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Research Article

The Effect of Flood Regime on Water Quality and Plankton Distribution in Bosso Area, Minna, Niger State

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Abstract

Flooding endangers lives and property, and it can lead to surface water pollution, reducing access to potable water and destroying wildlife habitats. This study investigated the effect of flood on water quality and plankton in two selected water bodies in within Minna Metropolis, Niger state, Nigeria. Water samples were collected for physicochemical parameters and plankton identification using standard methods and procedures. Samples were collected for a period of six (6) months (April to September 2021). The result of the physiochemical parameters showed temperature (26.0-28.5°C), flow velocity (0.23 to 0.26 m/s), dissolved oxygen (6.4-10.0mg/l), turbidity (30-240 NTU), pH (7.21-7.53), TSS (0.04-0.04), electrical conductivity (69-228 µS/cm) and total dissolved solid (60-220 mg/l). Most of these parameters were within the WHO permissible limits. From all the parameters measured, temperature, DO, pH and TSS showed no significance difference ($p>0.05$) between the water bodies while turbidity, total alkalinity, electrical conductivity and total dissolved solid exhibit significant difference ($p<0.05$) between the water bodies with Fadipe Pool recording higher values in most of the parameters. A total of 12 phytoplankton species were identified comprising of 3 families which are Bacillariophyceae (2), Chlorophyceae (6), and Cyanophyceae (4). For the zooplankton, a total of 11 species are made up of 3 taxa which are Cladocera (4), Copepoda (2), and Rotifera (5). In this study, several plankton species that serve as indicator organisms were identified which is indication of a disturbed water bodies.

Nomenclature and units

1.0 Introduction

Flooding is becoming more common in Nigeria and many other parts of the world, and it is linked to climate change. It has a wide range of consequences, including the destruction of life and property and the pollution of surface water (Onoyima *et al.,* 2022). Flooding occurs as a result of water accumulation in normally submerged areas caused by heavy rainfall, melting snow, glacial outbursts, and dam failure (Ching *et al.*, 2015; Onoyima *et al.,* 2022). Flooding affects many states in Nigeria due to annual increase in rainfall, which is caused by climate change (Echendu, 2020). Flooding endangers lives and property, and it can lead to surface water pollution, reducing access to potable water and destroying wildlife habitats (Olanrewaju *et al.*, 2019). There are numerous potential sources of contamination during and after flood events, such as dumping grounds, graveyards, chemical works, pesticides and fertilizers in warehouses, oil spillage, septic tanks, household and industrial hazardous chemicals, and so on (Onoyima *et al.,* 2022). Floodwater will either increase contaminants and decrease water quality or dilute contaminants and improve water quality. When floodwater reaches the contaminants, they are slowly dissolved, resulting in the formation of diluted solution; however, when some of the floodwater evaporates, the concentration of contaminants may increase (Gautam and van-der- Hoek, 2003).

Freshwater serves as favorable environment for plankton communities' development, which establish different assemblages in relatively short periods of time (Rocha *et al.*, 1999). Many factors do contribute to the establishment of plankton communities in a water body, among which are presence of nutrients, physico-chemical factors of water, hydrological characteristics of water body (Mustapha, 2010; Kpiagou *et al.*, 2022; Boukari *et al.,* 2022). Phytoplankton are usually at the base of aquatic food web and are the most important factor for production of organic matter in aquatic ecosystem. Most water bodies require significant number of plankton to have productive and sustainable fisheries (Mustapha, 2010). The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are structured by these factors (Simciv, 2005). Thus, any perturbations in these factors may affect their assemblage which could have a significant impact on water quality and fisheries of the aquatic environment. The zooplankton assemblage often influences energy flow through classical food chain, nutrient cycling and community population dynamics within a reservoir ecosystem (Simciv, 2005; Mustapha, 2010). The species composition, distribution, diversity and relative abundance of zooplankton of a reservoir could have significant impact on fisheries and public health of its users (Simciv, 2005). The importance of plankton in tropical reservoir ecosystems include its use in estimating potential fish yield, productivity, water quality, energy flow, trophic status and management. Thus, this study aimed at investigating the influence of flood on physico-chemistry and plankton assemblage of the Fadipe Pool and Bosso Dam Minna Niger State Nigeria.

