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RESEARCH PAPER

LITTORAL VEGETATION AND PHYSICO-CHEMICAL CHARACTERISTICS OF THE OWABI LAKE IN GHANA

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ABSTRACT
The littoral zone of water bodies serves as a habitat for plants and food source for fishes but could be detrimental to the longevity of the lake if the growth and spread of plants are not controlled. The littoral zones of the Owabi Lake is influenced by four river inlets that bring into the lake a lot of sediments and other pollutants. Though these may be detrimental to the water body, they also serve as nutrient source for the littoral vegetation. No work has been done previously on the characteristics of the littoral vegetation of the Owabi Lake. The study thus assessed the general floristic characteristics and the water quality of the Owabi Lake. The littoral perimeter of the lake was divided into zones of 78 plots with 5 m X 5 m quadrats at 50 m intervals. The plant species within each plot was assessed and enumerated. Additionally, the physico-chemical characteristics of the littoral zone were determined using standard protocols. The study yielded a total of 30 plant species which belonged to 25 families. Acrocera zizanioides recorded the highest density of 91.21% but relative frequency of 16.08%. An algae, Lemna minor registered the highest relative frequency of 16.35% but a relative cover of 0.013%. Acrocera zizanioides had the highest IVI of 107.30 with the herbs Chromlaena odorata and Lugwigia alata indicating an IVI of 0.27. Species from the Asteraceae family had the lowest relative density (<1%). The lower portion of the lake recorded higher plant cover with H and 1-D alpha diversity analysis indicating lower diversity within the plants species (H<2.0), with the evenness being significantly different (p=0.03) between the lower and upper portion of the lake. The physico-chemical characteristics of the lake indicated higher concentrations at the lower portion, and that influenced the inward growth of plants into the lake. The values obtained were within the WHO limits with only the light intensity being very low at the upper portion due to shades from tree covers. The higher concentrations of nutrients with adequate light intensity at the lower portion of the lake could account for the relative higher density and IVI of plants at that part of the lake. The uncontrolled inward growth of plants at the lower portion of the littoral zone of the Owabi lake could narrow its size with time and poses danger to the sustainability of the water body.

Key words: *littoral zone, Owabi lake, physico-chemical parameters, algae, concentrations*

INTRODUCTION

Littoral zone is an ecotone between land and water habitats, and serves as a buffer zone against sediments, macro-pollutants and nutrients build up in lakes. It harbours flora and fauna species varieties that should accommodate both wet and dry environmental conditions (IUCN & Ramser Convention Bereau 2009; Yeboah 2020). The vegetation is mainly composed of submerged, floating and amphibious plants species that serve as food and shelter for most aquatic animals (Oteng-Yeboah 1999). Owabi Lake (Fig 1B) is within the only protected inland wetland (Ramser site) in Ghana and was formed by the damming of the Owabi River and its tributaries in 1928, and provided water to the Kumasi Metropolis till the Barekese water works was built in 1971 (www.fcg.gov.org) to supplement the portable water production. The solid wastes and other dissolved materials from agricultural and industrial activities in the urban towns that surround the wetland (Fig 1A) are carried into the lake by its feeding rivers and get deposited in it (Akoto et al 2017). Open lakes receive water from rivers laden with chemical pollutants and suspended substances (Li & Wu 2019), and most of these tend to nourish the water bodies (Johnson et al (2007). The substances tend to provide nutrients in the water for the growth and spread of plant species in the littoral zone. However, excess leaching and over concentration of these substances in the water could cause the growth and spread of new plants into the water body (Badu et al 2013; Cao et al 2020). A high density reserved forest of the Moist Semi-deciduous type surrounds the lake, and provide water rejuvenation and protection to the lake from agro-industrial activities by nearby urban communities (Fig 1A&B). Littoral vegetation consists of mesophytic plants made up of trees, herbs and grasses. In areas where sedimentation of suspended solids and nutrients in the lakes are high, invasive plants abound in larger quantities (Ameka and Asare 2019). Though some work has been performed on the water quality of the lake (Akoto et al. 2017; Boadi et al. 2018), nutrients load (Badu et al. 2013) and the fringing forest (Teye 2008; Oppong 2021), no study has been done on the littoral vegetation of the Owabi Lake to serve as a baseline information upon which further studies could be done. This study focussed on assessing the characteristics of flora community and water quality's influence on their spread in the littoral zone of the Owabi Lake in Ghana. This work would enable the state of the present littoral vegetation to be documented, and allow the changes that may occur due to vegetation dynamics to be appreciated later.

