



Research Article

MACROINVERTEBRATES DIVERSITY AND SEDIMENT
COMPOSITION OF KANDOLLA SHELLA STREAM

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ABSTRACT

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This study delves into the macroinvertebrate diversity and sediment physicochemical parameters of Kandolla Shella Stream in Usmanu Danfodiyo University Sokoto, Sokoto State. A total of 231 individuals, representing 25 families across 11 macroinvertebrate orders, were recorded during the study period. The relatively low abundance (231 individuals) and diversity (Shannon index: 1.08) observed were attributed to habitat characteristics and the specific study timeframe. Factors such as nutrient availability, vegetation nature, canopy cover, and sandy substrate were identified as influential in supporting diverse macroinvertebrate groups. Ephemeroptera, represented solely by the Heptageniidae family, exhibited higher abundance at the headwater (Point 3), indicating lower pollution levels. Conversely, Points 1 and 2 showed reduced abundance due to anthropogenic activities and the degraded state of the stream. Corduliidae (dragonflies) and Hemipterans (*Neotibicean linnei*) were present, with their diversity linked to vegetation cover and river sediment characteristics. Sediment physicochemical analysis revealed elevated phosphate levels across all points, potentially stemming from human activities and surface runoff. Electrical conductivity increased across the points, indicative of rising sodium, calcium, and chloride ions. Contaminant assessment highlighted elements like calcium, potassium, magnesium, chlorine, and carbon, suggesting increased pollution that may impact macroinvertebrate diversity in the Kandolla Shella Stream.

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INTRODUCTION

Biodiversity is rapidly changing across the globe (Díaz *et al.*, 2019). Long-term datasets suggest declines in richness, abundance and biomass of terrestrial insects and other arthropods, including steep declines in biomass of flying insects (Didham *et al.*, 2020; Wagner *et al.*, 2021). The spatial and taxonomic extent of these declines are unclear, as well as whether declines are spread across both terrestrial and freshwater systems, and this is further complicated by reported abundance and biomass increases across several taxa at the local scale (Crossley *et al.*, 2020).

Macroinvertebrate organisms in fresh waters are organisms that live on the riverbed and attach to substrate or mud (Gething *et al.*, 2020). Identifying macroinvertebrates is a simple process, and they have the ability to adapt to changes in their environment. They play a vital role in balancing the nutrient levels in aquatic environments and can be used as bio-indicators to monitor water quality (Seriño *et al.*, 2018; Ojija and Laizer 2016). Environmental conditions such as bottom substrate and depth can represent enormous variations in the presence of macroinvertebrates so different species are often found in areas with different environmental conditions (Zelnik and Muc, 2020). The adaptation of macroinvertebrates to environmental conditions such as hard substrates is different from macroinvertebrates that live on soft substrates (Gething *et al.*, 2020). Changes in the environment and substrate greatly affect the number of species, diversity, and abundance of macroinvertebrates. Macroinvertebrates are highly dependent on the tolerance of ecological changes where the tolerance range of macroinvertebrates to different environments (Zelnik and Muc, 2020).

The Kandolla Shella Stream, located in Sokoto State, Nigeria, is emblematic of the challenges facing many freshwater ecosystems worldwide. This river sustains various ecological functions and provides essential resources for the livelihoods and well-being of local communities. However, increased urbanization, agricultural expansion, and industrial activities have raised concerns about the river's water quality and the potential consequences for both ecosystem health and human welfare (Magami *et al.*, 2019). Rivers are natural freshwater streams that flow into other rivers, lakes, or the sea (Erős *et al.*, 2019). River ecosystems benefit society in multiple ways, such as by providing water and food, acting in climate regulation, and serving as recreational spaces. Ecosystem services are the benefits that ecosystems provide to human beings. These benefits are classified into four categories: provisioning, regulating, cultural, and supporting services. The Kandolla Shella Stream provides essential provisioning ecosystem services, supplying humans with vital resources necessary for the livelihoods. Specifically, the stream offers; clean water for drinking, irrigation, and other domestic uses and also provides aquatic food sources, such as fish which contribute to local food security (Grizzetti *et al.*, 2019).

