Special Conference Edition, April, 2022
http://dx.doi.org/10.4314/bajopas.v13i1.28S

Bayero Journal of Pure and Applied Sciences, 13(1): 173 - 179
ISSN 2006 – 6996

MACROPHYTES ABUNDANCE IN RELATION TO EUTROPHICATION STATUS OF PERI-URBAN IMPOUNDMENTS IN KATSINA METROPOLIS, NIGERIA

[1,*]Babatunde Taofik Ademola, [1]Saifullahi Ibrahim Mahuta, [1]Babangida Abdulkarim and Lawali Alkali Argungu[2]

[1]Department of Biology, Umaru Musa Ya'radua University, P.M.B. 2218, Katsina State, Nigeria
[2]Department of Fisheries and Aquaculture, Faculty of Agriculture, Usmanu Danfodiyo University Sokoto
*Corresponding author email: attaofeeq@gmail.com

ABSTRACT
Aquatic Macrophytes refer to a diverse group of aquatic photosynthetic organisms that are large enough to be seen with the naked eye. Their abundance and species composition are greatly influenced by eutrophication. Macrophytes occurrence and their diversity in four seasonal peri-urban water bodies; Malalau (Site A), Rafin yan wanki (Site B), Kofar durbi (Site C), and Rafin yan tifa (Site D) in Katsina metropolis was assessed along with the pollution status of the water. The taxa diversity showed the presence of 7 species of Macrophytes in Site A and D identified as; red water fern (Azolla pinnata), water hyacinth (Eichhornia crassipes), duck weed (Spirodela polyrhiza), water lettuce (Pistia stratiotes), pond weed (Aponogeton subconjugatus), blue water lily (Nymphaea lotus), and floating heart (Nymphoides thunbergiana). Only (duck weed) was found in (Site B), whereas no single Macrophyte species was recorded in Site C. The results of physico-chemical parameters showed that the respective nitrate-nitrogen in site A (10.20 ± 0.14 mg/L), and site D (9.48 ± 0.11 mg/L) where significantly higher ($p < 0.05$) compared to site B (6.58 ± 0.13 mg/L) and site C (1.33 ± 0.09 mg/L). A similar trend was observed in phosphate level, but not significant ($p > 0.05$). The abundance of Macrophytes appeared to be more positively correlated with nitrogen than phosphorous. The occurrence of Macrophytes and their abundance in this research was an indication of urban pollution.
Keywords: Macrophytes; eutrophication; impoundments; Katsina metropolis

INTRODUCTION

The term "aquatic Macrophytes" refers to different groups of aquatic photosynthetic plants that are large enough to be seen with the naked eye. It includes algae, bryophytes, pteridophytes, and spermatophytes (Cosio *et al*., 2014). The Macrophytes' vegetative parts grow either permanently or periodically submerged, floating, or growing up through the water surface (Chambers *et al*., 2007). Most common Macrophytes are used as indicators of the trophic status of their habitats (Nagengast and Kuczyska-Kippen, 2015). Among the determinants of the composition of aquatic flora are water level fluctuation, light exposure, substrate composition, organic matter content, and water chemistry (Bornette and Puijalon, 2011). As Macrophytes are affected by environmental conditions, they in turn facilitate changes in water chemistry and physical habitats and may play a major role in aquatic ecosystem functioning (Havel *et al*., The nature of riparian use and urban pollution greatly affect the water quality of impoundments 2015). Part of the role of Macrophytes in ecosystem functioning includes; provision of habitat for aquatic organisms such as macro invertebrates and fish; reduction of erosion on stream banks; effects on the nutrient cycle; vertical mixing of water; increase in dissolved oxygen levels; reduction in water velocities; increase in water depth and channel width; increase sedimentation; and acting as a food source (Jones *et al*., 2020). These dynamic roles of Macrophytes have attracted the attention of researchers, as features of Macrophytes, like easy identification and immobility have make them suitable for bioassessment (Giller *et al*., 2004). In recent years, there has been increasing concern about the rate at which inland waters are polluted through run-off into streams and lakes and impoundments, which leads to eutrophication, affecting the specific composition of Macrophytes and variations in physico-chemical parameters as well as the quality of these water bodies. and dynamics in Macrophytes composition, as well as other biological factors. The current research investigated the occurrence of Macrophytes in seasonal peri-urban impoundments in Katsina.