MATERIALS AND METHOD

Description of the Study Area

The Owabi lake is located in the Owabi Ramser Reserved wetland within the Kumasi Metropolis and the Atwima-Nwabiagya District of the Ashanti Region (Fig 1A). The wetland covers an area between 06°47'3.32"N 001°37'53.4"W and 06° 41'52.3"N 001°44'0.81"W. The lake's littoral zone consists of the areas within the edges of the lake that lies within the coordinates 06°43'6.04"N 001°40'28.1"W; 06° 42'08.6"N 001°41'49.2"W for the upper and lower portion respectively: normally 5.0 metres into the water and the land. The lake receives water from four main rivers; Punpunase, Sukubriso, Akyeamponene and the Owabi (Fig 1A). The lake is surrounded by a high-density reserved forest that occupies an area of 3856.80ha, and the wetland is surrounded by urban communities like Amanfrom, Owhim, Atafua, and others (Antwi-Agyei et al (2019; Fig 1A). The feeding rivers are laden with human and industrial wastes from the towns, and leached agricultural substrates (Akoto et al 2017; Boadi et al 2018) which tend to affect the physico-chemical and nutrient levels of the lake.

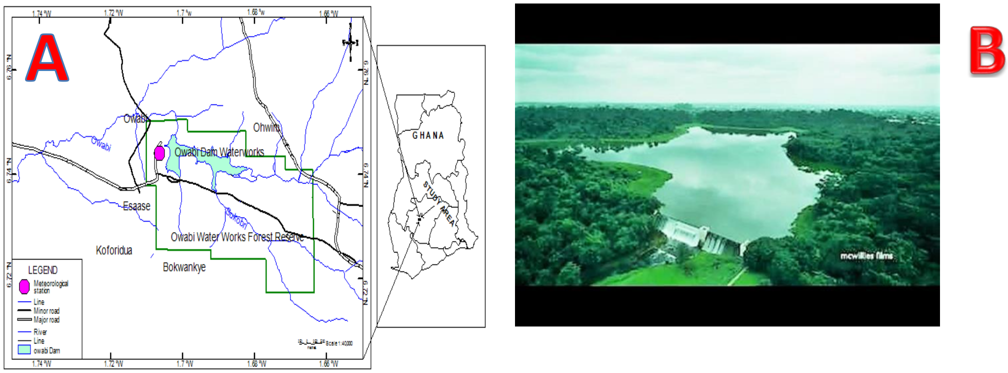

Figure 1: Map showing the location of the Owabi lake in the Ashanti Region (A), and an aerial view of the Owabi lake (B).

Vegetation Sampling Procedure

A total of 78 quadrats each measuring 5.0 m X 5.0 m were systematically demarcated at 50 metre intervals to cover the entire littoral zone of the lake (Fig 2A) using boats (Fig 2B). A 25 metre long measuring tape was used to demarcate the quadrats, and the four corners of each quadrat were marked with coloured cellophane marker tapes. The GPS coordinates of the plots on the littoral zones were taken with a handheld GPS reader instrument (Garmins Trex 10 model) with an accuracy of 15 meters at 95% of the time. With the help of a plant taxonomist and research assistants, plant species in each plot were observed, identified and enumerated. The composition of plant species in both water and on the land was obtained by identifying the different species within each plot while the abundance was by counting the number individual plants of each species within the plots as performed by Oppong (2021) and Coulston et al (2014).

The assessment was performed for large plants with stem diameter ≥ 10 cm which includes shrubs and trees that were found mostly on the upper portion of the lake (Fig 3A). The degree of cover/density for the littoral plants was obtained for the flora with diameter ≤ 10 cm that include herbs, floating and submerged plants. These lower plants could not be counted so density/cover was used for their assessment instead of abundance. The area covered by a species of the plants in each plot was determined against the area of the plot. These lower plants were found mostly along the lower littoral zone of the lake (Fig 2B). The frequency of occurrence for the plants in both the water and land was found from the number of times a particular plant species appeared in the total number of plots studied as described by Anning (2004) and Muhanguzi et al (2007).

