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Survey of Macrovegetation and Physicochemical Parameters of Samaru Stream, Zaria Nigeria

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Abstract: A survey was carried out from November to December 2003 and May to June 2004 to determine the current status of macrovegetation and physicochemical parameters of Samaru stream in Zaria (7° 38'E and 11° 11'N), Nigeria. Five sampling stations were chosen at approximately equal distances from each other along the stream length. Temperature readings were 19.5±1.05 and 29.0±0.67°C; pH 7.496±0.11 and 7.07±0.07; EC 328.1±63.92 and 364±75.37 µS cm^{-1}; TDS 163.3±31.99 and 185.5±37.20 mg L^{-1}; DO 6.05±0.51 and 4.03±0.49 mg L^{-1}; NO_3-N 1.37±0.17 and 5.32±0.90 mg L^{-1}; PO_4-P 136.0±53.07 and 42.3±4.74 mg L^{-1}; BOD 0.89±0.22 and 0.32±0.07 mg L^{-1} and Transparency 0.00 and 0.36±0.06 m in the dry and wet season respectively. Fifty three macrophyte species were recorded belonging to 26 families during the entire study. *Ageratum conyzoides* was the most frequent (80%) of all species observed in both wet and dry season. Very few true aquatic species were recorded during the study, these comprised *Hydrophilla auriculata*, *Jussiae ripens*, *J. decurrens*, *Polygonum limbatum*, *P. linigerum*, *Oryza barthi* and *Ipomoea aquatica*. The occurrence of macrophytes in the stream responded directly to eutrophication. This is because higher number species occurred in the dry season which significantly correlated ($p \leq 0.05$) with higher nutrient levels in the same season.

Key words: Macrovegetation, physicochemical parameters, eutrophication, stream, Nigeria

INTRODUCTION

The roles aquatic macrophytes play in water bodies comprise provision of habitat for lower animals including snails and prevention of resuspension of bottom sediments. The distribution and abundance of emergent and floating macrophytes species show close relationship with physical and chemical characteristics of aquatic systems (Gupta and Chandra, 1994; Ali and Soltan, 1999). Increased nutrient loading shifts the trophic status of shallow lakes from clear contaminated water dominated by macrophytes to a turbid water state where the producers are phytoplankton.

Nutrient induced dominance of phytoplankton and periphyton leads to reduced growth of submerged macrophytes with eventual dominance of emergent macrophytes, periphytic and enlitoral algae. On the other hand, there is tendency for allelopathic suppression of phytoplankton by macrophyte organic secretions (Gabi *et al*., 2006). Submerged macrophytes coverage often leads to increase in number of predatory fishes. Predation pressure, however may be reduced partly because submerged macrophytes concomitantly protect zooplankton against predation by fish fry foraging within the vegetation (Dehl, 1988). Submerged macrophytes can also be a direct food source for herbivore and detritivore invertebrates (Rooke, 1986). Bako and Daudu (2007) reported the possibility of bioremediation of water bodies with high heavy metal load using aquatic macrophytes.

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The wastes discharged into Samaru stream are of different forms and effects on aquatic organisms depending on the physicochemistry of the pollutants. Information gathered from the few laboratory studies of water from Samaru stream revealed that there is high concentration of organic and inorganic pollutants, suspended solids and heavy metals (Beecroft, 1990; Adakole, 1995). The only report on the fringing macrophyte communities of Samaru stream was reported by Smith (1975). A lot of changes are expected to have occurred 29 years after the last study. This is because there has been a geometric increase in the population and size of the Ahmadu Bello University (in terms of student and staff strength) and Samaru village. Infestation by aquatic macrophytes threatens many aquatic ecosystems in Nigeria (Bako and Oniye, 2004), hence the need to study the current macrophyte diversities and frequencies of Samaru stream course. The presence of aquatic macrophytes can also be an indication of the state and health of the stream as macrophytes help to reduce the rate of water loss from the stream and erosion around the its course. This study attempts to evaluate the occurrence of aquatic macrophytes and physicochemical parameters of Samaru stream in Zaria, Northern Nigeria.

MATERIALS AND METHODS

Study Area

The present study was carried out between November to December 2003 (Dry Season) and May to June 2004 (Wet season) in Zaria (11°3'N and 7°42'E) Nigeria. Samaru stream (11°8'N-11°10'N and 7°41'E-7°42'E) flows in a North-South direction along a gully situated in Samaru village and the main campus of the Ahmadu Bello University, Zaria. The gulley is about 3 km long and receives effluents from surrounding built up areas in Samaru village such as houses, wastes from piggeries, laundries and Kitchens and Ahmadu Bello University chiefly from two hostels (Danfodio and ICSA Halls). The stream discharges into the Ahmadu Bello University Dam which supplies portable water to the university and surrounding communities. Some parts of the gully that contain water throughout the year have been suggested to cut through a perched water table (Smith, 1975).

