MACROINVERTEBRATE DIVERSITY AND WATER QUALITY PATTERNS OF A MUNICIPAL STREAM IN DOKO DISTRICT, NIGER STATE, NIGERIA

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Abstract

The macroinvertebrate community of Emikpata stream, Doko district, Niger State, Nigeria were studied for a period of eight months using the modified kick sampling techniques. Four well marked stations were selected along the course of the stream designated as station 1, 2, 3, 4. Physicochemical parameters examined and readings were: Water temperature (23.0-27.0°c), Depth (20.96-24.10cm), Flow velocity (0.29-0.30m/s), Dissolved oxygen (5.97-6.35mg/l), Biochemical oxygen demand (3.25-3.87mg/l), pH (6.0-6.32, Conductivity (49.1-110.0µS/cm), Total hardness (12.3-18.0mg/l), Total alkalinity (13.0-20.5mg/l), Chlorine (10.71-32.79mg/l), Nitrate (1.83-3.69mg/l), Phosphate (0.60-1.12mg/L), Sodium (7.24-9.02mg/l), Potassium (1.74-1.92mg/l). A total of 625 individuals from 28 species and 19 families of invertebrate were recorded. Significantly higher ($P<0.005$) macroinvertebrate abundance was recorded during the dry season as compares to the wet season. The Canonical Correspondence Analysis (CCA) result showed strong relationship between species abundance and measured environmental variables. Higher population of pollution tolerant macroinvertebrates groups and the poor water quality observed during the sampling period were indications of pollution stress occasioned by anthropogenic activities, decomposing domestic wastes and inorganic fertilizer washed into the stream from various nearby farms.

Keywords: Macroinvertebrate, Community, Emikpata Stream, Doko, anthropogenic activities, domestic wastes, fertilizer

Introduction

Macroinvertebrate organisms form significant part of an aquatic ecosystem; they are of ecological and economic importance because they maintain various levels of interaction within aquatic environment (Dobson *et al*. 2002). Biomonitoring of these organisms may help to conserve and proffer appropriate management decisions in an aquatic ecosystem. Macroinvertebrates have limited mobility and can stay in an area for some time without moving away easily. The type of macroinvertebrates species obtained may be used as indicator of the status of the water quality of that environment at that location in a particular time (Arimoro and Keke, 2017). Macroinvertebrates have high variability and are significant to predict the effect of short term environmental variation which are used to distinguish some characteristics of rivers and streams across the globe (Barbour *et al* 1999). Substrate is perhaps one of the most important factor affecting the distribution of macroinvertebrates, although alterations in physicochemical parameters such as temperature, salinity and food availability also play vital role in determining the extent of distribution and abundance of benthic macroinvertebrates species in aquatic ecosystem. Also, they constitute a major link in the aquatic food chain (Olomukoro *et al* 2013; Uwem and Edet 2016). Freshwater pollution by different anthropogenic sources are becoming a matter of urgent concern threatening aquatic productivity, its sustainability and social economic development in Africa (Arimoro and Ikomi 2008; Arimoro and Keke 2017). Several uses of aquatic ecosystems, includes laundry, water source for drinking, irrigation, hydropower generation as well as riparian activities on rivers' catchments such as unregulated land use and landscape alteration, have led to both biotic and physical deterioration of aquatic environment (Nyenje *et al.* 2010). In Nigeria, land use changes on various catchments, agro-industrial activities and rapid urbanization pose threats to the well-being of aquatic environment and alters the composition and abundance of macroinvertebrates (Arimoro and Ikomi 2008; Andem *et al.* 2014; Arimoro *et al.* 2015).

There is the urgent need to monitor the conditions of aquatic ecosystem to ascertain their quality at any particular point in time. This study therefore explores the use of macroinvertebrates to monitor the quality of a small stream in Niger State where studies of this nature hitherto has not be undertaken. It will help to fill up the gap and add to the growing pool of data on the taxonomy and ecology of macroinvertebrates in Nigeria

Materials and Methods

Description of the Study area

The study was carried out at Emikpata stream in Niger state, North Central Nigeria. The town lies within the latitude of 090 03' 8N and 09006'40" N and longitude of 06001'0" E and 06002'42" E. it is in guinea savannah region characterized by wet and dry seasons. The wet season starts from April to October while the dry season is from November to March. Sampling stations were selected based on the level of activities of the riparian users. For the purpose of this study the study areas was divided into four stations (Emi–Bako, Kuchi-Gbako, Gadza, Angbasa) and each station is 6 km away from each another (Fig.1).

