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AQUATIC MACROPHYTE DYNAMICS OF ELEYELE LAKE, IBADAN, NIGERIA

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Abstract

This study evaluated the dynamic state of aquatic macrophytes in Eleyele Lake. Sampling was done temporally and spatially over a period of twenty-four months, covering two wet and dry seasons, in five hydrological zones (Z1–Z5) representative of the lake. Macrophytes composition was evaluated with point transect method, while data obtained were analysed using descriptive statistics. The results reveal that there were fourteen species of macrophytes present during rainy season, in contrast to seven species recorded during dry season. The value of aquatic macrophytes community index (AMCI) was higher in wet season (42) than dry season (33), although Z2, Z3 and Z4 had highest AMCI value (37). Also, results shows that the lake has moderate capacity to tolerate disturbances, low vegetative quality with increasing macrophytes coverage and decreasing open water area. Therefore, Eleyele Lake can be regarded as having diverse aquatic macrophytes population, although the biological quality is moderately poor.

Introduction

Aquatic macrophytes play a major important role in community structuring of aquatic ecosystem. It is an indicator of pollution in water quality (Cross and Mcinerny 2006, Oyedeji et al. 2013) Macrophytes have positive effects on water clarity (Boyd 1968, Peter 2000, Shekede et al. 2008). These effects include provision of habitat for plant-associated macro-invertebrates and refuge for cladocerans, both of which graze on phytoplankton and epiphytes. In lakes and reservoirs, the tropic interaction can

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be altered through extensive growth of aquatic plants. The population of fish that feed directly on planktonic algae could be negatively affected by dense macrophytes coverage. While aquatic macrophyte represents an important habitat for fish, excessive proliferations of these macrophytes reduce fish catch and productivity (PETER 2000).

Human activities have beneficial and adverse effects on aquatic macrophytes community. The upsurge in urban population and the production of house-hold products have resulted in increased production of household waste materials (OLADELE et al. 2018). The proximity of man to aquatic environments has made water bodies susceptible to various types of wastes from anthropogenic activities (OLADELE et al. 2019). Also the need to increase production of food due to increase in population growth has led to higher rate of production and use of agrochemicals (TETSURO et al. 2005). Influxes of domestic, industrial and agricultural wastes have been rising in both terrestrial and aquatic environments. When deposited in inland waters, such water body becomes a sink for an array of substances ranging from sewages, surface run-off, agrochemicals to industrial effluents (AROWOMOLE 1997, ADEWUYI et al. 2010, JENYO-ONI and OLADELE 2016, OLADELE et al. 2019). Direct channelling of domestic, agro and industrial wastes to inland water bodies enhances macrophytes proliferation (MUSTAPHA 2010). Wastes are sources of nutrients and pollutants, hence, it elevates the problem of waste disposal (OLADELE et al. 2018).

In Nigeria, a country where environmental safety procedures are not firmly enforced, macrophytes proliferation in inland water bodies causes waterways blockage, limited navigation through water, reduction in fishing area and fishing gear entangling and spoilage (OLOWU et al. 2010, MUSTAPHA 2010). All of these lead to reduction in the daily income of fisher folks. One of such inland waters facing the menace of macrophytes proliferation is Eleyele Lake, a freshwater lake located in South-western part of Nigeria. The operational activities of the various establishments around the lake expose it to surface run-offs and make it a destination for erosion and overland water flows. Such inflows do contain wastes from domestic, agricultural and industrial sources. `Hence, the need to assess the dynamic variation of the macrophytes in the lake becomes pertinent considering its socio-economic roles. Therefore, this study evaluated the dynamic state of aquatic macrophytes of Eleyele Lake in time and space.

Materials and Methods

Study area

The study was carried out in Eleyele Lake, an artificial lake located in Oyo State, Southwestern part of Nigeria. The Lake was built by the Water Corporation of the Old Western Region of Nigeria in 1939 (JEJE et al. 1997). Eleyele environ is surrounded by households, agricultural farm settlements, cassava-processing industries, small-scale industries such as block industry and palm kernel oil processing industry, worship centres and many others. The lake was built on River Ona, with a pool storing capability of 29.5 million litres. The dam is situated alongside Eleyele wetland in the North-eastern area of Ibadan city, precisely in Ido Local Government Area of Oyo State. The lake is located within longitude N07°25’00” and N07°27'00" and latitude E03°50'00" and E03°53"00" with a water surface area of about 162 ha.

Sampling techniques

Sampling was done based on time and space stratification over a period of 24 months. Time stratification covers two wet (May–Nov) and dry (Dec–April) seasons, based on the rainfall pattern of the environment (MUSTAPHA 2010, KAREEM 2016). Space stratification was done in line with the methods of AJANI (2001) and SUNDAY and JENYO-ONI (2018). Based on hydrological features, the lake was divided into five zones namely Oluseyi, Apapa-ijokodo, Oniyere, Dam and Igunle-ero, which were designated as zones 1 to 5 respectively. Three sampling points were randomly located in each zone. Using GPS, sampling sites coordinates were determined in each of the sampling stations. The coordinates of the sampling sites were presented in Table 1.