2.0 Materials and Methods

2.1 Study area

Minna is situated in the guinea savannah zone. Minna lies between Latitude 9º36'50"- 9º39'72N and longitude 6º32'25-6º35'00E in North central Nigeria. Bosso dam is an artificial dam constructed for the purpose of providing water for people of Bosso community and other neighboring communities in Minna Niger State. Fadipe pool is a natural water body that situated in Fadipe area in Minna Niger State. Most of the inhabitants of nearby settlements are involved in fishing and farming rice, sorghum, maize, yam, and groundnuts both for commercial purpose and for domestic consumption. Cattle, goats, sheep, chickens, and guinea fowl are reared for meat by the settlers of this communities.

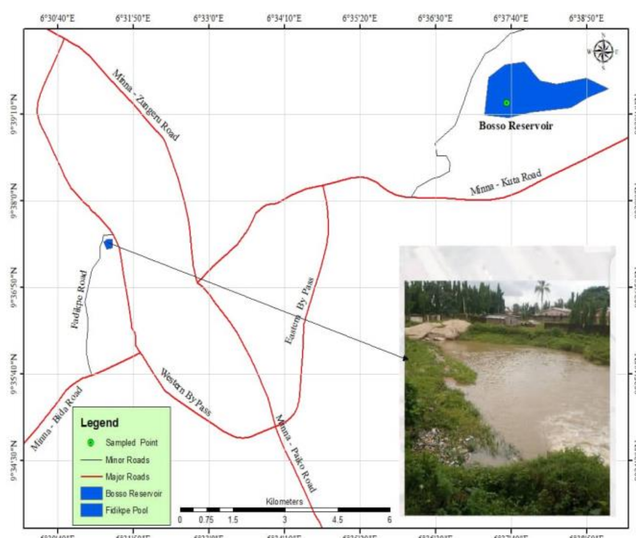

Figure 1: Map of the study area.

2.2 Measurement of Physicochemical parameters

The water samples for physicochemical parameters were collected from Bosso dam and Fadipe pool in Minna, Niger State. The samples were collected and analyzed once every month for a period of six months (April-September, 2021). On the sampling, site physicochemical parameters including water temperature, dissolved oxygen (DO), conductivity, turbidity and pH were measured using multipurpose meter (HANNA model 1910). Total alkalinity, total solid solvent (TSS), and total dissolved solid (TDS) where determined titrimetrically according to the methods of APHA (2012).

2.3 Plankton Sample Collection

Plankton samples were collected by horizontal towing using standard plankton net with mesh size of 20.0μm with a small bottle container (50ml) attached to its narrow end. The samples collected were immediately preserved in 4% formalin and transported to laboratory for plankton identification. In the laboratory, plankton samples were allowed to settle by gravity for 24 hours before decanting carefully the supernatant to achieve 50 ml volume. From the stock sample, 1 ml sub-sample was taken with the help of a Pasteur pipette and transferred into a Sedgwick Rafter counting chamber. Once the slide was filled, it was allowed to settle for approximately 5-10 minutes. The slide was examined under a light microscope and view under magnification (×40, ×100). Plankton enumeration was done by counting each cell as individual (Tash, 1971). Identification was done by comparing the specimen with plankton identification charts (Needhem and Needhem, 1975; Shiel, 1995; Botes, 2003; Perry, 2003; Witty, 2004)

2.4 Statistical Analysis

Data collected from the physico-chemical parameters analysis were subjected to descriptive statistics using Microsoft excel 2016 package. The mean value and standard error were determined to test for differences, where the mean values were compared using one way analysis of variance (ANOVA). The plankton were analyzed with biological indices such as taxa richness, number of individuals, dominance, simpsons index, shannon index, species evenness and margalef indices. Canonical correspondence analysis (CCA) was also used to establish association between planktons and measured physicochemical parameters using PAST statistical software version 4.

3.0 Results

3.1 Physicochemical parameters of Bosso dam and Fadipe pool, Minna Niger State

From Table 1, the result of the physicochemical parameters of Bosso dam and Fadipe pool Minna Niger State shows temperature ranging from 26.0 to 28.5°C, flow velocity mean value ranging from 0.23 to 0.26 m/s, dissolved oxygen ranging 6.4 to 10.0mg/l, turbidity ranging from 30 to 240 (NTU). The pH value ranging from 7.21 to .7.53 in both water bodies. TSS ranging from 0.04 to 0.04. Electrical conductivity ranging from 69 to 228 (μS/cm) and total dissolved solid ranging from 60 to 220 (mg/l). Among all the parameters measured, difference in turbidity, total alkalinity, electrical conductivity and total dissolved solid were significant ($p<0.05$) between Bosso dam and Fadipe pool and higher values were recorded for all the parameters at Fadipe pool.