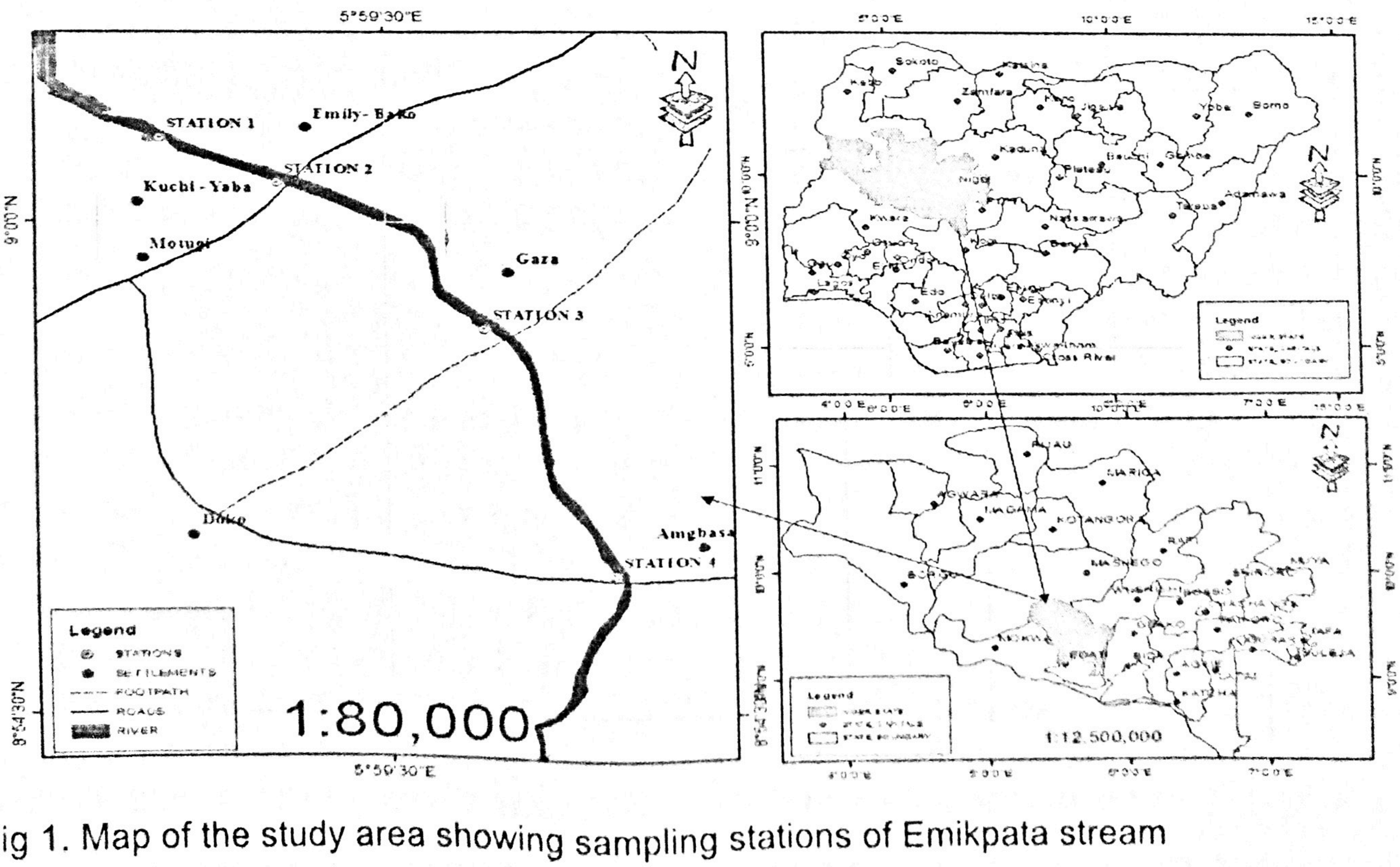

Fig 1. Map of the study area showing sampling stations of Emikpata stream

Sampling stations

Station 1 is located very close to Emi Bako village in Doko district. The vegetation cover is thick (with few mangoes trees nearby). The vegetation consists mainly of *Nymphae* species. There is very minimal human activities in this station. ***Station 2*** is located under a motorable bridge between Kuchi and Yaba. The vegetation cover is sparse with few trees covering the surrounding. The vegetation consists mainly of *Nymphae* species. Washing of clothes, washing of plates and other human activities that take place here. ***Station 3*** is 6km away from station 2 (Gaza). It was located in an open place with a lot of vegetative cover. ***Station 4*** is located 6km away from station 3 (Amgbasa). This station has few vegetation cover with macrophytes. This station was relatively free from human activities except for farming due to its location in the outskirt of the town.

Sampling techniques:

Water quality sampling; Water samples for physicochemical parameters were collected monthly for a period of Eight months (July 2018 to February 2019) from four selected sampling station in the streams. Sampling period covers both the dry and wet season. Temperatures, depth, flow velocity, dissolved oxygen (DO), Biochemical oxygen demand, Electrical Conductivity, pH, total alkalinity, total hardness, sodium, potassium, chlorine, Nitrate and Phosphate were all determined using standard methods and procedures (APHA, 2012).

Macroinvertebrates sampling; Kick samples of Macroinvertebrates were collected monthly (July 2018 to February 2019) with a D-frame net (250µm mesh size) within an approximately 50m wideable portion of the river. Samples were taken from different substrata (vegetation, sand, and gravel biotypes). Samples collected from the net were preserved in 70 % ethanol. In the laboratory, samples were washed in a 250µm mesh sieve to remove substrates and Macroinvertebrates taxa were picked out with the aid of forceps and observed using a stereoscopic microscope. Sorted Macroinvertebrates were also identified to lowest taxonomic rank using the taxonomic list of species known to be available in Africa (Arimoro 2008; Danladi *et al.* 2013)

