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Composition and Diversity of Aquatic Macrophytes in Lentic Ecosystem of Okpiri Igweleduoha Amagu Ikwo Peri–Urban, Ebonyi State

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ABSTRACT

An assessment of macrophyte composition and diversity aimed to provide baseline information on the species richness and diversity of aquatic macrophyte of lentic ecosystem in Ikwo PeriUrban was conducted. The composition, distribution and dominance of plant species, systemic random sampling method was applied with the help of a 40cm x 40cm quadrant in the determination of the composition, distribution and dominance of aquatic macrophyte plant species. Biomass estimation of plant species was done by harvest method. Soil samples were analyzed for their texture, pH, total nitrogen (%) and total organic matter (OM%) using standard methods. Results obtained from analyzed soil samples revealed that pH (5.12), organic matter (5.79%) and Nitrogen (0.22%) were lower at the shoreline and increased towards the centre of the pond. Eight (8) families of macrophytes were recorded representing 9 species. Onagraceae had the highest species with two (2) species while the remaining had one species each. The distribution status revealed that the studied macrophytes were non-endemic and five species were classified as least concern by the IUCN Red List. The diversity indices indicated that Persicaria amphibian belonging to the Polyonaceae family had the highest number of individual species (n=178), highest density (111.25m^2) and was the dominant macrophytes with 100% frequency of occurrence, while the macrophyte species with lowest abundance was *Sphenoclea zeylanica* and *Ceratophylium demersum*. The macrophytic plant biomass was 24.45g/m^2. The Shannon diversity index was found to be 1.22. The species richness, Shannon diversity index and evenness and were not fairly distributed in the pond. This showed that the macrophytes in the study area were not stable, The results of this research showed that a holistic approach to aquatic resources management is thus the most logical approach to harness plant resources and associated animal communities by their utilization monitoring and control.

Keywords: Aquatic Macrophytes, Lentic, Diversity, Ecosystem, Biomass, Distribution

INTRODUCTION

Aquatic macrophytes are aquatic plants growing in or near water. Aquatic macrophytes are normally macroscopic plants that may be ever emergent, submerged or floating examples are duckweeds, water hyacinths (Thomas *et al.*, 2010), etc. Macrophytes generally are divided into six (6) types which include angiosperms (flowering plants), peteridophytes mosses and liverworts.Charophytes (stoneworts and filamentous algae – Macrophytes colonize many different types of water bodies which include lakes, reservoirs wet land, streams, rovers, marine environments and even rapids and falls. The majority of submerged macrophytes in aquatic habitats contribute to the formation of the biota and the physical and chemical environments. (Jeppensen and Sonderganrd, 2019). Emergent macrophytes are thought to be the most particularly productive of all aquatic macrophytes since they make the best use of all three possible states (Christie *et al.*, 2009). Examples include lotus (*Nelumbo nucifera*) duckweed, water lily, bud mangroves. According to Gevrewo *et al*. (2017), emergent aquatic macrophytes are plants having a vegetative portion that rises above the water's surface and are rooted in shallow water. It is believed that of all aquatic macrophytes, emergent macrophytes are the most notably productive. Because of their roots in sediments beneath water and their aerial portion used for photosynthesis, they combine the best features of all three states (Gevrewo *et al*., 2017).

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Aquatic macrophytes are a crucial component of lentic ecosystems, playing significant roles in maintaining ecological balance and enhancing biodiversity. These plants provide essential services such as habitat for aquatic organisms, oxygen production through photosynthesis, and nutrient cycling, which contribute to the overall health and functionality of freshwater systems (Wetzel, 2001). In particular, the composition and diversity of aquatic macrophytes are vital indicators of environmental quality and ecological status (Heegaard *et al*., 2001).

The lentic ecosystem of Okpiri Igweleduoha Amagu Ikwo in Ebonyi State, Nigeria, represents a unique peri-urban water body characterized by varying degrees of anthropogenic influence. Understanding the composition and diversity of macrophytes in this ecosystem is essential for effective conservation and management strategies. Studies have shown that peri-urban water bodies are often subjected to pressures from urbanization, which can lead to changes in water quality and alterations in macrophyte communities (Gopal, 2016).

Previous research on aquatic macrophytes in similar ecosystems has highlighted the impact of environmental variables such as water depth, light availability, and nutrient concentrations on the distribution and abundance of these plants (Chambers *et al*., 2008). In the context of Okpiri Igweleduoha Amagu Ikwo, it is imperative to investigate how these factors interact to shape the macrophyte assemblages and to assess the implications for biodiversity conservation in the region.