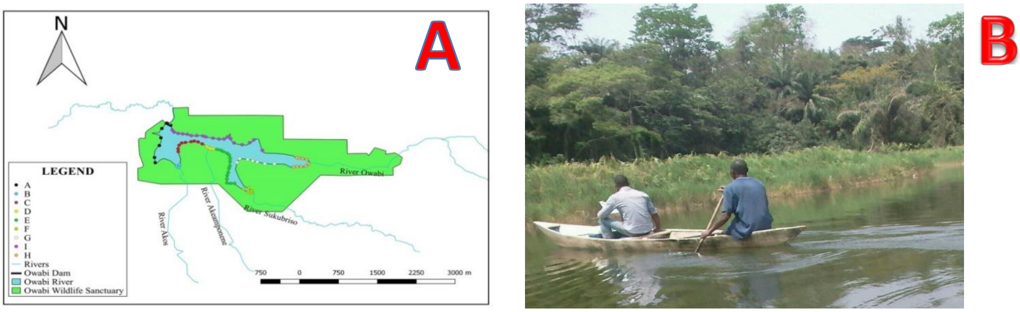

Figure 2: GPS plotting of the sampled sites on the littoral zones of the Owabi lake (A), and the using of canoes in demarcating the sampled plots along the littoral zones (B)

Determination of physico-chemical parameters in the littoral zone

Measurement for physical parameters was performed through in-situ process on the field with a portable Oakton waterproof field meter and Sekonic illuminometer i-346 light meter at each of the twenty six demarcated sites. The light meter was set at zero and readings taken in Lux at the sampled sites. The probe of the Oakland field meter was immersed into the lake at the depth of 5.0 cm at each site and the readings for temperature and dissolved solids taken. The probe of the instrument was then, cleaned with distilled water and inserted into a 250 mL beaker containing 100 mL of 12.84 mS standard calibrated liquid for EC calibration. The reading on the meter was adjusted to match that of the standard and the probe inserted into the lake for the measurement. For pH calibration, the probe was well cleansed with distilled water and inserted into standardized buffer solution in a beaker. The reading was compared with the known pH of the buffer and adjusted to match that of the buffer. The probe was then put into the lake at 5.0 cm and the readings taken.

Chemical analysis was performed through ex-situ process. Water samples from each of the twenty six sites were collected into 100 ml sampled bottles. At each site, the bottle was cleaned and filled with some of the water to the brim. The bottles were stoppered and put into ice containers at 0°C, transported to the KNUST Civil Engineering laboratory for chemical analysis by a titrating process; the Hach method (for nitrite-nitrogen), PhosVer 3 method (for phosphate) and spectrometric method (for metals). 1000 ml of each of the water samples were digested with 1.0 ml HCl (conc) and their filtrates mixed with 1.0 g of potassium iodide each. The contents were allowed to stand for an hour and analyzed with a flame atomic absorption spectrometer (Spectra AA-110/220/880 Varian) (Kowalkowski et al 2006). The samples were mixed with aerosol and ignited at a selected wavelength for each element. The results were read from the screen of the spectrometer.

Ecological and statistical analysis

The relative values in percentages of the ecological indices were obtained, from which the important value index (IVI) was calculated for each plant species. Alpha diversity indices; Simpson's (1-D) and Shannon-Weiner ($H' = -\sum_{i=1}^{S} p_i \ln p_i$) quantification tools (Okpiliya 2012) were used to find the degree of diversity within the species. T-test and ANOVA from the SPSS software were used to analyze the variations within the mean values obtained in the lower and upper portions of the lake, and the physico-chemical parameters measured respectfully at a significance level of 0.05.

RESULTS

Vegetation Structure

A total of 30 species that were distributed into 29 genus, 24 families and 6 life-forms were documented in the seventy eight (78) plots sampled at the littoral zones of the Owabi Lake. Means of frequency and densities of the ecological groups and Shannon's diversity index of plants differed insignificantly (P > 0.05) while Simpson's index of diversity (1-D) differed significantly (p=0.03) within the plants at the lower and upper portions of the lake. Herbs dominated with a relative cover of 94.21%, followed by the ferns being represented by *Diplazium* sp with 5.76% (Table 1). *Acrocera zizanioides*, a grass recorded the highest relative cover and frequency of 91.21% and 16.09% respectively, culminating in the highest IVI of 107.30. The plants were of six life-forms and were placed into 25 families (Table 1).

