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Assessment of the Ecology of Diatoms in Relation to Environmental Variables in Landzu River Bida Niger State Nigeria

[1]Mohammed, A. Z., [1]Adama, S.B., [1]Adamu, A.S., [1]Auta, Y. I. & [2]Mohammed Y.M.

[1]Department of Animal Biology,
Federal University of Technology,
Minna
Niger State.

[2]Department of Biological Sciences
Ibrahim Badamasi Babangida University,
Lapai,
Niger State.

Email: yakubmanbe@gmail.com

Abstract

Diatoms are widely utilised as excellent environmental indicators due to their ability to react to a wide range of physical, chemical, and biological changes that take place in the aquatic environment. This study was carried out to investigate some aspects of the ecology of diatoms in relation to environmental variables in Landzu River Bida, Niger state Nigeria. Samples were collected from five (5) sampling station and analysed using standard methods and procedures. The results show water temperature (23.63±2.18-25.75±0.25°C), Water depth (23.76±4.87-36.32±3.21cm), Flow velocity ranged (0.011±0.00-0.182±0.01), Water pH (7.28±0.37-7.48±0.35), Transparency (20.50±0.15-22.01±0.31cm), Electrical conductivity (118.95±0.21-144.6±0.23 µS/cm). Dissolved oxygen concentration (6.4±0.50-7.70±0.19 mg/l), the Biochemical oxygen demand (2.14±0.23-2.55±0.26mg/l), total hardness (30.5±3.19-31.26±2.8.33mg/l), alkalinity (13.83±0.74-14.00±0.71mg/l), Nitrate (0.014±0.00-0.035±0.00mg/l), Phosphate (0.028±0.01 to 0.03±0.00mg/l) the total dissolved solids (111.86±1.49 to 131.18±1.90), Magnesium (0.018±0.01-0.053±0.00mg/l), Zinc (12.02±9.00-23.45±3.00 mg/l), Nickel (4.90±0.45-5.51±0.52mg/l), Lead (0.44±0.07-1.84±0.04mg/l) and Manganese (12.58±1.30-19.43±2.70 mg/l). All the physicochemical variables measured show no significant (p>0.05) difference between the sampling stations except depth, flow velocity, dissolved oxygen, phosphate and total dissolved solids which differ significantly (p<0.05) among the sampling stations while all the heavy metal differs significantly (p<0.05) between the sampling stations except magnesium and nickel. A total of 2499 individual organisms from 25 species were identified. Station 2 had the highest number of individuals with 561 organisms, followed by station 5 with 511 organisms while station 4 had 505 organisms. Station 1 had 481 organisms, while station 3 had the lowest with 441 organisms. The study shows diatom assemblage is influenced by human activities.

Keywords: Freshwater, Biodiversity, Diatom, Landzu River.

**Author for Correspondence*

INTRODUCTION

The presence of a water body has been linked to civilisation (Hassan 2019), such that its availability determines the presence of human settlements (Fang and James, 2019). The earth's surface is about 71% water and only about 2.5% of this is fresh water. Freshwater pollution by human activities is becoming a matter of urgent concern as it threatens environmental productivity and sustainability (Mohammed *et al.,* 2020; Mohammed *et al.,* 2021). Numerous anthropogenic activities such as an increase in urbanization, industrialization and increased agricultural activities have significantly increased pressure on freshwater resources thereby altering the physical, chemical and biological uniqueness of these natural resources (Adamu *et al.,* 2021; Ebesi *et al.,* 2022; Adamu *et al.,* 2022). The physical and chemical characteristics of freshwater coupled with their biological characteristics have been used to ascertain the ecological health of freshwater bodies (Adamu *et al.,* 2021; Ebesi *et al.,* 2022; Adamu *et al.,* 2022; Mohammed *et al.,* 2023).