This study aims to provide a comprehensive assessment of the composition and diversity of aquatic macrophytes in the lentic ecosystem of Okpiri Igweleduoha Amagu Ikwo, Ebonyi State. By doing so, it seeks to contribute to the broader understanding of how peri-urban water bodies function and how they can be managed sustainably to preserve their ecological integrity and biodiversity.

MATERIALS AND METHODS

Study Area and Sample Collection

The study was conducted in a pond located at Okpuruigweledoha Amagu in Ikwo Local Government Area of Ebonyi State, South-East Nigeria. Ikwo is located at latitude 6° 4' 22" N and longitude 8° 6' 38" E (Northern part) of Ebonyi state and has an area of about 500km^2, with a population of about 214,969. This region experiences normal tropical weather, with dry and wet seasons, an average of 1300 mm of annual rainfall, and an air temperature of roughly 30^{0}C. Plant species collected were identified by a plant Taxonomist from the Department of Applied Biology, Ebonyi State University, Ebonyi State.

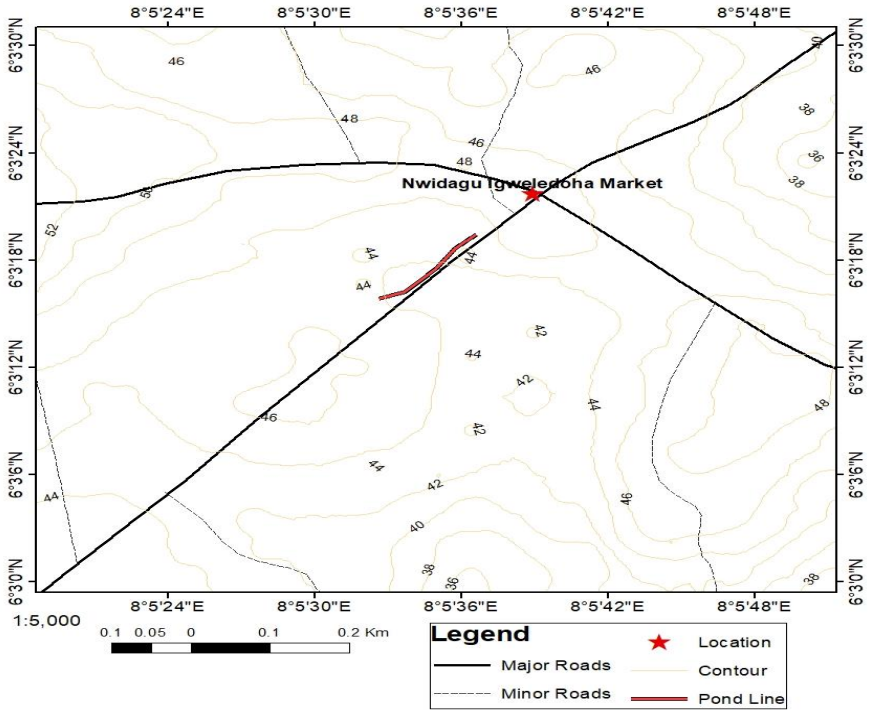

Figure 1: Map of Okpuruigweledoha Amagu in Ikwo Local Government Area of Ebonyi State.

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Determination of Composition, Distribution and Dominance of Plant Species

The pond was divided into four equal parts. To know the composition, distribution and dominance of plant species, a systematic random sampling method was applied with the help of 1mx1m quadrant. Altogether, 10 quadrants were sampled along each line transect at a distance of 10m intervals starting from the shoreline to the centre of the pond. All quadrants were sampled on the same side of each transect. The relative frequency and relative density of each species were calculated in the study by Singh *et al*. (2012) as follows:

$$\text{Frequency (\%)} = \frac{No\ of\ quadrants\ in\ which\ the\ species\ occurs}{total\ number\ of\ quadrants\ studied} \text{ x } 100$$

$$\text{Density/quadrants} = \frac{total\ number\ of\ individual\ species\ in\ all\ quadrants}{total\ number\ of\ quadrants\ studied}$$

$$\text{Abundance/quadrants} = \frac{total\ number\ of\ individual\ species\ in\ all\ quadrants}{total\ number\ of\ quadrants\ in\ which\ the\ species\ occurs}$$

Relative frequency = (frequency of A/total frequency all species) x100

Relative density = density of abundance A/total density of all species) x100

Relative abundance = (abundance of species A/total abundance of all species) x100

Specie Richness

The species richness is defined as the total number of species occurring one square meter, which is a common plot size in vegetation analysis of grassland (Bhattarui *et al*., 2004). All species rooted within the 1x1m^2 plots were recorded.