Data Analysis; The mean range and standard deviation of each physicochemical characteristics was calculated per station. Also, Biological indices such as taxa richness and evenness (E) abundance, number of taxa, diversity index and dominance were computed using Paleontological Statistics Software Tool pack (PAST). Canonical Correspondence Analysis (CCA) was also extrapolated to show relationship between environmental variables and macroinvertebrates abundance. Both the physicochemical characteristics and benthic fauna were compared across stations and months by using one-way analysis of variance (ANOVA).

RESULTS

Physicochemical parameters

In all the sampling stations of the stream, water Temperature, Flow velocity, Dissolved Oxygen Biochemical Oxygen Demand, Conductivity, Total alkalinity, Total hardness, phosphate and potassium showed no significance difference ($p>0.05$) among the sampling stations whereas Depth, pH, Chlorine Nitrate and sodium were significantly different (p<0.05) among the sampling stations (Table 1).

Macroinvertebrate assemblage
A total of 625 individuals from 28 species belonging to 19 families of macroinvertebrate were recorded (Table 2). Station 4 recorded higher macroinvertebrate abundance (197 individuals) than other stations followed by station 2 (175 individual), station 3 (139 individual) and the least was recorded in station 1 (114 individual).

Distribution of macroinvertebrates group
Macroinvertebrates groups were evenly distributed among the sampling stations. The abundance of the macroinvertebrate in the stream showed that Odonata, Hemipitera, Ephemeroptera Coleoptera and were the most common groups encountered in the stream. Decapoda, oligochaetes, Mollusc, and Diptera were also encountered virtually in all the stations of the stream (Fig. 2).

Seasonal changes in population of macroinvertebrates
In all the sampling stations, significantly higher (p>0.05) abundance of macroinvertebrates were observed in dry season than in rainy (Fig. 3).