Table 1

Morphometric features of the selected stations in Eleyele Lake
(Sampling Stations/ Design)

Zone	Station	Co-ordinates	Maximum depth [m]	Elevation [m]
Z1	*A* – Oluseyi	07º25'32.1"N 03º51'52.4"E	6.02	180
	B – Agbaje	07º25'54.1"N 03º51'61.3"E	7.50	181
	C – Babalegba	07º25'41.2"N 03º51"80.2"E	5.31	180
Z2	*A* – Apapa-ijokodo	07º25'47.2"N 03º51"60.4"E	5.80	181
	B – Apete	07º25’59.5”N 03º51’64.3”E	6.83	180
	C – Elewure	07º25’88.4”N 03º51’88.8”E	6.00	182

cont. Table 1

Z3	*A* – Oteru	07°25'64.2"N 03°51'43.1"E	6.41	181
	B – Idi-osan	07°25'69.7"N 03°51'54.4"E	5.60	181
	C – Oniyere	07°25'95.7"N 03°51'36.6"E	6.10	181
Z4	*A* – Dam	07°25'71.3"N 03°51'32.5"E	10.40	180
	B – Spillway	07°25'82.5"N 03°51'44.9"E	11.51	180
	C – Ologuneru	07°25'72.1"N 03°51'54.2"E	9.71	181
Z5	*A* – Adedokun	07°25'52.3"N 03°51'75.1"E	9.45	179
	B – Igunleero	07°25'63.4"N 03°51'81.5"E	8.91	177
	C – Fisheries	07°25'37.7"N 03°51'54.9"E	6.50	177

Sampling method

Aquatic macrophytes composition was evaluated with point transect method using a rake-based technique of collection (THOMAZ et al. 2009). Lake survey was done from a boat moving at slow speed through all the five zones. Hook was attached to a calibrated rope of 5 m and fixed with the rake. This was tossed parallel to the side of the transect which was parallel to the shore at a depth of 0.25, 0.5 and 1 metre. The rake was released into the water, and then dragged to recover the macrophytes. The rake was tossed four times in each of the three (3) sampling points which gave a total of twelve tosses in each zone (RICK MCVOY 1991, SUNDAY and JENYO-ONI 2018). Each time the rake was retrieved from the water, the number of occurrence of the macrophytes was recorded and the samples were kept in labelled polyethylene bags lined with aluminium foil, previously cleaned and treated with 5% nitric acid and rinsed with distilled water for further analysis (ACHIONYE-NZEH and ISIMAIKAIYE 2010). Macrophytes identification was done with JOHNSON (1997), AKOBUNDU and AGYAKWA (1998) and AYENI et al. (1999).

Data analysis

The data generated from collected samples were analysed temporally and spatially using analytical tools such as Frequency of Occurrence, Aquatic Macrophyte Community Index (AMCI) and Floristic Quality Index (FQI). SPSS statistical package was used for descriptive and inferential analyses. Biodiversity indices such as Simpson's dominance, Shannon index (H^1), Equitability (J) and Margalef index (R) were computed and data were analysed with the use of 'PAST' software package (HAMMER et al. 2001). In order to determine the nutrient components, the proximate composition and nutrients present in the macrophytes identified were carried out using standard techniques of AOAC (2000). Nutrients analysed for were sodium, magnesium, calcium, potassium and phosphate. Secondary data were also obtained from GIS UNIT, Geography Department, University of Ibadan to show the variation in aquatic macrophytes cover over the period of ten year (2007–2016).

Analytical Techniques for Determining Macrophytes Dynamics

Frequency of occurrence

The frequency occurrence was calculated by recording the number of times each macrophyte was present in each station each time the rake was tossed. The monthly proportion [%] of all the species, the concentration and area concealed were calculated by means of frequency of occurrence.

Aquatic macrophytes community index (AMCI)

To calculate the AMCI, seven (7) parameters were used to categorise plant communities and these parameters were given range value of 1–10. They are: Maximum depth of the plant growth, Littoral area vegetated, Simpson's diversity index, Relative frequency of submerged species, and Relative frequency of sensitive species, Taxa number, and Relative frequency of exotic species (NICHOLS et al. 2000)

Floristic quality assessment (FQA)

This method, developed by WILHELM Gerould in 1970, was used to determine the vegetative integrity area based on its plant community.

Biodiversity indices for assessing macrophytes dynamics

Various indices used include Simpson's Index, Shannon Wiener index, Equitability index and Margalef's richness index.

Simpson's index

These involve the richness and percentage (proportion) of individual macrophyte species. It takes into account the frequency of occurrence (i.e. abundance) of a particular macrophyte species in a zone and also the total number of species observed in all zones (SIMPSON 1949).

Shannon Wiener index

This index evaluates the richness and proportion of macrochyte present in each zone (SHANNON and WIENER 1949).

Equitability index (*J*)

The evenness with which individual macrophyte were divided among the taxa present were recorded. Shannon diversity is divided by the logarithm of number of taxa.

Margalef's richness index

Margalef index (*d*) (MARGALEF 1951) was enhanced to determine the species richness.

Results

The morphometric features of the selected stations with the use of GPS are shown in Table 1. The coordinates and sampling sites in each of the zones were presented.

The temporal distribution of aquatic macrophytes in Eleyele Lake is presented in Table 2. As shown in the table, there were fourteen species of macrophytes present, out of which *Poaceae* family has 3 species; *Onagraceae* has 2 species while the other families have one species each. During the wet season, all the fourteen species of macrophytes which belong to eleven families were present. However, only seven species were present during the dry season.