Biomass Estimation

The biomass of each quadrant was estimated by the harvest method. Each quadrant was divided into four equal parts (quarters) and one part was selected randomly for biomass harvest. Above-ground biomass was collected from the selected quarter (0.5mx0.5m) and separated into individual species. It was oven-dried at approx 75^{0}c for 1 hour in the Biology Laboratory of Alex Ekwueme Federal University, Ndufu Alike Ebonyi State.

Soil Sampling and Analysis

From each quadrant sampled, about 200gm soil was collected from about 10cm depth. It was air dried, sieved, and slightly ground in a mortar and then packed in airtight plastic bag for laboratory analysis. Soil was analyzed for its texture, PH, total nitrogen (%) and total organic matter (OM %) at the Department of soil and Environmental Management Laboratory, Ebonyi State University.

Analysis of Soil Texture

The Soil samples were oven-dried at 100^{0}c for 24 hours and passed through a series of sieves with different mesh sizes. Then, the mass of soil in each sieve was measured by electric balance (0.001g). Based on the mesh size of the sieves, three textures means the relative proportions of various size groups of individuals' soil particles soil particles were grouped according to Zobel *et al*. (1987) as coarse gravel (5cm), fine gravel (2mm to 5cm), Coarse sand (0.2mm to 2mm), Fine sand (0.002mm to 0.02m) and Clay (less than 0.002mm)

RESULTS

Species Composition

The aquatic macrophytes found in the lentic ecosystem in Ikwo Peri-urban are shown in Table 1 Altogether nine (9) species of plants belonging to 8 families were recorded from the study area. The family of Onagraceae

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had two identified aquatic macrophytes that includes *Ludwigia adscendens* (L.) and *Ludwigia decurrens,* whereas the families of Polyonaceae, Pontederiaceae, Nymphaeaceae, Lemnaceae, Convolvulaceae, Sphenocleaceae and Ceratophyllaceae had only aquatic macrophyte species each. The life forms namely emergent (*n* = 3 species) and floating (*n* = 3 species) and submerged (n= 3species) were recorded. Out of the 8 families documented in this study, family Polyonaceae, Pontederiaceae, and Nymphaeaceae, were found to be the most dominant.

Table 1: Aquatic macrophytes species recorded in a lentic ecosystem in Ikwo Peri-urban during the study period

S/No	Family	Species	Life form
1	Polyonaceae	*Persicaria amphibian* (Linnaeus) Gray	submerged
2	Pontederiaceae	*Eichhornia natans* (P. Beauv.) Solms	Submerged
3	Nymphaeaceae	*Nymphaea lotus* Linn	floating leaved
4	Onagraceae	*Ludwigia adscendens* (L.) H. Hara	floating-leaved
5	Lemnaceae	*Lemna pausicostata* Hegelm	free-floating
6	Onagraceae	*Ludwigia decurrens*	Emergent
7	Convolvulaceae	*Ipomoea triloba*	Emergent
8	Sphenocleaceae	*Sphenoclea zeylanica* Gaertn.	Emergent
9	Ceratophyllaceae	*Ceratophyllum demersum*	Submerged

The Distribution and Conservation Status of Aquatic Macrophyte Species.

In the Distribution and Conservation Status of aquatic macrophyte species in the studied lentic ecosystem according to IUCN Red List Criteria, the encountered species were grouped as follows: Not Evaluated (NE; *n* = 2 species), Least Concern (LC; *n* = 4 species) and Not Extinct (NE; *n* = 2 species). The distribution status revealed that most of the surveyed aquatic macrophyte species were non endemic as shown in Table 2

Table 2: The Distribution and Conservation Status of aquatic macrophyte species in a lentic ecosystem in Ikwo Peri-urban

Scientific Name	Family	Conservation Status	Distribution Status
Persicaria amphibian **(Linnaeus) Gray**	Polyonaceae	Least Concern	Non endemic
Eichhornia natans **(P. Beauv.) Solms**	Pontederiaceae	Not evaluated	Non endemic
Nymphaea lotus Linn	Nymphaeaceae	Not extinct	Non endemic
Ludwigia adscendens (L.) H. Hara	Onagraceae	Least concern	Non endemic
Lemna pausicostata Hegelm	Lemnaceae	Least concern	Non endemic
Ludwigia decurrens	Onagraceae	Not evaluated	Non endemic
Ipomea triloba	Convolvulaceae	Not extinct	Non endemic
Sphenoclea zeylanica Gaertn.	Sphenocleaceae	Least concern	Non endemic
Ceratophyllum demersum	Ceratophyllaceae	Least concern	Non endemic

