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Utilization of Aquatic Macrophytes in Nigerian Freshwater Ecosystem

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ABSTRACT

Aquatic macrophytes are basically seen as those plants that complete their life cycle in water and cause harm to the aquatic environment. The attention of fishery managers is always towards the eradication of aquatic macrophytes. This study is therefore timely as it reflects on the economic importance of aquatic macrophytes in aquatic ecosystem and therefore recommends a study on the utility value of aquatic macrophytes of ecological importance. The monitoring of colonized rivers and large water bodies by aquatic plant is necessary for proper management and development of colonization model is hereby advocated.

Key words: Aquatic macrophytes, freshwater ecosystem, nutrient recycling, food, medicine, habitat

INTRODUCTION

In the development of a master plan on the nation's water resources and in particular the development and administration of rivers, lakes and similar freshwater bodies cognizance must be taken of major aquatic plant ecological problems at both National and International levels. Good examples are *Eichhornia crassipes* (Water hyacinth) and *Typha australis* (Cattail plant) that constitute a major financial and socio-economic burden to the Federal Government of Nigeria as well as the emergent ecological problems. These aquatic plant problems have risen due to global mismanagement and pollution of the environment which favours rapid colonization of aquatic bodies by aquatic plants (Obot, 1985) and the complete absence of adequate strategies for proper harnessing and control of aquatic plants. When aquatic plants massively colonized water bodies, siltation, decline in fishing and fisheries activities, disruption in water transport, increased water accident due to blockages often resulting in loss of human life are common. The consequences on the fishing industry are increased unemployment and youth's unrest in fishing communities due to poor earnings from fishing, human conflict because of seeking new fishing grounds and decline in water transportation business. The National Institute for Freshwater Fisheries Research with mandate and responsibilities for inland waters in Nigeria made some modest achievements in identifying aquatic plants not necessarily as nuisance but aquatic plant resources that can be properly utilized. The 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.

USEFUL EFFECTS OF AQUATIC PLANTS

In Nigeria, aquatic plants offer a variety of products and services which are of immense benefits in:

- Habitat protection, nature conservation and livestock production
- Fisheries production and wildlife conservation
- Food and medicine
- Fertilizer and soil additive
- Industry
- Energy
- Recreation/aesthetics

AQUATIC MACROPHYTES AND FISHERIES PRODUCTION

Aquatic plants are basically seen as under-valued part of freshwater ecosystem. However, it plays an important role in fisheries production. Locally cultured species in aquaculture are dependent on macrophytes as a source of food. According to Shell (1993), herbivorous fishes like *Tilapia zilli, Tilapia rendalli, Ctenopharyngodon idella* and other invertebrates like *Astacus fluviatilis* and *Vertebrates manatee* feed on aquatic macrophytes. Aquatic plants such as *Lemna pausicostata* are eaten directly by fish (Mbagwu and Adeniji, 1988). Moreso, periphytic algae growing on the surface of the aquatic plants are fed upon by fish species (Ayeni *et al*., 1999). Members of the genus *Oreochromis* tend to eat coarser food including macrophytes (Ezeri *et al*., 2003). Ezeri *et al*. (2003) further observed that *Oreochromis niloticus* feeds on phytoplankton and aquatic vegetation. Table 1 shows the aquacultural organisms and the different macrophytes they feed on.

It has been documented that aquatic vegetation provides spawning ground for fish and shelter for fish, Kainji lake is an example of where aquatic vegetation has been indicated to be a valuable spawning and breeding ground for a large variety of economically important fish species (Imevbore and Bakare, 1974). According to Meade (1992), aquatic macrophytes exhibits a feeding relationship among fishes (Fig. 1), while Agbogidi *et al*. (2000) reported that the fingerlings of carnivorous fishes feed on aquatic macrophytes until the guts are mature enough to take animal. The adult carnivorous fishes also feed on invertebrates which are directly associated with macrophytes (Araujo-Lima *et al*., 1986).

Aquatic macrophytes are also rich in nutrients in relation to artificially prepared fish feed, necessitating its feeding by fishes. Studies on the efficiency of duckweed as low cost supplementary feed in monoculture of Nile Tilapia (*Oreochromis niloticus*) showed increase in the specific growth rate (SGR, %per day) of fish by 1.16% and net production of fish to 16.28 kg/year (Chowdhury *et al*., 2008).

Durocher *et al*. (1984) observed that fish production increases with an increase in aquatic plant density up to a certain point, after which further increase in plant density results in a decline in fish production (Fig. 2).

