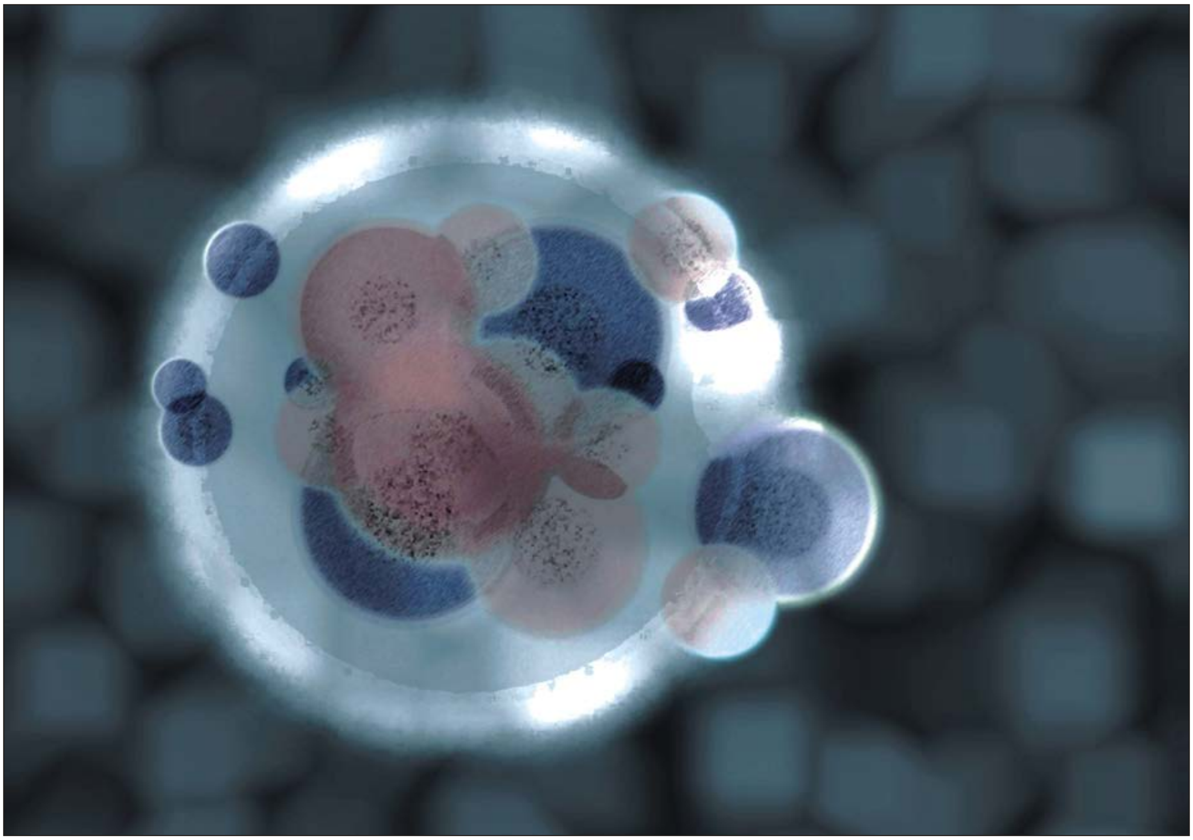

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Effect of Water Hyacinth Infestation on the Physicochemical Characteristics of AWBA Reservoir, Ibadan, South-West, Nigeria

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Abstract: Water hyacinth infested and open water areas in AWBA reservoir were sampled fortnightly between July and November 2005. The effect of water hyacinth infestation on the aquatic biota was assessed using physico-chemical parameters. The study showed that conductivity, total suspended solids, free carbon dioxide and turbidity were significantly higher ($p<0.05$) in water hyacinth infested area than in open water. Dissolved oxygen, pH and nitrate-nitrogen were significantly lower ($p<0.05$) in the infested areas when compared with open water. Temperature was higher in the infested area than open water but was also not significant ($p>0.05$). The study suggested that water hyacinth infestation negatively impacted on the reservoir and therefore should be eradicated.