Table 2

Temporal variation of aquatic macrophytes in Eleyele Lake

Scientific name	Family	Dry season	Wet season
Polygonum salicifolium Brouss. ex Willd.	*Polygonaceae*	–	xxx
Pistia stratiotes Linn.	*Araceae*	xxx	xxx
Cyperus rotundus Linn.	*Cyperaceae*	–	xxx
Luffa cylindrica (Linn.) M.J. Roem	*Cucurbitaceae*	–	xxx
Sacciolepis Africana Hubb & Snowden	*Poaceae*	–	xxx
Acroceras zizanioides (Dandy)	*Poaceae*	–	xxx
Leptochloa caerulescens Steud.	*Poaceae*	x	xxx
Ludwigia abyssinica A. Rich.	*Onagraceae*	–	xxx
Ludwigia decurrens Walter	*Onagraceae*	x	xxx
Ipomoea aquatica Forssk.	*Convolvulaceae*	xxx	xxx

cont. Table 2

Ceratophyllum demersum Linn.	*Ceratophyllaceae*	–	xxx
*Nephrolepis bisserrata (*Sw.) Schott	*Pteridophyta*	x	xxx
Nymphaea lotus Linn.	*Nymphaeaceae*	xxx	xxx
Costus afer Ker-Gauel.	*Costaceae*	x	xxx

Explanations: x – present; xxx – abundant; --- – not present

Table 3 shows the frequency of occurrence of aquatic macrophytes in Eleyele Lake. In each zone, varying number of occurrence was obtained for each of the macrophytes from which the percentage occurrence was calculated. The macrophytes with the highest percentage frequency observed during the study was *Ipomoea aquatica* with 14.06% occurrence, with percentage relative frequency of 76.67%, while *Cyperus rotundus* had the the least occurrence (4.30%) and percentage relative frequency (23.33%).

Table 3

Frequency of occurrence of aquatic macrophytes in Eleyele Lake

Species	Z1	Z2	Z3	Z4	Z5	TNO	%FO	Rel. %
Polygonum salicifolium Brouss. ex Willd.	0	6	7	8	0	21	6.42	35.00
Pistia stratiotes Linn.	6	8	7	8	5	34	10.40	56.67
Cyperus rotundus Linn.	0	5	5	4	0	14	4.30	23.33
Luffa cylindrica (Linn.) M.J. Roem	0	7	5	7	0	19	5.81	31.67
Sacciolepis Africana Hubb & Snowden	0	6	4	5	0	15	4.59	25.00
Acroceras zizanioides (Dandy)	0	7	5	6	0	18	5.50	30.00
Nephrolepis bisserrata (Sw.) *Leptochloa caerulescens* Steud.	5	4	6	5	3	23	7.03	38.33
Ludwigia abyssinica A. Rich.	0	6	5	6	0	17	5.19	28.33
Ludwigia decurrens Walter	5	3	6	4	1	19	5.81	31.67
Ipomoea aquatica Forssk.	8	10	9	10	9	46	14.06	76.67
Ceratophyllum demersum Linn.	0	6	7	8	0	21	6.42	35.00
Nephrolepis bisserrata (Sw.) Schott	7	4	2	3	6	22	6.73	36.67
Nymphaea lotus Linn.	3	10	8	5	3	29	8.87	48.33
Costus afer Ker-Gauel.	3	8	10	5	3	29	8.87	33.30
Total	–	–	–	–	–	327	100	–

Explanations: Z-Zone; TNO – total number observed; FO – frequency of occurrence; Rel. % – Relative percentage

The Aquatic Macrophyte Community Index (AMCI) in Eleyele Lake, based on time and space, is presented in Tables 4 and 5. As evident in Table 4, the AMCI value was higher in wet season (42) than dry season (33). This is obvious from the higher values of the variables obtained during the wet season. As presented in Table 5, the least AMCI value (30) was recorded in zone 1 while zones 2, 3 and 4 had the highest AMCI value (37).

Table 4

Temporal variation of aquatic macrophyte community index (AMCI) in Eleyele Lake

Category	Dry	Value	Wet	Value
Maximum depth of plant growth(m)	2.7	3	3.5	6
*Littoral area vegetated [%]	≥50	10	100	10
Submerge species (Rel %)	0	1	35	2
Simpson's diversity	0.81	1	0.90	1
Taxa number	7	3	14	7
Sensitive species	7	5	13	6
Exotic species	0	10	0	10
AMCI	–	33	–	42

*From a plant 'perspective' 100% of the littoral zone vegetated is the best

Table 5

Spatial variation of aquatic macrophyte community index (AMCI) in Eleyele Lake

Categories	Z1	Value	Z2	Value	Z3	value	Z4	Value	Z5	Value
Maximum depth of plant	2.2	3	2.5	3	2.7	3	3.2	5	2.4	3
Littoral area vegetated	40	7	≥ 50	10	≥ 50	10	40	8	45	9
Simpson's Diversity	0.9	1	0.89	1	0.89	1	0.90	1	0.90	1
Taxa number	8	3	13	6	12	6	11	5	7	3
Submerge species	0	1	25	1	20	1	35	2	0	1
Exotic species	0	10	0	10	0	10	0	10	0	10
Sensitive Species	8	5	13	6	12	6	11	6	6	5
AMCI	–	30	–	37	–	37	–	37	–	33

Floristic Quality Assessment (FQA)

Using the method of WILHEM (1970) as reported by WILHEM (1977), with an 'MC' of 4.29 and 'n' value of 14, the FQA of Eleyele lake was calculated to be 16.05. Ranking of Mean C-value ranges from low (most disturbance tolerant) with an MC of 2.0 to a high (least disturbance tolerant) of 9.5. Based on this ranking, the result of this study reveals that Eleyele Lake, with an MC of 4.29, has the capacity to tolerate disturbances moderately. Similarly, using the FQA rating of WILHEM and RERICH (2017) which reported that FQA value of 1–19 indicates low vegetative quality, 20–35 indicates high vegetative while FQA of above 35 indicates 'Natural area' quality, the result of this study shows that Eleleye Lake is of low vegetative quality.

