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The Effects of Effluent Discharged from Bottling Companies on Algal Composition in Kakuri Stream Kaduna, Nigeria

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ABSTRACT
This study determined the impact of soft drink effluent on algal composition in Kakuri stream, Kaduna South Local Government Area, Kaduna. Limnological studies of soft drink effluent were carried out for a period covering wet and dry seasons across three (3) sampling points code-named Stations A, B and C. Some physio-chemical parameters were analysed using standard methods. A total of 43 species were observed belonging to 5 families. Chlorophyceae and Cyanophyceae were the most abundant families across the three (3) stations. The total flora count was high during the dry season, 1965 cells than wet season, 1071 cells. The most dominant species were *Euglena sp., Microcystis sp.* and *Oscillatoria sp.* The pH of the three stations was more alkaline (pH 8.1) but reduces slightly at stations B and C during the months of May (pH 5.2) and August (pH 6.5). The biological oxygen demand (BOD) was relatively high across the stations, dissolved oxygen was generally low except for some months (December at station A and January at station B) that had its dissolved oxygen values above 5.00 mg/l. Euglenophyceae showed positive correlation to conductivity and BOD, Chlorophyceae was positively correlated with BOD, Cyanophyceae showed positive relationship with BOD and dissolved oxygen, Charophyceae was positively correlated with dissolved oxygen, Bacillariophyceae showed positive correlation with pH, temperature, phosphorus, BOD and dissolved oxygen. Effluent discharge and farmland run-off passed into the water body supports growth of dominant species indicating organic pollution, thus, poses a threat to the environment over a long period of time.
Keywords: Algae, Effluent, Biological oxygen demand, Dissolved oxygen.

INTRODUCTION
Algal succession in a given habitat depends on a number of environmental factors such as physical factors including light, temperature and space, Chemical factors such as nitrogen, pH, phosphorus and salinity and biological factors for example organic matter. Rabalais (2002) reported that nitrogen or phosphorus sometimes limits autotrophic production of freshwater algae. The biodiversity of algal species also depends on its ability to adapt to environmental stress on exposure, which could affect its distribution and abundance between seasons. Increased nutrient level, shifts in nutrient ratios or both may lead to excessive algal growth and may result to a proliferation of a single species (Chia and Bako, 2008). According to Hsu *et al.* (2009) the type of algal composition is depends on the pH of water. Alarming growth rate of green algae in lakes and rivers are related to the increase in pH of polluted waters. Akomeah *et al.,* (2010) stated that, algae being primary producers of the aquatic ecosystem occupy an important position in aquatic food chain and also producers of oxygen in the aquatic ecosystem. Change in the chemistry of the water could adversely affect the entire trophic levels. Effluent discharge in rivers from industries in Nigeria and the world at large could pose a serious threat in the diversity of algae. The distributions, abundance, species diversity, species composition of algae are used to assess the biological integrity of water body (Ajani, 2010, Kadiri, 2006). Although, their movement is controled by the water current, thus, they cannot escape pollution effects and this makes a good indicator of pollution in the environment. The aim of this work is to assess the effect of anthropogenic activities on algae

composition of streams.

MATERIALS AND METHODS

Study Area

The study area is located in Kakuri district of Kaduna South Local Government Area, Kaduna State, Nigeria. Kakuri is an industrial zone where soft drinks, textiles and other industrial products are manufactured. The Kakuri stream is situated in the Local Government Area at Longitude: 10º 28' 0" North and Latitude: 07º 25' 0" East. The effluent studied included waste water discharge from Coca-Cola and Seven – Up bottling companies.

Collection of Samples

Effluent sample for physiochemical analysis were obtained between the hours of 9am - 11am monthly (April, 2011 – March, 2012) in 250ml plastic bottles with crew caps at three (3) sampling points; i.e. Station A (Coca-Cola bottling company waste water run-off), Station B (Seven – Up bottling company waste water run-off) and Station C (Confluence point of Coca-Cola and Seven – Up bottling company effluents).

Collection of Algae

The algae were collected by filtering of water through plankton net of mesh size 55µm; the filtrate is then transferred into 20ml sample bottle and preserved in 4% formalin.