Diatoms can grow in fresh, brackish, or marine environments; they can also thrive in oligotrophic or eutrophic, acidic or alkaline, standing, or flowing fluids. Diatoms make up between 70 to 95 percent of the flora in aquatic systems, primarily found in the benthic population (Chia *et al.*, 2011). Diatoms are a dependable indication that have been utilised in bio-monitoring freshwater because of their potential as indicator organisms due to their tolerance of various physicochemical parameter levels (Nakanishi *et al.,* 2004; Ali *et al.*, 2015). Diatoms exhibit an integrated response to environmental and/or water quality changes, which chemical analysis may not always be able to detect. Diatoms are known to track the chemistry of river waters and other aquatic environments more carefully (Tapia, 2008; Adama *et al.,* 2023). Consequently, it is suggested that they are more beneficial and helpful than Macroinvertebrates as instruments for monitoring aquatic environments. They are recognised as the best biological elements of an aquatic environment for characterising disruptions caused by humans and by nature (Chia *et al.,* 2011). Diatoms have been used to create a wide range of indicators, including the ecological water quality index and the bioindicator value of a species or genus (Ali *et al.*, 2015). Despite the increasing urbanization and industrialization around the Bida metropolis, there is insufficient knowledge about the community structure of diatoms around the major water bodies. Thus this study is designed to explore the ecology of diatoms in river Landzu Bida Niger State Nigeria.

MATERIALS AND METHODS:

Description of the study area

Bida is a local government area located in Niger State, Nigeria. It lies in the North-Central region of the country and is situated in the northern part of the Niger State. Bida shares boundaries with Minna, Katcha, Gbako, Lavun, and Agaie local government areas (Mohammed *et al.,* 2021). The climate in Bida is typically tropical, with distinct wet and dry seasons. The dry season usually lasts from November to March, while the wet season extends from April to October. During the dry season, temperatures can soar as high as 40°C, while the wet season sees cooler temperatures with occasional heavy rainfall. The rainfall pattern in Bida follows a bimodal distribution, with the highest amount of rainfall usually recorded between June and September. This period is characterized by heavy downpours and occasional thunderstorms. The second peak of rainfall occurs in March and April, which marks the beginning of the wet season (Mohammed *et al.,* 2021). Bida experiences a humid climate with high levels of precipitation, particularly during the wet season. The region is known for its fertile soil and is suitable for agriculture, with crops such as maize, millet, and yams being commonly cultivated in the area.

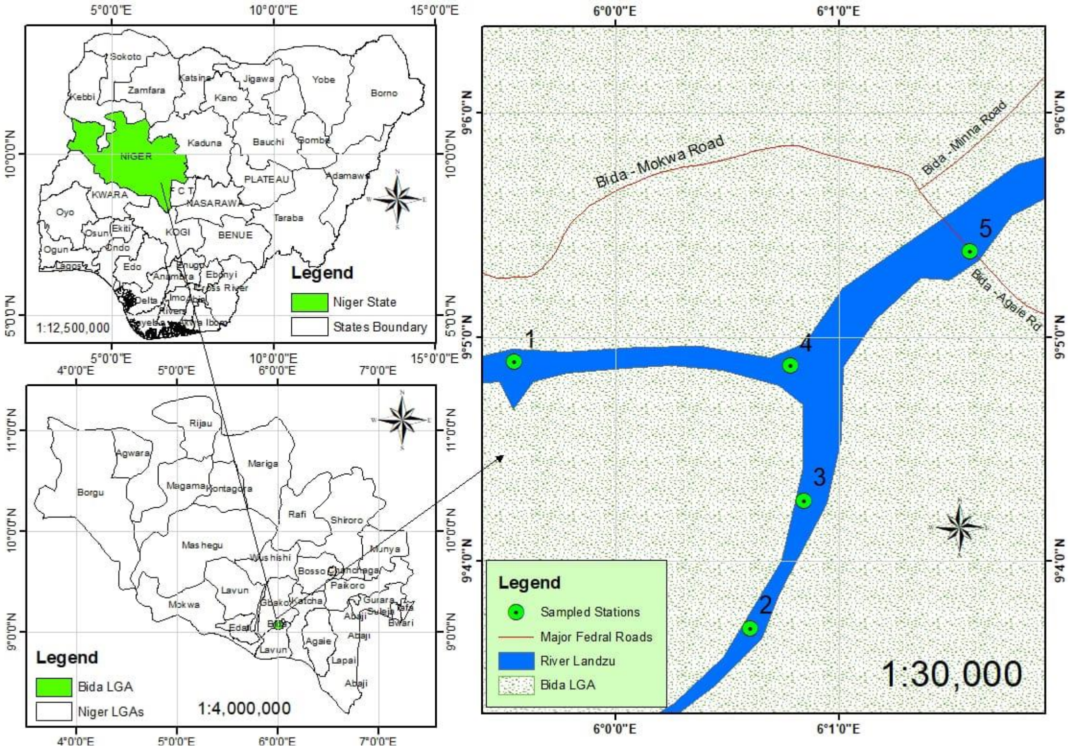

Fig. 1: Map of the study area with the location of sampling stations of Landzu River, Bida Niger State.