Key words: Water hyacinth, water quality, AWBA reservoir, physico-chemical properties

INTRODUCTION

The importance of freshwater bodies as an environmental resource that can be used for the benefit of mankind cannot be overemphasized. Water bodies are important for fisheries, domestic and industrial water supplies, recreation, transportation, irrigation, communication, tourism as well as for receiving waste water effluents. In African rivers, lakes, swamps and lagoons, water hyacinth infestation has been of tremendous increase. The spread of this aquatic weed to a new aquatic environment can be attributed to interdependences of adjoining networks of African waters in neighbouring states. The weed is reported to have gained entrance into Nigerian freshwater lagoon through Badagry creeks in Lagos and Ogun States via neighbouring Republic of Benin (Adekoya, 2000). In areas where people are dependent on lakes and rivers for transportation, fishing and drinking, water weeds have caused severe socio-economic losses and problems as well as interfere with irrigation and hydroelectric-power schemes. This invasive aquatic weed has made a tremendous in road into AWBA dam Reservoir thus forming dense mats. The dam has a lot of fisheries potentials, as well as source of water and fish protein to the University community who largely depend on this dam for their water supply and fish protein.

The influence of aquatic macrophytes on the physical and chemical environment of a water body has been recognized (Lee and McNaughton, 2004). Reddy *et al.* (1983) reported that as aquatic plant cover and density increases, it alters the physico-chemical characteristics of water bodies. The objective of the study therefore was to evaluate the effect of water hyacinth infestation on the physico-chemical properties of the reservoir. This required information may form the basis for the control of this aquatic weed in the dam.

MATERIALS AND METHODS

Study area: The study area, AWBA reservoir, is sited within the University of Ibadan, Ibadan-Nigeria. It lies between latitude 3°53'E and 7°26'N and at altitude of 185 m above sea level (Akin-Oriola, 2003). The Reservoir has a surface area of 6 ha. According to Ugwumba (1990), the Reservoir is 8.3 m high, 110 m long with a crest of 12.2 m high. It has a maximum depth of 5.5 m and a maximum length of 700 m. It can hold about 230 million litres of water (Omotosho, 1981). The mean daily air temperature is 24.6°C.

The reservoir is marked by two seasons. The wet and dry seasons. Rainy season occurs between April and October while the dry season is between November and March. In this study, two sampling areas were randomly selected consisting of areas with high water hyacinth presence and open water (without water hyacinth presence), which served as the control.

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COLLECTION OF WATER SAMPLES

Water samples were collected directly from each sampling areas with a 2 mL plastic containers washed with nitric acid to remove any form of contaminants. These were stored immediately in a cooler in order to ensure that the physical properties of the water samples were maintained and transported to the laboratory for analysis.

DETERMINATION OF PHYSICO-CHEMICAL PARAMETERS

Water temperature: The temperatures of the sampling areas were determined using mercury-in-glass thermometer and reading taken.

pH: Metrohm Herisau E520 pH meter was used for the pH measurement.

Dissolved oxygen: Dissolved oxygen concentration of the sampling areas was determined using Winklers titrimetric method (Mackereth, 1963). Water samples were collected in a 250 mL dissolved oxygen bottle below the surface of the water. Two milliliter of Manganous sulphate solution followed by 2 mL Potassium iodide (KI) solution were added to water samples in order to fix the oxygen. The bottle was carefully closed with a stopper to exclude air bubbles and mixed by thoroughly shaking of the bottle. The formed precipitate was immediately taken to the laboratory for analysis.