Table 1: Feeding relationships of selected aquacultures and macrophytes

Species	Macrophytes fed on
Astacus fluviatilis	*Ludwigia stolonifera*
Tilapia zillii	*Myriophyllum spicatum*
	Ceratophyllum demersum
Ctenopharyngodon idella	*Utricularia* sp. *Potamogeton natans*
	Spirodela Polyrrhiza
Heterotis niloticus	*Azolla Africana Lemna minor*

Source: Petre (1993)

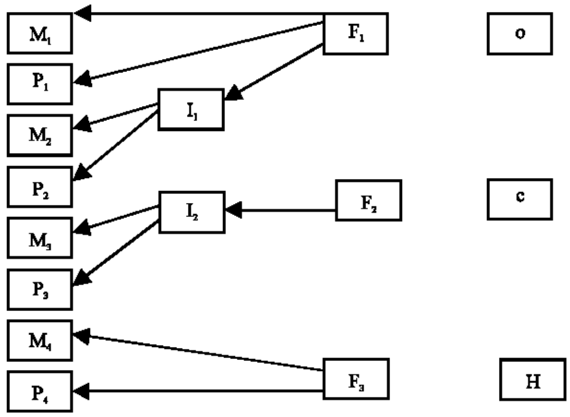

Fig. 1: Tophic relationship in a typical fish pond, M: Masrophyte, P: Phytoplankton, F: Fish, I: Inverterbrate, O: Omnivore, H: Carnivore. Source: Meade (1992)

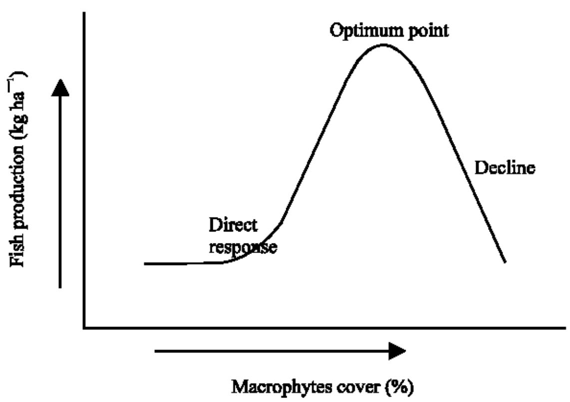

Fig. 2: Relationship between abundance of fishes and aquatic macrophytes, Source: Durocher *et al.* (1984)

FOOD AND MEDICINE

Aquatic macrophytes provides food for many animals, ducks eat the seeds, leafy parts and tubers of plants such as *Potamogeton* spp., *Brasenia Schreberi*, *Polygonum* sp. and *Lemna* sp. The fluffs from Cattails are used by Song birds as nest material and eat the seeds of many emergent plants. Turtles also graze on a variety of aquatic plants. Humans have also utilized aquatic plants as a source of food in many parts of the world and have historic medicinal value (Kio and Ola-Adams, 1987). The seeds of Burugu (*Echinochloa stagnina*) is collected for food in Monai on the western shore of Lake Kainji (Ayeni *et al.*, 1999). It has been reported that the seeds of *Echinochloa stagnina* is an important food item for fishermen in the Delta of River Niger (Ita, 1994). The medicinal uses of aquatic macrophytes have been reviewed by Kio and Ola-Adams (1987). From the Saltwater swamps (Maltaby 1986), reports that the mangrove palm (*Nypa fruticans*) yields alcohol, sugar and vinegar. This species which was introduced to Nigeria between 1906 and 1912 is presently displacing the native mangrove flora of the Niger Delta is not exploited for these products.

The Checklist of the utility value of common aquatic plants of the Kainji lake Basin are shown in Table 2.

Table 2: Checklist of the utility value of common aquatic plants of the Kainji lake Basin

Aquatic plants	Uses
Pistia stratiotes Linn	Part of concoction for treatment of flu
Ipomoea asarifolia (Desr)	Part of concoction for washing of new born babies
Ipomoea aquatica Forsek	It is used as a livestock fodder
Cyperus articulatus Linn	It is used as raw material for weaving mats
Scirpus articulatus Linn	It is also used as raw material for weaving mats
Mimosa pigra Linn	The stem is used for fencing
Neptunia oleracea Lour	Part of concoction for treatment of yellow fever
Lemna pausicostata Hegelmaier	It is used as feed for Tilapia
Nymphaea lotus Linn	The fruits are eaten, while the leaves and stem are sued as part of concoction for treatment of Guinea worm infections.
Nymphaea micrantha	It used as fish poison
Ludwigia stolonifera Forks	It is used as soup ingredient in Yelwa area of Kebbi State
Rhytachne triaristata Stapf	It is used as livestock folder
Echinochloa colona Link	It is used as livestock folder
Echinochloa stagnina Beauv	It is used as a livestock folder
Echinochloa pyramidalis Hitchc et Chase	It is used as a livestock folder
Leersia hexandra	It is used as a livestock folder
Leptochloa caerulescens steud	Used as a livestock folder and part of concoction for washing new born babies.
Oryza longiostaminata A Chev	It is used as livestock folder
Sorghum arundinaceum Stapf	The leaf extract is used as a dye
Vossia cuspidata Griff	It is use as a livestock fodder
Polygonum senegalense Meisn	Part of Concoction for treatment of small pox
Salvinia nymphelulla	It is used as livestock folder
Eichhornia crassipes	It is used as silage for fattening animals, ash used as organic fertilizer
Silvania molesta	Part of concoction for the treatment of flu
Cyperus exaltatus	Poultry feed, Perfume and Insecticide