Diversity indices: Diversity indices which include number of individuals, taxa richness, Simpson dominance, Shannon index, eveness index and Margalef index of the stream are shown in Table 3. Station 4 recorded the highest number in all the diversity indices while station 1 recorded lowest in all the diversity indices measured.

Relationship between measured variables and macroinvertebrates. The CCA correlated positively with the measured environmental variables. CCA axis 1 accounted for 39.9% variation in species and 0.095 engine value while axis 2 account for 36.76% species and 0.088 engine value of the measured variables. Organisms in axis 1 were positively influenced by depth, conductivity total harness, alkalinity, pH and dissolved oxygen while organisms in axis 2 were influenced by phosphate, flow velocity, nitrate, chlorine and biochemical oxygen demand.

Table 1. Mean summary of Physicochemical parameters of sampling stations in Emikpata stream, Doko district of Niger state.

Parameters	Stations				Probablities	
	1	2	3	4	Stations	Months
Temperature (°C)	23±0.94 (19.6-26.2)	23.42±1.13 (19.4-27.3)	27±1.09 (19.6-26.8)	24±1.04 (19.5-26.9)	0.361	1.74E-08
Depth (cm)	20.96±2.55* (10.6-28.6)	23.1±1.98 (15.3-28.2)	23.26±2.17 (12.5-29.1)	24.1±1.55 (16.5-29.2)	0.024	4.08E-10
Flow velocity (m/s)	0.286±0.01 (0.22-0.359)	0.287±0.01 (0.238-0.338)	0.300±0.01 (0.268-0.354)	0.292±0.01 (0.250-0.32)	0.737	0.0308
DO (mg/l)	6.35±o.42 (5-8)	6.17±0.29 (5-8)	5.97±0.43 (4-8)	6.15±0.42 (5-8)	0.806	0.007
BOD (mg/l)	3.65±0.32 (3-5)	3.87±0.22 (3-5)	3.62±0.18 (3-4)	3.25±0.31 (2-5)	0.254	0.015
pH	6.32±0.09 (5.95-6.75)	6.0±0.10* (5..46-6.4)	6.1±0.09 (5.8-6.5)	6.2±0.15 (5.4-6.71)	0.002	1.33E-07
Conductivity (µ/Sc)	49.1±3.47 (35-62)	65.0±5.15 (48-85)	110±7.46 (85-144)	108±13.35 (55-151)	0.136	7.35E-06
Total Hardness (mg/l)	12.3±1.25 (7-18)	12.3±1.85 (7-22)	17.1±1.43 (10-22)	18.0±1.63 (13-25)	0.054	0.084
Total alkalinity(mg/l)	13.0±0.90	15.0±1.60	20.5±0.90	20.0±0.53	0.812	0.001

	(10-18)	(10-22)	(18-26)	(18-22)		
Chlorine (mg/l)	11.04±0.33 (9.9-12.68)	32.79±0.96* (29.4-37.24)	13.35±1.37 (9.8-20.14)	10.71±0.45 (8.8-12.6)	1.33E-15	0.04
Nitrate (mg/l)	1.83±0.15 (1.3-2.62)	3.69±0.54* (2.32-6.85)	2.43±0.41 (1.53-5.25)	2.41±0.10 (2.18-3.11)	0.0003	0.001
Phosphate (mg/l)	0.60±0.04 (0.46-0.86)	0.90±0.09 (0.61-1.31)	1.12±0.14 (0.77-1.85)	1.01±0.12 (0.6-1.51)	0.092	0.18
Sodium (mg/l)	8.89±0.72 (6.28-11.2)	7.24±0.62* (5.81-10.3)	9.02±0.90 (6.35-13.3)	8.03±0.70 (6.39-10.5)	0.003	1.94E
Pottasium (mg/l)	1.74±0.34 (0.98-3.6)	1.81±0.37 (11.1-3.9)	1.92±0.47 (0.95-4.77)	1.90±0.35 (0.90-3.96)	0.479	4.08E