Sampling Stations

Five (5) station were sampled for this study base on different levels of anthropogenicity. Station 1 is located in a popular area called Dokodza, this area has GPS coordinates of 9.081522 and 5.992508. It is located in the sloppy area of the bridge. The soil around the area is red clay-like mixed with sand. Some of the activities around the area are car washing and laundry activities all of which flow into the catchment with giant trees like *Isobelina doka* and K*haya senegalensis*. Station 2 is located in an area called Kusodu-gboya: This study area has a coordinates of 9.061735N and 6.010079E. The vegetation is sparse made up of grasses, mango trees and residential houses. The soil is muddy red-brown coloured. Station 3 is popularly known as Laruta by the local inhabitants: This area has a coordinate 9.071222N and 6.014069E. Residential houses dominate the area with grasses and few shrubs. Station 4 is located in an area known as Ndamaraki: This area has a coordinate of 9.081222N and 6.013069E. Residential houses dominate the area with grasses and few shrubs. While Station 5 is called Zamfara and has Gps coordinates of 9.089726N and 6.026409E. The area does not have much vegetation only grasses. The soil is sandy with a flow of water covering the whole area it is about 40 feet by 40 feet and has bushy cover with a lot of grasses covering around

Water sample collection

The water samples for both Physico-chemical and heavy metals were collected using grab sampling in all sampling points at the surface without entrapment of air bubbles while the sediments and macro-benthic will be collected by kicking. Samples were collected monthly for a period of eight months from September to May 2022.

Determination of physicochemical parameters and heavy metal analysis of water samples from River Landzun

Water temperature was measured by dipping 100 graduated alcohol in a glass thermometer in the water in the field (^{O}C). The pH (Hydrogen ion concentration) was determined in situ using a pH meter (model number AG75pH), and conductivity was measured using a conductivity meter (model number LF90 (0.N) 0 300210). Transparency was also determined in situ using sechi disc. The Total dissolved solids, transparency, dissolved oxygen (DO) and biological oxygen demand (BOD_5), nitrate, phosphate, sodium and potassium were all determined using standard methods and procedures of the American Public Health Association method (APHA 1998).

Prior to analysis, the water samples were collected at the designated sampling points, mixed properly, and stored in a plastic container that was rinsed with 0.01N nitric acid and kept in a deep freezer. In the laboratory, 250.00 cm^3 of water sample was mixed with 5.00 cm^3 of concentrated hydrochloric acid, which evaporated to 25.00 cm^3. The concentrate was then transferred to a 50.00 cm^3 standard flask and diluted to the appropriate level with de-ionized water. Zinc, copper, iron, and manganese were measured in the water samples using an Atomic Absorption Spectrophotometer (AAS VGB 210 System), with the instrument setting and operating conditions carried out in accordance with the manufacturer's requirements.

Diatoms collection

Water samples for diatom research were collected in 100-millilitre glass jars and treated in the field with the necessary volume of Lugol solution In order to precipitate and preserve diatoms, (APHA, 1998; Chia *et al*., 2011). Diatom sample processing and analysis in the lab was done in accordance with APHA (1998) and Prescott (1977) protocols. Diatom biomass, or the number of cells per millilitre, was calculated with Bartram & Rees' drop count technique (2000). Using a 1000 × oil immersion microscope lens, hundreds of frustules were counted and species-identified on each slide in accordance with Prescott (1977) and APHA (1998).

Data analysis

The values of physico-chemical and heavy metals recorded were analysed using a statistical package for social sciences version 12.0. Duncan's multiple range analysis was used to separate the means. The taxa richness (Margalef), diversity (Shannon and Simpson dominance), and evenness indices were calculated using the PAST statistical package (Hammer *et al.* 2001) for the diatom encountered. Canonical correspondence analysis (CCA) was used to evaluate the relationship between the diatom and environmental variables.

