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Full Length Research

Exploring the Impact of Human Activities on Water Quality Characteristics of a Rural River in North-Central Nigeria using Macroinvertebrates Structural Assemblage

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Abstract

Rural rivers play an important role as a major water supply in most parts of Northern Nigeria. Wanzum River is a major source of water to nearby communities. It serves various purposes, such as source of drinking water, fishing, irrigation and other domestic purpose. In this study, we explored the impact of human activities on macroinvertebrates assemblage and physicochemical data to ascertain the water quality status of the river. Samples of Physicochemical parameters and macroinvertebrates were collected from four (4) different stations for 12 months (December 2021-November 2022) using standard methods and procedures. The result of all the physicochemical data measured showed no significant ($P>0.05$) difference among the sampling stations except dissolved oxygen and turbidity. However, all the monitored physicochemical parameters differed significantly ($P < 0.05$) among the sampling months except dissolved oxygen. A total of 1385 individuals from 36 macroinvertebrates species were collected from all the sampled stations. Hemiptera had highest number with 760 individuals, Coleoptera (228 individuals), Odonata (138 individuals) and Trichoptera (3 individuals). The constructed Principal Component Analysis (PCA) correlation matrix was able to separate the perturbed and the less perturbed stations from each other as station1 and 4 which were the less perturbed, correlated positively with PCA axis 1. The canonical correspondence analysis (CCA) result showed little or no positive correlation between macroinvertebrate assemblages and the measured environmental variables as eigen value of both CCA axis is less than 1 (<1). The low abundance of Pollution sensitive taxa such as the Ephemeroptera and Trichoptera, as well as the high abundance of Hemiptera, and Coleoptera indicate that Wanzum River is being stressed along its course. Obviously, sampling stations 2 and 3 showed this stress as they recorded no members of Trichoptera group.

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INTRODUCTION

Natural resources such as river systems are vital for life, the ecosystem, industrial and agricultural activities, proper hygiene and sanitation coupled with the production of electricity (Adamu *et al.*, 2022). River systems supply a variety of essential commodities and services to society, including movement of sediment, recreation areas and eco-tourist destinations (Mohammed *et al.*, 2021). The activities of the water system are challenged by industrial operations, accelerated urbanization, waste discharge and solid garbage (Mohammed *et al.*, 2020) along its coast. The freshwater ecosystem is not an exception to these pollution threats as effluent from industries, surface runoff from agricultural fields, channeling of domestic sewage into water bodies, mining and construction activities or other anthropogenic activities possess significant threats to living organisms throughout the world (Agboola *et al.*, 2020).

Human activities alter water quality conditions that have led to detrimental effects on aquatic life and the whole ecosystem processes (Ko *et al.*, 2020). Thus, rivers catchment is one of the most vulnerable ecosystems as they are increasingly being subjected to a variety of anthropogenic stressors, such as habitat loss, flow change, rising demand for water, increase urbanization, and intensification of agricultural activities (Mamun and An, 2020). As a result, riverine ecosystems' structure and function have been negatively impacted by reduced hydrological connection, exposure to invasive species, increase loads of nutrient and sediment which lead to loss in biodiversity (Achieng *et al.*, 2021). The majority of these effects are the result of numerous interrelated processes. The multiplicity of stressors and habitat changes associated with them make it difficult to predict how rivers will react to human activity, and thus makes it difficult to make an overall assessment of the health of the world's rivers (Zhao *et al.*, 2019). However, by identifying similarities in different stressors within categories of human activities and how rivers respond to these stressors, it may be possible to determine the impact of the stressors on direct or indirect regulation of the ecosystem services and better predict the effects of human activities (Achieng *et al.*, 2021). In many parts of the world, efforts to safeguard freshwater ecosystems have prioritized tracking changes in the quality of water using biological assemblages over time (Ko *et al.*, 2020; Aura *et al.*, 2020).

Based on the idea that the existence or disappearance of specific species at sampling site indicates certain ecological quality, biological communities have become particularly popular as markers of change (Aura *et al.*, 2021). Therefore, studies on the human impacts on freshwater ecosystem has significantly contributed to ascertaining the modification of the structure and functions of ecosystems. These researches have significantly improved for the past 4 decades by investigating how different taxa respond to different environmental variables and also developing how each species relates to pollution gradients as a result of human influence in the environment (Ko *et al.*, 2020; Aura *et al.*, 2020; Aura *et al.*, 2021).

In comparison to similar studies conducted in other part of the globe, the use of biological indicators in assessing the health of aquatic ecosystems within the Afrotropical region is generally lagging (Ruaro *et al.*, 2020). Although there are numerous aquatic organisms that can be taken into account when evaluating the health of rivers, regional indices have largely concentrated on macroinvertebrates which are rarely identified down to the species level and have some degree of accuracy because of regional differences in physiography and ecology (Masese *et al.*, 2020). These methods are used for research in the Afrotropical region despite this restriction. However, the identifying keys and indices are normally produced elsewhere. For instance, the South African Scoring System served as a model for the Zambia Invertebrate Scoring System, Tanzania River Scoring System, and macroinverte-brate-based biotic score system (Achieng *et al.*, 2021). Aquatic macro-invertebrates are the part of a river that are most responsive to human stresses (Agboola *et al.*, 2020; Ko *et al.*, 2020).

Macroinvertebrate responses to changes in the status of aquatic ecosystems are well acknowledged, and their responses are employed as indices to check the integrity of freshwater ecosystems and support management decision-making (Tampo *et al.*, 2021; Edegbene *et al.*, 2021). Studies have shown that macroinvertebrates combine a variety of advantageous traits, including ubiquity, varying degrees of perturbation tolerance, and cost-effective sampling, as they are frequently utilized in assemblages for biomonitoring (Agboola *et al.*, 2019; Ko *et al.*, 2020).