In the laboratory, 2 mL of H_2SO_4 was added and the bottle shook thoroughly to dissolve the precipitate. 10 mL of this solution was placed into a conical flask and titrated against 0.0125 $Na_2S_2O_3.5H_2O$ (sodium thiosulphate solution) using 2 drops of starch solution as indicator. Dissolved oxygen (mg L^{-1}) was calculated as follows:

$$\text{DO (mg L}^{-1}) = \frac{\text{Vol. of 0.0125N Thiosulphate (mL)} \times 101.6}{\text{Volume titrated}}$$

Determination of free carbon dioxide: Water samples were collected using 500 mL pyrex bottle. It was completely filled to leave no air space. The samples were siphoned into 100 mL graduated cylinder and were allowed to over flow. Five to ten drops of phenolphthalein indicator was added to the sample and it was colourless. Titration was rapidly carried out into the cylinder with standard alkali solution and stirred gently until pink colour persists for about 30 sec. A colour comparison is provided by adding 5-10 drops of phenolphthalein indicator to 100 mL $NaHCO_2$ solution in a similar graduated cylinder.

Calculations

$$CO_2 \text{ Mg/L} = \frac{\text{V M 44,000}}{\text{mL of sample used}}$$

Where, V = mL of Na_2CO_3 used for the titration of the sample
M = Molarity of the standard Alkali

Conductivity: Water sample conductivity was measured using HACH conductivity meter. This meter was standardized using distilled water and the probe inserted into the sample. The conductivity value was displayed on the meter and value recorded.

Turbidity: Turbidity was determined using Varian UV-Visible Spectrophotometer. The spectrophotometer was standardized with distill water at a wavelength of 450 nm for the turbidity analysis. Readings were indicated on the meter.

Total suspended solids: The Varian 634 UV-Visible Spectrophotometer was also used for the measurement of total suspended solids. This was obtained by standardizing the spectrophotometer at a wavelength of 830 nm (infra red). A total suspended solid was then determined by reading value shown on the metre.

Nitrate -nitrogen (NO_3^-): Fifty milliliter of water sample was added into a flask, equivalent amount of Cl^- ion determined was added to the standard Ag_2SO_4 solution to remove any Cl^- ion that may interfere as AgCl precipitate. A clear sample of the water was then evaporated to dryness over a hot water bath.

The residue was then rubbed with 1 mL Phenol disulphonic acid reagent and was heated mildly to dissolve all solids. Ten milliliter of distilled de-ionised water was added, followed by 3 mL of concentrated ammonium hydroxide solution. The solution was then transferred to a 50 mL volumetric flask. It was made to mark and thoroughly mixed. Absorbance readings were taken at wavelength of 410 nm with SP_6-200 spectrophotometer. Concentration of nitrate in water sample was deduced from the calibration curve.

Statistical analysis: Water quality variables from the two sampling points were compared by means of one-way analysis of variance (ANOVA).

RESULTS

The physico-chemical parameters assessed in the study areas are shown in Table 1.

Table 1: Variations in water quality (Mean value±Standard Error) between water hyacinth infested and open water areas in AWBA reservoir between July and November, 2005

Parameter	Water hyacinth infested	Open water	p-level
Dissolved oxygen	1.92±0.29	5.89±0.85	0.000*
Temperature	27.16±0.64	26.7±0.52	0.281NS
pH	6.92±0.04	7.71±0.05	0.000*
Turbidity	31.75±1.23	18.67±1.99	0.000*
Conductivity	323.8±2.32	290.3±4.39	0.000*
Nitrate	6.91±1.09	12.36±1.07	0.002*
TSS	92.48±4.00	54.09±5.85	0.000*
CO_2	26.45±1.02	12.89±1.92	0.000*

p Indicates significance of one way ANOVA $p<0.05$, * Significant $p<0.05$, NS- Not significant $p>0.05$

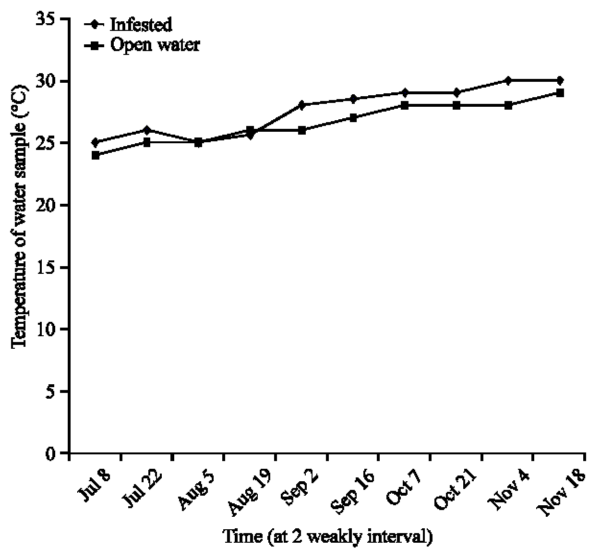

Fig. 1: Water temperature in water hyacinth infested and open water areas in AWBA reservoir