Source: Obot and Ayeni (1987); NIFFR (2000)

HABITAT

Aquatic macrophyte provides living space for small animals such as aquatic insects, snails and crustaceans, which in turn supply food for fish. Studies have shown that vegetated areas support more of these tiny creatures than do unvegetated areas. Mitchell (1974) cited by Agbogidi *et al.* (2000) reported that the finely dissected leaves of some macrophytes such as *C. dermesum* and *M. spicatum* provide shelter, spawning substrates and nursery sites for many fishes. Young fish use aquatic plants as a source of cover from predatory fish, thus making aquatic macrophytes as important nurseries for baby fish. The root of aquatic macrophytes such as *Pistia stratiotes* and *S. nymphellula* provides habitat as well as a hiding place for fishes and invertebrates from predation by other fishes (Beebee, 1992; ICAAE, 1992).

The nest-building fish (*Heterotis niloticus*) uses aquatic macrophytes to build its nest whereas *Gymnachus niloticus* (Elephant trunk fish) only breeds in still waters covered with aquatic plants but moves to more flowing body of water after breeding (Meske, 1985).

NUTRIENT CYCLING

Aquatic macrophytes are the cornerstones of an aquatic environment and have the physiological ability of removing mineral nutrients and heavy metals (Uka *et al.*, 2009a). The study of aquatic macrophytes is an essential component of understanding a waterbody due to its important ecological role and its ability to characterize the water quality (Ghavzan *et al.*, 2006). Aquatic plants are an important component of the complex system of chemical cycle in a water body and influence the supply of oxygen in the water. Recently aquatic plants have received a lot of attention for their ability to soak up pollutants from contaminated water. The utilize nutrients that would otherwise be used by algae, thereby improving water clarity. Increasing attention is being paid toward their possible use as indicators of water quality. Boyd (1970b) showed that vascular aquatic plants are used for the removal of nutrients from eutrophic or polluted water bodies especially where the source of effluent is near the fish pond. According to Agbogidi *et al.* (2000), the effluents are passed through the holding tanks containing populations of aquatic macrophytes to absorb and reduce the effluents nutrients and concentration before letting into the pond. Boyd (1970b) reported that this has been used in biomanipulation of fish ponds to enhance fish production. Dar *et al.* (2011) studied the phytoremediative potential of water hyacinth in the treatment of domestic wastewater. The results showed that the test plant reduced all the physicochemical and biological parameters to a significant level. Thus it can be used as an efficient, economical and ecological alternative to accelerate the removal and degradation of agro-industrial waste water pollutants. Chantiratikul *et al.* (2008) carried out studies on the feasibility of producing selenium-enriched water lettuce for animal nutrition in hydroponics. The result showed that selenium concentrations in leaves and roots of water lettuce increased significantly with increasing Se concentration in the solution and exposure time, hence water lettuce have high capacity in metal absorption. A passive phytoremediation study was carried out at Ologe Lagoon, Lagos-Nigeria. The study deduced that *Eichhornia crassipes* can accumulate heavy metals even when the concentrations of metals in water and sediment of the aquatic environment is low suggesting that *Eichhornia crassipes* can be used to remediate polluted water (Ndimele and Jimoh, 2011). The loss of mineral nutrients from the leaves of *Typha latifolia* an aquatic macrophyte had been reported by Boyd (1970a). Nutrients were lost from the plant after 20 days (Table 3). Aquatic macrophytes take up large amount of nutrients and which is an effective means of removing nutrients from effluents or natural waters (Uka *et al.*, 2009a). Brix and Schierup (1989) reported that international attention is now tilted towards the ability of aquatic macrophytes to control pollution and also to treat municipal and industrial wastewater. Therefore, macrophytes can be efficient indicators of water quality and their presence may enhance water quality due to their ability to absorb excessive load of nutrients (Petre, 1990). It has been demonstrated that aquatic weeds such as *Eichhornia crassipes* , *Lemna* sp., *Salvinia* spp., *Typha* ssp. *Phragmites* spp. and *Azolla* sp. has been utilized as a means of reducing the nutrient levels of polluted water (Oki and Une, 1989), While *Phragmites karka* has low heavy metal sequestering ability (Uka *et al.*, 2010). Table 4 shows the removal efficiency of metal ions by some common aquatic macrophytes.