MATERIALS AND METHODS

Study area: Katsina town is located some 260 Km east of the city of Sokoto and 135 Km northwest of Kano, close to the border with Niger. Four sampling sites were chosen for the purpose of this study. Site A was located at "Malalau", where mainly agricultural activities take place around the water body; Site B was located at "Rafin yan wanki," domestic activities are taking place here; Site C is located at "Kofar Durbi," a typically urbanized area; and Site D is located at "Rafin yan tifa," where there are more agricultural and fewer domestic activities (Figure 1).

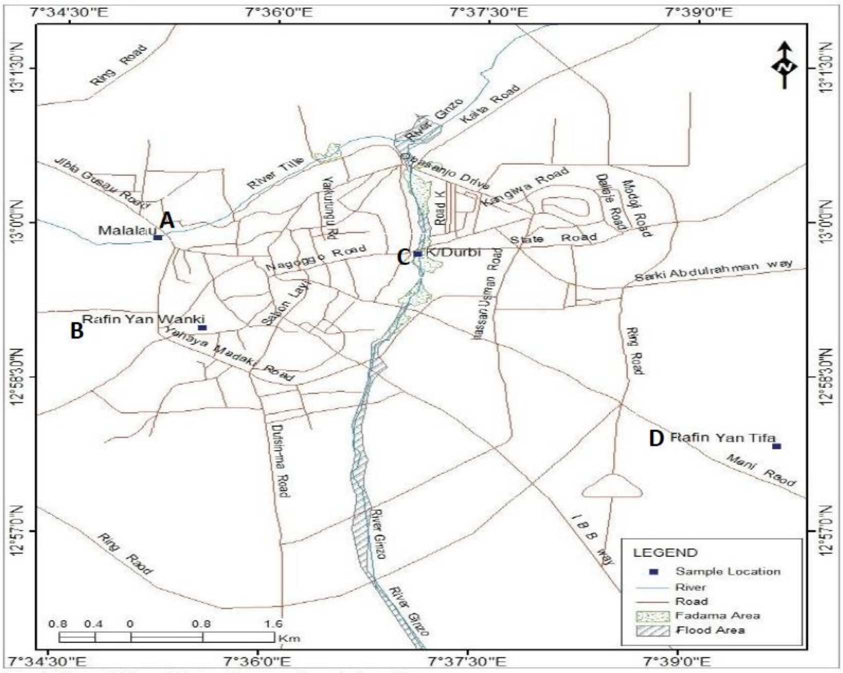

Figure 1: Map of Katsina State showing sampling stations

Source: Cartography laboratory, Department of Geography, UMYUK, Katsina (2021).

A simple random sampling method was adopted using a 1 m^2 light wooden quadrate (Lodge *et al.*, 1994) placed on the water surface (Figure 2) and the Macrophytes were handpicked and counted using a pointed wooden stick. Samples were collected monthly from June to December, 2019. The samples of Macrophytes collected were put in paper bags and dried, additionally; the samples collected were marked with different coloured labels, each colour indicating the appropriate category of the sample. Macrophytes taxonomic identification was achieved using the handbook of common aquatic plants of the Kainji Lake Basin, Nigeria (Obot and Ayeni, 1987).

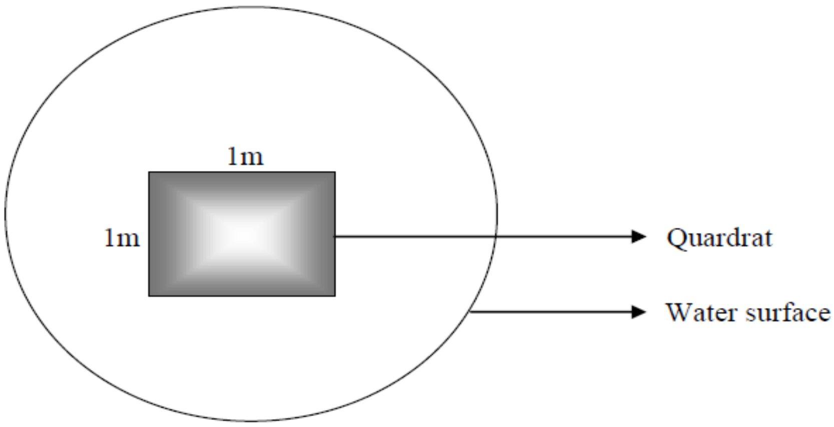

Figure 2: Sketch of quadrant for Macrophytes abundance determination

Water sampling and analysis: The water was sampled monthly during Macrophytes collection from June to December, 2019. The surface water was collected by dipping a one-liter plastic sampling bottle into the water and sliding it over the upper surface of the water with their mouth against the water current to permit undisturbed passage of the water into the bottle. The water samples were transported to the laboratory in the department of Biology at Umaru Musa Yar'adua University, Katsina for analysis of physico-chemical parameters. Temperature (°C), pH, and turbidity were measured *in-situ* with a Metrohm Herisau E520 pH meter, while dissolved oxygen, phosphate-phosphorus, and nitrate-nitrogen were determined using the method by American Public Health Association APHA (2005).