Quantitative Characteristics of Aquatic Macrophytes of Ikwo Peri-Urban Lentic Ecosystem

In the Ikwo Peri-urban Lentic Ecosystem throughout the study period, the aquatic macrophytes' quantitative characteristics are displayed in Table 3. It was determined that there were 284 distinct aquatic macrophytes in a lentic habitat. *Persicaria amphibian (*n=178*) had the highest* number of individual species observed in the study location, it was followed by *Eichhornia natans (*n=56*). Ceratophyllum demersum* (n=2) had the least number of individuals. *Persicaria amphibian* had the highest density (111.25m^2) and was the dominant macrophyte with the frequency of 100% and abundance of 17.8%. *Eichhornia natans* followed in their dominancy with the density of 35.00 $m^{2,}$ frequency of 60% and abundance 8.0. *Ceratophyllum demersum* had the least dominant; it had frequency (10%) and density (1.25%)

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Diversity of Aquatic Macrophytes Found in Ikwo Peri-Urban Lentic Ecosystem during the Study Period

A total of nine (9) aquatic macrophytes species were found in Ikwo Peri-urban lentic ecosystem during the study period. The result indicate that *Eichhornia natans* had the highest diversity -0.320) followed by *Persicaria amphibian* (-0.293), while the least diversity was recorded in *Ceratophyllum demersum* (-0.035). The total diversity H was 1.22 as shown in Table 3

Table 3: Quantitative characteristics of aquatic macrophytes found in Ikwo Peri-urban lentic ecosystem during the study period**.**

S/No	Species	No. of Individual species	Frequency	Relative frequency	Density per (m^2)	Relative density	Abundance
1	*Persicaria amphibian* (Linnaeus) Gray	178	100	26.32	111.25	62.68	17.8
2	*Eichhornia natans* (P. Beauv.) Solms	56	60	18.42	35.00	19.72	8.0
3	*Nymphaea lotus* Linn	20	30	7.89	12.5	7.04	6.66
4	*Ludwigia adscendens* (L.) H. Hara	09	40	10.53	5.63	3.17	2.25
5	*Lemna pausicostata* Hegelm	07	30	7.89	4.38	2.46	2.33
6	*Ludwigia decurrens*	05	40	10.53	3.13	1.76	1.67
7	*Ipomea triloba*	04	20	5.26	2.50	1.41	2.0
8	*Sphenoclea zeylanica* Gaertn.	03	30	7.89	1.88	1.06	1.0
9	*Ceratophyllum demersum*	02	10	5.26	1.25	0.70	1.0

Table 4: Shannon's Diversity index of aquatic macrophytes found in a lentic ecosystem in Ikwo Peri-urban

Species	Number (p)	pi	*In(pi)*	pi*In(pi)
Persicaria amphibian **(Linnaeus) Gray**	178	0.627	-0.467	-0.293
Eichhornia natans **(P. Beauv.) Solms**	56	0.197	-1.624	-0.320
Nymphaea lotus Linn	20	0.070	-2.659	-0.186
Ludwigia adscendens (L.) H. Hara	09	0.031	-3.474	-0.107
Lemna pausicostata Hegelm	07	0.025	-3.689	-0.092
Ludwigia decurrens	05	0.018	-4.017	-0.072
Ipomea triloba	04	0.014	-4.269	-0.060
Sphenoclea zeylanica Gaertn.	03	0.010	-4.605	-0.046
Ceratophyllum demersum	02	0.007	-4.962	-0.035
	284			**1.22**

Note: <1.5 = low diversity; 1.5-2.5 = medium diversity; > 2.5 = high diversity

Shannon Diversity Index (H): **1.214599**

Shannon Equitability Index (E_H): **0.552788**

Table 5: Average values of the ecological characteristics from shore to centre of the studied pond

Quadrant	No. of species	Biomass	pH	% N	% OC	% OM
1	4	27.37	4.60	0.28	3.76	6.48
2	1	16.78	5.40	0.196	3.19	5.5
3	4	21.24	4.70	0.224	3.6	6.2
4	3	23.17	4.60	0.168	2.38	4.11
5	8	15.27	4.75	0.238	3.48	5.99
6	3	31.56	5.59	0.203	3.4	6.24
7	4	31.24	4.75	0.221	2.99	6.36

