankton population and MBI index observed in this study also support the fact that water quality is affected by high population of aquatic plants.

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