In line with these considerations, this paper aimed to determine the diversity of macro invertebrate and sediment physiochemical analysis of Kandolla Shella Stream.

MATERIALS AND METHODS

This study was conducted at the Kandolla Shella Stream in Usmanu Danfodiyo University, Sokoto State. This stream is a Fadama wetland and is used for fishing, agricultural practice, domestic uses and irrigation farming purpose for neighboring villages.

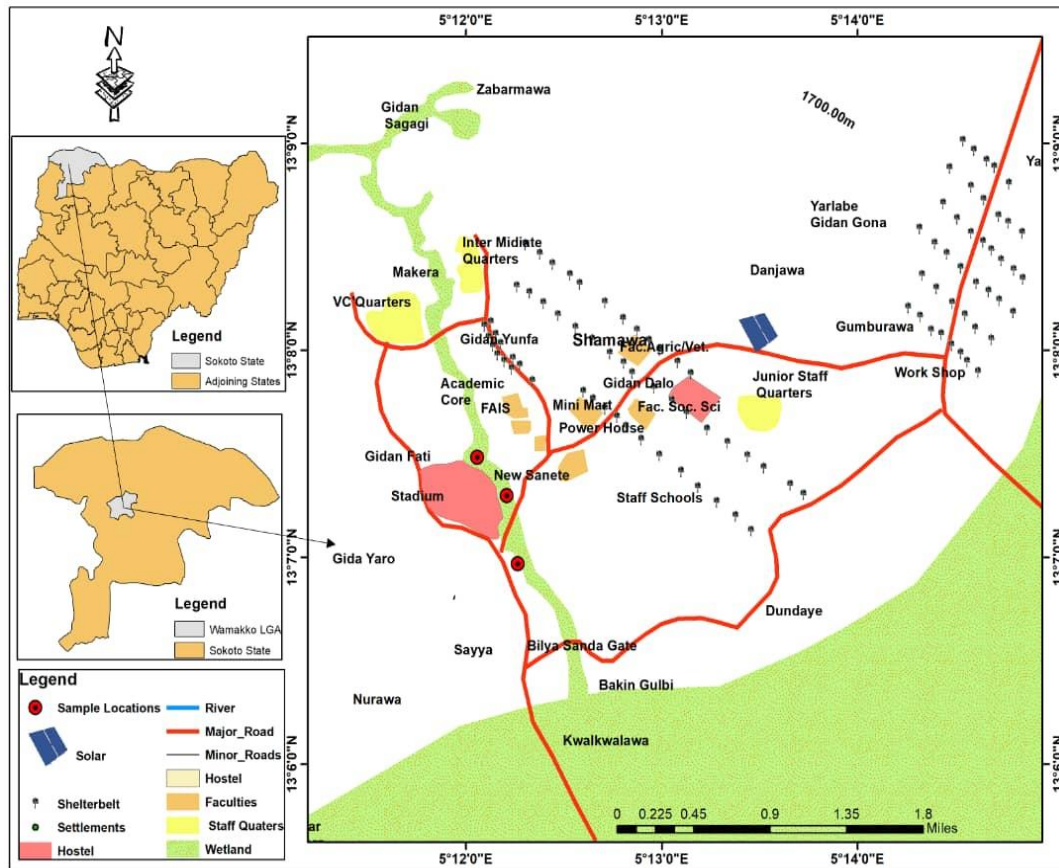


Figure 1: Map showing the Study Area

The climate of the study area is tropical continental, with much of the rain occurred between June and September. The dry season is between October and May. Rainfall is torrents that are short-lived and at the beginning of the season, usually accompanied by storms. The mean annual rainfall is about 600mm with most of it falling in July and August. The highest temperature is 40°C (Ekoh H.C., 2020). Sokoto is located in the extreme North-Western Nigeria. It lies between latitudes 12°57' 30"N to 13°8' 0"N and longitudes 05°9' 0"E to 05°19' 30"E. (Google Map, 2019).