Analysis of algal samples

Identification was carried out using binocular microscope and reference on the identification of species were made to Lackey (1938), Patrick and Reimer (1966), Needham and Needham (1962), and Kadiri (1988, 1993 and 1996). Algal counts were carried out using the method of Verlencar and Desai (2004).

Analyses of physico-chemical properties

Temperature, pH and Conductivity were determined in-situ using a portable HANNA/pH/EC/Temperature meter model 210. Dissolved Oxygen (DO) was estimated *in-situ* with HACH oxygen DO-5509 meter. Total Dissolved Solid (TDS) was determined using a handheld HACH TDS meter model 5358236. Nitrate was analysed using ultraviolet spectrophometric meter and Phosphate was analysed using stannous chloride method **(APHA 1985).**

Statistical analysis: Analysis of variance (ANOVA) was used to test for station differences in values of the physic-chemical parameters in the water. Correlation matrix was between various physico-chemical parameters and algal families. Data obtained from abundance of phytoplankton between dry and wet season was compared using Diversity Index

RESULTS

Algal composition was studied for the period of twelve (12) months from April 2011- March, 2012. Taxonomic listing of the observed algal species at Kakuri, Kaduna-Nigeria across three (3) stations A, B, C is given in Table 2. A total of forty-three (43) genera belonging to five (5) families were identified during the study. The taxa Chlorophyceae and Cyanophyceae were most diverse classes represented by 23 and 13 genera respectively followed by Bacillariophyceae with 6 genera; the least was Charophyceae and Euglenophyceae 1 genera each. The maximum numbers of genera were found during the months of December, January, February and March (dry season) and August (wet season). The month with minimum number was July (wet season). The percentage of occurrence was Chlorophyceae at 45.42%, Cyanophyceae at 35.60%, Bacillariophyceae at 9.52%, Euglenophyceae at 9.03% and Charophyceae at 0.43%. The most dominant algal species were *Euglena sp., microcystis sp.* and *oscillatoria sp.*

Table 1: Physico-chemical properties determined in the dry and wet season of selected effluent points

SEASON	STATIONS	MONTHS	pH	Temperature⁰C	Electrical Conductivity(µ/cm)	Nitrate	Phosphorus	Biological Oxygen Demand	Dissolved Oxygen
DRY	A	April	7.2	30	249	1	2.3	4.9	3.1
		Oct	7.8	31	266	1	0.04	5.56	1.74
		Nov	7.6	31	419	1.2	0.07	5.6	2.3
		Dec	7.5	30	239	1.2	0.03	4.56	6.5
		Jan	7.5	30	239	1.2	0.75	4.6	2.18
		Feb	7.2	30	249	1	0.01	5.75	2.88
		March	7.5	31.5	239	1.4	2.5	4.95	4
	B	April	7.3	31.3	240	1.1	2.2	5	3.6
		Oct	7.4	27.9	239	0.01	0.32	5.08	2.23
		Nov	8.1	27	364	0.06	0.56	4.5	2.15
		Dec	6.5	23.6	188	0.01	0.32	4.58	5.4
		Jan	7.3	30	239	0.01	0.91	5.23	2.19
		Feb	8	26.3	218	0.28	0.55	5.32	2.5
		March	8	31	241	0.03	0.12	5.78	3.8
	C	April	7.5	31.5	238	2.08	2.4	5.25	3.4
		Oct	7.6	29.1	241	0.5	1.1	3.6	2
		Nov	7.9	29	390	0.62	0.6	4.6	4.2
		Dec	7.8	27	214	0.61	1.1	4.6	2.2
		Jan	7.4	29	243	0.6	1.1	4.9	2.2
		Feb	7.6	28	233	0.64	2.3	4.95	3.1
		March	7.6	31.5	245	0.56	1.25	5.43	3.4
		Means±SD	**7.54±0.353**	**29.32±2.069**	**258.71±58.034**	**0.72±0.553**	**0.98±0.870**	**4.99±0.517**	**3.10±1.201**
WET	A	May	7.8	31	266	1	1.1	4.8	3
		June	7.8	31.5	283	4	1.2	4.3	3.5
		July	7.5	31	263	4	1.1	4.4	3.3
		Aug	7.8	31	270	1	1.6	3.84	3.1
		Sep	8.1	29.4	641	6.3	1.57	4.4	2.73
	B	May	6.8	26.5	223	0.1	2	4.9	3.5
		June	7	27.5	226	0.1	2.05	5	4
		July	6.8	26.5	224	0.09	1.12	4.96	3.72
		Aug	5.2	27	209	0.13	1.1	4.22	2.58
		Sep	6.7	25.6	558	1	1.1	5.15	1.74
	C	May	7.5	26	242	2.06	1.2	4.2	3.2
		June	7.5	29.5	245	2.07	1.6	4.85	4.01
		July	7.3	28.7	243	2.04	2.05	4.6	3.51
		Aug	6.5	29	239	0.56	2.05	6.9	2.84
		Sep	7.4	27.5	599	8.6	0.62	4.8	2.23
		Means±SD	**7.18±0.722**	**28.51±2.014**	**315.40±149.098**	**2.20±2.520**	**1.43±0.451**	**4.76±0.697**	**3.13±0.635**
		ANOVA between season	0.57	0.252	0.121	0.013	0.074	0.257	0.925

