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Incidence of Freshwater Aquatic Macrophytes in Relation to the Nutrients Content of Gwaigwaye and Mairuwa Reservoirs, Funtua, Nigeria

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Abstract

Studies were conducted between (September, 2017 to October, 2018) to investigate the variation in the compositional distribution of macrophyte communities in relation to the nutrient contents in the water and sediments of Mairuwa and Gwaigwaye reservoirs, Funtua located in the Northern vegetation of Nigeria. All the nutrients from sediments were analyzed using Standard procedures using Spectrophotometer, flame photometer and titration methods. Nitrogen, Phosphorus and Calcium were higher in Mairuwa reservoir than in Gwaigwaye; while Potassium on the other hand, was higher in Gwaigwaye than in Mairuwa reservoir. Magnesium was not detected in either of the two reservoirs. The modified method of flora collection was used with a random sampling technique. The correlation analysis indicated that the distribution and abundance of aquatic macrophyte composition were significantly ($P<0.05$) different. The overall community structure was made up of nine (9) from Mairuwa and eleven 11 species from Gwaigwaye reservoirs. Both the number of species present and the densities of such species were higher in Mairuwa than in Gwaigwaye reservoir. Four growth patterns of macrophytes were observed viz; Emergent macrophytes were the dominant (56.7%), Floating macrophytes (26.5%), submerged macrophytes (13.4%) and the least marginal macrophytes (3.4%). Similarly species densities (stands per square metre) ranged from 1-29m, in Mairuwa, and 4-90m in Gwaigwaye. Implications of these trends to the well being of the two ecosytems are highlighted. Government and non-governmental organizations at all levels should ensure that the precious aquatic resources are solely protected by enacting laws against the anthropogenic action of the inhabitants in and around the catchment.

Keywords: Reservoir, mairuwa, gwaigwaye, nutrients, ecosystem

INTRODUCTION

Several species of aquatic macrophytes have been regarded as invasive and reported to infest a large number of Nigerian aquatic habitats either directly or indirectly (Bender, 2018).There are some notorious cases, such as water hyacinth (*Eicchornia crassipes*), which has invaded the river and Reservoir systems of the Niger, Benue and Kaduna (Ita, 1994). The Typhaceae family among others, represented worldwide by genus *Typha* and the weed is a perennial aquatic herb with cosmopolitan distribution in freshwater habitat, it is an erect perennial and can grow to two or more meters in height (Bender, 2018). The Typhaceae family has higher growth rate than any other aquatic plant and the family, is characterized by having rhizomes, extensive fleshy stems, tall, leaf blades, strap-like, stifle, spiraling in top half, sheathed together at base flattened (Yakubu *et al.,* 2015). The weed is inflorescence spike like, densely packed with tiny male flowers in top cluster, and female flowers in bottom cluster. The fruits are hairy and about 5-8mm long (Yerima, 2016). The Typha has been implicated for reducing agricultural activities and fishes in wetlands, and impeded navigation in water ways (Kutama *et al.,* 2016). The plant can be used for food, medicines, biomass products (baskets, hats, mats, mattress, pillows, thatch for roofs and fences, biofuel). However, it can be used for phytoremediation. Aquatic macrophytes such as *Typha latifolia* present in dense biomass have the ability to influence plant structure and distribution and also, extensive litter deposition by *T. latifolia* also buried mineralized substrates necessary for many native plants to germinate (Kutama *et al.,* 2016).

Consequently, this may decline the abundance of economically valuable species, in particular those used for food, fodder and/or medicinal plants and loss of local genetic resources thus, genetic diversity (Kutama *et al.,* 2016). More so, primary production may increase or decrease if plant invader leads to a shift in the major vegetation type of a wetlands area (Ringim *et al.*, 2017). However, most invasive plants increase net primary productivity as in the case with giant reed (*Arundodonax*), and other Typha spp. such as Phragmites in marshes (Ehrenfeld, 2003). In Tukwikwi flood area of the Hadejia-Nguru wetland, about 70 % of the wetland was covered by both Typha and other grasses (Yakubu, 2015).