Sampling Methods

This study covers Kandolla Shella Stream. Three sampling stations were selected and sampling was done at three different points was (A, B, C). Global Positioning System (GPS) was used to locate the sampling points. Sediment samples were collected from the rivers in leather bags in the hours of 08:00a.m to 09:00a.m and were taken to Agricultural Laboratory for the sediment physicochemical analysis. The samples (both physicochemical and biological analyses) were collected weekly for a period of two weeks.

Sediment Physicochemical Parameters Analysis

The sediment soil sample for physicochemical parameters analysis were collected for a period of 2weeks. Samples were collected in a clean leather bag. Collection was carried out by careful immersion containers in the water to scoop the sediment sample. The content of the containers was sieved using a 250µm to separate finer particles before refrigerating at 4°C prior to analysis. Water samples from the sediment were processed according to the method prescribed by the American Public Health Association (APHA, 2012). The pH, Electrical conductivity (EC) and total dissolved solids (TDS) of the water samples were tested using pre-calibrated pH, TDS and conductivity meter in-situ with (Hanna microprocessor pH/ EC/TDS Meter). Collected and preserved water sample were used to test the phosphate (PO₄), magnesium, calcium, nitrate, phosphorus, carbon, sodium and cation exchange capacity using the method of the APHA (2012) in Agric Laboratory Usmanu Danfodiyo University Sokoto State.

Macroinvertebrates Sampling and Identification

Macroinvertebrates samples were collected from a 100m stream reach using a 0.09m² sober sampler with a 250µm mesh size. The collection method considered the three microhabitats/flow regimes (the pools, riffles, and runs) and all the different substrata (vegetation, sand, gravel biotopes), were included to avoid bias, three random samples were collected from each of the three microhabitats using a bucket and scooping the water from the sampling point for a total of three times, and then pooled to form one composite sample per station. The water was then sieved and macroinvertebrate species were handpicked. This was to ensure that all microhabitats were adequately sampled, the three microhabitats per sampling event per site were pooled into one composite sample. The collected samples were preserved in a 10 % formaldehyde solution and transported to the laboratory for sorting and subsequent identification. In the laboratory, samples were washed in a 500 mm mesh sieve to remove sediment and macroinvertebrates were sorted using a stereoscopic microscope (magnification x10). All animals were separated, enumerated and identified under a binocular dissecting microscope. All sorted macroinvertebrates were identified to the lowest taxonomic level possible using Merritt and Cummins (1996), Day *et al.*, (2002) and De Moor *et al.*, (2003). References were made to the taxonomic lists of species known to be present in Nigeria (Arimoro *et al.*, 2012).

Data Analysis

The data collected were analyzed using SPSS (statistical package for social sciences). Charts and tables were used in representing the macroinvertebrate diversity Shannon constant was used to correlate the species diversit

RESULTS

Macroinvertebrate assemblages collected from the Kandolla Shella Stream were diverse, with 3 Phylum identified and 231 individuals/m² recorded during the study (Table 1). The total number of taxa and individuals present at stations 1, 2, and 3 were 62, 80 and 89 respectively. Dragonfly (*Somatochlora viodianenea*) made up the largest and most dominant specie accounting for 18.8%, closely followed by Snail (*Melanoides tuberculata*) 18.4% and the least, Sexpunctata (*Lilioceris lilac*) and Hygrophila (*Physella acuta*)

accounting for only 1.8% each of the total macroinvertebrate density (Figure 1). The most abundant species, Odonata (*Somatochlora viodiaenea*) was present in all the stations. The second most dominant species, Mollusca (*Melanoides tuberculata*) was also present in all the stations, while the least common Sexpunctata (*Lilioceris lilac*) and Hygrophila (*Physella acuta*) were absent in station 3 and 1 respectively. The insect group comprising of Ephemeroptera, Mantodea, Trichoptera Coleoptera, Hemiptera, and Odonata was dominated by Odonata (18.8%) and closely followed Ephemeroptera accounting for 9.9% of the total composition (Figure 1). The abundance of species and prevalence was represented using a pie chart (Figure 1). Biological indices were discovered using Shannon constant. The Shannon index value of 1.08 indicates low diversity reflecting the degraded conditions of the stream due to anthropogenic pressures (Table 2).