From visual observation, there were a lot of pollutants/solid waste substances along the lower portion of the littoral zone of the lake from the feeding rivers (Fig 3A). The lower portion of the lake contains large deposit of sediments and high sunlight intensity which promoted the growth of grasses and other invasive plants species (Fig 2B). The upper portion of the lake had little deposit of suspended sediments and low light intensity as a result of the trees shade, so there was no visible growth of new plants along the littoral zone (Fig 3B). It was also observed that algae and submerged plants preceded the growth of emergent plants in the open areas of the lower littoral zone of the lake (Fig 3 C).

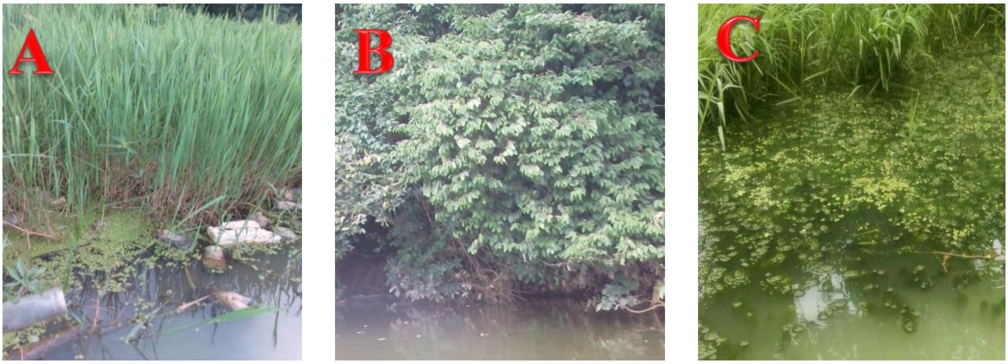

Figure 3: Solid pollutants observed at the lower portion of Owabi lake (A), no growth of plants in the lake at the upper portion (B), spread of plants on the lake being preceded by the appearance of algae and submerged plants (C).

Table 1. Composition, family, life forms and important value index (IVI) of littoral plants.

SPECIES	FAMILY	LIFE FORM	R. FREQ-UENCY/%	R.COVER/ DENSITY/%	IVI / 200
Acrocera zizanioides (Kunth) Dandy	Poaceae	herb	16.09	91.21	107.30
Alchornea cordifolia (Scumach & Thonn.)	Euphorbaceae	Liana	2.41	0.012	2.42
Bambusa vulgaris Schrad.	Poaceae	Tree	0.54	0.003	0.543
Cassia siamea Lam.	Xantholaceae	Tree	0.54	0.004	0.544
Ceratophyllum demersum L.	Ceratophylaceae	Submerged plant	10.19	0.004	10.19
Chromolaena odorata (L.) R.M.King & H. Rob.	Asteraceae	Shrub	0.27	0.002	0.27
Colocasia esculentus (L.) Schott	Araceae	Herb	0.54	0.001	0.54
Commelina africana L.	Commelinaceae	Herb	0.27	0.002	0.27
Culcasia caudate Engl.	Arecaceae	Herb	1.34	0.008	1.35
Cyperus esculentus L.	Cyperaceae	Herb	0.80	0.042	0.42
Cyperus iria L.	Cyperaceae	Herb	0.88	0.061	0.94
Diplazium somattii Maxon & C.V.Morton	Arthyriaceae	Fern	9.92	5.745	15.67
Elaeis guineensis Jacq.	Palmae	Tree	2.14	0.002	2.14
Eclipta alba (L.) Hassk	Asteraceae	Herb	1.87	0.02	1.89
Hyptis alata (Ref.) Shinners	Lamiaceae	Herb	0.54	0.001	0.54
Heteranthera callifolia Rchb. ex Kunth	Ponteridiaceae	Floating	2.14	0.28	2.43
Lemna minor L.	Lemnaceae	Floating plant	16.29	0.01	16.30
Limnocharis flava (L.) Buchenau	Alismataceae	Herb	1.07	0.001	1.01
Ludwigia abyssinica A.Rich.	Onagraceae	Herb	0.27	0.001	0.27
Luffa cylindrical (L.)Reom.	Cucurbitaceae	Herb	0.27	0.014	0.28