Eutrophication is a special case of water pollution that often occurs as a result of organic pollution. Over the last few decades, many wetlands have undergone gradual eutrophication mainly through agricultural runoff and municipal wastewater from different sources (Wen *et al.*, 2020). The main sources of nutrients for plants in a reservoir are the sediment and the water. Nutrient inputs can directly modify or alter biological communities. Fluctuation in hydrological conditions influences changes in nutrient input. The high dependence on hydrology is particularly important in semi arid and arid areas, where surface water levels fluctuate both seasonally and inter annually (Sanchez-Carrillo and Alvarez-Cobelas, 2001). These complex interactions, in turn make nutrient dynamics change with biotic and abiotic changes (Bako and Balarabe, 2005). Emergent macrophytes are particularly well adapted to hydrological fluctuations and hence are probably the best indicators of such dynamics (Sanchez-Carrillo and Alvarez-Cobelas, 2001). Macrophyte cover changes inter annually, so nutrient cycles in freshwater marsh ecosystems are particularly difficult to assess because of spatial heterogeneity and metabolic variability of emergent macrophytes (Sanchez-Carrillo and Alvarez-Cobelas, 2001). Macrophyte biomass has usually been neglected in classical eutrophication models since these plants obtain their nutrient requirements from sediments and do not compete directly with phytoplankton for nutrients (Sanchez-Carrillo and Alvarez-Cobelas, 2001).

Sanchez-Carrillo and Alvarez-Cobelas (2001) stated that since emergent macrophytes are by far the highest biomass of all the biological communities, they might be controlled by nutrient dynamics and their response could explain eutrophication patterns better in this type of ecosystem. Such a hypothesis was suggested by the fact that macrophyte cover changed every year throughout the sampling period. These changes might not only be conditioned by the size of inundated area, but also by fluctuations in nutrient concentration (Kolo and Oladimeji, 2004). The current rapid invasions of a number of reservoirs by these plants (macrophytes)and the problems they pose to socio-economic system of the country have become more apparent. In Nigeria, studies on nutrient dynamics and the response of aquatic macrophytes to such are rather limited. The objective of this study therefore, is to investigate the distribution of aquatic macrophytes in Mairuwa and Gwaigwaye reservoirs in relation to the nutrients content.

MATERIALS AND METHODS

Study Area

The study sites were Mairuwa and Gwaigwaye reservoirs in Funtua. Funtua is located at latitude 11°51`N and 7°31`E. It is 733 m above sea level in the Southern part of Katsina State Nigeria.

Gwaigwaye reservoir is an open artificial reservoir ecosystem around the catchments characterizes by lot of farming (rain fed and irrigated) activities in addition to animal grazing all year through. Mairuware servoir on the other hand was formed by the impoundment of the Mairuwa stream that receives a significant level of municipal waste from the surrounding Funtua town and Dikke village among others.

Macrophytes Samples Collection and preservation

The modified method of macrophytes collection by Wood (1975) was used to take samples twice in a month from the five mapped cardinal points between September, 2018 to October, 2019. Sampling of the macrophyte species was done by throwing 1m by 1m quadrats on the land-water interface i.e the littoral zone. Collections of plant species with their flowers, seeds and roots by hands were made around the reservoirs. These samples were rinsed and taken to the herbarium Laboratory in the Department of Botany ABU, Zaria, for proper identification using standard keys such as: Cook *et al*. (1974) and Obot and Ayeni (1987).

Determination of Nutrient contents

Sediments core was collected in a sterile polythene bags from five designated cardinal points.

These were oven dried before determination of chemical variables. The chemical variables were determined according to standard methods, these includes; nitrate, phosphorus, potassium, magnesium, calcium and electrical conductivity or organic carbon. Phosphorus was determined using spectrophotometer (JENWAY

6100) at 660nm (wavelength); potassium and sodium were determined using flame photometer (corning 400 Essex, England), while magnesium and calcium were determined using ethylenediamine tetraaecetic acid (EDTA) titration method. Soil texture (sand, silt and clay) were determined using hydrometer (Nollet, 2007).