Proximate and nutrient compositions of the macrophytes collected during the study are presented in Table 6. Having analysed all the sampled macrophytes, the highest moisture content (23.15±3.39%) was obtained in *Ipomoea aquatica* while the lowest (12.85±1.26%) was obtained in *Polygonum salicifolium*. *Polygonum salicifolium* has the maximum crude protein mean value of 7.00±0.63% while *Ceratophyllum demersum* has the minimum mean crude protein content (1.46±0.07%). Table 6 also shows that the nutrient elements had varying values among the macrophytes. The highest and lowest levels of the nutrient elements are distributed among the macrophytes.

The values of diversity indices in each zone, in space and time are presented in Tables 7 and 8 respectively. Table 7 shows that Simpson's index ranges from 0.89 to 0.90, Shannon-Weiner index ranges from 2.35 to 2.40, Margalef index ranges from 1.91 to 2.14 while equitability index ranges from 0.94 to 0.97. Also, the table shows that the index values of the zones are relatively close to each other. It is evident in Table 8 that all the indices had higher values during the wet season than the dry season.

Table 6

Mean variation and standard deviation of mineral composition in aquatic macrophytes

	Moisture	Ash	CP	CFIBRE	CFAT	C	Na	Mg	Ca	K	PO4
PS	21.85±2.48	2.76±0.5	2.06±0.18	31.58±2.30	0.22±0.11	41.58±4.26	11.60±6.22	14.56±7.29	46.95±217	13.54±4.10	5.94±3.26
AZ	18.25±0.13	2.60±0.11	2.74±0 .59	29.0±5.75	0.29±0.08	49.12±4.73	7.51±4.83	9.76±1.14	40.78±26.16	11.59±4.01	2.32±0.87
NL	23.15±2.59	1.87±0.17	2.58±0.13	23.75±4.39	0.14±0.03	43.05±3.52	14.58±0.87	34.48±2.19	32.23±1.40	18.83±0.49	10.63±0.71
CD	16.45±4.88	5.64±1.99	1.46±0.07	43.48±8.65	0.50±0.12	32.08±5.53	21.13±11.67	28.37±7.86	12.03±0.38	24.43±17.54	4.95±0.43
PS	12.85±1.26	4.50±0.44	7.0±0.63	38.68±1.67	0.38±0.03	34.6±0.96	5.0±0.22	78.03±10.39	14.6±0.77	9.7±0.88	3.25±0.28
NB	17.38±0.76	5.08±0.85	2.31±0.59	41.18±2.53	0.74±0.08	33.18±1.33	7.06±1.23	65.18±16.47	8.71±0.55	8.75±0.95	2.88±0.20
LD	20.85±0.93	2.17±0.39	2.94±0.79	30.30±2.45	0.29±0.08	43.00±1.20	4.69±0.83	89.38±9.76	32.83±13.43	11.57±3.81	3.73±1.66
LA	16.63±4.84	2.66±0.26	2.39±0.25	38.00±1.13	0.14±0.03	46.35±0.80	15.00±1.05	87.18±3.98	31.00±1.83	8.88±0.46	9.76±0.29
LCY	18.98±0.22	5.73±0.74	5.99±0.37	35.15±1.71	0.38±0.05	34.4±0.55	5.01±1.05	88.05±11.46	12.75±0.31	7.77±1.32	3.02±0.19
IA	23.15±3.39	2.73±0.37	2.46±0.24	30.08±2.69	0.25±0.11	40.28±3.32	6.76±2.71	64.7±3.38	22.20±9.43	9.11±3.18	5.43±3.33
CR	15.1±2.49	6.93±1.19	5.38±0.96	38.43±2.29	1.13±0.23	33.65±0.54	6.82±1.42	81.45±3.16	10.31±1.62	14.58±1.49	3.22±0.43
LCA	11.53±0.15	1.90±0.15	2.67±0.09	26.05±4.77	0.19±0.09	47.00±1.66	14.93±0.92	40.83±11.38	35.08±4.65	19.05±0.61	10.56±0.54
SA	13.22±0.21	1.52±0.17	2.43±0.44	22.11±2.33	0.16±0.07	32.11±1.54	7.01±0.45	42.11±6.51	18.61±0.78	17.51±0.87	8.61±0.73
CA	11.03±0.51	3.34±0.56	2.06±0.57	25.06±2.06	0.47±0.03	38.08±1.41	4.55±0.61	25.77±5.67	10.44±0.45	15.89±0.62	4.55±0.65

Explanations: horizontal axis: Cp – Crude protein; Cfibre – crude fibre; Cfat – crude fat; C – carbohydrate; Na – sodium; Mg – magnesium; Ca – calcium; K – potasssium; PO_4 – phosphate; Vertical axis: PS – *Pistia stratiotes;* AZ – *Acroceras zizanioides;* NL – *Nymphaea lotus;* CD – *Ceratophyllum demersum;* PS – *Polygonum salicifolium,* NB – *Nephrolepis biserrate;* LD – *Ludwigia decurrens;* LA – *Ludwigia abyssinica;* LCY – *Luffa cylindrica;* IA – *Ipomoea aquatica;* CR – *Cyperus rotundus;* LCA – *Leptochloa caerulescens;* SA – *Sacciolepis africana;* CA – *Costus afer*

