Influence Of Persistent Presence Of Water Hyacinth On Specific Physicochemical Properties Of A Freshwater Body In Southwestern Nigeria

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ABSTRACT

Water hyacinth (*Eichhornia crassipes* [Mart] B. Solms) constitutes a very important economic aquatic weed species in tropical sub-Saharan African countries and its impact on water bodies where they occur affects the living conditions of the human populace dependent on such water bodies for their livelihood. This study was aimed at assessing the effects of continued occurrence and persistence of the water hyacinth on specific physicochemical characteristics of a freshwater ecosystem. Measurement of water properties was carried out for water samples collected from water hyacinth infested areas of the water body surface and also open water areas devoid of the plants' presence. Biological oxygen demand (BOD), Chemical oxygen demand (COD), phosphate and ammonia content were evaluated and compared for these areas of the water body. It was observed that BOD and COD values for water hyacinth infested areas were significantly higher ($p<0.05$) than values recorded for water hyacinth free areas. Phosphate and ammonia-nitrogen values for water hyacinth infested areas showed lower values, though non-significant ($p>0.05$) compared to free areas. General marked differences in water quality of hyacinth thriving areas with regard to free areas indicate potential ability of the plant to permanently alter physicochemical properties of freshwater ecosystems if allowed to thrive in the system over long periods. Thus adequate attention should be given to controlling spread and prevalence of this aquatic species in freshwater bodies found in tropical coastal regions of Nigeria.

Key words: water hyacinth, water quality, physicochemical characteristics, freshwater ecosystem.

INTRODUCTION

Freshwater bodies constitute a vital component of a wide variety of living environments as integral water resource base in many human societies of tropical Africa. They have been regarded as key strategic resources essential for sustaining human livelihood, promoting economic development and maintaining the environment (UNWDR, 2005). Utilization of freshwater resources include use as source of drinking water, fishing activities, sites for domestic and industrial effluents discharge, recreation and transportation activities. Aquatic macrophytes usually occur as regular features in these water bodies as biotic flora; and of these one of the most economically important is the water hyacinth (*Eichhornia crassipes* [Mart] B. Solms). The water hyacinth is a widely studied invasive water weed species considered one of the most notorious weed species in tropical West Africa (FAO, 2000). Water hyacinth infestation of freshwater ecosystems has been recently reported by several workers (Luken and Thieret, 1997; Bolorunduro, 2000; Osumo, 2001; Masami *et al.*, 2008); and its major effect appears to be disruption of normal ecological functioning of aquatic ecosystems where it is found thriving. Equally, beneficial effects of the water hyacinth have also reported as an aid in water purification through conversion of toxic ammonia to usable nitrates as well as capacity to absorb heavy metals and organic compounds from water body (Simeon *et al.*, 1987; Cowx and Welcomme, 1998; Ingole and Bhole, 2002).

The influence of aquatic macrophytes on the limnological properties of waterbodies has been recognized (Petre, 2000; Lee and McNaughton, 2004); therefore they may be regarded as efficient indicators of water quality. There is often greater emphasis directed at the effect of aquatic environmental factors on macrophyte/plant life, but relatively less emphasis has been focused on effects of such macrophytes in the environments they exist in. This study therefore aims at assessing the impact of continued persistence of the water hyacinth as an aquatic macrophyte in a fresh water body in tropical South Western Nigeria using the Awba reservoir of the University of Ibadan as a case study. The information provided by the study will provide a basis for monitoring the biological status of this freshwater resource to enhance its immense applications within the University community.

MATERIALS AND METHODS

The study was carried out between July and November 2005 at the Awba reservoir, a freshwater body located within the University of Ibadan-Nigeria. The Awba reservoir lies between latitude 3^{O} 53'E and 7^{O} 26'N at an altitude of 185 meters above sea level (Akin-Oriola, 2003). Maximum depth and length values are 5.5 and 700 meters respectively and have an approximate surface area of 0.06 square kilometers (Uka, 2006). The mean daily air temperature during the period of study was 24.6^{O} C and mean rainfall range of above 1,300mm.

Water samples were collected from two sampling stations on the water body; the water hyacinth infested areas where growth of the species thrived abundantly (Area A) and open water area (Area B) where there was no occurrence of the weed species. These samples were collected using 2mL plastic bottles previously washed with nitric acid. Water samples were stored immediately in a cooling apparatus to prevent degrading of the water samples and then transported to the laboratory for further analyses.

LABORATORY ANALYSES OF PHYSICO-CHEMICAL PARAMETERS

Biochemical Oxygen Demand (BOD)

This was determined for water samples from both stations using the modified Winklers method for determination of BOD. Data readings were taken five days after incubation in BOD incubator dark chamber.