Statistical Data Analyses

Statistical software package (SPSS, Version 16) and Microsoft office excel software were employed in this study. Analysis of variance (ANOVA) was used to test for between seasonal and stations differences at 5% probability level.

Frequency of occurrence

This represents the number of times an individual flora species occurred. Hence calculated according to the formula:

$$\frac{y}{X}x100 \ldots\ldots\ldots\ldots\ldots\ldots..(1).$$

where y = individual floral species observed

X = total number of all the observed floral species

RESULTS AND DISCUSSION

Table 1 indicates that Nitrogen, Phosphorus and Calcium were higher in Mairuwa Reservoir than in Gwaigwaye. Potassium on the other hand, was higher in Gwaigwaye than in Mairuwa Reservoir. Magnesium was not detected present in either of the two Reservoirs.

Emergent aquatic plant species dominated the vegetation of the two Reservoirs during the period of sampling. Both the number of species present and the densities of such species were higher in Gwaigwaye (Table:3), than in Mairuwa Reservoir (Table:2). While 9 species were recorded in Mairuwa Reservoir, 11 were recorded in Gwaigwaye Reservoir. Four growth pattern of macrophytes were observed viz; Emergent Macrophytes were the dominant (56.7%), Floating macrophytes (26.5%), Submerged macrophytes (13.4%) and the least Marginal macrophytes (3.4%) (Table: 4). Similarly species densities (stands per square metre) ranged from 1-29m, in Mairuwa, and 4-90m in Gwaigwaye reservoirs.

Table 1: Concentration (ppm) of the major plant nutrients in sediments of Gwaigwaye and Mairuwa reservoirs

Sampling sites	N	P	K	Ca	Mg
Gwaigwaye	21	20	47800.0	0.0	0.0
	15	14	22300.0	0.0	0.0
	10	15	16700.0	0.1	0.0
Mairuwa	32	22	13300.0	0.0	0.0
	17	20	12990.0	6230.0	0.0
	15	17	1830.0	0.0	0.0

[F= *8.86 for Nutrients; * = Significant at $p \geq 0.05$]

Table 2: Densities of Aquatic Macrophytes in Mairuwa Reservoir

Species	Family	No. of Stands(m^{-2})	Growth Pattern
Fuirena ciliaris	Cyperaceae	20	Emergent
Eclipta prostrata	Asteraceae	1	Marginal
Emilia coccinea	Asteraceae	1	Marginal
Axonopus compressus	Poaceae	20	Emergent
Hecklechoa sp	Poaceae	1	Emergent
Polygonum lanugerum	Polygonaceae	29	Emergent
Ludwigia abyssinica	Onagraceae	6	Emergent
Ipomea aquatic	Convulvulaceae	2	Emergent
Typha australis	Typhaceae	10	Emergent

Table 3: Densities of Aquatic Macrophytes in Gwaigwaye Reservoir

Species	Family	No. of Stands(m^{-2})	Growth Pattern
Nymphaeae lotus	Nymphaeaceae	8	Submerged
Najas pectinata	Najadaceae	30	Emergent
Typha australis	Typhaceae	28	Emergent
Ludwigia stolonifera	Onagraceae	55	Marginal
Ludwigia sp	Onagraceae	27	Emergent
Polygonum lanugerum	Polygonaceae	5	Emergent
Polygonum sp	Polygonaceae	4	Emergent
Salviniamolesta	Salviniaceae	85	Floating
Utricularia gibba	Lentibularaceae	35	Submerged
Hydrolea sp	Hydrophylaceae	5	Marginal
Mimosa paudica	Fabaceae	4	Marginal

Table 4: Percentage Composition of Aquatic Macrophytes in Mairuwa and Gwaigwaye Reservoirs