Sediment Physicochemical Analysis

The Physicochemical parameter of the sediments across the three locations were recorded. During the collection (Table 3) pH ranged from 7.44-7.47 across the three points with the highest reading recorded at point B, Nitrogen reading varied across the three points with 1mg/L, Phosphorus ranged from 0.215-0.216, EC ranged from 205-327, Carbon ranged 16.8mg/L to 20.7mg/L, Magnesium 3-3.4, CEC 2.5- 3.6. All readings for the locations are documented in (Table 3). The mean was calculated to summarize the parameters across all three locations and is documented in (Table 3). The highest pH (7.48) was recorded at Location C and lowest pH (7.45) was recorded at Location A. Nitrogen levels were consistent across all locations, with a mean value of 1. Phosphorus (P), the highest phosphorus (0.2207) was recorded at Location B and the lowest phosphorus (0.2157) was recorded at Location A. The highest electrical conductivity (265.33) was recorded at Location A and the lowest electrical conductivity (110.53) was recorded at Location C. Highest carbon (21.83) was recorded at Location C and the lowest carbon (18.5) was recorded at Location A. The highest potassium (29) was recorded at Location B and the lowest potassium (20.33) was recorded at Location C. Calcium levels were relatively consistent across all locations. The highest magnesium (3.6) was recorded at

Location C and the lowest magnesium (3.2) was recorded at Location A. Highest cation exchange capacity (3.6) was recorded at Location C and lowest cation exchange capacity (3.07) was recorded at Location B.

The highest sodium value (7) was recorded at Location B and the lowest sodium (5.33) was recorded at Location A. (Table 3). The Mean Sediment physicochemical parameters were represented in a Line chart (Figure 2).

Table 1: Diversity of Macroinvertebrate in Kandolla Shella Stream

Family Name	Common Name	Species	1	2	3	Total
Corduliidae	Dragonfly	<i>Somatochlora viodiaenea</i>	9	18	26	53
Dytiscidae	Striola	<i>Hydroghyphus godeffroyi</i>	7	14	6	27
Thiaridae	Snail (red rimmed melania)	<i>Melanoidea tuberculata</i>	18	20	14	52
Chrysomelidae	Sexpunctata	<i>Liliocoris lilac</i>	4	1	0	5
Physidae	Hygrophila	<i>Physella acuta</i>	0	3	2	5
Trichoptera	Caddisflies	-	3	4	0	7
Cicadoidea	Cicada	<i>Neotibicen linnei</i>	4	9	7	20
Nassariidae	Plough snail	<i>Nassarius fossatus</i>	3	0	8	11
Heptageniidae	Mayflies	<i>Rhithoogena germanica</i>	8	6	14	28
Mantidae	Mantid	<i>Mantis octospilota</i>	6	5	12	23
Total			62	80	89	231