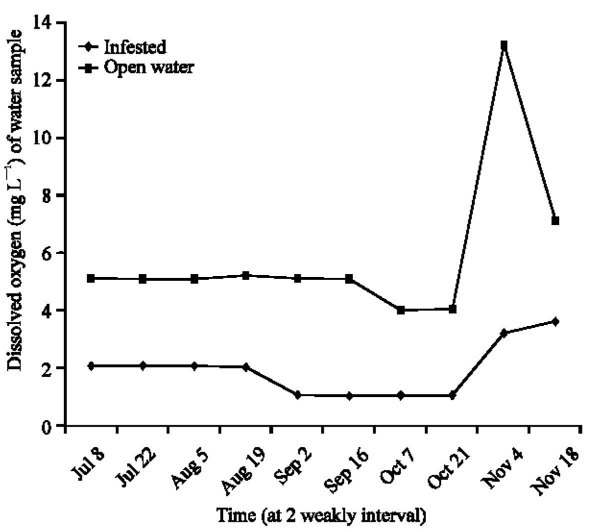

Fig. 2: Dissolved oxygen content in water hyacinth infested and open water areas in AWBA reservoir

Water temperature: Water temperature values in the sampling areas are shown graphically in Fig. 1. Water temperature values in the water hyacinth infested area are in the range of 25 to 30°C, while open water temperature values ranged from 24 to 29°C. Mean water temperature of the infested area (27.5±0.60°C) was slightly higher than that of the open water (26.7±0.52°C). The analysis of variance showed that there was no significant difference between water hyacinth infested area and open water area.

Dissolved oxygen: The dissolved oxygen concentrations in the water hyacinth infested and open water areas during the period of study are shown in Fig. 2. The infested areas showed low values of dissolved oxygen in the range of 1.02 to 3.60 mg L^{-1}. while open water had high concentrations of dissolved oxygen values ranging from 4 to 13.2 mg L^{-1}. The mean dissolved oxygen in the infested area is 1.96±0.71 while open water had a mean of 5.89±0.85. These results when subjected to one-way ANOVA showed significant differences at 5% level between the values of the sampling areas 1and. In early November, dissolved oxygen rose sharply to 13.8 mg L^{-1} in the open water and 4 mg L^{-1} in the infested (Fig. 2).

pH: The pH values of the sampling areas are shown in Fig. 3. Water hyacinth infested area showed low pH values ranging between 6.7 and 7.1 (6.92±0.04), while open water area had higher values ranging from 7.4-7.95 (7.71±0.05) as shown in Table 1. ANOVA result showed that pH is significantly lower in water hyacinth infested area compared to open water at 5% level.

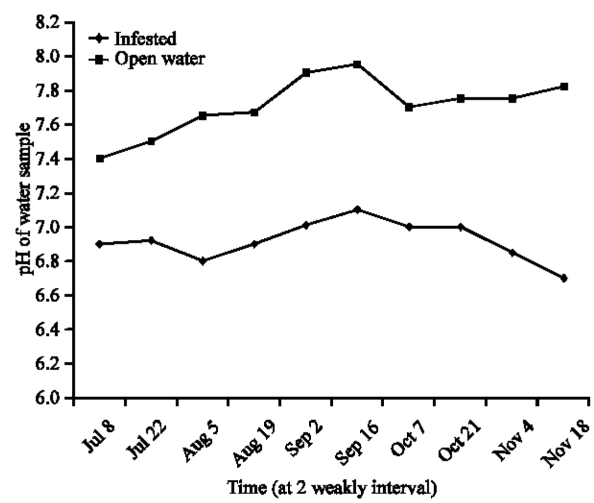

Fig. 3: pH of water in water hyacinth infested and open water areas in AWBA reservoir