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8	3	13.34	5.30	0.25	2.93	6.18
9	3	25.36	5.70	0.227	3.44	5.15
10	5	39.18	5.78	0.239	3.6	5.69

Relationship between aquatic macrophytes species richness and Biomass of the studied pond

A significant positive correlation was observed between species richness and plant biomass in pond. But negative correlation was obtained between species richness and soil pH. A positive correlation was observed between species richness and aquatic macrophytes biomass. Similarly, positive correlation was also obtained for species richness and soil organic carbon and species richness and soil organic matter as shown in Table 6

Table 6: Pearson's correlation coefficient between different ecological characteristics of the studied pond**.**

	SR	Biomass	SpH	N	OC	OM
SR	1	0.040	-0.302	0.405	0.349	0.259
Biomass		1	0.305	0.038	0.263	0.074
pH			1	-0.041	0.217	-0.057
N				1	.670*	.693*
OC					1	0.617
OM						1

DISCUSSION

Aquatic macrophytes are one of the essential elements of a lake ecosystem and have a significant impact on both physical and chemical processes. Aquatic macrophytes provide a variety of aquatic resources, including shelter, places for fish to breed and feed. According to the Pennsylvania Fish and Boat Commision (2014), a lack of vegetation in aquatic habitats makes shoreline stability more susceptible to erosion, decreases the population of habitat that is accessible and lowers the richness and total biomass of the lake ecosystem.

Eight (8) taxonomic families of the macrophytes composition were present in the examined pond (including floating plants, emerging plants and submerged plants). Onagraceae had two species, whereas the other families (Ceratophyllaeae, Polygonaceae, Onagraceae, Pontederiaceae, Lemnaceae, Sphenocleaceae and Convolvulaceae) each had one. This shows that the existence of these macrophytes, as well as their diversity resulted in a greater degree of species development in the lake. Findings in this study supported Lynch *et al.* (2023), the presence of plants in an aquatic system often suggests that the lake is rich in biodiversity. The Onagraceae family was shown to be dominant during the study. This family's aquatic plant species exhibit a variety of physical and physiological features such as resilience to disturbance and ecological adaptation, which may explain their dominance (Linder *et al.*, 2018).

The life forms of the aquatic macrophytes observed in the study area were emergents, floating leaf and submerged species. According to Pang *et al.* (2023) hypothesis, increased precipitation encourages the rapid development of emergent aquatic macrophytes. Furthermore, Ali *et al.* (2007) proposed that environmental factors including excessive rainfall and nutrient inputs might affect the populations of emergent and free-floating life forms to develop rapidly. Dissolved inorganic carbon concentrations, light intensities, pollution, rain, temperature, turbidity, and water levels can all have a major impact on the primary production and population of submerged organisms, according to studies of Duarte *et al.* (1994) and Croft & Chow-Fraser, (2007).

The distribution range and endemism of a species are two of the most crucial aspects taken into account when evaluating its conservation status (IUCN, 2004). The distribution status of the aquatic macrophytes in the analyzed ponds was determined to be non-endemic, which means they are not only present in the pond as shown in Table 3. This study revealed that while (n=3) species were not examined, some (n=5) species found in the pond were designated as least concern by the IUCN, indicating that they had been assessed against the

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Red List criteria and did not meet the criteria for Endangered Near Threatened (A species is widespread and abundant). A species that has been designated as not evaluated (NE) on the IUCN Red List of Threatened Species is one that has not yet undergone an evaluation by the international Union for Conservation of Nature.

Persicaria amphibian had the highest number of quantitative characteristics (No. of individual species, frequency, density and abundance) of aquatic macrophytes found in the studied pond. Thus, these aquatic macrophytes represent the pond's dominant plant species or features are said to drive ecosystem functioning.

CONCLUSION

The work offers details on the lentic environment that existed in Ikwo Peri-Urban throughout the study period. There were found to be Nine (9) different species of aquatic macrophytes, divided into Eight (8) different groups. With two species, Onagraceae had the most species; the other families each had one species. The researched macrophytes were not endemic, according to the distribution status, and five of the species were given IUCN Red List's least concern designation. Due to the potential similarity of the macrophytes communities over all transects the diversity index of aquatic macrophytes discovered in the pond indicated low species diversityof 1.22. The biomass of macrophytic plants was 24.45g/m^2. Different ecological aspects of the pond under study were related to one another. Human activity poses a hazard to the community of macrophytes and may have an influence on it. The results of this study might serve as a starting point for future research particularly in relation to strategies for monitoring and conserving sustainable macrophyes species and ecosystem services.

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