The inferences about pollution loads have been made using the diversity and composition of freshwater macroinvertebrate species, which alter in response to organic pollution (Tampo *et al.*, 2020). High abundances and richness of species can typically be found in natural, pure rivers (Tampo *et al.*, 2021). The biodiversity and assemblages of the river fauna undergoes significant changes as a result of the high impact produced by human activities (Tampo *et al.*, 2021).

The Wanzum River is a tributary of River Kaduna popularly called Edu by the Nupe people who are the indigenous tribe found along the bank of the River Kaduna in Niger State, Nigeria. Wanzum River serves as the primary source of water for the neighboring communities, which consist primarily of farmers engaging in rice cultivation and fishing along the riverbank. The river provides water for consumption, cleansing, bathing, and irrigation. It is also a means of conveyance during floods. Insufficient literature exists on the biological communities of the Wanzum River. This study provides an insight into the impact of human activities on the distribution, diversity of macroinvertebrates and the physicochemical status of the Wanzum River, Niger State, Nigeria.

MATERIALS AND METHODS

The study area

The study area lies within the interception of latitude of 8°802N to 8°805N and longitude 5°960 to 5°943E of the equator. Wanzum River (Figure 1) is located along Mambe-Tifin and Mambe-Tako, a rural settlement in Niger floodplain of Lavun Local Government of Niger State. The study area falls in the savannah region of Northern Nigeria. The study area is characterized with two distinct seasons which is the dry season (which falls within the months of November to March, and is completely devoid of rainfall) and rainy season (which spans from April to October). Wanzum River is annually flooded by the Kaduna River between the months of August and October. The vegetation of the area reflects that of the

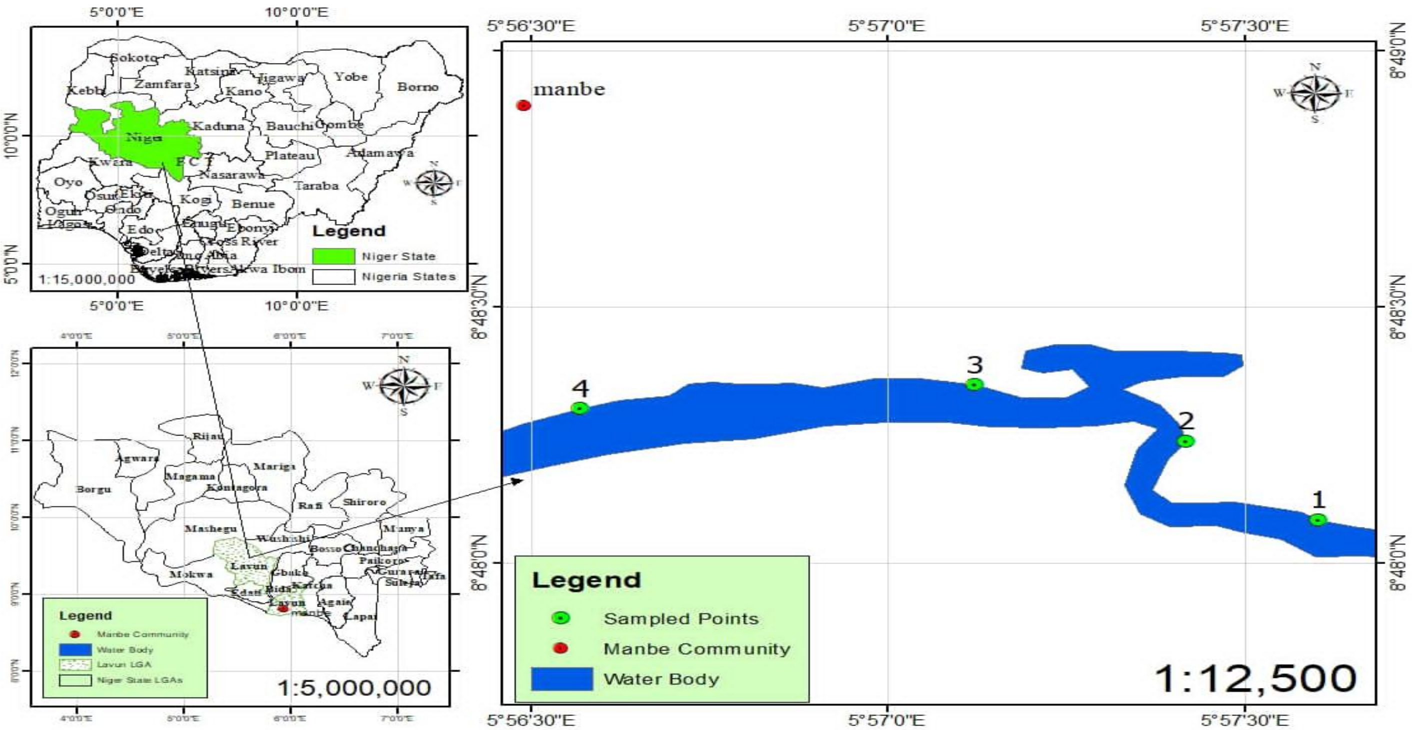

Figure 1. Map of the sampled stations of Wanzum River in the studied area.

savannah region which is characterized with grasses, shrubs and few scattered trees along the bank of the river.

Sampling stations

Sampling station 1: This was located along Mambe-Tifin and Gbade axis. It is called *Kponkparagi* by the local inhabitants. This station is characterized by few anthropogenic activities such as fishing and irrigation of water to farms at the bank of the river.