Table 2: Distribution of identified algal species in Station A, B and C from April, 2011- March, 2012

TAXA					STATIONS											
BACILLARIOPHYTA	**CHLOROPHYTA**	**CYANOPHYTA**	**CHAROPHYTA**	**EUGLENOPHYTA**	**A**				**B**				**C**			
					1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Cyclotella sp.	*Ankistodesmus sp.*	*Aphanothece sp.*	Mougeotia *sp.*	*Euglena sp.*	+	-	-	+	+	-	+	-	+	+	-	+
Cosmarium sp.	*Anabaena sp.*	*Coelospharium sp.*			+	+	+		-	-	-		+	+	+	
Coscinodiscus sp.	*Closterium sp.*	*Chroococcus sp.*			-	-	-		+	+	+		+	+	+	
Amphora sp.	*Coelastrum sp.*	*Microcystis sp.*			-	-	+		+	-	+		-	+	+	
Cocconeis sp.	*Crucigenia sp.*	*Oscillatoria sp.*			+	+	+		+	-	-		+	+	+	
Cymbella sp.	*Chlorogonium sp.*	*Gomphosphaeria sp.*			-	+	+		-	+	+		+	-	+	
Diatoma sp.	*Haematococcus sp.*				+	+			+	-			+	-		
Gomphonema sp.	*Pediastrum sp.*				+	-			-	-			-	+		
Gyrosigma sp.	*Sphacrocystis sp.*				+	+			-	-			+	-		
Hantzchia sp.	*Tetraedron sp.*				-	+			-	+			+	-		
Navicula sp.	*Ulothrix sp.*				+	-			-	+			+	-		
Nitzschia sp.	*Westella sp.*				+	+			+	-			+	+		
Pinnularia sp.	*Microspora sp.*					+				-				-		
	Elakatothrix sp.					+				+				+		
	Chlamydomonas sp.					+				+				+		
	Pleodorina sp.					-				+				-		
	Pandorina sp.					+				+				-		
	Tetrastrum sp.					+				-				-		
	Volvox sp.					-				+				+		
	Arthrodesmus sp.					-				-				+		
	Geminella sp.					+				+				+		
	Palmella sp.					-				-				+		

+ = present, - = not present.

TABLE 3: Algal composition during wet season (May – October) and dry season (January.-April, November – December) across selected effluent points April, 2011- May, 2012

	Wet season		Dry season	
Taxon	**Total count**	**Frequency (%)**	**Total count**	**Frequency (%)**
Bacillariophyceae	135	12.61	326	16.59
Chlorophyceae	560	52.29	749	38.12
Cyanophyceae	270	25.21	758	38.58
Charophyceae	4	0.37	12	0.61
Euglenophyceae	102	9.52	120	6.11
Total Count (cells mgl^{-1})	1071	100	1965	100

Table 4: Biological Indices of Algal Composition In wet season ((May – October) and Dry Season (January-April, November – December) Across The Three (3) Stations

Diversity Indices/ Season	**Wet Season**	**Dry Season**
Total Algal Count **(**Cells Mgl^{-1})	1071	1965
Shannon_H	1.192	1.235
Simpson_1-D	0.6381	0.6579
Evenness_e^H/S	0.6589	0.6877