Nephrolepis rachis (Desv.) Christ	Nephrolepidaceae	Fern	0.54	0.050	0.39
Nymphaea lotus L.	Nymphaceae	Floating	2.15	0.014	2.16
Raphia hookeri G.Mann & H.Wendle	Arecaceae	Tree	0.54	0.004	0.54
Rhynchospora corymbosa (L.) Britton	Cyperaceae	Herb	0.54	0.003	0.54
Smilax bella J.F.Macbr.	Smilacaceae	Liana	1.88	0.005	1.89
Spirogyra sp.	Zygnemataceae	Submerged plant	2.41	0.002	2.42
Polygonium lanigerium	Polygonaceae	Herb	10.45	2.138	12.59
Pistia stratiotes L.	Aracaceae	Floating plant	8.84	0.169	9.02
Thalia geniculate L.	Taliaceae	Herb	6.42	0.351	6.78
Typha latifolia L.	Typhaceae	Herb	2.15	0.023	21.17

*Scientific names were verified from www.plantlist.org

The ecological grouping of the plants had the terrestrial plants recording the highest species of 16 and submerged having 2. The emergent plants recorded the highest relative frequency of 45% and 99.40% relative cover, resulting in an IVI of 144.40 (Table 2). Emergent plants mostly have roots in the soil in shallow waters and leaves above the water surface, and are capable of tolerating temporal dryness (Bourton & Tiner 2012; Ameka & Asare 2019). This ecotone harbours fishes due to food availability and adequate dissolved oxygen concentrations (Cronk & Fennessey 2001; Churchill et al 2016).

Table 2. Ecological plant types with their abundance and dominance values

Ecological Description	Number of Plant Species	R. Frequency /%	R. Density /%	IVI /200
Submerged	2	12.60	0.01	12.61
Floating	4	29.50	0.47	29.97
Emergent	8	45.00	99.40	144.40
Terrestrial	16	13.49	0.02	13.51

Diversity Indices

The Shannon-Weiner Diversity index (H) indicated low value of 0.60 for emergent plants species at the lower and 2.42 at the upper portion, while submerged plants registered 3.0 and 1.9 at the lower and upper portions respectfully (Table 3). Simpsons Diversity index (1-D) indicated a higher spread of 0.41 for the lower portion of the lake while the upper part recorded 0.6 2 (Table 3). Thus, the lower portion of the lake contains less diversity but more cover of plants species than the upper portion.

Table 3. Shannon-Weiner and Simpson's diversity indices of plants in the littoral zones

Diversity indices	Range of Index	Ecological description of plants	Location		p-value
			Lower Portion	Upper Portion	
Shannon's (H)	0-7	Submerged	3.06	1.95	0.19
		Floating	0.21	0.84	0.53
		Emergent	0.62	2.42	0.36
		Terrestrial	0.39	0.25	0.52
Simpson's (1-D)	0-1		0.41	0.62	0.03

Relative Density of flora

Acrocera zizanioides (a grass) with a density of 91.21% dominated the littoral vegetation. This was followed by a fern, *Diplazium sommattii* with 5.75%. *Polygonium lanigerium*, *Heteranthera cordifolia* and *Typha latifolia* recorded 2.14%, 0.27% and 9.26% respectively (Table 1). The relative high density of these plants were found growing at the lower portion of the littoral stretch (Fig 2B), except

Ceratophylum and *Lemna* spp. The high levels of the physico-chemical parameters (Table 4) obtained at the lower portion of the Owabi Lake made it conducive for the growth and spread of the vegetation (Table 3; Fig 3A&C). *Ceratophylum demersum* recorded a higher relative density of 10.10% in the upper portion of the lake where there was inadequate light intensity (lower than the WHO thresholds) and low sedimentation of suspended substances in the water (Table 3). The profuse spread of *Lemna* and *Ceratophyllum* spp was also observed in an earlier study by Dennison et al (2005) who indicated the presence and abundance of submerged flora depends on the quality of water bodies. Polluted waters with higher chemical concentrations have little or no growth of *Ceratophylum* sp (Ameka & Asare 2019). The low density of *Ceratophylum* and *Lemna* spp. in the lower portion of the Owabi Lake (0.004%) may indicate a high pollution index in the water at that part of the lake. This phenomenon was observed in earlier work by Churchill et al (2016) who indicated a long-term change in the appearance and abundance of littoral vegetation when the physico-chemical levels of a lake rise above threshold limits.