Sampling station 2: This was approximately one kilometer away from station 1 and it is located close to a motorable bridge along Mambe-Tifin and Egbagi road. This station is called *Mindu* (*Kpatayizagizhi*). The station is characterized with numerous anthropogenic activities such as laundry and washing of household utensils by women, car wash, fishing and irrigation of water to farms at the bank of the river. Sometimes, sand dredging also takes place at this station.

Sampling station 3: This was approximately one kilometer away from station 2 and it is one of the prominent landing sites for fishermen. This station is called *Tachin* and it is located in between Mambe-Tifin and Mambe-Tako. The station is characterized by numerous anthropogenic activities such as bathing, laundry, car wash, fishing and irrigation of water to farms at the bank of the river.

Sampling station 4: This was approximately three kilometers away from station 3. The station is quiet and an enclose region of the river. This station is called *Edzwanbiye* by the inhabitants. Fishing and fetching of water for household use are the only activities that take place at this station.

Physicochemical variables sampling and analyses

Water samples were collected at monthly intervals for a period of one year (December 2021 to November 2022). This study analyzed the monthly physicochemical data of water temperature, depth of the water, flow velocity and pH of the water as well as the concentration of dissolved oxygen (DO) and biochemical oxygen demand (BOD), total alkalinity (TA), electrical conductivity (EC), total hardness (TH), nitrate, phosphate and turbidity.

The water temperature was determined *in-situ* using a thermometer (mercury-in-glass type). The water depth was determined using a calibrated stick as described by Gordon *et al.* (1994) Flow rate was measured by timing a drifted ball on top of the water for three trials and average of the trials were taken as the flow rate of each sampled stations measured in meters per seconds (m/s). The pH, electrical conductivity and turbidity, were measured with the aid of a digital multipurpose metre (Hannah model HI 991300/1) while total hardness, total alkalinity, nitrates, phosphates, DO and BOD concentrations were determined using the standard methods and procedures of the American Public Health Association (APHA 2012).

Sampling, sorting and identification of macroinvertebrates

To collect the macroinvertebrates samples, a modified kick net with a mesh size of 500µm was towed against the water current within a 40-meter wadable section of each station's diverse sediments. Each sampling stations was sampled for 10 minutes and in each sampling station, macroinvertebrates samples were collected from the riffle, run and pool to achieve heterogeneity.

The macroinvertebrates collected from each sampling station's diverse habitat were combined into a single composite sample. Preliminary sorting was performed in the field by emptying all collected samples per station onto a white enamel tray and using forceps to transfer movable organisms to a 10% formalin-filled container. Samples were taken to the Biology Department research laboratory, Ibrahim Badamasi Babangida University Lapai for final sorting and identification. Identification was carried out using identification keys available in Nigeria (Arimoro and James, 2008; Umar *et al.,* 2013) and supplemented with other identification keys available in Africa (Day *et al.,* 2002; Gerber and Gabriel, 2002; De Moor *et al.,* 2003).

Data analyses

In this study, physicochemical variables for all the sampled stations were subjected to descriptive statistics (mean and standard error) using paleontological statistical software (PAST version 4.02). Mean values of all the physicochemical variables measured among the sampled stations and sampled months were compared using two-way analysis of variance (ANOVA) without replication to test for significant differences ($P < 0.05$). Furthermore, Tukey's Honestly Significant Difference (HSD) test was used as a post-hoc analysis when the ANOVA indicated significant differences to identify the stations that varied. To determine the impact of anthropogenic stressors on the water quality of the river, we compared the physicochemical variables in this study with those of Standard Organization of Nigeria (SON, 2005) and World Health Organization (WHO) standards for surface and drinking water. The structural assemblage of macroinvertebrates was presented in tables. Bar charts were used to showed the monthly distribution of each station. Principal component analysis (PCA) was used to link physicochemical variables with the sampling stations. The diversity function on PAST was used to calculate ecological statistics such as the Margalef index, Simpson diversity, Evenness index, and Shannon-weiner diversity (Hammer *et al.,* 2001). In the PAST software programme, we used canonical correspondence analysis (CCA) to investigate the connections between macroinvertebrates and examined physicochemical variables (Hammer *et al.,* 2001). The physicochemical variables and macroinvertebrates at the four sampled locations were compared using 999 permutations of the Monte-Carlo permutation test.

RESULTS

Physicochemical variables of the sampling stations of Wanzum River

The summary of the mean values of physicochemical variables of Wanzum River (Table 1) revealed water temperature ranged from 23.99±0.42°C in station 4 to 24.90±0.50°C in station 3. The water depth ranged from 49.50±4.78cm in station 2 to 57.16±4.52cm in station 3. Flow velocity ranged from 0.07±0.01m/s in station 1 to 0.10±0.01m/s in station 3. The pH ranged from 6.88±0.11 in station 2 to 7.10±0.10 in station 4. Conductivity was lowest (66.90±7.24µS/cm) in station 3 and highest (76.60±8.74 µS/cm) in station 2. The alkalinity ranged from 23.00±0.91mg/L in station 2 to 28.6±1.09mg/L in station 4. Total hardness ranged from 30.7±1.76mg/L in station 2 to 33.20±2.62 mg/L in station 3. Dissolved oxygen ranged from 5.86±0.21mg/L in station 3 to 6.73±0.31mg/L in station 1. Biochemical oxygen demand ranged from 3.74±0.21mg/L in station 3 to 4.17±0.36mg/L in station 2. Nitrate ranged from 1.26±0.31mg/L in station 1 to 1.47±0.41mg/L in station 3. Phosphate ranged from 0.40±0.11mg/L in station 1 to 0.77±0.25mg/L in station 4. Turbidity ranged between 125.22±1.76 NTU in station 4 to 143.88±4.25 NTU in station 2.