Table 3: Loss of Mineral Nutrients from the leaves of *Typha latifolia*

Minerals	Remaining (%)
Sodium	7 (After 20 days)
Potassium	5
Magnesium	10
Calcium	25 (After 200 days)
Phosphorus	50
Nitrogen	60

Source: Boyd (1970a)

Table 4: Removal efficiency of metal ions by some common aquatic macrophytes

Aquatic macrophytes	Metals	Removal efficiency
Eichhornia crassipes	Fe, Cu, Zn, Cd	80.0
Azolla spp.	Hg	93.0
Ceratophyllum demersum	Pb, Zn and Cu	80.0
Ipomeae aquatica	Hg	90.0
Lemna spp.	Pb	90.0
Ludwigia repens	Hg	99.8
Pistia stratiotes	Cd, Hg and Cr	85.9

Source: Srivastava *et al*. (2008)

NEGATIVE EFFECTS

Some alien aquatic plants, for example water hyacinth, have invaded Nigerian freshwater ecosystem causing considerable socio-economic problems. Water hyacinth is not new in the ecological history of man (Uka *et al*., 2007). Its extensive growth and multiplication has created problems associated with navigation, fishing, irrigation among others (Uka and Chukwuka, 2007).

The possible negative effects of aquatic weeds fall into two main categories.

Effect on the storage and engineering operation: The effect of the presence of aquatic weeds in water bodies on water loss through evapotranspiration is a subject of controversy but most experimental data indicate an increase in water loss from surface covered by aquatic weeds. Experimental data from Lake Kainji shows that the relationship between evapotranspiration 'ER' and area of Lake Surface 'A' covered by *Echinochloa stagnina* is in the exponential form (Obot, 1985):

$$E_R = 0.62\ e^{2.2} \times 10^{3A}$$

This implies that there is critical area above which the presence of an additional area of the weed will not have a significant effect on the increase in water loss. Water loss through evapotranspiration from the grass become very important in lake management and power generation in dry years. For example, in 1985 a 15% reduction in the effective volume of the lake was found to be due water loss through the grass (Obot, 1985). This may partly explain the shortage in electric power and regular power failures experienced throughout the country, during periods of low water levels in the lake. The grass is often uprooted by wave action .When so uprooted; the grass floats about the lake as 'floating mats'. The floating mats often clog power generation equipment in the dam thus further interfering with power generation and increasing the cost of maintenance.

Aquatic weeds may occupy useful volume. However, in large bodies of water the volume occupied by plants is negligible. Estimates for lake Kainji indicated that the macrophyte do not occupy more than 0.1% of the lake volume.

EFFECT ON THE MULTIPURPOSE USE OF THE WATER BODY

The floating mat of vegetation covers available sunlight from the water surface. The direct effect of this is low production in natural fish food (Phytoplankton-zooplankton species) thus resulting in overall low fish productivity. The bloom of vegetation result also in massive fish kills due to high oxygen demand and competition for available nutrient. These invasive aquatic weeds affect biodiversity as well as water quality (Uka *et al*., 2009b). Floating mat led to blockage of water crafts transportation route, clog up the propellers of outboard engines thus hampering craft transportation. The presence of floating mat render water bodies unsafe in view of risk associated to craft infiltration of large carnivorous aquatic animals and other mechanical problems.

STRATEGIES

Aquatic plant Ecologists as well as relevant agencies should collaborate with a view to updating the inventory of aquatic plants of inland freshwater bodies in Nigeria and identify those that are of ecological importance. Studies on the utility values on aquatic macrophytes already identified as important ecological problems such as water hyacinth, *Lemna pausicostata* and *Echinochloa stagnina* among others should be intensified. The monitoring of aquatic plant colonization of rivers and large water bodies is necessary for proper management and for development of colonization model. This could be achieved through inventory of aquatic plant of all the major lakes and rivers in Nigeria with emphasis on the ecological zones of Nigeria. Since *Echinochloa stagnina* is utilized in Kainji lake basin as animal fodder, human food and fibre, while *Lemna pausicostata* has been utilized in pollution control in Jankara reservoir using limnological parameters, therefore relevant Research Institutes and Universities should intensify their research effort on aquatic weed utilization.

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