Footnote: 1, 2 and 3 are the Stations selected for the study

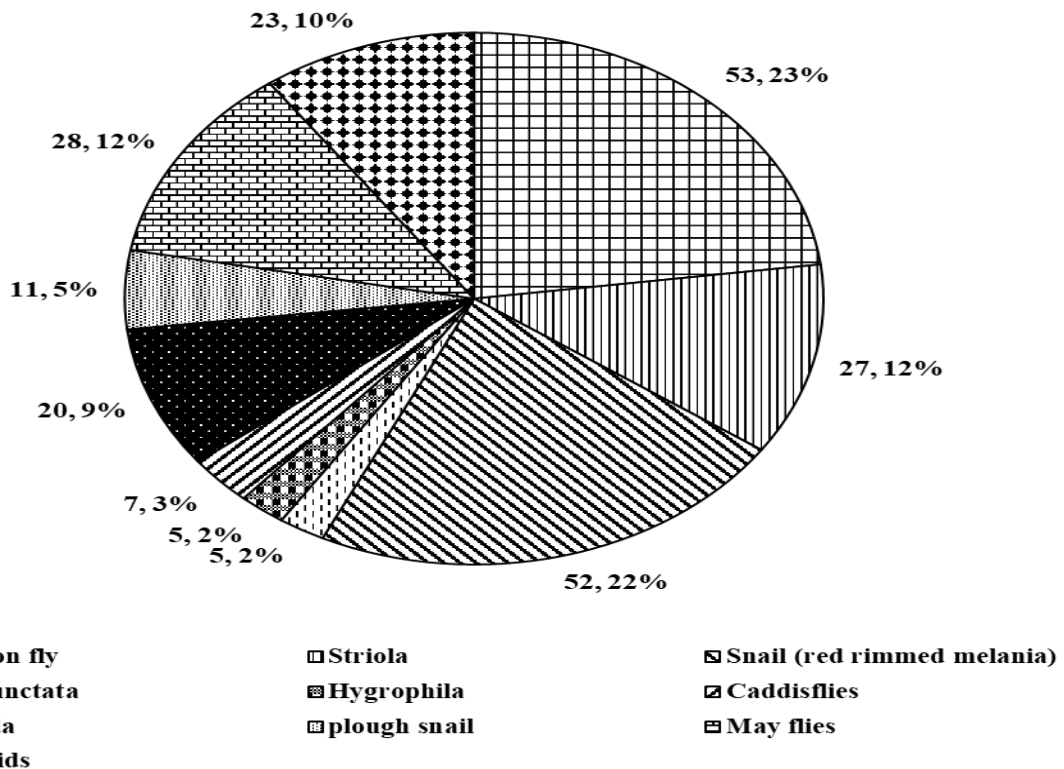


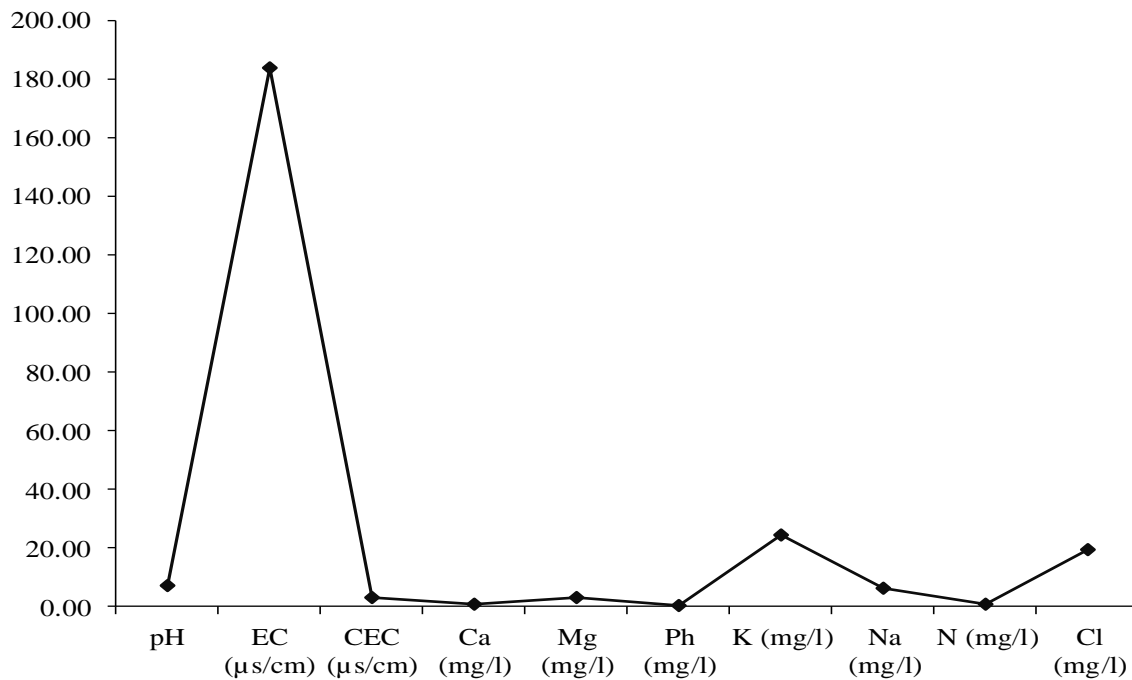
Figure 2: Diversity of Macroinvertebrate in Kandolla Shella Stream