RESULTS

Physicochemical characteristics of sampling stations in Landzu River Bida Niger State

Table 1 shows the mean value of the physicochemical parameters of the sampling stations of Landzu River Bida Niger State. Water temperature ranged from 23.63±2.18 °C in station 1 to 25.75±0.25°C in station 2. Water depth ranged from 23.76±4.87 in station 2 to 36.32±3.21 in station 5. Flow velocity ranged from 0.011±0.00 in station 2 to 0.182±0.01 in station 5. Water pH ranged from 7.28±0.37 in station 2 to 7.48±0.35 in station 4. Transparency ranged from 20.50±0.15 cm in station 2 to 22.01±0.31cm in station 5. Electrical conductivity ranged from 118.95±0.21 µS/cm in station 4 to 144.6±0.23 µS/cm in station 3. Dissolved oxygen concentration ranged from 6.4±0.50 mg/l in station 2 to 7.70±0.19 mg/l in station 4. The Biochemical oxygen demand concentration ranged from 2.14±0.23mg/l in station 5 to 2.55±0.26 in station 2. Total hardness mean value ranged from 30.5±3.19 mg/l in station 1 to 31.26±2.8.33 mg/l in station 5. Alkalinity mean value ranged from 13.83±0.74mg/l in station 1 to 14.00±0.71 in station 5. Nitrate mean value ranged from 0.014±0.00 mg/l in station 1 to 0.035±0.00 mg/l in station 5. Phosphate mean value ranged from 0.028±0.01 mg/l in station 1 to 0.03±0.00 in stations 2, 3, 4 and 5. The total dissolved solids ranged from 111.86±1.49 mg/l in station 1 to 131.18±1.90 in station 2. All the physicochemical variables measured show no significant ($p>0.05$) difference between the sampling stations except depth, flow velocity, dissolved oxygen, phosphate and total dissolved solids which differ significantly ($p<0.05$) among the sampling stations.

Table 1: Mean water physicochemical characteristics of sampling stations in Landzu River Bida Niger State from September 2021 to April 2022.

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5
Temperature (°C)	23.63±2.18a	25.75±0.25a	24.75±0.31a	23.87±0.21a	24.0±0.24a
Depth (Cm)	31.34± 3.45c	23.76±4.87a	25.32±2.54b	27.86±2.3b	36.32±3.21c
Flow velocity (M/S)	0.13±0.003b	0.011±0.002a	0.021± 0.001a	0.032±0.002a	0.182±0.01b
pH	7.38±0.43a	7.28±0.37a	7.39±0.39a	7.48±0.35a	7.36±0.36a
Transparency (cm)	20.78±0.18a	20.50±0.15a	20.69±0.15a	21.36±0.17a	22.01±0.31a
Electrical Conductivity (µS/cm)	126.62±0.36a	122.37±0.19a	144.6±0.23a	118.95±0.21a	139.458±0.22a
DO (mg/l)	6.66±1.12a	6.4±0.50a	7.33±0.21b	7.70±0.19b	7.64±0.39b
BOD_5 (mg/l)	2.45±0.33a	2.55±0.26a	2.26±0.18a	2.14±0.23a	2.13±0.27a
Total Hardness (mg/l)	30.5±3.19a	30.83±3.19a	30.98±3.04a	30.922.78a	31.26±2.8.33b
Alkalinity (mg/l)	13.83±0.74a	13.87±0.74a	13.90±0.69a	13.98±0.76a	14.00±0.71a
Nitrate (mg/l)	0.014±0.00a	0.017±0.007a	0.015±0.007a	0.04±0.006a	0.035±0.004a
Phosphate (mg/l)	0.028±0.01a	0.03±0.00b	0.03±0.00b	0.03±0.00b	0.03±0.01b
Total Dissolved Solids (mg/l)	111.86±1.49a	123.81±1.67b	117.96±2.15a	131.18±1.9b	123.19±1.71b

Values are Mean ± Standard Deviation. Different superscript letters (a, b and c) in a row show significant differences (P < 0.05) indicated by Duncan's multiple range test.

Heavy metal characteristics of sampling stations in Landzu River Bida Niger State.