Table 7

Spatial diversity indices of macrophytes composition

Diversity index	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Simpson 1-D	0.90	0.89	0.89	0.90	0.90
Shannon-*H*	2.40	2.35	2.35	2.36	2.36
Margalef	2.14	2.02	1.92	1.91	2.03
Equitability	0.97	0.95	0.94	0.95	0.95

Table 8

Temporal diversity indices of aquatic macrophytes

Diversity index	Wet season	Dry season
Simpson 1-D	0.90	0.81
Shannon-*H*	2.41	1.70
Margalef	1.60	0.88
Equitability	0.97	0.95

Table 9 present the variation in the spatial distribution of macrophytes and water in Eleyele Lake. Over the years under consideration (secondary data, Source: GIS UNIT, Geography Department, University of Ibadan, Nigeria), Table 9 shows that there was increase in the macrophytes coverage of the water body coupled with decreasing area of macrophytes turning to water. The table also shows that there were fluctuations in the area of water to turning to macrophytes while open water area reduced. The pictorial representation of Table 9 is presented in Figures 1, 2 and 3 respectively.

Table 9

Percentage change in spatial distribution of macrophytes of Eleyele Lake between 2007 and 2016

Aquatic Macrophytes dynamics	2007–2012 Change [%]^{A}	2012–2014 change [%]^{B}	2014–2016 change [%]^{C}	DF (B–A)	DF (C–B)	DF (C–A)
Macrophytes to macrophytes	23.13	32.60	48.06	9.47	15.46	24.93
Macrophytes to water	14.62	8.49	3.36	-6.13	-5.03	-11.26
Water to macrophytes	15.56	20.07	8.54	4.51	-11.53	-7.02
Water to water	46.69	38.84	39.94	-7.86	1.11	-6.75
Total	100	99.99	100	-0.01	0.01	-0.1

Explanation: DF – difference

Source: GIS Unit, Geography Department, University of Ibadan

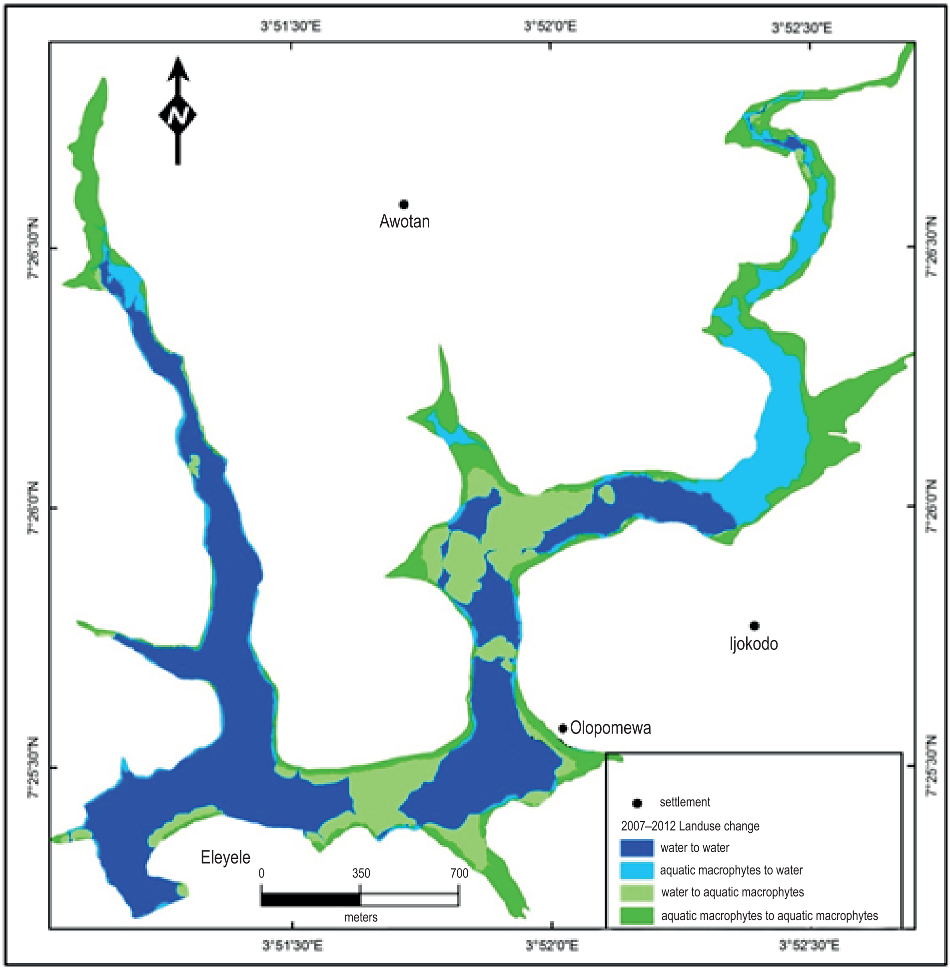

Fig. 1. Spatial distribution of macrophytes in Eleyele Lake in 2007–2012
Source: own study based on data from GIS Unit, Geography Department, University of Ibadan, Nigeria