Table1. Mean and standard error of physicochemical parameters of Bosso Dam and Fadipe pool Minna Niger state

Parameters	Bosso dam	Fadipe pool	WHO standard
Temperature (°C)	27.29±1.01[a]	27.25±1.25[a]	20-33
	(26.28-28.3)	(26.0-28.5)	
Flow velocity (m/s)	0.23±0.04[a]	0.25±0.03[a]	
	(0.13-0.28)	(0.26-0.30)	
Dissolved oxygen (mg/l)	7.2±0.8[a]	8.5-1.5[a]	5-9.5
	(6.4-8.0)	(7.0-10)	
Turbidity (NTU)	82.5±1.75 [a]	135±1.05[b]	5
	(65-100)	(30-240)	
pH	7.42±0.11 [a]	7.23±0.02 [a]	6.5-8.5
	(7.31-7.53)	(7.21-7.26)	
Total Suspended Solid (mg/l)	0.18±0.014 [a]	0.2±0.02 [a]	100
	(0.04-0.40)	(0.18-0.22)	
Total alkalinity (mg/l)	120±0.00 [a]	130±0.50[b]	200
	(120-120)	(80-180)	
Electrical conductivity (μS/cm)	140±71.0 [a]	209±1.90[b]	≤400
	(69-211)	(190-228)	
Total Dissolved Solids (mg/L)	105±45.0[a]	190±30.0[b]	500
	(60-150)	(160-220)	

Note: Values in same row with different superscript differs significantly ($p<0.05$).

3.2 Plankton distribution of Bosso Dam and Fadipe Pool Minna Niger State

Twelve phytoplankton species from three phyla namely: chlorophyta (6 species), baccillarophyta (2 species) and cyanophyta (4 species) were recorded from both water bodies (Table 2). *Chlorella* spp had the highest number of occurrences across the stations, followed by *Analytis* spp while *Scenedesmus incrasatulus* had the least occurrence. The relative abundance showed Chlorophyta with 53.9%, Cyanophyta 35.1% and Bacillarophyta recorded lowest with 11.0%. A total of eleven zooplankton species from three phyla were observed and they included Cladocera (4 species), Rotifera (5 species) and Copepoda (2 species) as shown in table 3. Specie *Moina micrura* was the most encountered species across the stations, followed by *Cyclopoida copepod,* while *Brachionus caudatus* had the least number of occurrences. Cladocera recorded highest abundance percentage (58.7%), followed by Copepoda (30.0%) and the lowest percentage abundance was recorded in Rotifer with 11.3%.

Table 2: Phytoplankton assemblage of Bosso dam and Fadipe pool Minna Niger state

Group	Species	Bosso dam	Fadipe pool	Abundance (%)
Chlorophyta	*Chlorella* spp	310	190	
	Scenedesmus incrasatalus	20	0	
	Scenedesmus quadricauda	27	19	
	Ulothrix spp	112	89	
	Spirogyra spp	73	47	
	Pediastrum spp	28	11	53.9
Bacillarophyta	*Melosira granulata*	88	61	
	Diatomella spp	0	40	11.00
Cyanophyta	*Microspora* spp	76	90	
	Analytis spp	150	69	
	Athrospira spp	51	70	
	Oscillatoria spp	97	0	35.1
	Total	1032	686	100

Table 3: Zooplankton assemblage of Bosso dam and Fadipe pool Minna Niger state

Group	Species	Bosso dam	Fadipe pool	Abundance (%)
Cladocera	*Nauphi* sp	8	3	
	Moina micrura	138	78	
	Ceriodophnia cornuta	7	0	
	Diaphnosoma excisum	13	17	58.7
Rotifera	*Synchaeta oblonga*	7	0	
	Brachionus colyciflous	17	8	
	Asplanchna spp	0	8	
	Brachionus angularis	7	0	
	Brachionus caudatus	3	1	11.3
Copepoda	*Cyclopoida copepoda*	101	26	
	Copepodis spp	8	0	30.0
	Total	309	141	100

3.3 Plankton diversity indices of Bosso dam and Fadipe pool of Minna Niger State

Bosso dam recorded a total of 10 species while Fadipe pool recorded 7 species of zooplankton. The zooplankton dominance, Simpson, Shannon, species evenness and Margalef's index showed no significant difference (p>0.05) between Bosso dam and Fadipe pool (Table 4). Similarly, Bosso dam recorded a total of 11 species of phytoplankton while Fadipe pool recorded a total of 10 phytoplankton species. Dominance, Simpson, Shannon, specie evenness and Margalef's index of observed phytoplankton showed no significant difference (p>0.05) between Bosso dam and Fadipe pool of Minna Niger state (Table 4). Table 4: Diversity indices of plankton in Bosso dam and Fadipe pool in Minna Niger state