Frequency of flora

The frequency of occurrence indicated *Lemna* minor, an algae was the highest occurring plants with relative abundance of 16.35% and followed closely by the grass *Acrocera* sp with 16.09% *Polygonium lanigerium* and *Ceratophylum demersum* followed with 10.48% and 10.19% respectively (Table 1). However, many herbs including mainly terrestrial plants accounted for low frequency since their presence was perhaps by accident. They were found growing on floating corks and other solid substances on the lake (Fig 3A) and at the lower portion which recorded higher physico-chemical levels (Table 3). It could be observed from Fig 3B that areas along the littoral zones of the Owabi Lake with low light intensity due to tree canopies, did not exhibit any growth and spread of new plants. The high relative cover (99.40%) and IVI (144.40) of plants at the lower portion in the Owabi lake could be attributed to the deposition of sediments carried by the rivers and high levels of physico-chemical characteristics of the lake at that portion.

Physico-chemical parameters of the Owabi Lake

The physico-chemical parameters obtained from sampling the lake recorded mean values that were within the WHO limits except light intensity and nitrite-nitrogen (No_2-N^+) levels. The light intensity level at the upper portion of lake was below the World Health Organization (WHO) limit and could be described as inadequate while the No_2-N^+ and dissolved oxygen (DO) recorded concentrations above the WHO and indicated p-values below 0.05 (Table 4). The WHO limits set a standard on which water parameters are considered adequate or inadequate. Unfortunately, light intensity, DO and No_2-N^+ are important to plant growth, and may cause eutrophication in water bodies if their levels are unchecked (Adamu et al 2013; Johnson et al 2007). Total dissolved solids (TDS) affect transparency and light penetration in water bodies, and it is an important criterion for ascertaining the suitability of water for domestic, drinking and industrial purposes (Addo et al 2016; Wikurendra et al 2022). The source of the chemicals may have arisen from the dissolution of cations and anions from the host rock by the running rivers (Adamu et al 2013; Cao et al 2020), and may be deposited in the middle and lower portions of lakes (Boesch et al 2007).

Table 4. Mean physico-chemical characteristics of the Owabi lake

PARAMETERS STUDIED	SAMPLED PLOTS			P-VALUES
	UPPER PORTION	LOWER PORTION	WHO	
Temperature/ ⁰C	25.1± 0.02	27.5 ± 0.01	25-30	0.551
Light intensity/ lux	890×10^3	1.26×10^4	1.0×10^4	0.042
Tot. hardness/mgL-1	105.52 ± 0.14	122.02 ± 0.07	500	0.281
TDS/mgL-1	104.3 ± 2.15	212.1 ± 1.52	1000	0.096
EC/µScm-1	366 ± 5.66	416.5 ± 1.11	1000	0.662
Turbidity/NTU	5.25 ± 0.03	11.5 ± 0.2	75	0.828
DO/ mg/L	2.2 ± 0.03	1.8 ± 0.02	6	0.047
BOD/ mg/L	2.91± 0.01	4.8 ± 0.02	25	0.066
pH	6.1± 0.01	7.88 ± 0.01	6.5-8.5	0.072
No_2-N^+/mg/L	290 ± 0.21	2100 ± 0.32	100	0.038
PO_3^+/ mg/L	187.43 ± 6.28	132.18 ± 6.18	250	0.051
Alkalinity/ mgL	116.05 ± 0.08	111.34 ± 0.06	150	0.082

*red colour indicates mean values with significant variation (p<0.05)

DISCUSSION

They littoral zone recorded 30 different plant species. The species richness 30 species was low as compared to the composition of plants in the surrounding forest which recorded 139 plant species (Teye 2008; FCG 2008)). Studies on some riparian vegetation of some rivers in Ghana indicated lower species composition between 18 and 23 (Yeboah 2020; Ameka & Asare 2019). *Acrocera zizanioides* and the fern, *Diplazium sommattii* dominated and occurred frequently in most parts of the littoral zones Within the ecological groupings, emergent plants showed the highest IVI of 144.40 indicating its dominance in the littoral zones (Table 2) with a low Simpson's diversity index of H=0.62 and 2.42 among the plant species at the lower and upper portions of the Owabi Lake respectively, and an insignificant variation (p=0.03). There were more species under the terrestrial but they were located only at the littoral zone of the upper portion of the lake while the lower part was dominated by *Acrocera zizanioides* (an emergent) (Table 2; Fig 2B).