Statistical analyses: One-way analysis of variance (ANOVA) was used to compare the means of macrophytes and water quality parameters between sites. Duncan Multiple Range Test was used to separate the means. Pearson's correlation was used to test the relationship between Macrophyte abundance and water quality parameters for all the sites pooled together. A significant level was taken as $P < 0.05$. All the analyses were carried out using IBM SPSS software version 21.

RESULTS

Macrophytes Abundance and Diversities

The Macrophytes diversities and densities in the four sampling sites in Katsina metropolis is presented in Table 1. Seven (7) species of Macrophytes were identified during the study period. Water hyacinth and water lettuce were the most frequently observed species, while red water fern was the species with the least frequency. The taxa diversity showed the presence of 7 species of macrophytes in Site A and D; Red water fern (*Azolla pinnata*), Water hyacinth (*Eichhornia crassipes*), Duck weed (*Spirodela polyrhiza*), Water lettuce (*Pistia stratiotes*), Corp pond weed (*Aponogeton subconjugatus*), Blue water lily (*Nymphaea lotus*), and Floating heart (*Nymphoides thunbergiana*), only (Duck weed) was found in Site B, whereas no single Macrophyte species was recorded in Site C. Site A had a significantly higher abundance of water hyacinth, duck weed, and water lettuce ($p < 0.05$), while in Site D, Corp Pond Weed, Blue Water Lily, and Floating Heat were found to have higher numbers. The Simpson diversity index was highest for Site A (0.78) (Table 1).

Table 1: Macrophytes Diversities and Densities (species/m^2) in the Four Sampling Sites in Katsina Metropolis

Sites	Red Water Fern	Water Hyacinth	Duck Weed	Water Lettuce	Corp Pond Weed	Blue Water Lily	Floating Heat	Simpson diversity index
A	4.07 ± 2.60^a	31.38 ± 9.27^a	25.22 ± 9.15^a	36.86 ± 10.55^a	7.50 ± 3.76^b	8.43 ± 3.83^c	7.67 ± 3.49^b	0.78
B	0.00 ± 0.00^b	0.00 ± 0.00^c	2.22 ± 69.76^c	0.00 ± 0.00^c	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00
C	0.00 ± 0.00^b	0.00 ± 0.00^c	0.00 ± 0.00^d	0.00 ± 0.00^c	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00 ± 0.00^a	0.00
D	3.91 ± 2.68^a	12.38 ± 5.07^b	17.17 ± 6.37^b	25.57 ± 6.39^b	14.61 ± 6.83^c	9.18 ± 5.15^b	8.06 ± 3.83^b	0.82

Values represent Mean ± S.D, means with the same superscript across the column are not significantly different ($p>0.05$); Site A; Malalau, Site B; Rafin yan wanki, Site C; Kofar durbi, and Site D; Rafin yan tifa.

Physico-chemical Parameters

The temperature of the study sites ranged between 28.93 and 29.21°C with no significant difference across sites ($p < 0.05$) (Table 2). Similar trend was found in other parameters including pH and electrical conductivity. The DO showed significant difference between sites ($p < 0.05$) with higher value in sites B (5.02 mg/L) and lowest in site C (3.10 mg/L). Total hardness was also higher in sites B (87.53 mg/L) and D (86.89 mg/L). Nitrates and phosphates were significantly different between the sampling sites ($p < 0.05$) with the highest value (10.41 mg/l) in site A and the lowest (2.49 mg/L) in site C. The nitrate values ranged from 10.20-10.49 mg/L for site A, 6.58-6.91 mg/L for site B, 1.33-2.75 mg/L for site C, and 9.48-10.17 mg/L on site D. The mean values of nitrate in sites A (10.41 mg/L) and D (9.76 mg/L) were higher compared to sites B (6.69 mg/L) and C (2.49 mg/L) (Table 2). The permissible limit of phosphate is 0.050 mg/L (James, 1997). The phosphate content of the water during our study was slightly varied between sites. Only site D had a significantly lower ($p > 0.05$) phosphate level of 0.14 mg/L.