Sampling

Five sampling stations were chosen along the stream course at equal distances (400 m) from each other. Plant and Water samples were collected once a month from November to December (Dry season) 2003 and May/June (Wet season) 2004. Samples for water analysis were collected according to the procedure described in APHA (1998).

At each station, an area of 30 m along the stream length and 10 m across the stream was measured, within which three 5×5 m quadrats were measured on each bank (left and right). Representative samples of each species were collected from each bank along the stream course.

Analysis of Physicochemical Parameters

The Azide modification of the Winkler method (Lind, 1979) was used to determine Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD). Nitrate-Nitrogen (NO_3-N) and Phosphate Phosphorus (PO_4-P) were measured using a HACH DR/2000 Spectrophotometer. Transparency was measured using a Secchi Disc (Ø 20 cm). Water Temperature (°C) readings were obtained *in situ* using a Mercury Thermometer. pH, Total Dissolved Solids (TDS) and Electrical Conductivity (EC) were measured using a Hannan Portable Instrument (pH/EC/TDS/Temperature meter) model H19913300.

Macrophyte Identification

Macrophytes were identified in the Herbarium of the Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria. Identification of macrophytes was done according to Hutchinson and

Datzield (1954-1972), Miles *et al.* (1970), Cook *et al.* (1974), Heywood (1978) and Obot and Ayeni (1987). Estimates of frequencies of occurrence were made according to methods described by Higgins *et al.* (1994).

Data Analysis

Analysis of variance at 5% level of significance was used to compare physicochemical parameters between dry and wet seasons. Correlation coefficient ($p \leq 0.05$) was used to determine possible relationship that might exist between the frequency of occurrence with physicochemical parameters.

RESULTS

A total of 53 taxa were recorded in this study belonging to 26 families. *Ageratum conyzoides* had the highest frequency of occurrence of 80% along the stream length in both dry and wet season (Table 1). *Hydrophilla auriculata* (40%/40%), *Jussiaea ripens* (10%/0%), *J. decurrens* (10%/10%), *Polygonum limbatum* (40%/30%), *P. linigerum* (10%/10%), *Oryza barthi* (20%/20%) and *Ipomoea aquatica* (20%/10%) were the only true aquatic species that occurred in the wet and dry seasons. More macrophyte species were observed in the dry season than in wet season. *Paspalium arbicularis* that was recorded only the dry season occurred in station 5. Similarly, *Jussiaea ripens* occurred only in the dry season in station 1, station 4 and station 5. In terms of occurrence of macrophytes across the stations, station 1 had the highest number of species (27) followed by station 2 (21). The least number of species were recorded in station 4 with 9 species followed by station 5 with 11 species. Station 3 was midway in terms of species diversity with only 14 species recorded throughout the study period. The higher frequency of occurrence of species like *Alternanthera nodiflora*, *Setaria pallidofusca*, *Urena* sp., *Polygonum limbatum* and *Lycopersicon esculentum* in the dry season than the wet season showed strong positive correlation ($p \leq 0.05$) with Phosphate Phosphorus, Dissolved Oxygen (DO) and pH. Nitrate Nitrogen also showed significant positive relationship with the occurrence of *Hydrophilla auriculata* ($p \leq 0.05$). Shannon Weiner diversity index showed rainy season macrophyte diversity of the families to be higher (2.681) than that of the dry season (2.655) though not significantly different. Contrary to what was observed in the case of species diversity index, species evenness was lesser (0.6086) in the rainy season than the dry season (0.6185). Species Dominance (D) was similarly found to be less in the wet season (0.0985) than the dry season (0.1026).