Table 2 shows the heavy metal characteristics of water samples collected from the sampling stations in Landzu River Bida Niger State from September 2021 to April 2022. Magnesium mean value ranged from 0.018±0.01 mg/l in stations 1 and 2 to 0.053±0.00 in station 3. The Zinc mean value ranged from 12.02±9.00mg/l in station 5 to 23.45±3.00 mg/l in station 4. Nickel mean value ranged from 4.90±0.45mg/l in station 5 to 5.51±0.52 in station 3. Lead mean value ranged from 0.44±0.07 mg/l in station 2 to 1.84±0.04mg/l in station 5. Manganese mean value ranged from 12.58±1.30 mg/l in station 5 to 19.43±2.70 mg/l in station 1. All the heavy metal differs significantly ($p<0.05$) between the sampling stations except magnesium and nickel.

Table 2: Some heavy metal characteristics of sampling stations in Landzu River Bida Niger State from September 2021 to April 2022.

	Station 1	Station 2	Station 3	Station 4	Station 5
Magnesium (mg/l)	0.018±0.011a	0.018±0.011a	0.053±0.009a	0.031±0.002a	0.03±0.019a
Zinc (mg/l)	17.70±8.18a	17.04±8.2a	14.10±6.8a	23.45±3.0b	12.02±9.00a
Nickel (mg/l)	4.93±0.4a	5.25±0.4a	5.51±0.52a	5.5±0.5a	4.90±0.45a
Lead (mg/l)	0.59±0.09a	0.44±0.07a	0.34±0.05a	01.79±0.03b	1.84±0.04b
Manganese(mg/l)	19.43±2.7b	17.14±2.1b	14.30±1.5a	16.67±2.0a	12.58±1.30a

Diatom distribution in the sampling stations of Landzu River Bida Niger State.

Table 3 shows the diatom distribution and diversity in the five sampled stations of Landzu River. A total of 1260 individual organisms from 15 families comprising 17 genera and 26 species were identified. Table 4 shows the diversity indices of Diatoms in the sampled stations of Landzu River Bida Niger State Nigeria. The highest number of taxa was recorded in stations 1, 4 and 5 while the lowest number of taxa was recorded in station 2. A number of individuals was highest in Station 2, followed by Station 5, and the lowest number of individuals was observed in Station 3. Station 2 was more dominant when compared to other sampling stations. Evenness was highest in station 5 and lowest in station 4. Station 1 had the highest Margalef index followed by Stations 4 and 3 and Station 2 had the lowest Margalef index

Table 3 Diatom distribution in the sampled stations of Landzu River Bida Niger State.

Diatoms	**Sampling station**				
	S1	S2	S3	S4	S5
Aulacoseira_granulata	7	35	13	33	11
Campylodiscus_clypeus	10	22	13	36	40
Campylodiscus_echeneis	11	0	25	14	11
Cocconeis_placentula	24	33	2	7.0	7
Cyclotella_meneghiniana	9	4	5	3	30
Dimerogramma_minor	4	3	3	4	4
Diploneis_didyma	4	5	5	4	5
Epithemia_adnata	7	2	1	2	3
Epithemia_sorex	22	26	32	15	15
Gomphonema_gracile	13	43	14	13	22
Grammatophora_marina	22	22	13	35	22
Hyalodiscus_laev	12	24	13	11	18
Hyalodiscus_scoticus	66	54	20	24	35
Seminavis aegyptiaca	15	48	29	33	16
Navicula_cincta	22	22	29	19	19
Navicula pygmeaa	32	40	39	18	46
Nitzschia_obtusa	21	43	19	32	22
Nitzschia_scalaris	33	19	17	24	27
Planothidium_hauckianum	24	36	33	49	17
Pleurosira laevis	21	31	29	14	14
Rhoicosphenia curvata	14	0	0	3	36
Rhopalodia acuminata	15	6	17	35	23
Rhopalodia gibba	46	28	33	51	51
Synedra ulna	13	0	22	15	6
Tryblionella granulata	14	15	15	11	11

Table 4: Diversity indices of Diatoms in the sampled stations of Landzu River Bida Niger State from September 2021 to April 2022

Diversity indices	Station 1	Station 2	Station 3	Station 4	Station 5
Taxa_S	25	22	24	25	25
Individuals	481	561	441	505	511
Dominance_D	0.05976	0.06117	0.05582	0.05938	0.0559
Evenness_e^H/S	0.812	0.8154	0.8226	0.7771	0.8202
Margalef	3.886	3.318	3.777	3.856	3.848

Relationship between environmental variables and diatom assemblage in the sampled station of Landzu River