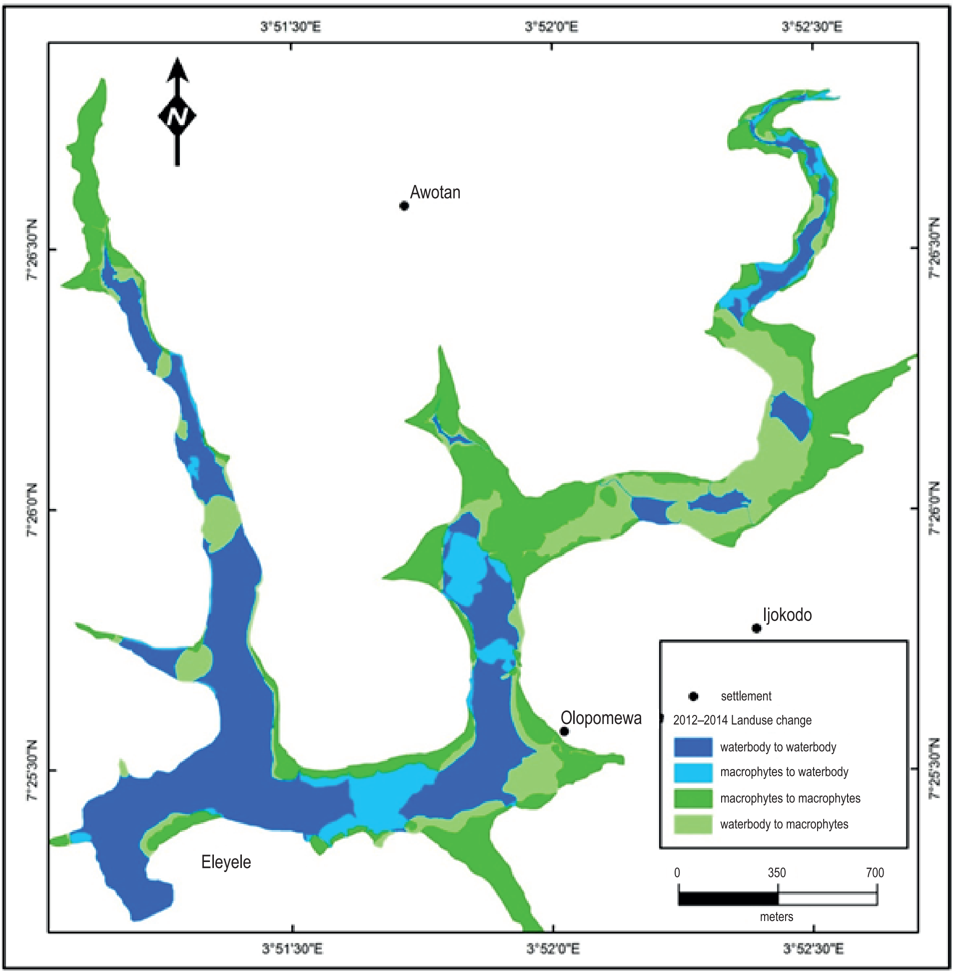

Fig. 2. Spatial distribution of macrophytes in Eleyele Lake in 2012–2014
Source: own study based on data from GIS Unit, Geography Department, University of Ibadan, Nigeria

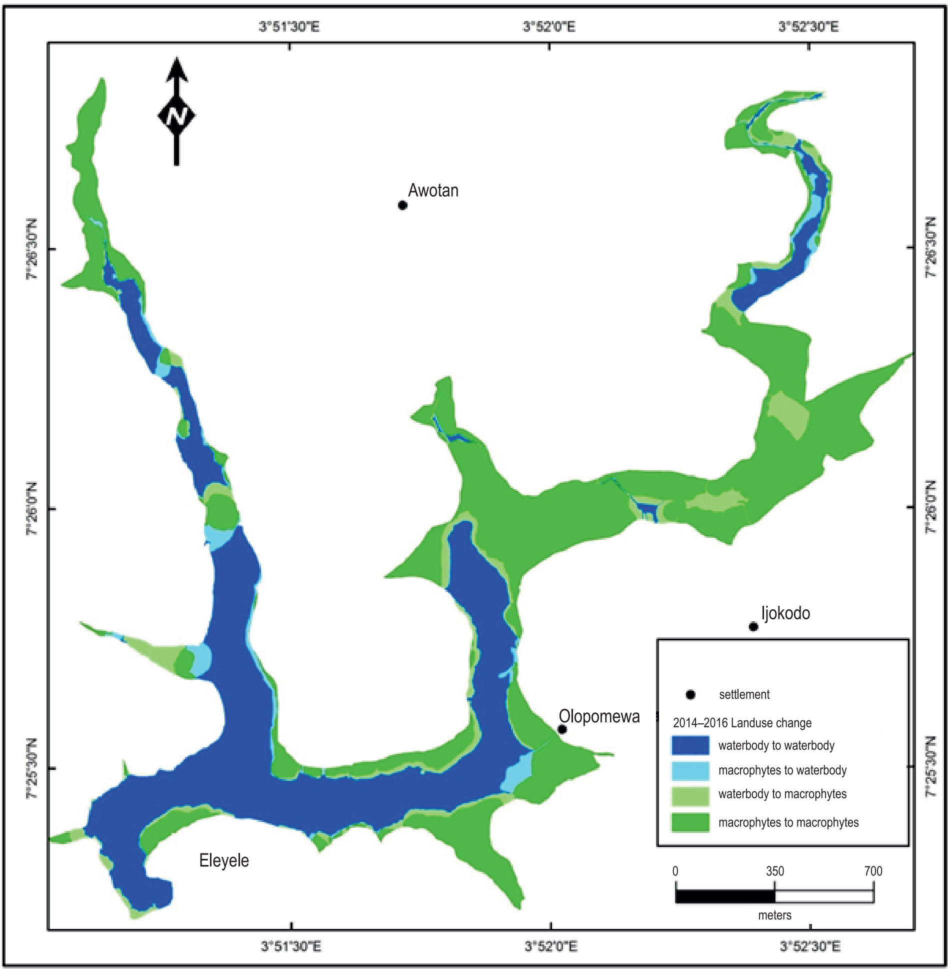

Fig. 3. Spatial distribution of macrophytes in Eleyele Lake in 2014–2016
Source: own study based on data from GIS Unit, Geography Department, University of Ibadan, Nigeria