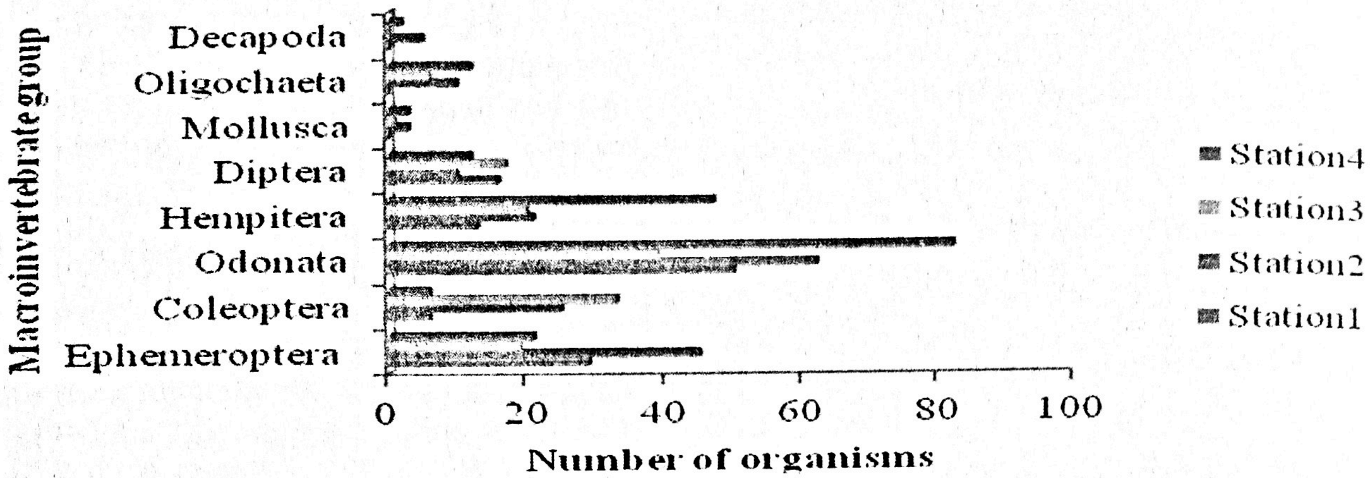

Fig 2: Abundance (number of individuals) of macroinvertebrate groups in each sampling station of Emikpata stream.

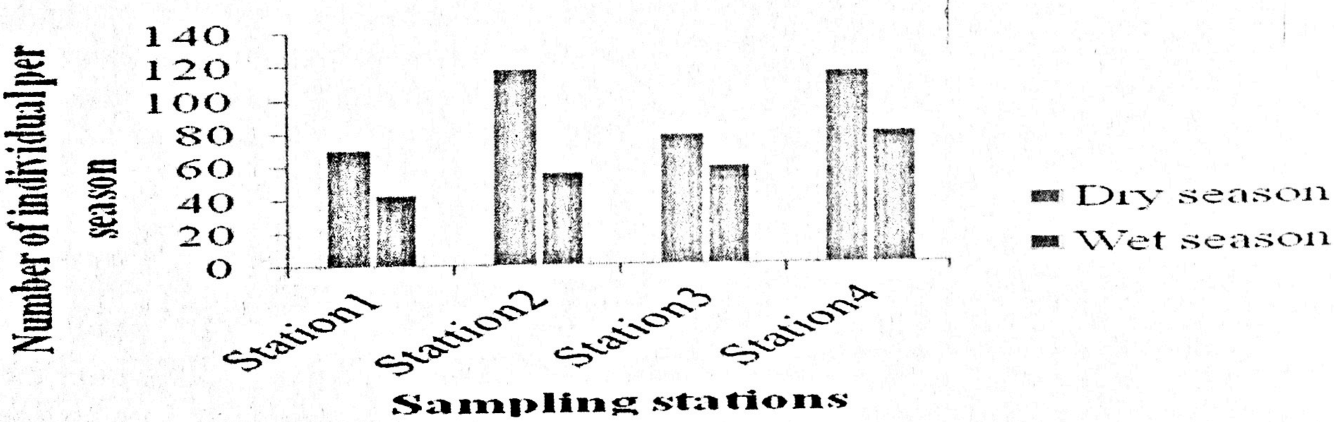

Figure 3: seasonal assemblage of macroinvertebrates per station

Table 2. Macroinvertebrate assemblage of sampling stations in Emikpata stream, Doko district of Niger state