During the dry season Electrical Conductivity (328.1 $\mu S\ cm^{-1}$) and Total Suspended Solids (163.3 mg L^{-1}) were found to be lower than the wet season (364.5 $\mu S\ cm^{-1}$ and 185.5 mg L^{-1} for EC and TDS, respectively). Mean water temperature value was 19.50°C in the dry season and 29°C in the wet season. pH was 7.50 and 7.07 in the dry and wet season respectively. Dissolved Oxygen (DO) was recorded to be lower (4.03 $\mu g\ L^{-1}$) in the wet season than the dry season (6.05 $\mu g\ L^{-1}$). Biochemical Oxygen Demand (BOD) followed the same trend as DO with 0.89 $\mu g\ L^{-1}$ in the dry season and 0.32 $\mu g\ L^{-1}$ in the wet season. Nutrient concentrations in the stream showed different trends in different seasons with Phosphate phosphorus having higher concentrations in the dry season (136 mg L^{-1}) than wet season (42.30 mg L^{-1}) while Nitrate Nitrogen had higher concentration in the wet season (5.32 mg L^{-1}) than dry season (1.37 mg L^{-1}). Due to the low water level/depth during the dry season, transparency could not be measured but in the wet season it was 0.36 m. All parameters except pH determined between the rainy and wet season were significantly different at $p \leq 0.05$ (Table 2).

Table 1: Diversities and frequency of occurrence of macrophytes in Samaru stream Zaria, Nigeria

		Stations					Composition (%)		
Family name	Species	S1	S2	S3	S4	S5	Dry season	Wet season	Habit
Acanthaceae	*Dycheriste peroteltis*	+	+	+	-	-	10	10	Aquatic
	*Hydrophilla auriculata**	+	-	-	+	-	10	40	Aquatic
Amaranthaceae	*Amaranthus spinosus*	+	+	+	-	-	40	40	Terrestrial
	Alternanthera sessiles	+	-	-	+	-	20	20	Terrestrial
	*Alternanthera nodiflora***	-	-	-	-	+	30	10	Terrestrial
	Achyranthus aspera	+	-	-	-	-	10	10	Terrestrial
Apocyanaceae	*Carrisa edulis*	-	-	+	-	-	10	10	Terrestrial
Asclepiadaceae	*Asclepias carrassavica*	-	+	-	-	-	10	10	Terrestrial
	Leptadenia pyrotechnica	+	-	-	-	-	10	10	Terrestrial
Caesalpinoideae	*Senna occidentalis*	-	-	-	-	-	10	10	Terrestrial
	Tamarindus indica	-	+	-	-	-	10	10	Terrestrial
	Senna thora	+	-	-	-	-	10	10	Terrestrial
Chenopodiaceae	*Chenopodium ambroisode*	+	-	+	-	-	10	10	Terrestrial
Compositae	*Eclipta alba*	+	-	-	-	-	20	20	Aquatic
	Blumen aurita	+	-	-	-	-	20	20	Terrestrial
	Ageratum conyzoides	+	+	-	+	-	80	80	Terrestrial
	Syndrella nodiflora	-	+	-	-	-	10	10	Terrestrial
	Ethulia conyzoides	-	+	-	-	-	30	30	Terrestrial
	Biden bipinnatum	-	+	+	-	+	40	40	Terrestrial
	Cosmos sulphureus	-	-	+	-	-	10	10	Terrestrial
Cannabaceae	*Cannabis sativa*	+	-	-	-	-	10	10	Terrestrial
Commelinaceae	*Commelina africana*	-	-	+	-	-	10	10	Aquatic
	Commelina gbengalensis	-	+	+	-	-	40	40	Terrestrial
Convolvulaceae	*Ipomea aquatica***	-	-	-	+	+	20	10	Aquatic
Cucurbitaceae	*Luffa aeyptica*	+	-	+	-	-	20	20	Terrestrial
Cyperaceae	*Cyperus iria*	+	-	+	+	-	60	60	Aquatic
Euphorbiaceae	*Recinus communis*	+	+	-	-	-	30	30	Terrestrial
Graminae	*Setaria barbata*	+	-	-	-	-	10	10	Terrestrial
	Panicum ripens	+	+	+	-	-	60	60	Aquatic
	Cynodon dactylon	-	+	-	-	-	10	10	Terrestrial
	Oryza barthi	-	-	-	+	+	20	20	Terrestrial
	*Setaria pallidofusca***	-	-	-	-	-	60	40	Terrestrial
	*Paspalium arbicularia***	-	-	-	-	+	10	-	Terrestrial
Liliaceae	*Cana indica*	-	+	-	-	-	10	10	Terrestrial
Labiatae	*Ocimum canum*	-	+	-	-	-	10	10	Terrestrial
Malvaceae	*Urena lobata***	+	-	-	-	+	30	20	Terrestrial
	*Sida acuta***	+	-	-	+	+	30	10	Terrestrial
Meliaceae	*Azadirachta indica*	+	-	-	-	-	10	10	Terrestrial
Moraceae	*Ficus* sp.	-	+	-	-	-	10	10	Terrestrial
Mimosoidaea	*Albizza lebbek*	-	+	-	-	-	10	10	Terrestrial
	Dychrostachys cinera	-	+	+	-	-	40	40	Terrestrial
Onagraceae	*Jussiaae ripens***	+	-	-	+	+	10	-	Aquatic
	Jussiaea decurrens	-	-	-	-	+	10	10	Aquatic
Papilinoideae	*Desmodium scorpiorus*	+	-	-	-	-	10	10	Terrestrial
	Centrosenna pubescent	-	+	-	-	-	10	10	Terrestrial
Polygonaceae	*Polygonum lingerum*	-	-	-	-	+	10	10	Aquatic
	*Polygonum limbatum***	-	-	-	+	+	40	30	Aquatic
Rubiaceae	*Nauclea latifolia*	-	+	-	-	-	10	10	Terrestrial
Solanaceae	*Solanum nigrum*	+	+	-	-	-	20	20	Terrestrial
	Physalis angulata	+	-	+	-	-	20	20	Terrestrial
	*Lycopersicon esculentum***	+	+	+	-	-	60	50	Terrestrial
Verbeneaceae	*Lantana camara*	+	-	-	-	-	10	10	Terrestrial
	Isoberlina doka	+	-	-	-	-	10	10	Terrestrial