Figure 2 shows the relationship between environmental factors and diatom species recorded in the study area. The strongest negative relationship was exhibited between electrical conductivity, temperature and Manganese with total hardness, transparency, Alkalinity, Total Dissolved Solids, Phosphate, Dissolved Oxygen and lead (Table 5). It was observed that *Synedra ulna* and *Tryblionella granulata* were very much associated within the vicinity of electrical conductivity, whereas *Navicula cinta*, and *Planothidium haukainum*, were associated in the vicinity of temperature, Nickel, manganese were associated with sampling stations 1 and 3. Above 37% of the variations in the species abundance data were encountered by the environmental variables measured in axis 1. The Monte Carlo permutation test indicated that all the axes were significant. The main environmental parameters in axis 1 are pH, nitrate and TDS.

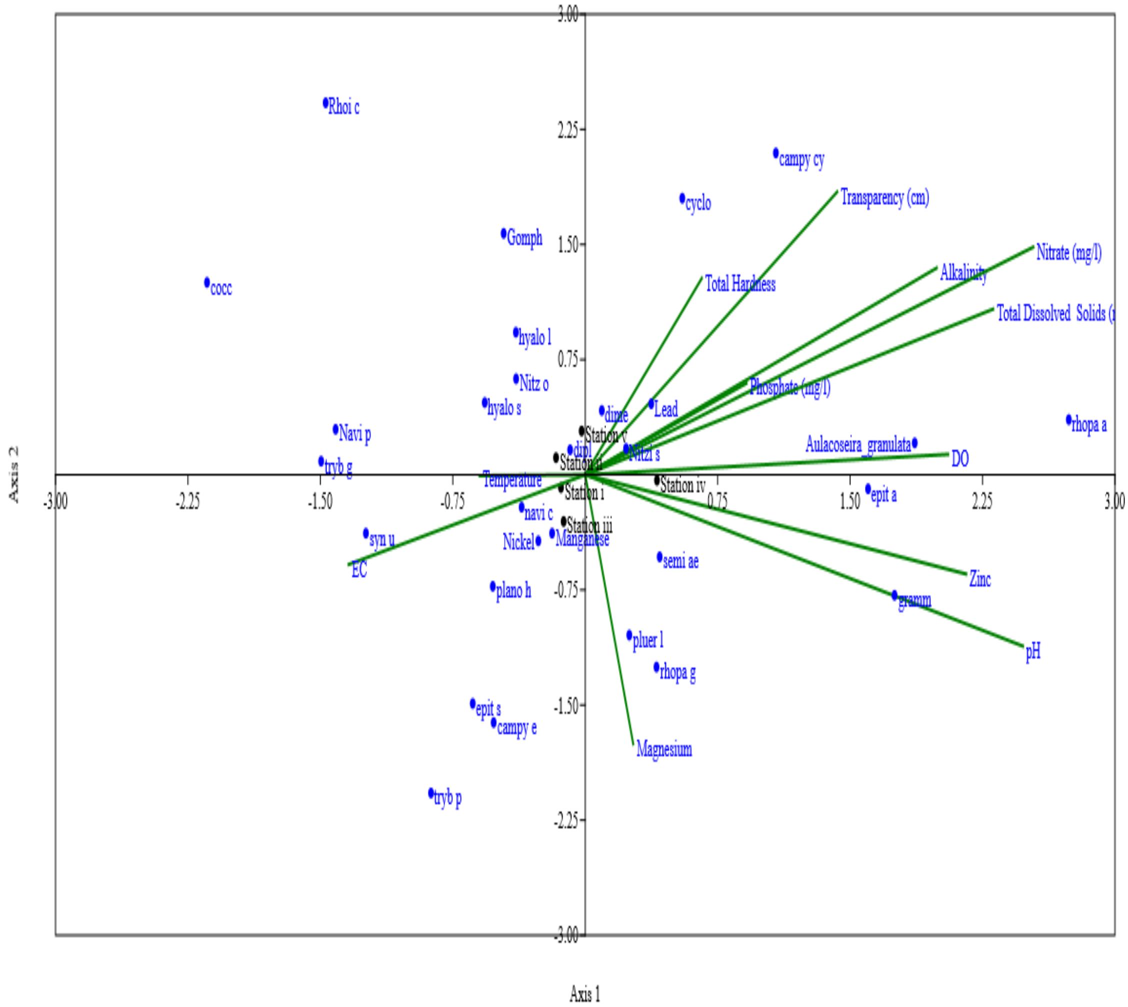

Figure 2: Canonical correspondence analysis of physico-chemical parameters and Diatoms of Landzu River from October 2022 to 2023.