Chemical Oxygen Demand (COD)

COD may be represented as the deficiency in dissolved oxygen in water samples and corresponding increase in organic matter content (Hernandez-Romero *et al.*, 2004). It was determined by adding 5ml of 0.125N potassium dichromate ($K_2Cr_2O_7$), 10ml of concentrated sulphuric acid (H_2SO_4) and 1ml of silver sulphate (Ag_2SO_4) to 5ml of the water samples respectively. After digestion, the compounds were cooled and stored in a flasks washed with distilled water. These were then titrated with ferrous sulphate using two drops of ferroin indicator. The same procedure was repeated for the blank samples with equal volume of water compared to the samples.

Calculation

$$\text{COD (mg/L)} = \frac{\text{Blank titration} - \text{Sample Titration} * 100}{\text{Volume of sample (ml)}}$$

Phosphate (PO_4^{3-}) content

40ml of water samples were added to 50ml volumetric flasks followed by 8ml of reducing agent. Samples were made to mark with distilled water and allowed to stand for ten (10) minutes; after which absorbance was taken using SP6-200 spectrophotometer set at 850nm. Concentration of phosphate in the samples was deduced from the calibration curve.

Ammonia-Nitrogen (NH_3-N) content

Ammonia-nitrogen content of water samples was determined by the standard procedure as described by APHA (1985).

Statistical Analyses

Water quality variables of tested water samples were analyzed by means of One Way Analysis of Variance (ANOVA).

RESULTS

The physical water quality (physico-chemical) parameters variables for the two stations evaluated during the course of the study are represented in Table 1 represented below.

Biological Oxygen Demand (BOD)

The comparative values of BOD values for water hyacinth infested area (Area A) and open water area (Area B) are shown in Figure 1. BOD values for Area A were relatively higher, ranging from 0.38 to 19.20 mg/L than those of Area B with 0.13 to 4.62mg/L. There were no observable differences between Areas A and B in the early period of observation (i.e. from July to August). However, there was a sharp and pronounced increase in the following months with the peak between August and September (Fig. 1) in Area A and overall fluctuation of BOD in this area was greater than that in Area B which exhibited steady fluctuation, though at relatively lower BOD levels.

Chemical Oxygen Demand (COD)

The variations in COD of the two sampling areas during the period of study are shown in Figure 2. Area A values for COD were significantly higher ranging from 1.16 to 88.22mg/L when compared to Area B with 0.39 to 3.50 mg/L. As observed with the BOD values, there were no observable differences between Areas A and B in the early period of observation (i.e. from July to August). The following period from August to November displayed marked increase in COD fluctuations for Area A with little or no changes in the trend for Area B.

Ammonia-Nitrogen (NH_3-N) Content

The trend of variation for ammonia nitrogen content for both sampling areas showed that there was no significant difference in values recorded for both areas. Both Areas A and B showed fairly uniform values for NH_3-N content which dropped in mid-August and then steadily inclined to maximum values as the study period progressed to November (Fig. 3).

Phosphate (PO_4^{3-}) Content

Phosphate values were slightly higher in Area B ranging from 0.04 to 3.98mg/L compared to Area A values of 0.09 to 2.78mg/L. This difference was however not significant (Table 1). There was steady build up of phosphates in both sampling areas from the beginning to the end of the study period (i.e. from July to November). Fluctuations however appeared to more steady in Area A with regard to Area B throughout the study period (Fig. 4).

DISCUSSION

The occurrence of aquatic macrophytes in any freshwater body generally has been shown to affect water quality parameters as well as abundance of fauna diversity. The continued presence of water hyacinth as a dominant macrophyte in the Awba reservoir has been observed to affect specific water quality parameters of this reservoir. This is revealed in the significant values of both BOD and COD values for hyacinth infested areas compared to hyacinth free areas (Table 1) within the study period. These results indicate rapid depletion in dissolved oxygen concentrations in the infested areas and steady build up of organic matter sediments probably caused by decomposing and decaying mats of older water hyacinth plants. Smith-Rogers (1999) noted the ability of the water hyacinth to impede mixing of oxygen rich surface water where the weed thrives with water levels deeper in the water column. Also generation of large amounts of organic matter during decomposition of water hyacinth mats increase BOD which leads to reduction of water quality. Since the Awba reservoir is a relatively shallow water body, complete deoxygenation of deeper water levels and sediments can occur. Such conditions are not favorable or compatible for survival of other aquatic macro/microorganisms such as fish and other invertebrates in this water body. Chukwuka and Uka (2007) reported low abundance of zooplankton in water hyacinth infested areas of the reservoir as compared to water hyacinth free areas.