Of all the parameters measured, only dissolved oxygen and turbidity showed significant ($P < 0.05$) difference while the remaining parameters showed no significant difference between the stations. All the parameters measured in this study differed significantly ($P < 0.05$) among the sampling months except dissolved oxygen

Correlation matrix between physicochemical variables of the sampling stations of Wanzum River, Niger State

The constructed principal component analysis revealed that the first and second component (Axes) of the principal component accounts for 93.45% of the variance (Figure 2). The PCA correlation matrix shows that station 1 and station 4 which are the less perturbed correlated positively with PCA axis 1 which had an eigen value of 101.37 with 72.64% variance of the dataset. PCA axis 1 of this study was influenced by depth, flow velocity, conductivity, BOD, nitrate and turbidity. PCA axis 2 had an eigen value of 29.04 with 20.81% variance of the dataset, and its correlation matrix correlated positively with station 2 and 3 which are the perturbed sites. PCA axis 2 of this study was influence by conductivity, DO, BOD and turbidity.

Macroinvertebrates assemblages in the sampling stations of Wanzun River

A total of 1385 individual from 36 species of macroinvertebrates were collected from all the sampled station of

Table 1. Physicochemical parameters of sampled stations of Wanzum River, Niger State.

Parameter	Stations				Stations		Months		Maximum Permissible limit	
	S1	S2	S3	S4	F-value	P-value	F value	P-value	SON	WHO
Water temperature (°C)	24.5±0.55[a] 22.20-27.80	24.25±0.44[a] 21.30-26.3	24.90±0.50[a] (22.00-27.00)	23.99±0.42[a] (21.20-26.40)	0.641	0.592	5.782	2.70E-05	Ambient	
Depth (cm)	51.07±5.04[a] (33.00-80.80)	49.50±4.78[a] (33.07-77.90)	57.16±4.52[a] (37.00-83.00)	50.57±4.78[a] (34.2-77.00)	0.523	0.668	57.468	1.85E-19		
Flow velocity (m/s)	0.07±0.01[a] (0.01-0.12)	0.09±0.01[a] (0.01-0.12)	0.10±0.01[a] (0.01-0.18)	0.09±0.01[a] (0.01-0.13)	1.173	0.33	6.589	7.01E-06		
pH	7.07±0.14[a] (6.62-7.93)	6.88±0.11[a] (6.54-7.56)	7.00±0.12[a] (6.57-7.78)	7.10±0.10 [a] (6.70-7.56)	0.641	0.5935	15.861	3.86E-09	6.5-8.5	7.0-8.5
Electrical Conductivity (μS/cm)	74.8±8.80[a] (22.0-110.00)	76.60±8.74[a] (31.0-114.00)	66.90±7.24[a] (25.00-92.00)	69.20±7.50[a] (24.00-92.00)	0.322	0.809	19.899	2.47E-10	1000	600
Total alkalinity (mg/L)	23.7±1.39[a] (14.0-28.00)	23.00±0.91[a] (16.00-26.00)	24.00±11.63[a] (16.00-32.00)	28.6±1.09[a] (16.00-28.00)	0.105	0.956	8.703	2.75E-06		600
Total hardness (mg/L)	31.30±2.39[a] (20.00-46.00)	30.7±1.76[a] (20.00-40.00)	33.20±2.62[a] (20.00±50.00)	32.8±2.12[a] (25.00-46.00)	0.279	0.839	13.838	1.89E-08		
Dissolved oxygen (mg/L)	6.73±0.31[a] (5.40-8.00)	6.48±0.15[a] (6.00-7.20)	5.86±0.21[b] (5.00-7.00)	6.58±0.21[a] (5.80-7.20)	3.115	0.003	1.238	0.309		5
Biochemical oxygen demand (mg/L)	3.80±0.29[a] (3.00-5.50)	4.17±0.36[a] (2.00-6.10)	3.74±0.21[a] (3.00-5.00)	3.89±0.16[a] (2.90-4.80)	0.497	0.686	2.498	0.028		5
Nitrate (mg/L)	1.26±0.31[a] (0.23-2.81)	1.39±0.40[a] (0.18-3.36)	1.47±0.41[a] (0.23-3.65)	1.33±0.33[a] (0.20-2.74)	0.055	0.982	5.782	2.90E-05	50	
Phosphate (mg/L)	0.40±0.11[a] (0.12-1.22)	0.55±0.13[a] (0.11-1.38)	0.70±0.28[a] (0.17-2.88)	0.77±0.25[a] (0.19-2.52)	0.618	0.608	12.268	3.22E-07		
Turbidity (NTU)	131.55±2.69[b] (120-142)	143.88±4.25[a] (125-163)	140.11±3.32[a] (126-150)	125.22±1.76[c] (120-136)	7.096	0.008	2.647	0.027		

Note: *Values: mean ± standard error (range); values with different superscript differs significantly (*$p<0.05$*) across column

Wanzum River (Table 2). Number of individuals was highest in station 1(371) and lowest in station 3 (323). The record of Hemiptera was highest with 760 individuals and were presence in all the sampled stations. This was followed by Coleoptera with 228 individual and the lowest Coleoptera was in station 4. Odonata record 138 individual and highest Odonata was found in station 1 with 38 individuals. Decapoda record 96 individuals, Arachnida 77 individuals, Ephemeroptera 40 individuals and Diptera has 14 individuals, Trichoptera record was lowest with 3 individuals in all the samples stations and were only