Table 2: Biological Index of the Kandolla Shella Stream

Family	Total	Proportion	-Log	Proportion * -Log
Corduliidae	53	0.229	-1.471	-0.336
Dytiscidae	27	0.117	-2.145	-0.251
Thiaridae	52	0.225	-1.492	-0.335
Chrysomelidae	5	0.022	-3.819	-0.084
Physidae	5	0.022	-3.819	-0.084
Trichoptera	7	0.030	-3.508	-0.106
Cicadoidea	20	0.087	-2.441	-0.212
Nassariidae	11	0.048	-3.037	-0.146
Heptageniidae	28	0.121	-2.108	-0.255
Mantidae	23	0.100	-2.302	-0.230
Total	231	1.000		-1.935

Table 3: Level of Physicochemical Parameters of Sediment along Kandolla Shella Stream Stations

PARAMETERS	STATIONS			Means	SD
	A	B	C		
pH	7.45	7.3	7.48	7.41	0.0964
EC ($\mu\text{s}/\text{cm}$)	265.33	176	110.53	183.95	77.7058
CEC ($\mu\text{s}/\text{cm}$)	3.2	3.07	3.6	3.29	0.2762
Calcium (mg/l)	1.1	1.07	1.07	1.08	0.0173
Magnesium (mg/l)	3.2	3.27	3.6	3.356	0.2136
Phosphorus (mg/l)	0.2157	0.2207	0.2197	0.2187	0.0026
Potassium (mg/l)	24.33	29	20.33	24.5533	4.3393
Sodium (mg/l)	5.33	7	6	6.11	0.8404
Nitrogen (mg/l)	1	1	1.23	1.0766	0.1328
Chloride (mg/l)	18.5	17.97	21.83	19.433	2.0924

**Figure 3:** Means of Physicochemical Parameters of the Sediment along Kandolla Shella Stream

DISCUSSIONS

This study shows the diversity of macroinvertebrates diversity and sediment characteristics of the Kandolla Shella Stream. A total of 231 individuals, representing 25 families across 11 orders of macroinvertebrates, were identified. The relatively low abundance and diversity of macroinvertebrate recorded during the align with findings from Arimoro *et al.*, (2015), which identified habitat characteristics and study timelines as influencing factors. The Kandolla Shella Stream is characterized by sandy substrate, variable vegetation cover, and anthropogenic impacts, creating conditions that both support and limit macroinvertebrate diversity. In this study Ephemeroptera was only represented by the Heptageniidae family. Abundance of most species was higher at Location 3, the head water, where the rate of pollution is less. The abundance reduces in Stations 1, and 2 as a result of their sensitivity to pollution caused by antropogenic activities and the deteriorated state of the stream by the riparian users (Arimoro and Ikomi, 2008). The findings from location 3 (headwater) is consistent with the work of Keke and Arimoro (2016) who reported high abundance of macroinvertebrate in River Gbako, North Central Nigeria. Similar finding was reported by Arimoro *et al.*, (2015) from River Ogbako, Niger Delta Nigeria. Edegbene *et al.* (2015) reported low diversity and abundance of Ephemeroptera from his study in River Chanchaga, Niger State. The low abundance of macro inveterbate in location 1 and 2 are in conformity with the work of Emere and Nasiru (2009) who also reported low abundance of Ephemeroptera group in urbanized stream, Kaduna Nigeria. The low abundance of Ephemeroptera and absence of Plecoptera and Trichoptera in sampling location 1 and 2, is commonly linked to unpolluted waters (Arimoro and Ikomi, 2008), underscores the stream's pollution levels. Many studies have reported higher abundance and diversity of these groups of macroinvertebrates to clean and pollution free water bodies (Arimoro and Ikomi, 2008; Odume *et al.*, 2012; Keke and Arimoro, 2016). Corduliidae, (dragonflies) were also found in both location 1, 2 and 3. Their diversity and abundance in both stations were as a result of the vegetation cover and the bottom sediment of the river that favored their colonization. They were represented by