Table 5: Weighted Intraset Correlation with the Axes of Canonical Correspondence Analysis (CCA) of Diatom and Environmental Variables in the Study Area.

Axis	1	2	3	4
Eigenvalue	0.05*	0.034	0.028	0.016
%	37.82	27.16	22.35	12.67
Monte Carlo permutation test	0.785	0.764	0.801	0.662
Zinc	**0.56***	**-0.41***	0.27	**0.60***
Nickel	-0.27*	**-0.45***	**0.86***	-0.07
Lead	0.32	**0.53***	0.13	-1.22178
Manganese	-0.18	-0.39	**0.64**	**0.61***
Temperature	-0.23	0.01	-0.96**	-0.03
pH	**0.85****	-0.35	0.27	-0.08
Transparency (cm)	0.45*	0.63*	0.46*	-0.46*
EC	-0.45*	-0.20	0.27	-0.82**
DO	0.67**	0.08	0.21	-0.67*
BOD	0.56*	0.50*	-0.22	-0.65*
Total Hardness	0.18	0.46*	-0.15	-0.87**
Alkalinity	0.63*	0.49*	0.01	-0.62*
Nitrate (mg/l)	**0.82****	0.53*	0.05	-0.27
Phosphate (mg/l)	0.26	0.24	-0.68	-0.67*
Magnesium	0.09	-0.56	-0.12	-0.80
Total Dissolved Solids (mg/l)	**0.73****	0.41*	-0.54*	-0.19

Note: * Significantly different at $p<0.05$ ** Significant at $P<0.01$

Discussion

Since diatoms react directly and sensitively to a wide range of physical, chemical, and biological changes that take place in the aquatic environment, they are important environmental indicators (Ekhator *et al.,* 2015, Ebesi *et al.,* 2022, Adamu *et al.,* 2021). In favourable circumstances, diatom blooms have the potential to harm other biological systems (Adamu *et al.,* 2021; Ebesi *et al.,* 2021). A river's phytoplankton diversity, quantity, and distribution are directly correlated with the water quality and, by extension, the composition of the entire community (Adamu *et al.,* 2022). The water temperature recorded in this study was within the expectation of African surface waters and allowed for fish production and the survival of aquatic organisms in warm waters (Fadimatu *et al.*, 2020; Adamu *et al.,* 2022; Maishanu *et al.,* 2022). Ambient temperature was reported to support normal biological activities of all living organisms as it is the best temperature at which all enzymes that power the living tissue operate. Consequently, a higher number of diatoms were recorded in station two which tallied with a higher temperature recorded compared to other stations which had a lower number of individuals. The pH values recorded from this study are within that which is most suitable for the survival of all aquatic organisms in surface freshwaters (Golmarvi *et al.*, 2019; Mohammed *et al.*, 2020, Junita *et al.*, 2020). The transparency of lakes and rivers is normally observed to affect productivity, water temperature and distribution of organisms **(**Keke *et al.* 2015**)**. Most likely because the river Landzu is shallow and allows for so much turbulence of the water with the sediment. The transparency was observed to provide a significant contribution ($P< 0.05$) to the distribution of both the organisms. In this study, the DO value observed was fairly high and this high value was similar to the report of Susilowati, *et al.* (2018) who recorded a higher value of DO ranging from 3.1 mg/L to 9.52mg/L in Madiun River which flows through Madiun city in Indonesia. Oscar *et al.* (2015) postulated that better aeration and exposure to the atmosphere air could result in high photosynthetic activity and therefore higher dissolved oxygen. Better water quality is expected in the upper reaches of most water bodies before it gets the polluted areas, but in this case, a higher water quality was observed in station 5 most likely because the water drops from a fall and it attracts oxygen into it. This is contrary to the report of Keke *et al.* (2017) who reported a higher value in the upper reaches of Gbako River in Niger State. The poor water quality in station 1 may be due to the use of detergent used in the laundry activities in the area.