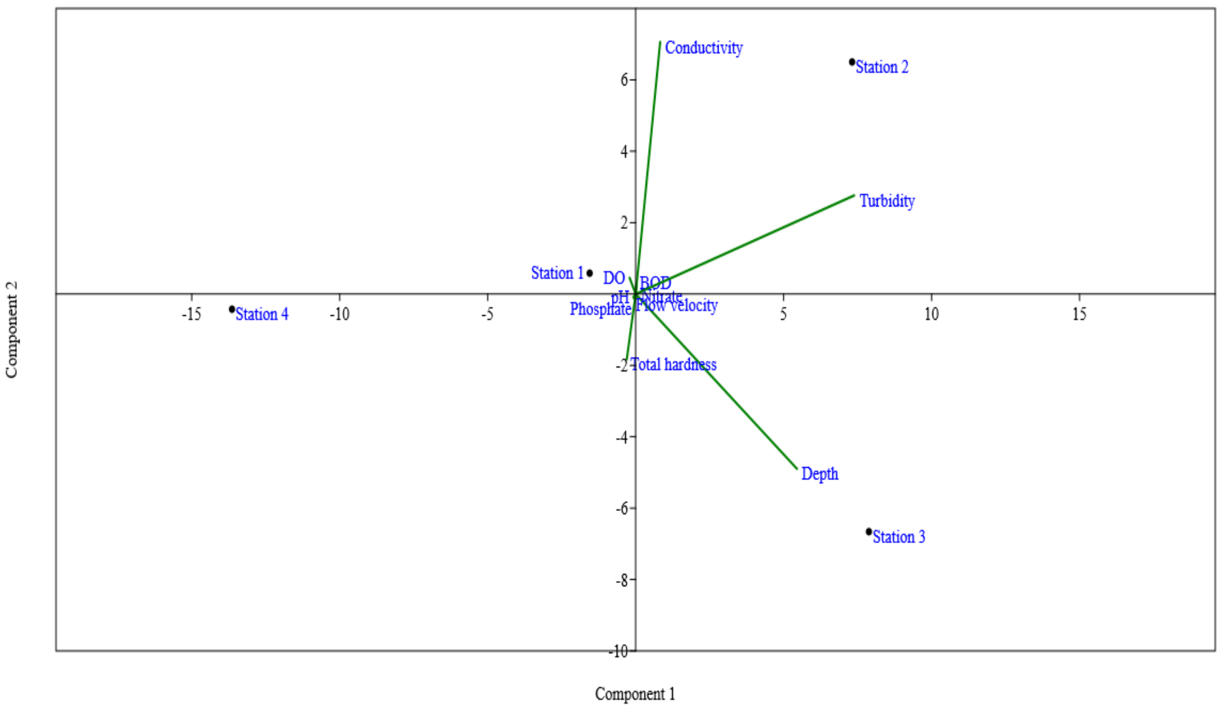

Figure 2. Correlation matrix of PCA showing the relationship between Physicochemical parameters and the sampling station of Wanzum River.

Table 2. Macroinvertebrate assemblage of the sampled station Wanzum River Niger State Nigeria.

Group	Family	Species	Codes	Station 1			
				1	2	2	4
HEMIPTERA	Nepidae	*Ranatra* sp.	Ran	10	5	12	3
		Nepa sp.	Nep	1	4	2	2
	Notonectidae	*Notonecta* sp.	Not	107	131	139	146
	Vilidae	*Rhagovelia* sp.	Rha	0	0	3	2
	Belostomatidae	*Belostoma* sp.	Bel	8	27	17	12
	Hydrometridae	*Hydrometra* sp.	Hyd	2	2	0	3
	Naucroridae	*Naucoris* sp.	Nau	6	23	13	12
	Gerridae	*Gerris* sp.	Ger	1	0	3	0
	Corixidae	*Corixini* sp.	Cor	21	15	14	14
ODONATA	Coenagrionidae	*Coenagrion* sp.	Coe	21	8	22	15
		Pseudogrion sp.	Pse	8	9	4	16
	Lestidae	*Lestes* sp.	Les	5	0	0	0
	Gomphidae	*Ophigomphus* sp.	Oph	1	12	2	0
	Libellubidae	*Libellula* sp.	Lib	3	8	4	0
COLEOPTERA	Hydrochidae	*Hydrochus* sp.	Hydr	13	0	0	0
	Gyrinidae	*Orectochilus* sp.	Ore	2	0	0	0
	Staphlinidae	*Staphlina* sp.	Sta	5	1	0	1
	Dytiscidae	*Dytiscus* sp.	Dys	21	23	16	13
		Cybister sp.	Cyb	5	3	6	0
	Hydrophilidae	*Crenis* sp.	Cre	20	18	8	8
		Hyphydrus sp.	Hyp	10	9	11	7
		Hydrophilus sp.	Hyr	11	12	3	2

Table 2. Continue.

EPHEMEROPTERA	Baetidae	*Baetis* sp.	Bae	12	5	5	15
	Teleganonidae		Tel	0	0	0	1
	Leptophlebidae	*Adenophleboides* sp.	Ade	2	0	0	0
TRICOPTERA	Hydropsychidae	*Hydropsyche* sp.	Hyp	1	0	0	1
	Ecnomidae	*Paracnomina* sp.	Par	0	0	0	1
ARACHNIDA	Pisauridae	*Dolomesdes* sp.	Dol	23	25	4	15
	Tetragnatidae	*Tethragnatha* sp.	Tet	0	0	5	5
DIPTERA	Chironomidae	*Chironomus* sp.	Chi	2	2	5	1
	Culicidae	*Culex* sp.	Cul	0	0	0	3
	Ceraptopogonidae		Cer	0	0	0	1
MOLLUSCA	Thiaridae	*Melanoides tuberculosis*	Mel	0	2	3	0
		Stagnicola sp.	Sta	0	3	0	1
	Physidae	*Bulinus globasus*	Bul	1	5	9	2
	Unionidae	*Unio Mancus*	Uni	1	0	2	0
DECAPODA	Atydae	*Caridina gabonensis*	Car	48	12	11	25
		Grand total		**371**	**364**	**323**	**327**