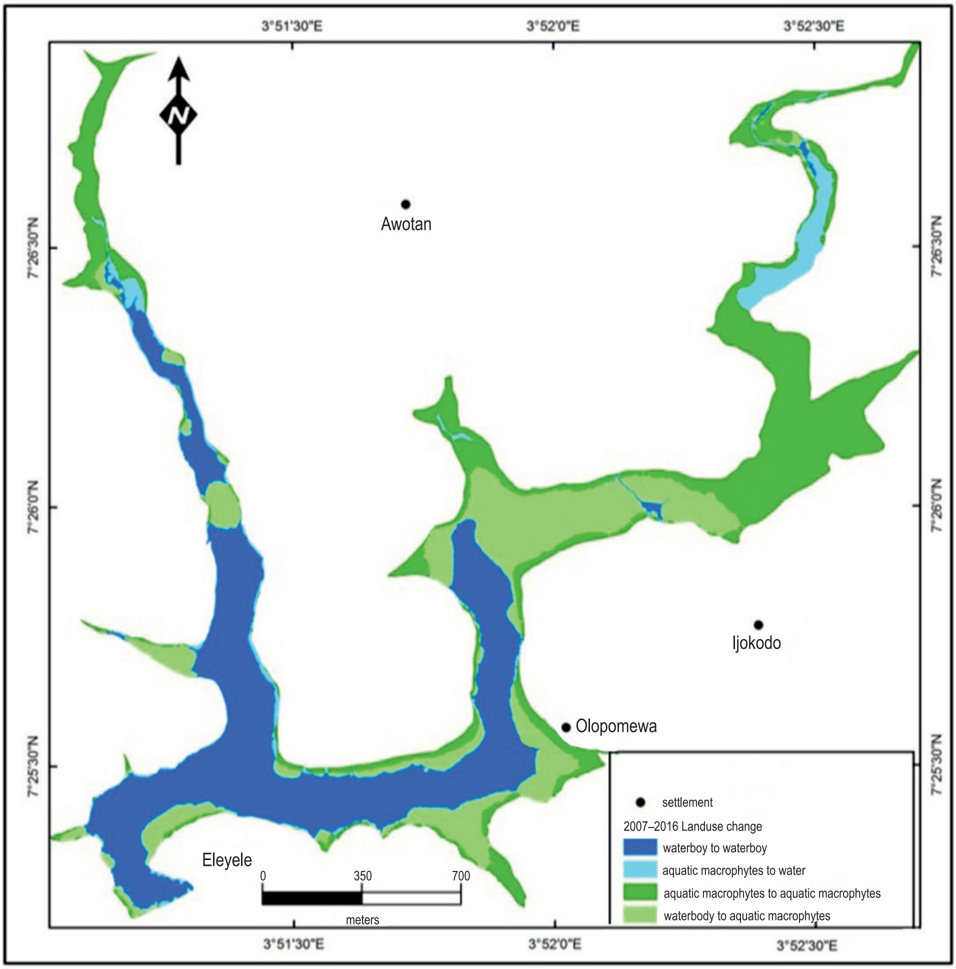

Fig. 4. Macrophyte dynamics and spatial distribution in Eleyele Lake in 2007–2016
Source: own study based on data from GIS Unit, Geography Department, University of Ibadan, Nigeria

Discussion

The composition of aquatic macrophytes identified in Eleyele lake shows that the lake has diverse aquatic plant population. Inflow of nutrient rich eroded water, which is capable of increasing the nutrient level of the water body may have played important role in the diversity observed among the macrophytes. According to the findings of PANKHURST (2005), LUND (2017), SUNDAY (2019), nutrient availability in fresh water bodies enhances aquatic macrophytes proliferation. The effect of wind and tidal action on macrophytes movement may have aided the distribution of plants in various parts of the lake. Macrophytes diversity observed in this study is relatively lower when compared with the findings of DELPHINE et al. (2015). In their report, DELPHINE et al. (2015) identified a total of 38 and 46 species of aquatic macrophytes in Gyawana and Kiri lakes, respectively. These freshwater lakes, however, are located in Adamawa State, North-eastern Nigeria. Several factors may be responsible for this variation, among which is the water volume, nutrient content, interaction among plant species, anthropogenic activities in and around the lake, among others (CONNORS et al. 2000, DAR et al. 2014, SUNDAY 2019). Also, differences in physiological characteristics of macrophytes, in addition to the effect of nutrient inflow and tidal action, may have supported the proliferation of some macrophytes over others (VERMAAT and DE BRUYNE 1993, PANKHURST 2005). This is evident in the relatively higher frequency of occurrence displayed by *Ipomoea aquatica* in the lake when compared with other macrophytes.