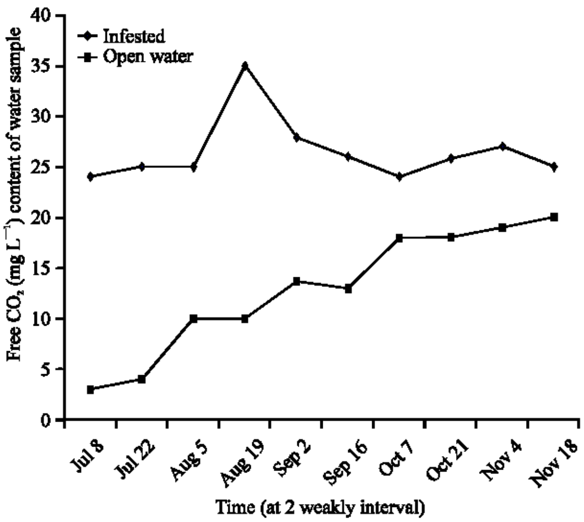

Fig. 4: Free CO_2 content in water hyacinth infested and open water areas in AWBA reservoir

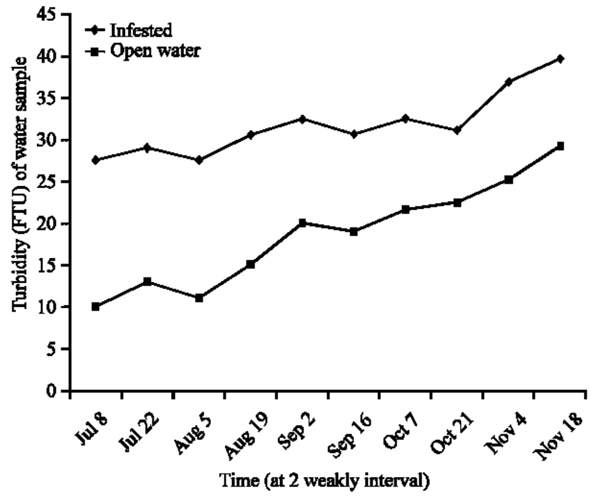

Fig. 6: Turbidity of water hyacinth infested and open water areas in AWBA reservoir

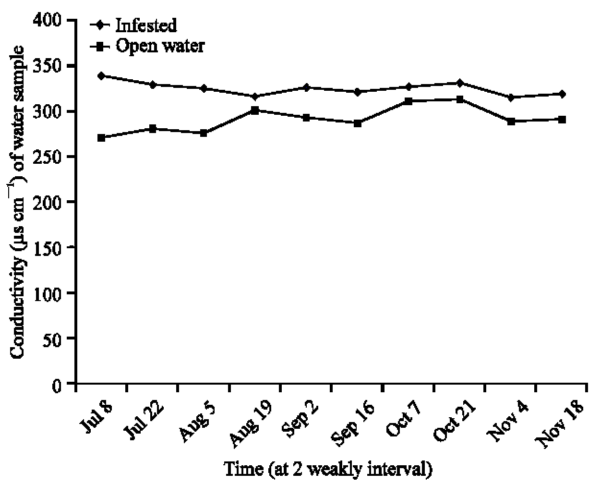

Fig. 5: Conductivity potentials of water hyacinth infested and open water areas in AWBA reservoir