+ = Present, - = Absent, * = Significant positive correlation ($p \leq 0.05$) with Nitrate nitrogen, ** = Significant positive correlation ($p \leq 0.05$) with pH, DO and Phosphate phosphorus

Table 2: Physicochemical parameters determined in the dry and wet season in Samaru stream

	Water temp (°C)	pH	EC (µS cm^{-1})	TDS (mg L^{-1})	DO (µg L^{-1})	Nitrate-Nitrogen (µg L^{-1})	Phosphate-phosphate (µg L^{-1})	BOD (µg L^{-1})	Transparency (m)
Dry season									
Station 1									
Nov	17.00	7.86	502.00	251.00	2.05	1.60	425.00	2.20	0.00
Dec	18.00	7.64	776.00	388.00	5.10	1.45	375.00	1.80	0.00
Station 2									
Nov	18.00	7.14	372.00	185.00	5.90	1.45	185.00	1.30	0.00
Dec	17.00	7.39	318.00	159.00	6.50	1.20	280.00	1.10	0.00
Station 3									
Nov	18.00	7.14	351.00	171.00	6.40	2.40	45.00	0.75	0.00
Dec	15.00	7.69	290.00	145.00	7.30	1.90	50.00	0.71	0.00
Station 4									
Nov	22.00	8.13	317.00	158.00	7.00	0.80	0.00	0.10	0.00
Dec	21.00	7.06	138.00	69.00	5.40	0.60	0.00	0.30	0.00
Station 5									
Nov	25.00	7.60	101.00	50.00	7.31	1.20	0.00	0.29	0.00
Dec	24.00	7.31	116.00	57.00	7.50	1.05	0.00	0.31	0.00
Means±SE	19.50±1.05	7.50±0.11	328.10±63.92	163.30±31.99	6.05±0.51	1.37±0.17	136.00±53.07	0.89±0.22	0.00
Wet season									
Station 1									
May	29.00	7.24	502.00	282.00	1.20	7.40	30.00	0.58	0.20
June	26.00	7.17	542.00	271.00	3.30	7.80	33.00	0.52	0.20
Station 2									
May	28.00	7.19	634.00	293.00	2.50	7.50	25.00	0.32	0.60
June	26.00	7.34	628.00	314.00	5.50	7.60	29.00	0.28	0.60
Station 3									
May	30.00	7.23	479.00	250.00	4.10	7.40	70.00	0.54	0.55
June	28.00	7.12	482.00	241.00	5.60	7.50	65.00	0.56	0.55
Station 4									
May	32.00	7.01	101.00	63.00	5.50	1.50	45.00	0.1	0.35
June	29.00	6.84	92.00	45.00	5.70	1.70	41.00	0.08	0.35
Station 5									
May	32.00	6.89	97.00	52.00	2.80	2.50	45.00	0.12	0.10
June	30.00	6.62	88.00	44.00	4.10	2.30	40.00	0.08	0.10
Mean±SE	29.00±0.67	7.07±0.07	364.50±75.37	185.50±37.20	4.03±0.49	5.32±0.90	42.30±4.74	0.32±0.07	0.36±0.06
ANOVA (between seasons)	13.20588**	1.327838^{ns}	29.75**	29.91**	4.18*	368.52**	49.11**	19.16**	