Temporally, the aquatic macrophyte community index (AMCI) in Eleyele Lake reflects the importance of seasonality on macrophytes population. Water addition to the lake from rainfall, erosion and the lake's feeding rivers was higher during raining season. This led to increase in water volume which in turn provides greater space for macrophytes growth (KUMAR and PANDIT 2008). The incursion of nutrient elements from these inflows provide higher nutrient base for macrophytes proliferation during the wet season. Therefore, it is not unexpected that zones 2, 3 and 4 (Apapa-ijokodo, Oniyere and Dam respectively) had the highest AMCI values among other locations. This is so because these three (3) zones are bordered with agricultural farms, industrial and residential establishments, whose wastes and effluents are deposited in the lake. Such wastes have been reported to contain nutrient elements (SUNDAY and JENYO-ONI 2018, SUNDAY 2019), thereby enhancing greater macrophytes proliferation in those zones.

However, human disturbance in form of macrophytes clearing is largely responsible for the low AMCI recorded in zone 1 (Oluseyi), since the zone is utilized for anthropogenic activities such as washing, bathing, swimming and navigation. Despite that the AMCI values obtained in this study showed that Eleyele Lake was moderately poor in biological quality, this finding is in agreement with the set limit by WEBER et al. (1995). The need for space for domestic water use, fishing and navigation has made constant clearing of macrophytes in Eleyele Lake a continuous activity. This could be responsible for the low vegetative quality of macrophytes recorded in the lake. The role of herbivorous fishes inhabiting the lake in reducing macrophytes vegetative quality cannot be overruled. According to the findings of CONNORS et al. (2000), herbivorous activities of aquatic vertebrates and invertebrates and plant interaction among other factors affect the composition and distribution of aquatic vegetation in freshwater lakes.

The availability of aquatic plants as source of food has been reported as one of the factors that enhances growth and reproduction of herbivorous fish species, especially the cichlids MUSTAPHA (2010), EDWARD (2013), OLOPADE and RUFAI (2014). The dominance of this fish species in Eleyele Lake may have played significant roles in altering the value of FQA recorded during this study. The low FQA also buttresses the primary purpose of constructing the lake, which is for the provision of potable water to Ibadan metropolis, thereby attaching little or no importance to the macrophytes composition and diversity.

Proximate composition of the aquatic plants reveals that the plants have relatively high moisture and crude fibre contents while other proximate parameters were low. This finding is in agreement with the submission of BOYD (1968) and HAZRA et al. (2018) which stated that variation in mineral composition of aquatic plants depends on plant type and age as well as the nutrient content available in the water body. However, the crude protein content observed in the aquatic plants analysed falls within the crude protein range established by the findings of BOYD (1968). All the aquatic plants were rich in minerals elements, at levels similar to the findings of BANERJEE and MATAI (1990).

This study also reveals that there were increases in the macrophytes coverage of the water body coupled with decreasing area of macrophytes turning to water. This may be attributed to inflow of nutrients into the water body (ROSSET et al. 2010, ALAHUHTA 2011, DAR et al. 2014, SUNDAY 2019). This finding was also buttressed by the fact that there were fluctuations in the area of water turning to macrophytes while open water area reduced. The decrease in the area of water distribution observed in this study may lead to reduction or loss of fish habitats. According to the submissions of TIJANI et al. (2011), reduction in the water area has negative impact on the catchment/shoreline area, in addition to degradation or loss of habitat. This finding also supports the findings of SUNDAY (2019) which stated that reduced water area in Eleyele Lake affects water navigation, reduced the recreational activities and restricted the fishing area for the fishermen. These factors reduce fish catch and adversely affect daily income of the fisher folk fishing the lake. Increase in macrophytes proliferation reduces the rate at which light penetrates the water column which in turn affects the water transparency.

Conclusion

Fourteen species of aquatic macrophytes were identified in Eleyele Lake, out of which *Poaceae* family has 3 species; *Onagraceae* has 2 species while the other families have one species each. Therefore, the lake can be referred to as having a diverse aquatic macrophytes population. Water inflow from feeder streams, nutrient addition from point and non-point sources as well as tidal action must have played important roles in enhancing macrophytes population over the years. However, the lake's macrophytes diversity is relatively low when compared with those of other freshwater lakes in Nigeria. The relative low diversity recorded during this study could be attributed to the effects of different activities on water like domestic water use, fishing, navigation and other anthropogenic activities. Among the macrophytes present, the condition of the water body must have supported greater proliferation of *Ipomoea aquatica*, as evident in the relatively higher frequency of occurrence displayed by the plant.

In Eleyele Lake, AMCI reveals that the rainy season supported greater macrophytes performance while Apapa-ijokodo, Oniyere and Dam zone had higher AMCI spatially when compared with other zones. The proximity of these zones to human interference and nutrient inflow may have accounted for the species richness observed in those zones. Despite the AMCI values obtained in this study, Eleyele Lake was moderately poor in biological quality when compared with standard rating. This may have resulted from continuous macrophytes clearing and herbivorous feeding by aquatic vertebrates and invertebrates inhabiting the water body. The low FQA value obtained in this study also corroborate the poor biological quality rating of the lake. This study also reveals that there were increases in the macrophytes coverage of the water body. This is buttressed by the decreasing area of macrophytes turning to water as well as declining open water area. In addition to reduction or loss of fish habitats, continuous macrophytes coverage of the lake will hinder such activities as domestic water use, fishing and navigation. Therefore, there is the need for regular monitoring of macrophytes proliferation on the Lake in order to ensure sustainable use of the water resources.

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