families such as *Somatochlora viodiaenea*. Hemipterans (*Neotibicean linnei*) were also found in some locations. Similar studies reported the above hemipteran from their works on Nigeria Freshwater (Arimoro and Ikomi, 2008; Emere and Nasiru, 2009; Arimoro *et al.*, 2015; Keke and Arimoro, 2016; Ndana, 2017). Favorable environment variables such as substrate type, vegetation covers are the factors responsible for increased species richness and diversity of subtropical African waters (Arimoro *et al.*, 2015).

Sediment physicochemical parameters from the three location was analyzed and a mean table was gotten from all three stations. The mean Phosphate value ranged from 0.2157 and 0.2207 mg/L for location 1, 2 and 3. High phosphate value observed in this study could be as a result of different human activities around the water body and surface run-off (Magami *et al.*, 2019). This finding is in consonance with the findings of Arimoro *et al.* (2015) who recorded phosphate range of 0.10-1.14 mg/L in Ogba River, Niger Delta Nigeria. Similarly, Keke and Arimoro (2016) observed phosphate ranging between 0.06-1.40 mg/L from Gbako River North-Central Nigeria. This work is in conformity with the work of Edegbene *et al.* (2015) who reported a much higher phosphate (value) from River Chanchaga Niger State, Nigeria. This finding shows contrast with the work of Okayi *et al.* (2011) who reported low phosphate level in River Benue with a range of 0.07-0.17 mg/L. Phosphate is one of the limiting factors of environmental variables because when used up aquatic environment can be unproductive (Arimoro *et al.*, 2015).

Mean Electrical Conductivity range recorded during this study was between 110 μ S/cm in Station C and 265.33 μ S/cm in location 3. The conductivity increases across the stations, this could be as a result of increase in the level of sodium ions, calcium ions and chloride, this finding is in-line with the work of Keke *et al.* (2015) who reported a high conductivity value range of 32.00-72.00 μ S/cm from surface water of downstream Kaduna River, Zungeru. Similar studies recorded a higher conductivity value range of 284-330 μ S/cm obtained from Tropical River in Southern Nigeria (Ayoade and Olusegun, 2012). The sediment analysis of this study also considered the presence of contaminants, such as heavy metals and pollutants. Contaminants in sediments can

have direct and indirect effects on aquatic organisms, influencing their health and reproductive success. The study identified specific contaminants and assessed their potential impact on species diversity. Elevated levels of calcium, potassium, magnesium, chlorine and carbon suggest pollution from agricultural runoff, aligning with findings from Ogba River (Arimoro *et al.*, 2015).

CONCLUSION

The assessment of macroinvertebrate composition revealed a rich diversity of taxa populating the Kandolla Shella Stream. Diverse orders, families, and genera were identified, and observed diversity serves not only as a testament to the ecological richness of the environments under scrutiny but also as a foundation for gauging the overall health and resilience of freshwater ecosystems.

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