Order	Family	Species	Station1	Station2	Station3	Station4
Ephemeroptera	Baetidae	*Bugillesia* sp	14	10	8	11
		Chloen sp	15	35	11	10
Coleoptera	Dystcidae	*Phylodyte* sp	0	1	0	1
	Hydrophilidae	*Crenis digesta*	3	10	16	8
		Hydrophilus sp	2	9	13	6
		Hyphydrus sp	1	0	1	1
		Culymbetes Sculptilis	0	5	3	4
Odonata	Coegnoridae	*Coenagrion* sp	13	15	6	25
		Pseudoigrian sp	14	17	15	14
	Plactinemidae	*Mesocnemis* sp	8	6	4	7
	Gomphidae	*Ophiogomphus* sp	0	2	4	6

	Aeshnidae	*Aeshna* sp	2	7	6	10
	Cordillidae	*Epitheca* sp	1	5	4	7
	Libellubidae	*Libellula* sp	5	1	0	3
		Zyxomma sp	2	1	1	3
		Brachythermis sp	5	2	3	7
Hempitera	Nepidae	*Ranatra* sp	3	1	0	4
		Laccocotrophes sp	7	13	12	16
	Hydrometridae	*Hydrometra* sp	0	1	2	16
	Naucoridae	*Macrocroris* sp	0	1	2	1
		Naucoris sp	0	1	0	1
	Notonectidae	*Notonecta* sp	1	3	3	4
	Gerridae	*Gerris* sp	2	1	1	3
Diptera	Chironomidae	*Chironomus* sp	16	10	17	12
Mollusca	Unionidae	*Unio mancus*	0	2	1	2
	Physidae	*Physa* sp	0	1	0	1
Oligochaeta	Lumbricoides	*Lumbricoides* sp	0	10	6	12
Decapoda	Caridianae	*Caridina gabonensis*	0	5	0	2
Total			**114**	**175**	**139**	**197**

Table 3 Diversity indices of macroinvertebrate of Emikpata stream Doko district of Niger state

Diversity indices	Station 1	Station 2	Station 3	Station 4
Total Individuals	114	175	139	197
Taxa Richness	18	27	22	28
Simpson Dominance index	0.9044	0.9158	0.9243	0.9404
Shannon index (H)	2.537	2.797	2.77	3.017
Evenness e^H/S	0.7023	0.6071	0.7254	0.7294
Margalef index	3.589	5.034	4.256	5.111

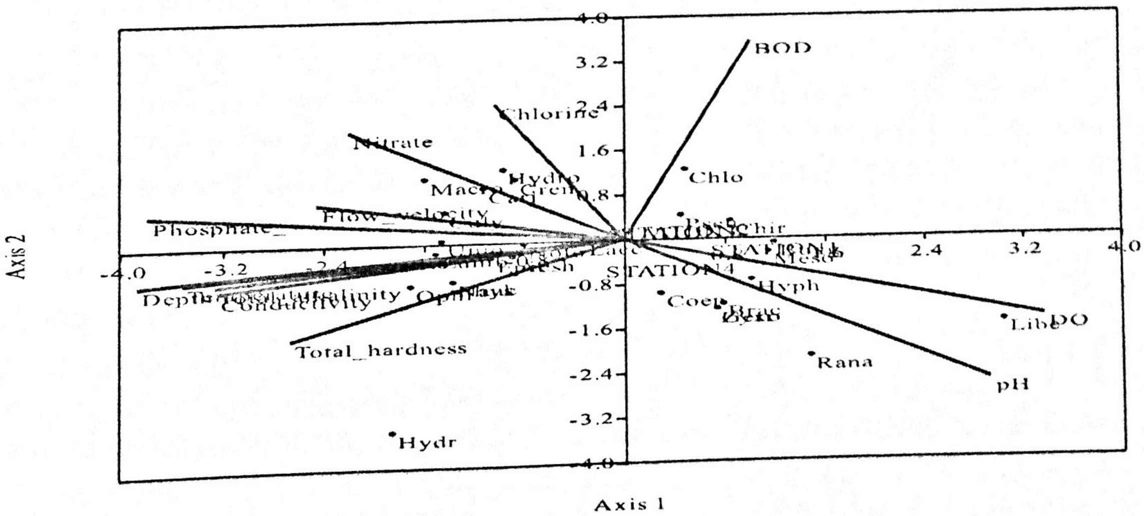

Figure 4: Canonical correspondence analysis (CCA) ordination plots of measured environmental variables and macroinvertebrates of Emikpata stream