Increased nutrient loads in freshwater bodies from various external organic and inorganic sources have been attributed by several workers to be responsible for the infestation of weeds such as the water hyacinth in such systems (Bugenyi and Balirwa, 1998; Osumo, 2001; Masifwa *et al.*, 2004). The establishment of water hyacinth in the Awba reservoir has been enhanced through increased enrichment of the water body by nutrient runoffs from human and agricultural wastes. Chukwuka and Uka (2007) highlighted the use of the Awba reservoir as a repository for domestic effluents from the living quarters of the University. Moreover under hypoxic (low oxygen) conditions created by dense water hyacinth mats, phosphate and ammonia are released into water from anoxic sediments further enriching the freshwater ecosystem (IDRC, 2000).

Beneficial roles of aquatic vegetation in the functioning of aquatic ecosystems include cycling of nutrients and minerals. This phenomenon occurs through absorbance of nutrients into the plants' systems for life activities such as respiration and release when they die and decay forming sediments in the water ecosystem. Steady increase in ammonia and phosphate contents of both water hyacinth infested and free areas (Figures 3 and 4) indicate the ability of decomposition of water hyacinth and other aquatic macrophytes to result in release of nutrients and other chemical constituents in the water environment. This eventually has both direct and indirect effect on water quality and other ecosystem components (Masifwa *et al.*, 2004). The water hyacinth also possesses natural ability to absorb vast amounts of nutrients into its tissues causing formation of nutrient sinks in infested zones, which essentially removes these nutrients from the ecosystem (Ogunlade, 1996). This phenomenon is reflected in the observation that phosphate contents were relatively lower in water hyacinth infested areas compared to water hyacinth free areas (Figure 4).

This study emphasized the impact of water hyacinth persistence in freshwater ecosystems using Awba reservoir as case study. Water hyacinth is observed to have direct influence on limnogical properties of such water bodies i.e. causes significant changes in physical and chemical conditions in the water and sediments. The study also generally highlighted the great influence aquatic macrophytes such as the water hyacinth has on their immediate physical environment and how this affects other components of the ecosystem. Since the blooming of water hyacinth populations in the Awba reservoir may be traced directly to nutrient enrichment of the water body, there is need to control influx of nutrients into the water body particularly from extraneous sourcesIn conclusion, this study does not merely advocate for an eradication of the water hyacinth perceived to be a nuisance species in the water body evaluated in the study. Rather we advocate further concerted and coordinated research efforts at assessing the environmental impact of this water weed in tropical freshwater ecosystems. This will ensure that only appropriate and environmentally sustainable means of the weed control are initiated and developed. This will also result in the judicious utilization of scarce financial resources to effectively manage this prolific water weed in an environmentally benign manner.

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Table 1. Water quality parameters of water hyacinth infested area and open water area in the Awba reservoir (July to November, 2005).

Parameter	Water Hyacinth Infested area (Area A)	Open water area (Area B)	p-value
Biological Oxygen Demand (BOD)	10.82±2.78	2.43±0.61	0.009*
Chemical Oxygen Demand (COD)	40.54±1.03	1.84±0.36	0.003*
Phosphate (PO_4^{3-})	1.18±0.33	1.64±0.45	0.429 NS
Ammonia-Nitrogen (NH_3-N)	2.02±0.52	3.13±0.67	0.297 NS

p indicates significance of ANOVA; *Significant ($p<0.05$)

NS- Not Significant ($p>0.05$)

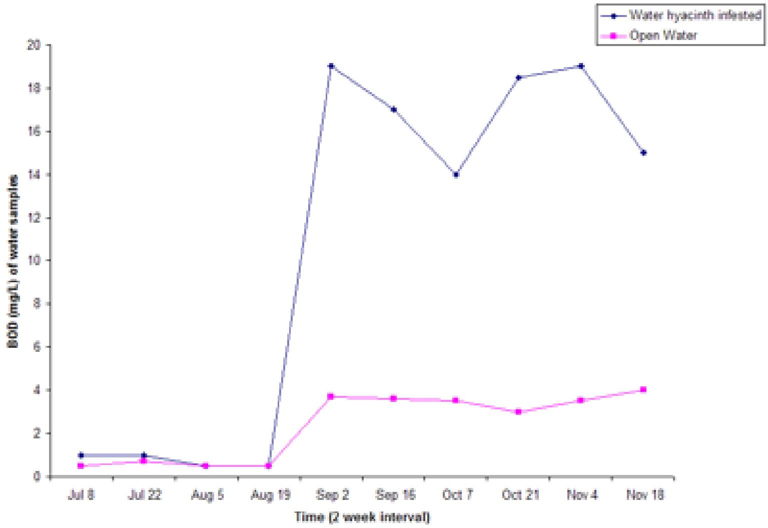

Figure 1. Biochemical Oxygen Demand (BOD) of Water Hyacinth Infested and Open Water Areas in Awba Reservoir