DISCUSSION

Silva (2005) reported that the overwhelming presence of *Microcystis sp.* in Shahpur dam especially in summer could be attributed to the presence of bright sunshine, isothermal water column and extensive catchment area draining calcium rich agriculture land. Physiological and behavioural flexibility of *Microcystis sp.* can accommodate environmental stresses better than most fast growing species and it is found to be an excellent example of phytoplankton in the tropics (Silva, 2004). This could explain perhaps the dominance of *Euglena sp.* and *Oscillatoria spicrocystis sp.* High number of *Oscillatoria sp.* and high percentage of Cyanophyceae is an indication of pollution in the water. This was in agreement with the findings of Pramila *et al.* (2008). This research finding is in line with the work of Odhiambo and Gichuki (1998) who reported that algae of Lake Baringo in Kenya were dominated by the Cyanophyta and Chlorophyta and that the lake is in a state of gradual deterioration of water quality. Khan *et al.* (1983), Kemdirim (2001) and Reynolds (1984) identified Chlorophyceae as the most abundant group in Nigeria fresh waters. The total number of flora count in dry season of 1965 was greater than that of wet season, 1071 (Table 3). Abowei *et al.* (2008) recorded more species of phytoplankton in wet season in the lower Sombreiro River, Niger Delta, Nigeria.

From the calculated result, Shannon-Weiner's, Simpson's and Evenness Indices value were high in the dry season than in the wet The relationship between species diversity and pollution status of aquatic ecosystem were classified as follows; >3 = clean water, 1-3 = moderately polluted < 1 = heavily polluted, which indicates that the stations were moderately polluted.

The mean and standard deviation of the different physico-chemical parameters of the three (3) stations during April 2011 – March, 2012 is presented in Table 1. The pH value of 7.2 was recorded in station A during the month of April, and pH 8.1 was obtained in the month of September. On the other hand, the surface water temperature was low in the month of September (29.4^{0}C), and was high during months of March and June (31.5^{0}C). Conductivity was highest at the month of September and lowest during the month of December and January. Nitrate concentration was at a high during the month of September and was low at 0.01 mg/l in January to April and October to December. Phosphorus concentration was highest at the month of March and low in May and July. Biological oxygen demand was lowest at the month of February and the highest at the month of August. Dissolved oxygen was lowest in the month of September and highest in December.

At station B; pH was low in the month of August at 5.2 and at a high in November at 8.1. Surface water temperature was highest in April at 31.3ºC and low in December at 23.6˚C. Conductivity was high during the month of September at 558 and low at December 188. Highest nitrogen concentration observed in station B was at the month of September at 1.00mg/l and at low in June at 0.09 mg/l. phosphorus concentration was at high during the month of April at 2.2 mg/l and low in march at 0.12mg/l. biological oxygen demand was at a low in the month of August at 4.22 mg/l and high at March at 5.78 mg/l. dissolved oxygen was high at December at 5.4 mg/l and low at September at 1.74 mg/l.

At station C; pH was low in August at 6.5 and high in November at 7.9. Surface water temperature was low in May at 26^{0}C and high in April, March at 31.5^{0}C each. Conductivity was highest at September at 599 and low in the month of December at 214. Highest nitrogen concentration was observed in the month of September at 8.6 mg/l and lowest in the month of October at 0.5 mg/l. Low phosphorus concentration was observed in the month November at 0.6 mg/l. and at high in February at 2.3 mg/l. Biological oxygen demand was highest at 6.9 mg/l in the month of August and low in the month of October at 3.6 mg/l. Dissolved oxygen was at low in October at 2.00 mg/l and high in November at 4.2 mg/l. Analysis of variances of physico-chemical parameters across the three (3) stations between wet and dry season showed significant difference except for nitrate concentration that showed no significant difference between the seasons.

Correlation matrix between various physico-chemical parameters and algal families are given in Table 6. Bacillariophyceae showed positive correlation with pH, temperature, phosphorus, biological oxygen demand and dissolved oxygen. Chlorophyceae had negative relationship with pH, temperature, electrical conductivity, nitrogen, dissolved oxygen and phosphorus but was positively correlated with biological oxygen demand. Cyanophyceae had a positive relationship with biological oxygen demand, dissolved oxygen but had negative relationship with other physico-chemical parameters. Charophyceae only had positive relationship with dissolved oxygen and negative relationship with other physico-chemical parameters. Euglenophyceae had a negative correlation with pH, temperature, nitrogen, phosphorus and dissolved oxygen but had positive correlation with electrical conductivity and biological oxygen demand.