* = Significant at p<0.05, ** = Highly significant at p<0.01, ns = Not significant at p<0.05, EC = Electrical Conductivity; TDS = Total Dissolved Solids; DO = Dissolved Oxygen; BOD = Biochemical Oxygen Demand, *Cited from Tiseer *et al.* (2008) on Seasonal occurrence of Algae and Physicochemical parameters of Samaru stream, Zaria, Nigeria

DISCUSSION

Interactions at the environmental level of rainfall with the atmosphere, vegetation, rocks and soil, are the chief source of dissolved solids in Samaru stream. Another source of Total dissolved solids is Groundwater entering the stream. The amount of dissolved solids in water to a great extent determines the Electrical conductivity. Electrical conductivity of this stream falls within Class I of the classification of African waters by Talling and Talling (1965) with ionic content less than 600 µS cm^{-1}. It is important to note that determination of TDS alone does not indicate the nature or exact type of materials that make it up hence the need for further analysis. Significantly higher values of EC, TDS and Nitrate-Nitrogen in the rainy season than the dry season could be as a result of surface runoff. The current study agrees with the study of Kemdirim (2005) on the hydrochemistry of Kangimi reservoir, Kaduna state, (Northern) Nigeria, though disagrees with that of Chindah and Braide (2004) on the

Lower Bonny River, Niger Delta (Southern). Chindah and Braide (2004) reported a higher EC, TDS and Nitrate-Nitrogen concentrations in the dry season than the wet probably due to differences in the bedrock material, activities around the catchment and climate of the Southern part of Nigeria. The harmattan which is an extremely dry dusty wind that blows from the Sahara towards the western coast of Africa, especially between November and March was responsible for significantly lower dry season temperatures than wet season.

Increase in Nitrate and Phosphate concentrations (eutrophication) were responsible for increase frequencies of plant species in the stream system. This is further supported by the higher frequency of occurrence of macrophytes in the dry season than the wet season that significantly correlated with increase Phosphate phosphorus concentration. Availability of moisture alongside abundant nutrients received from sewage from Samaru stream catchment might have supported the survival and dominance of herbs in both seasons that are normally seasonal in occurrence. During photosynthesis macrophytes are involved in raising pH values by active removal of carbon-dioxide from water. This explains the correlation between the frequencies of occurrence of certain species with pH. In photosynthesis macrophytes contribute significantly to the amount of Dissolve Oxygen (DO) which means where standing crop is high there would be a corresponding high level of Dissolved Oxygen. The macrovegetation community of the stream course showed higher diversities in both seasons that were greater than unity. Although, it has been reported by Magurran (1991) that Shannon Diversity index does not exceed 3.5 and on very rare occasions exceeding 4.5 (Margalef, 1972; Kadiri, 2006). The values for diversity index found here could be said to be relatively on the high side, hence suggesting an unstressed system (Rosenberg, 1976; Magurran, 1991). This is further supported by the high number of species (though differing in their frequency of occurrence) found that have developed and established themselves in the available niches in both seasons (Reynolds, 1984, 1997). Most species recorded in this study were either emergent or terrestrial in habit which means an encroachment of terrestrial vegetation into the stream course. This encroachment could have been favored mainly by the siltation processes that occur in the stream which result in increase silt and nutrient influx into the stream. A large quantity of untreated sewage from households is regularly discharged into the stream from Samaru village. This may have contributed to the occurrence of the highest number of species in station 1 as it receives raw sewage from households in Samaru which is diluted or taken up as it moves downstream by microphytes and macrophytes. Surface runoff brings down fertilizers and other chemicals from agricultural fields into the stream. In several countries adequate control measures have been adopted in to control eutrophication though these measures are found to be only partially effective in controlling the phosphorus unloading in water bodies (Khan and Ansari, 2005). Nutrient influx encourages the growth and establishment of aquatic macrophyte communities, while sediments formed by deposition of silt provide substratum for root growth (Bako and Oniye, 2004). The Hydroseres observed in this stream indicates a succession process is going on in this stream which means if measures are not taken to reduce or stop the rate of succession there is a risk of losing the stream as the gulley is narrowing in its width and capacity.

The physical and chemical characteristics of the stream significantly varied spatially and temporally except for pH. Herbaceous plants constitute a greater percentage of the total number of plants recorded in the present study. Macrophytes in the stream responded directly to eutrophication. As empirical evidence showed increase macrophyte species in the dry season as nutrient content increased than the wet season when the nutrient levels dropped significantly.

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