Index	**Zooplankton**		**Phytoplankton**	
	Bosso dam	Fadipe Pool	Bosso dam	Fadipe Pool
Taxa_S	10	7	11	10
Dominance D	0.3141	0.3615	0.1539	0.1483
Simpson 1-D	0.6859	0.6385	0.8461	0.8517
Shannon H	1.51	1.337	2.112	2.081
Evenness e^H/S	0.4527	0.5439	0.7517	0.8013
Margalef	1.57	1.212	1.441	1.378

3.4 Correlation between plankton and physicochemical parameters of Bosso dam and Fadipe pool Minna

CCA axis 1 account for 95.43% of species variation for data set and CCA axis 2 account for 4.09% of the variation in species data set. The CCA axis 1 and 2 were positively influenced by all the measured physico-chemical paramters except electrical conductivity and total dissloved solid which correlated negatively with CCA axis 2 (Figure 2) . The dataset distribution of the organism that correlated positively with axis 1 were *Scenedesmus qua, Ulothrix* sp., *Spirogyra* sp., *Melosira granulata*, *Diatomella* sp., *Microspora* sp., *Athospira* sp., *Nauphi* sp., *Diaphanosoma exiscum* and *Asplanchia* sp. While organism that correlated positively with axis 2 were *Scenedesmus incrasatulus, Pediastrum* sp., *Oscillatoria* sp., *Nauplii* sp., *Ceriododaphnia cornuta, Synchaeta oblonga, Ranchious calyciflorus*, *Branchious calyciflorus*, *Branchious angularis, Branchious caudatus* and *Copepodis* sp. as shown in figure 2.

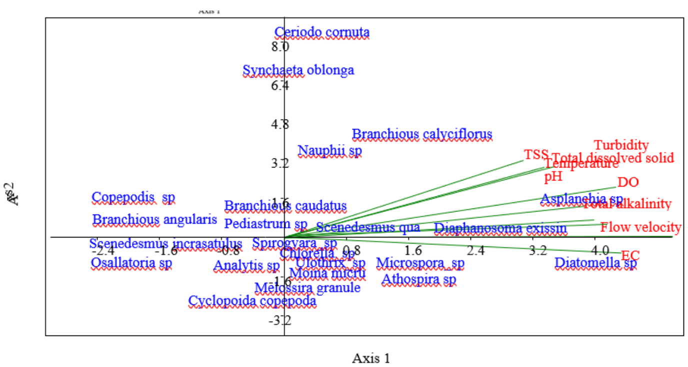

Figure 2. Triplot of first and second Canonical correspondence analysis of plankton and physiscochemical characteristics of Bosso Dam and Fadipe Pool Minna Niger state.

4.0 Discussion

The research study was carried out to assess the effect of flood on water quality and plankton assemblage of two water bodies in Bosso Area, Minna, Niger State. The mean value of the water temperature recorded for both water bodies in this study was typical of tropical inland fresh water and rivers (Adamu *et al.*, 2021; Adamu *et al.*, 2022). The temperature ranged observed from both water bodies fells within the permissible limits of WHO guideline for drinking water and aquatic life sustainability. This result agreed with previous reports that water temperature in tropics vary between 21°C and 32°C (Mohammed *et al.*, 2020; Mohammed *et al.*, 2021). The moderate flow rate observed could be due to influx of water from nearby surroundings and turbulence act of the water caused by flood (Mohammed *et al.*, 2020b; Mohammed *et al.*, 2021; Onoyima *et al.*, 2022). Similar trend of flow rate was also observed in Chikke Stream, Niger State and River Hadejia, Jigawa State (Mohammed *et al.*, 2021; Garba *et al.*, 2022).

Dissolved oxygen obtained during the period of this study for both water bodies were relatively high. The high dissolved oxygen observed in this study could be due to the turbulence act of the water caused by flood facilitating the dissolution of atmospheric oxygen and increased solubility of oxygen at lower temperature (Onoyima *et al.*, 2022). This result is contrary to the works of Garba *et al.*, (2022) who observed lower dissolved oxygen from their work on Hadejia River, Jigawa State. Turbidity values recorded exceeded the acceptable limits of 5 NTU by WHO for drinking water. The high turbidity value observed could be due to runoff from rain as well as high sedimentation rate of suspended materials during flood. This finding agreed with the work of Ibrahim *et al.*, (2009) who also made similar observation in their study carried out at the Kontagora reservoir.