The water body is loaded by the effluent of seven up (7up) and Coka-cola bottle company. The mean surface water temperatures were high in all stations and nearly uniform. The changes in the temperature of the water body could be attributed to influence by the dilution of effluent and the intensity of sunlight in the months of the dry season and lower temperature during the months of rainy season could be implicated by surface water runoff into the stream and cloud cover since it is rainy season. Manoj and Pooj (2012) observed a similar trend of result in their work on a wetland affected by pulp and paper mill effluents, noted the difference in temperature which is attributed to the effluent and prevailing air-masses. The pH values recorded in the stream were within the expected range of inland water (pH 6.5 – 8.5) as reported by WHO, (2006). The high electrical conductivity in the wet season could be due to dilution effect of effluent and rain water with concentration of dissolved constituents. The noticeable increase in electrical conductivity in the dry season may be attributed to high evaporation process this resulted in the concentration of the ions in the water (Allan, 2001). The high values of nitrate and phosphorus in the wet season could be as a result of run-off of nutrients from agricultural lands, livestock and human waste from the catchment areas of the stream (Ezra, 2006). Dissolve oxygen (DO) values were high in the wet season than in dry season, could be due to the increased current flow that enables the dilution of atmospheric oxygen with the water. This agrees with the finding of Nirmal and Cini, (2011). The values of biochemical oxygen demand (BOD) were higher in station A and B during dry season than wet season. The high BOD concentration in dry season could be attributed to increase input of decomposes organic matter into the stream by effluent. The appreciable increase in BOD value in wet season could be due to increase input of organic matter into the stream through surface run-off (Essien-Ibok et al.;2010).

Six major algal classes were present in the Kakuri stream, namely: Bacilloriophyceae (diatom), Chlorophyceae (green algae), Cyanophyceae (blue green algae), Chrysophyceae (golden algae) and Euglenophyceae (euglena). The present of these algal classes is typical of fresh water stream (Adakole et al.; 2002), representatives of these algal groups were identified in the lower Sombreiro river Niger Delta (Abowei et al.; 2008). Algae in each class are listed in Table 2. The class with the largest species composition was the Chlorophyceae followed by Cyanophyceae, Bacilloriophyceae. Chrysophyceae and Euglenophyceae were scare, represented by only one species each. Compare to coastal water system in the estuarine this diversity is relatively low (Onyema, 2007). The high density of 1965 cells mgl^{-1}) in dry season could be due to sufficient light penetration into the water with its attendant high productivity. The low cells density during wet season could be associated with dilution by effluent and rainfall which flushed away algal materials by flood. The growth and dominant Chlorophyceae in the study area reflects the oligotrophic nature of the stream as also reported by Rafia et al. (2013). The change from green algae dominant to blue green algae is attributed to relatively higher temperature and lower values of conductivity (Jafari and Alavi, 2010); this indicates deterioration in water quality probably as a result of large amount of decomposing organic matter present in the stream. In the present study, pH was found to be at neutral range (7.0 – 8.0) which support a good population of Bacilloriophyceae (Nirmal and Cini, 2011).The high growth of Chlorophyceae and Bacilloriophyceae has earlier been associated with high water temperature, phosphorus, nitrate and low DO (Rafia et al., 2013), the present findings support this view. The growth of blue green algae and euglenoides is enhancing by higher value of pH. The present finding agrees with this view.

This study revealed that variation in abundance plankton can be best explained on environmental factors jointly influence. Thus, it may be concluded that the composition of algae is dependent on seasonal variation and load of pollutants directly or indirectly.

CONCLUSION

Algal diversity and abundance could be used as an important tool in monitoring changes across three (3) stations. The rich ecological heritage of the stream is being threatened by the current state of environment perturbation from industrial effluent, though some species were able to withstand this stressful situation. Kakuri stream supports growth of *Euglena sp, Microcystis sp. and Oscillatoria sp*. which is an indication of organic pollution. This could pose a threat to the environment over a long period of time.

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