Macrophytes	Frequencies	Percentage (%)
Emergent	182	56.7
Marginal	11	3.4
Floating	85	26.5
Submerged	43	13.4
Total	321	100

All the species densities were observed to be higher in Gwaigwaye than in Mairuware servoir. This could be as a result of enhanced deposition of plant nutrients obtained from animal manure, and application of fertilizers (such as nitrates and phosphates) in the catchments, that are washed into the water (Gao *et al.,* 2020). Precipitation and surface run off/drainage from the catchments are important contributors to the nitrogen and phosphorus loads of the reservoir ecosystems and these have been known to alter their functioning (Majaliwa *et al.*, 2005; Wlodzimierz, 2005; Sa'ad and Hemeda 2005). High levels of these plant nutrients are known to encourage vegetative growth of plants. Extensive human activities including cultivation/tillage, application of fertilizers and over grazing in the catchments could result in marked fluctuations in the physicochemical parameters of lentic ecosystems (Ezealor *et al.*, 1999; Gbem *et al.*, 1999). Nutrient availability is a crucial factor in aquatic macrophyte, phytoplankton and periphyton growth (Hough *et al.*, 1989). The total pool of nutrients is less important than the amount of its exchangeable fraction. The amount of this fraction depends on ecosystem efficiency and to some extent on macrophytes occupying the water body as they both depend on and create a nutrient budget for their environment. The most common result of such a modification of the ecosystem is eutrophication. Eutrophication is a special case of water pollution that often occurs simultaneously with organic pollution. Human sewage, wastewater of intensive husbandry and run off from agricultural fields are the most common causes of eutrophication.

Majority of the species of macrophytes encountered were emergent growth forms table :4, (56.7%). This implies an encroachment of terrestrial vegetation into the Reservoirs probably due to siltation processes, which have reduced the depths of the Reservoirs. Excessive vegetation accelerates silting, makes difficult the movement of fish and stops the water from warming. Macrophyte structure and abundance in Reservoirs depend on different factors, which include trophic status, light penetration and water currents. Sedimentation and infestation by aquatic macrophytes over the years have been major problems that threaten many aquatic ecosystems in Nigeria because they seriously reduce the depths of Reservoirs. Decrease in depth favours the occurrence of emergent species of macrophytes, which in turn displace floating types. Commonly a pattern of succession involving several seral stages is observed as these aquatic ecosystems transit into terrestrial ones (Bako and Oniye, 2004). Development of aquatic macrophyte communities in lentic habitats is a function of events that modify physical and chemical characteristics of the habitat such as water temperature, organic matter, soil depth, etc. those factors influence the occurrence, establishment, survival and reproduction of macrophytes (Bako and Balarabe 2005; Bako *et al.*, 2005). Uncontrolled development of aquatic plant communities in fish farming/fisheries systems has several undesirable implications (Balogun *et al.*, 2000) These include further depletion of water volume through additional evapor-transpiration from surface of plants (especially emergents), hindrance to navigation and fish cropping, clogging of machinery and turbines (where applicable) and depletion of oxygen from the water column) especially during decay processes. All these factors will reduce the well being, growth and reproduction of fish and consequently, lead to lowered production rates and poor returns from investment made on the fish farm/Reservoirs (Bako and Oniye, 2004).

CONCLUSION

The abundance of emergent aquatic macrophytes species in the two reservoirs parells those in any other similar ecosystems. With respects to spatial patterns they are not progressively distributed which could be attributed to pollution effects.

An understanding of the factors controlling the structure of macrophyte communities is critical if these reservoirs are to be protected, restored and managed (Vaithiyanathan and Richardson, 1999).

Recommendations

This important aspects of aquatic system should be maintained and prevented from further pollution deterioration through nutrients impulses introduction, hence the need of frequent Monitoring through surveillance and maximum utilization of these macrophytes.

Government and non-governmental organizations at all levels should ensure that the precious aquatic resources are solely protected by enacting laws against the anthropogenic action of the inhabitants in and around the catchment.

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