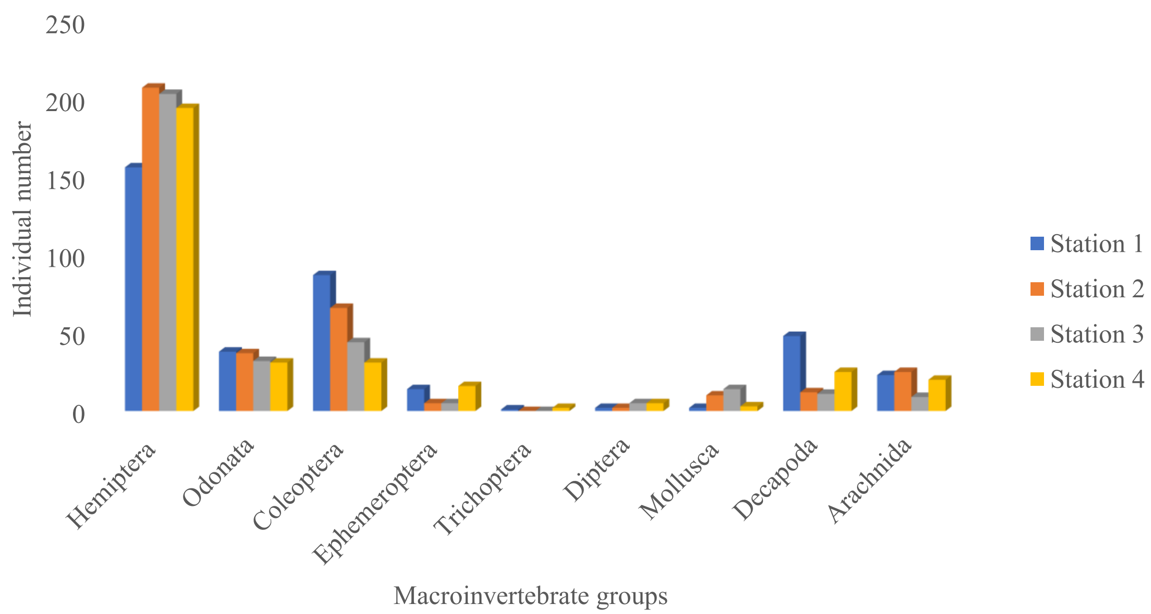

Figure 3. Macroinvertebrates abundance of sampled station of Wanzum River, Niger State Nigeria.

present in station 1 and 4 (Figure 3).

Diversity indices of the sampled stations of Wanzum River, Niger State Nigeria

Number of species taxa was highest in station 1(29) and the lowest was recorded in station 2 (24). Station 1 had the highest individual number (371) and lowest was recorded in station 3 (323). Dominance was highest in station 4(0.22) and lowest was recorded in station 1(0.12). Station 1 recorded highest in Simpson diversity (0.87), Shannon-weiner index (2.62) and Margalef index (4.73). Station 2 was more even (0.49) than station, 1, 3 and 4. Station 4 had highest Berger-Parke r index

Table 3. Diversity indices of macroinvertebrates in the sampled station of Wanzum River Niger State Nigeria.

Indices	Station 1	Station 2	Station 3	Station 4
Taxa S	29	24	25	27
Number of Individuals	371	364	323	327
Dominance index (D)	0.12	0.15	0.20	0.22
Simpson diversity index (1-D)	0.87	0.84	0.79	0.77
Shannon wiener index (H)	2.62	2.46	2.35	2.24
Evenness index (e^H/S)	0.47	0.49	0.42	0.35
Margalef index	4.73	3.90	4.15	4.49
Berger-Parker index	0.28	0.35	0.43	0.44