The pH (hydrogen ion concentration) of water is important because many biological activities can occur within a narrow range of pH. Thus, any variation beyond acceptable range will have impact on aquatic lives (Ebesi *et al.*, 2022; Adamu *et al.*, 2022). The pH range obtained in this study was within the acceptable level for 6.5 to 8.5 for culturing tropical fish species and the recommended limit for drinking water (WHO, 2011). The pH range obtained in this study was also in conformity with that of Dangana Lake reported by Adamu *et al.*, (2022). The high alkalinity value observed in this study could be due to high nutrients in water caused by dissolution of calcium carbonate from limestone bedrock that erodes during the natural process of weathering and dilution factor as a result of flood (Kadhim, 2014). The values were moderate and within the WHO standard limits of 200mg/l. This result is in conformity with the research of Odo *et al.*, (2014) who reported a similar alkalinity value in a tropical freshwater lake in Nigeria. Conductivity value ranged from 69 to 228 µS/cm. The high conductivity observed in this study could be due to surface run off from surrounding water bodies coupled with high nutrient loads (Mohammed *et al.*, 2021). Most of the results obtained for the physicochemical parameters were within the acceptable limits for drinking water and aquatic life which could be also responsible for the distribution of plankton species identified in the water bodies

The phytoplankton species assemblages showed that Chlorophyceae was the most abundant, closely followed by Cyanophyceae, then Bacillariophyceae. High abundance of some phytoplankton species was observed in this study. This could be attributed to increase in light intensity that could be captured by phytoplankton, hence increased photosynthesis and other metabolic activities which lead to subsequent increase in population density of planktons (Mustapha, 2010; Tanimu *et al.*, 2011). Chlorophyta, Bacillariophyta and Cyanophyta were the phytoplankton groups encountered in this study. Their presence has also been reported in other freshwater bodies in Nigeria

(Magami *et al.*, 2014; Essien-Ibok and Ekpo, 2015; Yusuf, 2020). The dominance of diatoms in this study could be due to the fact that they can withstand broadly changing hydrographical conditions (Yusuf, 2020). Similarly, high intensity of the light in the tropics favors the development of Chlorophyta (Yusuf, 2020). Most of the zooplankton group observed in this study have been recorded in lakes, streams, ponds and artificial impoundment in the tropics (Mustapha 2010; Arimoro and Oganah 2010). In the present study, the zooplankton groups encountered in the lake are Copepoda, Rotifera and Cladocera. Tropical lakes are characterized by the presence of these groups of zooplankton (Arimoro and Oganah 2010; Ebesi *et al.,* 2022). The low abundance and diversity of planktons in both Fadipe pool and Bosso dam could be due to flood effect as the habitat structure were disrupted during the flood (Onoyima *et al.*, 2022).

The tri-plot of the CCA in this study revealed little or no association between plankton and the physicochemical parameters as the axis 1 and 2 eigenvalue was less than <1.0. Eigenvalues associated with each axis equal the correlation coefficient between species and sampling scores (Palmer, 1993). Thus, an eigenvalue close to 1 represents a high degree of correlation between species and stations or any other variable and an eigenvalue close to zero indicates little correlation (Garba *et al.*, 2022). The CCA triplot showed that axis 1 had an eigenvalue of 0.1046 while axis 2 was 0.044 which was an indication of very poor correlation between the physicochemical parameters and plankton of Bosso dam and Fadipe pool.

5.0 Conclusion

Water quality is important to aquatic lives that inhabit these water bodies. The different physiochemical parameters examined were within the WHO permissible limits, while some exceeded the limit during flood. Although, there was deviation in some parametric values which causes the water quality to deteriorate to some extent due to organic waste. These deviations observed from some of the parameters had impact on the species composition of plankton which indicates a change in the ecological state of the studied flooded sampling stations. Extremely low plankton abundance characterized the turbid state of the flooded water across the study stations (Bosso dam and Fadipe pool). The study also supported the fact that water level fluctuation is the main driving force in shaping the plankton and aquatic lives succession.

Competing interest

The authors declare no competing interest.

Authors Contribution

ABS and SPO designed and supervised the study. MYM MIN and SJ collected the samples and carried out laboratory analysis. ABS and MYM managed the data analyses and literature search of the study. All authors read and approved the final manuscript.

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