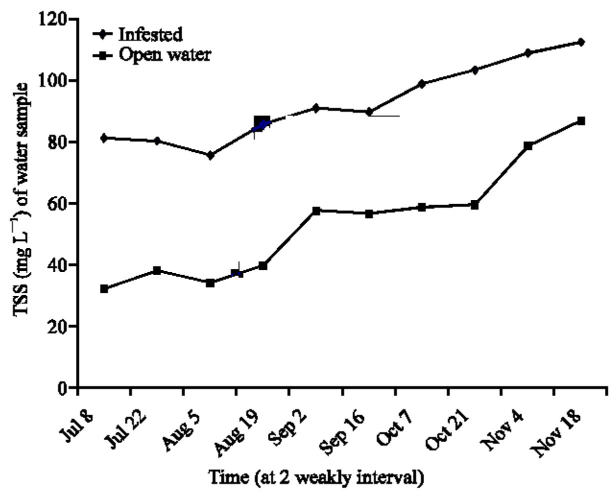

Fig. 7: Total suspended solids of water hyacinth infested and open water areas in AWBA reservoir

Free carbon dioxide: Figure 4 shows variations in the values of free carbon dioxide (CO_2) in the two sampling areas. Free carbon dioxide contents of the sampling areas was higher in the water hyacinth infested areas with values ranging from 23.97-34.97 mg L^{-1} (26.45±1.02) mg L^{-1} when compared to open water values which ranged between 3-20 mg L^{-1} (12.86±1.92) as shown in Table 1. ANOVA revealed that water hyacinth infested is significantly higher ($p<0.05$).

Conductivity: Figure 5 graphically illustrates the variations in the conductivity values of the two sampling areas during the period of study. The range of values for the infested areas was between 314-338 µs cm^{-1} (328.8±2.32) while open water values ranged between 270-312 µs cm^{-1} (290.3±4.39) as shown in Table 1. Analysis of variance showed that conductivity values in water hyacinth infested is significantly higher $p<0.05$ than open water.

Turbidity: Turbidity fluctuations in the two sampling areas are as shown in Fig. 6. Turbidity values ranged between 27.5 to 39.6 FTU (31.75±1.23) for the water hyacinth area. While the open water values ranged from 10.02 -29.24 FTU (18.67±1.99). The infested area was significantly higher the open water ($p<0.05$).

Total suspended solids: Total suspended solids values varied in the water hyacinth infested area and open water

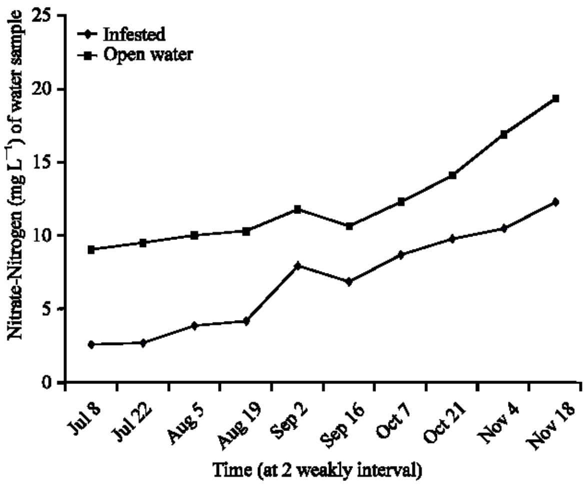

Fig. 8: Nitrate-Nitrogen content of water hyacinth infested and open water areas in AWBA reservoir

areas during the period of study as shown in Fig. 7. Infested areas showed high values of total suspended solids ranging between 75.40-112.22 mg L^{-1} (92.48±4.00) while Open water areas has lower value in the range of 32.01-86.62 (54.0±5.85) as in Table 1. There was significant differences in the values of water hyacinth infested area when compared to open water area at 5% level (Table 1).

Nitrate: Nitrate concentration values for water hyacinth infested areas ranged from 2.58-12.24 mg L^{-1} while open water areas ranged from 9.02-19.26 mg L^{-1} during the period of study (Fig. 8). The mean values (6.91+1.09) of infested area was lower than open water mean values (12.36±1.07). The analysis of variance revealed that infested area is significantly lower $p<0.05$ than open water (Table 1).