Table 2: Physico-chemical Parameters of the Macrophytes sampling sites in Katsina Metropolis

Sites	Temp. (^{0}C)	pH	DO (mgL^{-1})	BOD (mgL^{-1})	EC (µS/cm)	TDS (mgL^{-1})	Turbidity (NTU)	T. Hardness (mg (CaCO$_3$L^{-1})	NO$_{3}$-N (mgL^{-1})	PO$_4$-P (mgL^{-1})
A	29.21 $\pm0.76^{a}$	7.36 $\pm0.45^{a}$	4.25 $\pm0.88^{b}$	2.1 $\pm0.81^{b}$	1.29 $\pm1.53^{a}$	4.87 $\pm0.69^{b}$	1.59 $\pm1.32^{a}$	66.57 $\pm9.82^{a}$	10.41 $\pm0.11^{a}$	0.29 $\pm0.05^{a}$
B	28.99 $\pm0.82^{a}$	6.36 $\pm0.92^{a}$	5.02 $\pm0.53^{b}$	1.93 $\pm0.83^{bc}$	1.30 $\pm3.93^{a}$	14.39 $\pm1.66^{a}$	4.43 $\pm1.72^{b}$	87.53 $\pm6.87^{a}$	6.69 $\pm0.12^{b}$	0.26 $\pm0.01^{a}$
C	28.93 $\pm0.99^{a}$	6.28 $\pm0.27^{a}$	3.10 $\pm0.54^{a}$	1.68 $\pm0.13^{c}$	2.24 $\pm8.58^{b}$	14.08 $\pm0.91^{a}$	5.14 $\pm2.00^{b}$	72.49 $\pm1.24^{a}$	2.49 $\pm0.13^{c}$	0.14 $\pm0.02^{b}$
D	29.13 $\pm0.97^{a}$	6.52 $\pm0.51^{a}$	4.92 $\pm0.98^{b}$	4.44 $\pm4.50^{a}$	1.24 $\pm3.38^{a}$	3.64 $\pm0.44^{b}$	2.76 $\pm6.29^{a}$	86.89 $\pm4.87^{a}$	9.76 $\pm0.24^{a}$	0.33 $\pm0.06^{a}$
WHO Standard	<40	6.5-8.5	3-7	4	na	na	na	na	na	0.5

Values represent Mean ± S.D, means with the same superscript across the column are not significantly different ($p>0.05$); Site A; Malalau, Site B; Rafin yan wanki, Site C; Kofar durbi, and Site D; Rafin yan tifa. DO – Dissolved Oxygen, PO_{4-} P – Phosphate, NO_{3-}N – Natrates and Nitrates, pH – pH value, Temp. – Temperature, EC – Electrical Conductivity, TDS – Total Dissolved Solids, T.H – Total Hardness, BOD – Biological Oxygen Demand, TUR – Turbidity.

The correlation of Macrophytes and water quality parameters is presented in Table 3. The abundance of red water fern had an inverse relationship with pH (-0.85) and floating heart (-0.73). Total dissolve solids showed a direct relationship with water hyacinth (0.79) while turbidity shows a positive direct relationship with water hyacinth (0.79). Nitrate showed a direct relationship with red water fern (0.79) and corp pond weed (0.76).

Table 3: Correlation between Macrophytes abundance and physico-chemical parameters in Katsina Metropolis

	Temp	pH	DO	BOD	EC	TDS	TUR	T.H	NO$_{3-}$N	PO$_{4-}$ P	RWF	WH	DW	WN	CPW	BWL	FH
Temp	1.00																
pH	0.18	1.00															
DO	-0.19	-0.53	1.00														
BOD	0.07	-0.52	0.83	1.00													
EC	0.23	0.30	-0.82	0.01	1.00												
TDS	-0.39	0.16	-0.25	-0.50	-0.00	1.00											
TUR	-0.33	0.33	-0.11	-0.39	0.10	0.94	1.00										
T.H	-0.12	-0.05	-0.22	-0.02	-0.15	-0.32	-0.42	1.00									
NO$_{3-}$N	-0.27	-0.53	0.28	0.12	-0.16	0.65	0.55	-0.42	1.00								
PO$_{4-}$ P	-0.28	-0.76	0.27	0.17	-0.21	0.33	0.15	-0.16	0.75	1.00							
RWF	-0.07	-0.85	0.16	0.15	-0.20	-0.04	-0.27	-0.13	0.44	0.79	1.00						
WH	-0.44	0.06	-0.03	-0.14	-0.10	0.79	0.79	-0.26	0.67	0.26	-0.17	1.00					
DW	-0.15	-0.68	0.04	0.12	-0.13	0.24	0.02	-0.02	0.66	0.51	0.71	0.24	1.00				
WL	-0.13	-0.58	0.10	0.28	0.00	-0.57	-0.74	0.49	0.68	0.23	0.53	-0.52	0.033	1.00			
CPW	-0.34	-0.67	0.21	0.10	-0.14	0.32	0.12	-0.04	0.62	0.56	0.66	0.23	0.74	0.18	1.00		
BWL	-0.14	-0.69	0.19	0.05	0.13	0.31	0.15	-0.10	0.71	0.45	0.73	0.13	0.73	0.29	0.68	1.00	
FH	-0.58	-0.73	0.56	0.39	-0.14	0.30	0.19	-0.02	0.69	0.55	0.52	0.38	0.61	0.19	0.82	0.65	1.00