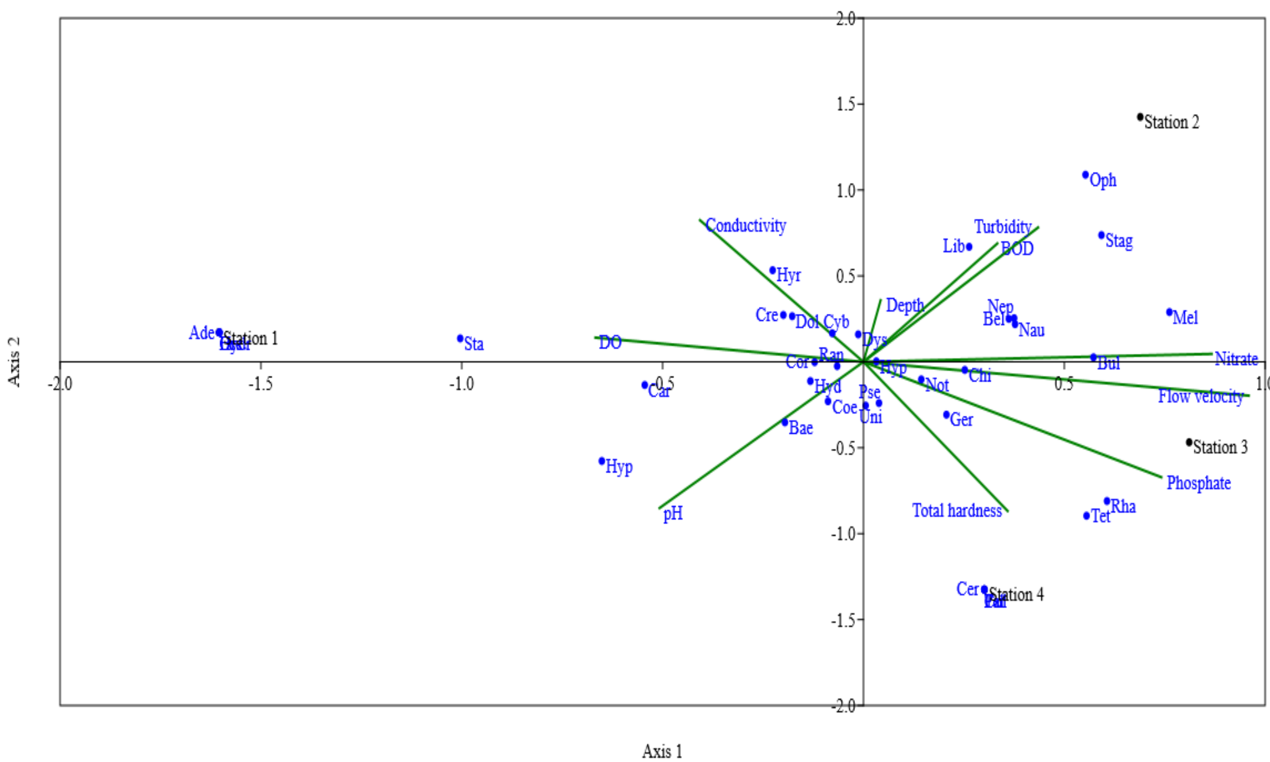

Figure 4. Canonical correspondence analysis of Macroinvertebrates and Physicochemical characteristics of Wanzum River Niger State.

(0.44) and lowest was recorded in station 1(0.28) as shown in Table 3.

The relationship between the measured biotas and physicochemical parameters of Wanzun river

The canonical correspondence analysis (CCA) result revealed that CCA axis 1 has eigen value of 0.127 while axis 2 and 3 have eigen value of 0.068 and 0.053 respectively. CCA Axis 1 account for 51.12% variation in data set while axis 2 and 3 accounts for 27.32% and 21.56% (Figure 4). Organisms in axis 1 of the CCA where influence by depth, flow velocity, total hardness, BOD_5 and nitrate, phosphate and turbidity. Organism associated with CCA axis 1 are *Nepa* sp., *Notonecta* sp., *Rhagovelia* sp., *Belostoma* sp., *Naucoris* sp., *Gerris* sp., *Hydrochus* sp., *Hyphydrus* sp., *Tetragnatha*., *Chironomus* sp., *Ophiogomphus* sp., *Melanoides tuberculata*, Teleganonidae, *Bulinus globosus* and *Unio mancus*. Organisms in axis 2 of the CCA where influence by depth, conductivity, dissolved oxygen, biochemical oxygen demand, nitrate and turbidity. The organism associated with CCA axis 2 are *Lestes* sp., *Libellula* sp., *Orectilus* sp., *Staphlina* sp., *Dytiscus* sp., *Cybister* sp., *Crenis* sp., *Hydrophilus* sp., *Adenophleboides* sp and *Stagnicola* sp.

DISCUSSION

Macroinvertebrates assemblage in the sampling stations of Wanzum River

This study investigated the impact of human activities on a rural river in Northcentral Nigeria using physico-chemical variables and macroinvertebrates structural assemblage. In this stud, some sampled stations were observed with deteriorating water quality due to high concentration of pollution indicating physico-chemical variables such as the nutrient level (nitrate and phosphate), conductivity, dissolved oxygen BOD_5 and turbidity. Generally, all the physicochemical variables recorded in this study are in consistent with the tropical climate reported previously in other studies in Northern Nigeria (Mohammed *et al.,* 2020; Mohammed *et al.,* 2021; Omovoh *et al.,* 2022; Maishanu *et al.,* 2022; Adamu *et al.*, 2022 Garba *et al.,* 2022; Edegbene *et al.,* 2023). The elevated pH and conductivity values obtained in this study indicate that the river under investigation has been exposed to various human activities. Other research had linked the deterioration of water quality in rivers and streams to increased agricultural activity along their reaches and catchments (Mohammed *et al.,* 2020; Edegbene *et al.,* 2023). In this study, the findings of deteriorating water quality could be because the river surroundings are utilized for a variety of agricultural activities, as the majority of the inhabitants of the nearby settlement are farmers and fishermen who rely on the river for irrigation and other agricultural activities. The elevated values of pollution signaling physic-chemical variables posed a harsh ecological threat to the majority of aquatic organisms, particularly macroinvertebrates, in aquatic environments (Omovoh *et al.,* 2022). All of the sampled stations had high DO concentrations, indicating that the stations are relatively unaffected, as increased DO has been used as a standard for measuring relatively unaffected sites (Mustapha, 2008; Omovoh *et al.,* 2022).

On the other hand, we recorded the presence of pollution tolerance species in some sampled stations which were grossly impacted by human activity (agricultural activities). These finding agree with many studies from Northern Nigerian that have reported high levels of nutrients due to numerous agricultural activities in the area (Keke *et al.* 2020; Mohammed *et al.,* 2021; Edegbene *et al.*, 2021). A total of 1385 individuals from 36 species of macroinvertebrates were recorded in the Wanzum River. According to Arimoro *et al.,* (2015), the high abundance of macroinvertebrates observed in this study may be attributable to habitat structure, including vegetation, substrate type, and vegetation cover. Diverse groupings of macro-invertebrates are favored by nutrient availability, vegetation type, canopy cover, and substrate type (Odume *et al.,* 2012; Arimoro *et al.,* 2015). Surface runoff or organic materials dispersed into the river also facilitated the distribution of some species (Arimoro and Keke, 2016).