Discussion

Most water bodies in Nigeria have been compromised in their physical, chemical and biotic characteristics because of discharges of organic and inorganic wastes from anthropogenic activities around our freshwater bodies (Arimoro and Ikomi, 2008). The physicochemical characteristics of the stream showed some variation between sampling stations and sampling periods. Depth, pH, chlorine, nitrate and sodium were statistically significant among the sampling stations ($p<0.05$). All the physicochemical parameters measured in the stream were statistically significant ($p<0.05$) among sampling months. Water level and physicochemical characteristics of aquatic ecosystem are usually influenced by pattern of rainfall (Mustapha, 2008). The medium temperature and pH obtained from this study could be as a result of sample collection time and the nature of vegetation around the stream.

Temperature is one of the important environmental variables because it regulates the physiological behaviour and distribution of aquatic organisms (Mustapha, 2008). Depth and flow rate increased slightly during rainy season. This could be as a result of increase in the water volume as a result of rain and wind blowing across the streams which were absence during the dry season. The DO, BOD_5 ranged observed is an indication of moderately polluted water (Emere and Nasiru, 2009; Arimoro & Keke, 2016). The Low Conductivity, Total hardness, and Alkalinity value obtained in dry season whereas high values were recorded in rainy season. This could be due to increase in volume of water in rainy season and surface run off into the stream which increases the amount of suspended and dissolved solid materials in the stream (Mustapha, 2008; Arimoro *et al.*, 2015). Suspended and dissolved solid materials increases the concentration of cation such as calcium, magnesium and sulphate in our water bodies (Mustapha, 2008). The high Chlorine, Nitrate, Phosphate, Sodium and Potassium values recorded during the study period are indicators of different anthropogenic activities around the stream. The influx of run-offs from surrounding farm lands in some reaches of the river are likely responsible for the perceived deterioration of the water quality.

The 28 species comprising of 625 individuals were low compared to other studies from Northern Nigeria (Emere and Nasiru, 2009; Dadi-Mamud *et al.*, 2014). The abundance and diversity of macroinvertebrates could be due to habitat type, substrate type and vegetation cover. Nutrient availability and nature of habitat also favours the abundance and distribution of macroinvertebrates (Arimoro & Keke, 2017). Taxonomic breakdown of macroinvertebrates from the stream showed the overriding dominance of Odonata, Hemiptera, Ephemeroptera and Coleoptera. These groups except Ephemeroptera belong to pollution tolerant class in most water bodies (Arimoro and Ikomi, 2008; Emere and Nasiru, 2009). These groups are moderately tolerant of pollution and their presence could be attributed to the vegetation cover and bottom sediment of the stream enhancing their colonization (Arimoro and Keke, 2017). Few presence of Decapoda, Oligochates, Molluscs and Diptera is an indication of pollution due to presence of organic wastes in the stream (Edegbene *et al.*, 2015). They are very tolerant to pollution and are mostly found in polluted environment. The presence of Ephemeroptera species are indication of clean water quality and were mostly common during the rainy season. This could be as a result of influx of rain leading to dilution in the water which enhanced the water quality (Arimoro and Ikomi, 2008; Arimoro and Keke, 2017).

Conclusion

Emikpata Stream is found to be affected by human impact and is impaired in the downstream sections with poor water conditions. On the other hand, the stream is used for a variety of purposes such as irrigation, cattle drinking and domestic purposes. The survey of macroinvertebrate organisms therefore gives an important insight into the status of the stream and appends the knowledge and understanding of the management strategies involved in biomonitoring as a significant tool in River restoration studies.

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