DISCUSSION

The analysis of variance (Table 1) on the physicochemical parameters revealed that there was no significant difference with respect to temperature between water hyacinth infested and the open water areas; however infested area had a higher temperature. This slight increase in temperature is as a result of dense mats of water hyacinth over the surface, which blocks the exchange of heat between the water column and the atmosphere. This is in agreement with the findings of Rai and Munshi (1977) in their report on the diurnal fluctuations of certain physico-chemical factors of three tropical swamps of Darbhanga (India). The result also agrees with Dale and Gillespie (1976) who reported that floating macrophytes has an influence to bear on temperature fluctuation.

There was lower dissolved oxygen content in the water hyacinth infested area. The reduction of dissolved oxygen concentration in the water hyacinth infested area was a result of metabolic activity of epiphytic organisms and dense mat of water hyacinth formation. The result also agrees with Frodge *et al.* (1995), who asserted that dissolved oxygen content is lower in patches of the *Brasinia scherberi* in lake Northwest of USA.

Oke (1999) reported that aquatic plants impede water movement and vertical circulation of dissolved oxygen. The result is also in agreement with the assertion of Ogbogu (1991) that the coverage of water surface by *Azolla africana* at IITA Lake in Ibadan led to a reduction in dissolved oxygen content of the lake. Low dissolved oxygen (less than 2 mg L^{-1}) indicates poor water quality and makes sustenance of aquatic life difficult. Medera (1982) reported that fish feed better at high oxygen concentration and grow poorly at lower oxygen concentrations. The mean dissolved oxygen content of 1.92 mg L^{-1} in the water hyacinth infested area falls below the desirable range for fish survival (Boyd, 1979). The low dissolved oxygen content reported in the water hyacinth infested area may suggest that aquatic life will be threatened and consequently the protein intake of the University community in which the AWBA dam is located. The sharp increase in dissolved oxygen in the open water between late rains and early dry season could be as a result of seasonality. According to Chapman and Kramer (1991) marked variations in temperature and rainfall between seasons influence physico-chemical properties of water bodies. Water hyacinth proliferates better in slightly acidic to neutral pH but grows poorly above pH 8 (Pillai *et al.*, 1982). Dense mats of water hyacinth on water surface leads to low pH (Oke, 1999) thus increase the acidity arising from the removal. The removal of some categories of ions and replacement with compounds such as CO_2 promote acidity.

The higher free CO_2 values in the water hyacinth infested area was caused by water hyacinth dense mats which prevented the vertical diffusion of gases thereby preventing entry of oxygen into water than carbon dioxide going out. This is in agreement with the findings of Rai and Munshi (1979) on the influence of thick floating vegetation on the physicochemical environment of a freshwater wetland. The decomposition of water hyacinth tissues contributed greatly to high carbon dioxide input and sustenance. There was higher conductivity in the water hyacinth infested area. Conductivity values are indication of mineralization and nutrient level of the water. Water hyacinth proliferates in nutrient rich medium from domestic effluents and agricultural runoff. Turbidity was also high in the water hyacinth infested area. Water hyacinth mats trap detritus and phytoplanktons, its high density and decay matter in suspension may have caused the decrease in water clarity when compared to open water. The high level of turbidity as a result of heavy load of suspended particles will not favour the abundance of zooplankton organism. Aquatic plants have been known to forestall the movement of water (Green, 1967). Therefore, sand particles, silts and fine organic matter such as leaves on entering the water hyacinth infested areas became trapped, thus increasing the total suspended solids in the infested area.

The fact that nitrate was lower in the water hyacinth infested area could be due to the absorption of the nutrients by water hyacinth. Ogunlade (1996) reported that water hyacinth has the ability to remove nutrients and heavy metals from aquatic environments. However, this aquatic plant was not analysed to ascertain the concentration of these nutrients on the plant. It can therefore be deduced from the results that water hyacinth dense mats altered the physico-chemical properties of the AWBA reservoir.

Water hyacinth (*Eichhornia crassipes*) is rapidly spreading and may soon cover the entire water body of AWBA dam if unchecked. Therefore, it is recommended that the university administration, government and donor agencies should take rational decision in allocating resources to aquatic weed control in the dam.

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