Nitrate and phosphate are among the limiting nutrients required for aquatic environment productivity (Mohammed *et al.,* 2020; Mohammed *et al*., 2021; Mohammed *et al.,* 2023). Normal nitrate level expected of inland waters should not be more than 5.00 mg/l and the values observed in this study ranged between 0.035±0.04 mg/l to 0.17±0.007 mg/l. The result obtained here agrees with the findings of Adedokun *et al.* (2008). The low nitrate value recorded in this study could be due to the influence of runoff into the channel resulting in the dilution of the excesses from homes (Ibrahim *et al*., 2009). The phosphate value observed in this study is in line with the report of Keke *et al.* (2015).

Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes. The problem is the narrow range between essentiality and toxicity (Addo *et al.,* 2012). The diet is normally the principal source of zinc. Although levels of zinc in surface water and groundwater normally do not exceed 0.01 and 0.05 mg/l, respectively (WHO 2008), concentrations in tap water can be much higher as a result of the dissolution of zinc from pipes. The concentration of Zinc recorded in this study varies from 1.20 mg/l to 2.35 mg/l. Holcombe and Andrew (1978) have related the toxicity of zinc to pH and water hardness and they proved that increased hardness results in an increase in zinc toxicity. Lead is an element that is not much use in terms of nutrition. It is useful for industrial purposes. Though the WHO (2008) limit expected for freshwater is 0.01mg/l, its presence in any amount of water is considered toxic. The concentration recorded in River Landzu has made it polluted with heavy metals. Vincent-Akpu and Yanadi, (2014) recorded a value of 43.2 (mg/Kg) of lead in the sediment of Iwofe site on the New Calabar River, Rivers State, Nigeria. This value is higher than the permissible limits of WHO (2011). The high value of the lead in station 5 could be due to the proximity to mechanic workshops and trailer yards close by.

In this study, a total of 2499 individual organisms from 25 species were identified. More of the organisms were recorded in station 2 with 561 organisms, followed by station 5 with 511 organisms while station 4 had 505 organisms. Station 1 had 481 organisms, while station 3 had the lowest with 441 organisms. The nature of the study area may account for the rich number of organisms that were encountered. Once the natural community of the organisms can be predicted, deviations due to organic and anthropogenic activities can be more easily implicated. The 26 species recorded in this study are low when compared to other studies like 53 diatom species reported by Ekhator *et al.,*(2015), Onyema 2010 also reported 56 diatom species for Lagos beach. Davies *et al.,* (2009) recorded 108 diatom species for Elechi Creek, Niger Delta and Emmanuel and Onyema, (2009) also recorded 69 diatom species for an estuarine creek, South Western Nigeria; while it is higher than the observations of other researchers like the reports of Kadiri and Opute (2003) who recorded 18 diatom taxa from Ikpoba reservoir, Kadiri and Omozusi (2002). reported 12 diatom species for Okhuahe River. By this investigation, information on the composition and abundance of diatoms of Osse River which prior to this time was not documented has been brought to the fore. Moreso, with the information provided, the Osse River can be seen as a water body which is ecologically safe and can support aquatic life.

The Eigenvalues produced from the CCA of Diatom and the environmental variables accounted for about 84% of changes in the dataset. The Monte Carlo permutation test has indicated that the parameters under the test significantly affect the distribution of the organisms most especially pH, nitrate and TDS. Barranguet *et al.* (2005) investigated the effects of pH on diatom communities in freshwater sediments and found that acidic conditions (pH < 6) significantly reduced diatom biomass and diversity. Conversely, high pH levels, associated with alkaline conditions, can also affect diatoms. Alkaline pH values can lead to the dominance of certain diatom species that are more tolerant to high pH conditions. A study by Padisák *et al.,* (2003) explored the effects of pH on diatom communities in shallow alkaline lakes and reported a shift in species composition towards alkaline-tolerant diatoms as pH increased.

CONCLUSION

From the study it was observed some of the Physico-chemical factors and the heavy metals in the study area are higher than expected in the flowing metals, showing an indication of pollution. More of the organisms were recorded in station 2 with 561 organisms, followed by station 5 with 511 organisms while station 4 had 505 organisms. Station 1 had 481 organisms, while station 3 had the lowest with 441 organisms. Results have shown that all the organisms identified in all the stations were significantly different, while in some sampling stations no organisms were detected. In general, a total of 1260 different organisms were observed in the study area.

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