It is therefore, evident that the Wanzum River is moderately polluted based on the relatively high values of physico-chemical variables and macroinvertebrate communities at the four sampling stations. In this study, Hemiptera were the most abundance group in term of number of individuals, and there were represented by the family Nepidae. Corixidae, Notonectidae, Gerridae, Belostomatidae. The high abundance of this group could be due to the nature of their specialized mouthparts, which are adapted for piercing and sucking fluids from plants, animals, or other insects which enable them to dwell well in most freshwater bodies (Jusoh et al., 2015; Pinto-Juma *et al.,* 2015).

The abundance of Hemiptera in Wanzum River could also be due to habitat complexity, and resource availability (Arimoro and Keke 2016). This group plays important roles as both predators and prey, contributing to the overall biodiversity and functioning of these ecosystems.Coleoptera were also abundant in Wanzum River by the family Hydrochidae, Gyrinidae, Staphlinidae, Dytiscidae and Hydrophilidae. The presence and abundance of Coleoptera in Wanzum River could be due to the nature of the habitat and its complexity, resource availability, bottom sediment and vegetative cover of the habitat which favors their colonization and distribution in aquatic ecosystem (Arimoro and Keke 2016). Beetles in freshwater ecosystems play essential ecological roles as are important predators, preying on other invertebrates, and even small vertebrates, contributing to the regulation of prey populations.

Additionally, beetles serve as decomposers, breaking down organic matter and functioning as detritivores in freshwater ecosystems (Ferreira *et al.,* 2017). Due to their wide range of habitat preferences and high sensitivity to ecological disturbances, beetles are commonly used as bioindicators of water quality in freshwater ecosystems and changes in beetle community composition and abundance can indicate the health and condition of aquatic habitats, making them valuable tools for monitoring water quality as the presence of species such as *Oreoctichilus* sp. has been reported to be sensitive to pollution and only associated with clean water (Edegbene *et al.,* 2023).

The Odonata were also represent in quite a few numbers in Wanzum river and were represented by the family, Coenagrionidae, Gomphidae and Libellubidae. Their presence in aquatic ecosystem is an indication of moderate pollution, they have been reported to be moderately tolerance to pollution (Arimoro and Keke 2016). The presence of Odonata in Wanzum River could be as a result of the vegetation cover or the bottom sediment of the river streams favoring their colonization.

In this study the dipterans were represented by the Chironomidae, Culicidae and Ceraptopogonidae family. The presence of dipterans in aquatic ecosystem is an indication of gross pollution due to organic waste (Edegbene *et al*., 2015; Arimoro and Keke 2016) and they are mostly found in abundance in lotic area of the stream of rivers. Mollusca have mostly been associated with polluted areas of water bodies due to the level of their tolerance to pollution and their presence is supported by favorable environment variables such as substrate type and vegetation covers. Similarly, molluscs were represented by Thiaridae, Physidae and Unionidae. The study of Dadi-Mamud *et al.,* (2014) also reported the presence and abundant of this group of organisms in River Ndakotsu Lapai, Niger state.

In Wanzum River pollution sensitive group such as Ephemeroptera, Trichopterans and Plecoptera were under-represented by just few taxa. The low abundance of this groups in all the sampling stations is an indication that the water body is been stress along it courses due to different anthropogenic activities which can also lead to a decline in ecological health. Ephemeroptera, Plecoptera, and Trichoptera (EPT) are only associated with clean water (Akamagwuna *et al*., 2019; Odume, 2020). Therefore, the low number of Ephemeroptera in this research is owing to their sensitivity to polluted water and the diverse anthropogenic activities around the Rivers and the sampling stations (Edegbene *et al.,* 2023). The principal component analysis constructed for the physicochemical parameters of sampling stations was able to delineate the station according to pollution gradient as reported by Ogidiaka *et al.,* 2022). The canonical correspondence analysis developed for this investigation found little or no association between the macroinvertebrate assemblages and the physiochemical factors (Garba *et al.,* 2022). Similarly, its triplot axes 1 and 2, recorded eigenvalue value of < 1.0 an indication that there is minimal correlation (Pielou, 1984; Palmer, 1993). There is little relationship between the measured physico-chemical variables and macroinvertebrates species assemblage in Wanzum River as the eigen value recorded was less than 1 (<1.0). The low abundance Trichoptera, Ephemeroptera and no record or absence of Plecoptera in Wanzum River is a signal of pollution which is also an indication of deterioration in the overall ecological health of the river. Several authors have documented the absence or scarcity of this group in many water bodies of Nigerian (Arimoro *et al.,* 2015; Edegbene *et al.,* 2015; Arimoro and Keke 2016, Garba *et al.,* 2022).

For over a period of time, there has been an increasing agricultural activity around Wanzum River which is due to increase human population in nearby settlement. The increase in Human activities around Wanzum River have negative impacts on the water body. The eroded river banks and agricultural activities around the river also have impact on water quality as shown in some elevated pollution indicating parameters such BOD_5, turbidity and Nitrate, coupled with the distribution and abundance of certain groups of macroinvertebrates in the River.

Conclusion

This study gives an insight into the comprehensive information on impact of anthropogenic activities on Wanzum River using key physico-chemical parameters and macroinvertebrate assemblage. The physicochemical parameters and macroinvertebrate assemblages indicate an impaired river system due to human activity. In addition, the extremely low number of EPT taxa in all sampled river stations is indicative of the river's deteriorating condition. The present results shows that the Wanzum River is losing its uniqueness due to several anthropogenic factors as result of high concentration of pollution indicating physico-chemical parameters such as BOD_5, conductivity, phosphate, nitrate and Turbidity. With this, it is obvious that human activities such as all year-round farming activities around Wanzum River has contributed to the change of physico-chemical variables and macroinvertebrate assemblage, thus factors could lead to disabling the efficiency and utilization of river water for domestic purpose. These findings will pave way for further research on other biotic communities of the River for better management and sustainability of the River and its potential resources.

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