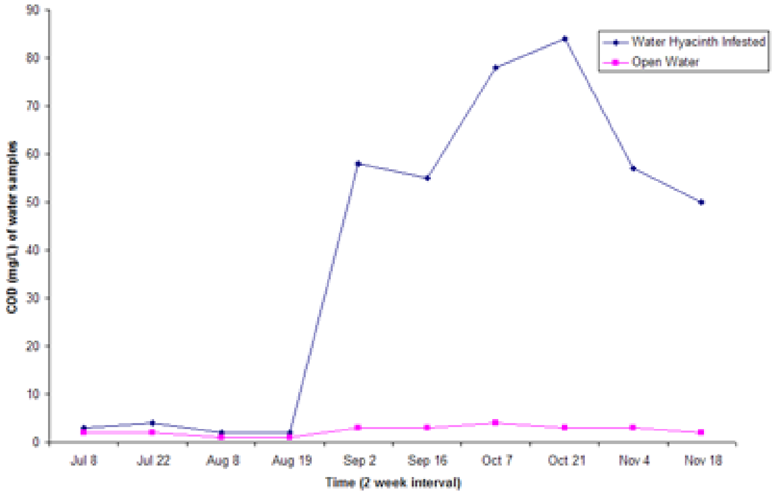

Figure 2. Chemical Oxygen Demand of Water Hyancinth Infested and Open Water Areas in Awba Reservoir

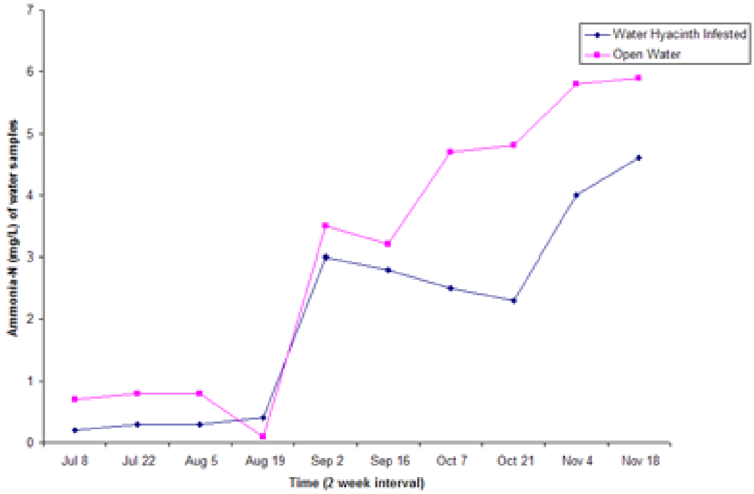

Figure 3. Ammonia-Nitrogen content in Water Hyacinth Indested and Open Water Areas in Awba Reservoir

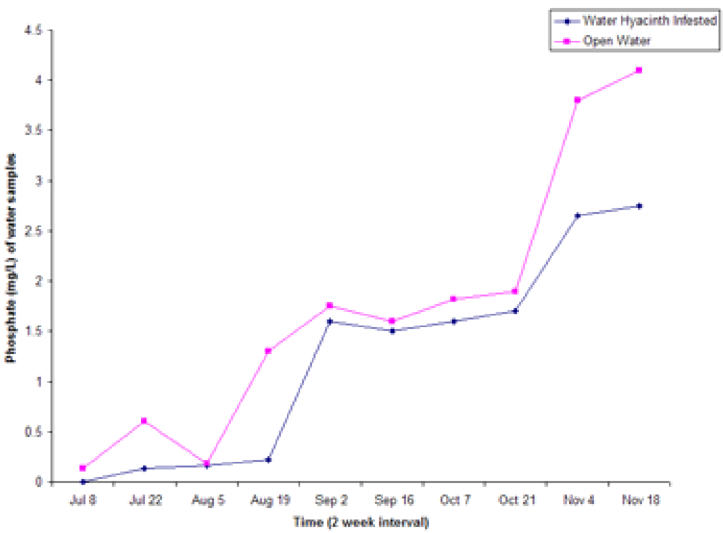

Figure 4. Phosphate content in Water Hyancinth infested and Open Water Areas in Awba Reservoir