Most of the plants species in the littoral zone of the Owabi wetland is of the emergent and terrestrial types as compared to the real hydrophytes. The emergent plants have access to adequate nutrients and firm grip on a solid substratum created by the deposition of suspended substances in the water, and therefore can grow and spread well in the presence of adequate sunlight as observed at the lake's lower portion (Table 4; Fig 3A). Changes in water levels pose environmental difficulties to plants in littoral zones, though the emergent plants tend to tolerate the variations better (Yeboah 2020; Cronk & Fennessey 2001).

Most physico-chemical parameters studied like pH, alkalinity, electrical conductivity and turbidity indicated values that were well within the WHO given limits and also, exhibited non significance in their p-values except light intensity, dissolved oxygen and No_2-N^+ (Table 2). Low light intensity of 890 x 10^3 Lux on the littoral zone of the upper portion of the lake as a result of the shades from fringing trees prevents sun-loving invasive plant species from appearing and spreading at that portion, while the lower portion contained relatively high cover with significant variations of p=0.03 between the two locations. The low light intensity and lower chemical concentrations recorded at the upper portion of the lake may be responsible for the little plant growth and low diversity observed at that part of the lake (Tables 3&4, Fig 3B). Thus only few shade loving herbs like *Ludwigia abyssinia* and *Hyptis alata* were occasionally observed under the trees in the upper littoral zone of the lake.

It was also, observed that the spreading plants were zoned in horizontal arrangement with the plant community being preceded by algae and submerged plants (*Lemna* and *Ceratophylum* spp. respectively) (Plate 4). The high levels of light intensity, total dissolved solids and nitrite at the lower portion of the lake facilitated the growth and high density of invasive plants into the inner portion of the lake as was observed by Ameka and Asare (2019). The succession of plant communities in riparian zones follow a definite order in which each seral stage shifts but get preserved (Clement 2000). The high density of lower plants, especially *Acrocera zizanioides* (IVI=107.30) and *Diplazium sommattii* (15.67) dominated the lower portion of the lake with a preceding growth of *Lemna* and *Ceratophyllum* spp. (Table 1; Fig 3C).

The high levels of nitrogen and phosphate compounds (Table 4) in the lake as a result of leaching of industrial and agricultural activities by the feeding rivers supported the introduction and spread of invasive native and non-native plants into the water. Ameka & Asare (2019) observed similar phenomenon in their study on macrophytes in Coastal Southern Ghana. The inward growth of plants into the inner portion of lakes tends to close their surface area and reduce the water surface-atmosphere interaction that promotes dissolve oxygen (DO) concentration in the water. It could also reduce the volume of water in the lake by the plants invasion. The volume of the Cao River (Cao et al 2020) and Pucang river (Wikurendra 2022) in Vietnam and Malaysia respectively were reduced by invading plant species into the water bodies. Awotwe et al (2018) observed a reduction in depth of water at the littoral area of the Bosomtwe Lake in Ghana in an earlier study and attributed it to the growth of invading plants and deposition of eroded sediments into the water body.

Commelina africana and *Chromolaena odorata* which are terrestrial plants occurred occasionally at the lower portion of the lake where corks and bottles (solid pollutants) availed in the littoral zone and recorded density and IVI lower than 0.30 (Table 1). The plants thus appeared accidentally on the hard objects in the water (Fig 2A). Frequency of plants in littoral zones of water bodies was assessed by Boesch (2007), Jason et al (2018) and Dennison et al (2005) in previous studies and concluded that nutrient enrichment and high light intensity impacted positively the growth of algae and macrophytes in water bodies as was observed in the Owabi Lake (Table 1). Though nitrogen and phosphate compounds are essential for plant growth in lakes, their concentrations that are above recommended level of 0-5 (Mitchel 1990) would promote algae bloom and eutrophication which may affect the water body's resilience.

CONCLUSION

The species richness of plants was low, and the lower portion of the lake the recorded higher frequency, density and dominance of plants than the upper portion as most of the nutrients from the feeding rivers got deposited at the lower portion of the Owabi Lake, thus making available enough nutrients for the growth and spread of plants in the littoral zone in the lower portion of the water body. Though, the measured physico-chemical parameters were within the WHO thresholds, the relatively low levels of the light intensity and chemicals at the upper portion of the lake did not promote invasive plant growth into the water body as at the lower portion. The invasion of native and non-native plants species into the lake was profuse at the lower portion of the lake's littoral zone. The uncontrolled spread of the plants into the lake would narrow its size and render it unsustainable in the near future.

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