KEY: RWF – Red water fern, WH – Water hyacinth, DW – Duck weed, WL Water lettuce, CPW – Corp pond weed, BWL – Blue water lily, FH – Floating heat, LN – DO – Dissolved Oxygen, PO_{4-} P – Phosphate, NO_{3-}N – Natrates and Nitrates, pH – pH value, Temp. – Temperature, EC – Electrical Conductivity, TDS – Total Dissolved Solids, T.H – Total Hardness, BOD – Biological Oxygen Demand, TUR – Turbidity.

DISCUSSION

This study on the dynamics of Macrophytes abundance and the eutrophication status of some selected impoundments in Katsina metropolis has contributed to knowledge about the Macrophytes response to physico-chemical parameters of water. In our findings, two sites A and D had the highest number of Macrophytes of which all the seven species were found. These two sites were nutrient-rich with values of nitrate compared to the other two sampling areas. Previous findings have shown that the occurrence of aquatic Macrophytes depends on a combination of factors like sediment characteristics, water quality, sediment types, and other physico-chemical parameters of the environment (Bornette and Puijalon, 2011; Jones *et al*., 2020). The nature of riparian use by human activities, as in urban areas and farms, was found to contribute to the nature of nutrient input in these bodies, significantly altering the water parameters (Adeogun *et al*., 2012; Babatunde, 2019). This impact aquatic biodiversity as well as Macrophytes abundance (Tockner and Stanford, 2002). Macrophytes respond well to these changes, as reported by many authors (Tiseer *et al*., 2008; Okayi *et al*., 2011). This is also supported by the current finding. However, site C has no single growth of Macrophytes species (Plate 1) which could be attributed to the complex nature of pollutants accumulated in this water, as the water is higher in turbidity and lower in DO. High dissolved oxygen in water has been linked to high photosynthetic activity by Macrophytes, which releases oxygen into the water (Kotadiya and Acharya, 2014). The number of Macrophytes observed in this study is low compared with Anwana *et al*., (2021) in the Enyong River and Tiseer *et al*., (2008) in the Samaru Stream. This may be due to the nature of water in our study area as the impoundment water was satagnant. In addition, our study location was in a semi-arid area. The heterogeneity and diversity of Macrophytes may be due to changes in anthropogenic perturbations and pollution. Similar observations have been reported by Ogbemudia and Ita (2016).

Plate 1: Cross section of the surface water in the sampling sites (A: Malalau, Site B: Rafin yan wanki, Site C: Kofar durbi, and D:Rafin yan tifa).

Temperatures in all our sampling sites were not significantly different, and they were typical of the tropics. It has been reported that temperature promotes the growth and reproduction of aquatic plants, their growth, morphology, photosynthesis, and chlorophyll composition (Ronzhina *et al.*, 2004). The abundance of Macrophytes appeared to be more positively correlated with nitrogen than phosphorous in this study, although site dependent. The levels of nitrogen and phosphorus observed in this study were higher than those reported by Okayi *et al.* (2011). Considering that anthropogenic activities pose a significant impact on water quality and Macrophytes assemblage, there is a need for an effective pollution input control program for biodiversity conservation.

CONCLUSION

This study has contributed to knowledge about the Macrophytes response to physico-chemical parameters of waters. The two sites (A and D) that recorded a high number of Macrophytes diversity index of 0.75 and 0.82 respectively were nutrient rich compared to the other two sampling areas. The nature of riparian use was found to contribute significantly to the nutrient impute in these bodies of water. The majority of the aquatic Macrophytes show a correlation to the trophic state of the impoundments. Hence, this work showed that inland water quality and Macrophytes composition are influenced by riparian land use.

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