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THE RELATIONSHIP BETWEEN AQUATIC MACROPHYTES AND WATER QUALITY IN NTA-WOGBA STREAM, PORT HARCOURT, NIGERIA.

Uedeme-Naa, B., [1], Gabriel U. U[2] and 3Akinrotimi O. A.

[1]Dept of Animal Science and Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, Nigeria. [2]Department of Fisheries and Aquatic Environment Faculty of Agriculture, Rivers State University of Science and Technology Nkpolu,-Oroworukwo, Port Harcourt, [3]African Regional Aquaculture Central Nigerian Institute for oceanography and Marine Research, P. M. B. 5122, Port Harcourt Nigeria

ABSTRACT

An empirical survey of macrophytes distribution and biomass from four stations, along Nta-wogba stream in Port Harcourt, Nigeria, was conducted between April and December 2007, to quantify the relationship between biomass, in stream nutrients and dissolved ions. The correlation analysis indicated that the biomass of the aquatic macrophytes under consideration, *Einochloa pyramidalis; Diplazum sammatii; Cyperus difformis; Alternathera sessilis* and *Ludwigia decurrens* were significantly ($P<0.05$) related to the nutrients: sulphate, ammonium; nitrate, and phosphate in all the stations. The measurement of total dissolved solid, which is correlated to ionic concentrations and turbidity, provided a rough indication of in stream light availability.

KEYWORDS: Macrophytes, water quality, aquatic environment, stream, and dissolved ions

INTRODUCTION

Aquatic macrophytes are group of large macroscopic photosynthetic organisms usually growing with their roots in soil or water (Jones *et al.*, 2010). They can be described as emergent, floating, submerged and encrusting, depending on the position of plant relative to the water surface and substrate, with individual species often displaying plasticity among these growth forms (Puijalon *et al.*, 2008).

They play a significant role in hydro ecosystems by providing breeding substrate for organisms including fish, aquatic insects and zooplankton and many of them serve as food for fishes (Ratusshnyale, 2008). However, in most subtropical and tropical rivers the excessive growth of aquatic macrophytes may provoke some negative effects (Bini *et al.*, 2005). Aquatic plants develop in to explosively large population only when the environment is altered either physically or through the introduction of some nutrients (Okayi and Abe, 2001). In the aquatic ecosystem, nutrient concentrations are continuously affected by a wide range of physical, chemical and biological processes resulting in a dynamic water quality status (Desmet *et al.*, 2006). Dumen, *et al.*(2007) noted that aquatic macrophytes growing in the rivers are known to induce substantial changes to the water quality.

Some of these effects are due to direct interactions such as uptake of nutrients, whereas others may be merely attributed to indirect effect of the water plants on hydrodynamics or sediment chemistry (Yaowakhan *et al.*, 2005). Many water bodies all over the world have become eutrophied, as a result of the input of excessive nutrients from urban and agricultural activities. According to Jeffries and Mills (1990), eutrophic water are those which show signs of excess nutrient loading with associated changes in flora and fauna. The input of excessive plant nutrients may occur together with an increase in solid effect that accelerates sedimentation. Zimmels *et al.* (2007) observed that excessive nutrient input also alters macrophyte communities. Some tolerant species, which are able to use the increased nutrients, may flourish as is characteristic of aquatic weed, while sensitive species are lost and as a result the diversity declines.

Among the least understood and least studied components of urban stream biota are aquatic macrophytes. This is rather unfortunate since changes in macrophyte communities may be especially indicative of major categories of urban stress, such as nutrient run off, hydrologic regime, and invasion by exotic species (Havry, 1996; King and Buckney, 2000). As such, the health and structure of macrophyte communities are likely to be important determinants of water quality (Gregg and Rose, 1982; Suren 2000; Balanson *et al.*, 2005). In order to improve water quality by integrated management practices, a more profound understanding and further quantification of the interactions between the macrophytes and the aquatic system is indispensable. This necessitates this work to be carried out. The study therefore focused on the effects of aquatic macrophytes on water quality of Nta-Wogba a popular stream that flows through Port Harcourt metropolis.

MATERIALS AND METHODS

Study Area

This research was carried out at the Nta -Wogba stream situated between 7^0.20E and latitude 4^0.58 and 4^0 .65N, which runs across Port Harcourt metropolis and empties into the Bonny Rivers through Amadi creek. Its head water drains through the Oroazi forest of Rumueme and passes through the densely populated Port Harcourt city across Abacha Road, Rebisi (Olu Obasanjo Street), Oromenike (Okija street), Afam street off Port Harcourt-Aba Express Road, Amassoma street and Eastern by-pass (Fig 1).

Sampling Procedure

A total of four different stations were chosen. They were 500 m apart along the stream. The stations were: (1) Abacha Road (2) Olu-Obasanjo (3) Afam and (4) Okija street. The sampling was done twice in a month from April 2007 to December 2007, which covered four dry and five wet seasons' months

Macrophyte sample collection and analyses

Samplings of macrophytes were done by throwing 1 m by 1 m quadrant on water surface. Collected samples were rinsed and harvested using a knife and taken to the laboratory. All species within the collected samples were identified following the identification keys described by Akobundu and Agyakwa (1987) and weights were taken using a balance.

Surface water sample collection for physico-chemical parameters

At each site a set of water samples were collected in a pre cleaned one litre poly propylene container and transported to the laboratory in an ice chest for further analysis.

Dissolved oxygen (DO) in the water samples was determined by Winkler's method (APHA 1985). Biological oxygen demand was determined by dilution method (APHA 1985). The value of total dissolved solids (TDS) and conductivity was determined using the Lovibond field meter. Alkalinity, nitrate and sulphate by titrimetric method and phosphate and ammonia were determined by spectrophotometer (APHA, 1985). The values of salinity in the stream were evaluated in situ by hand held refractometer (Model HRN-2N Atago Product, Japan). Turbidity was determined using sechi disk following the method of Chindah (2003). While temperature was measured using mercury thermometer, and hydrogen ion concentration (pH) was taken by the use of a pH meter (Model HI 9812, Hannah Products, Portugal).

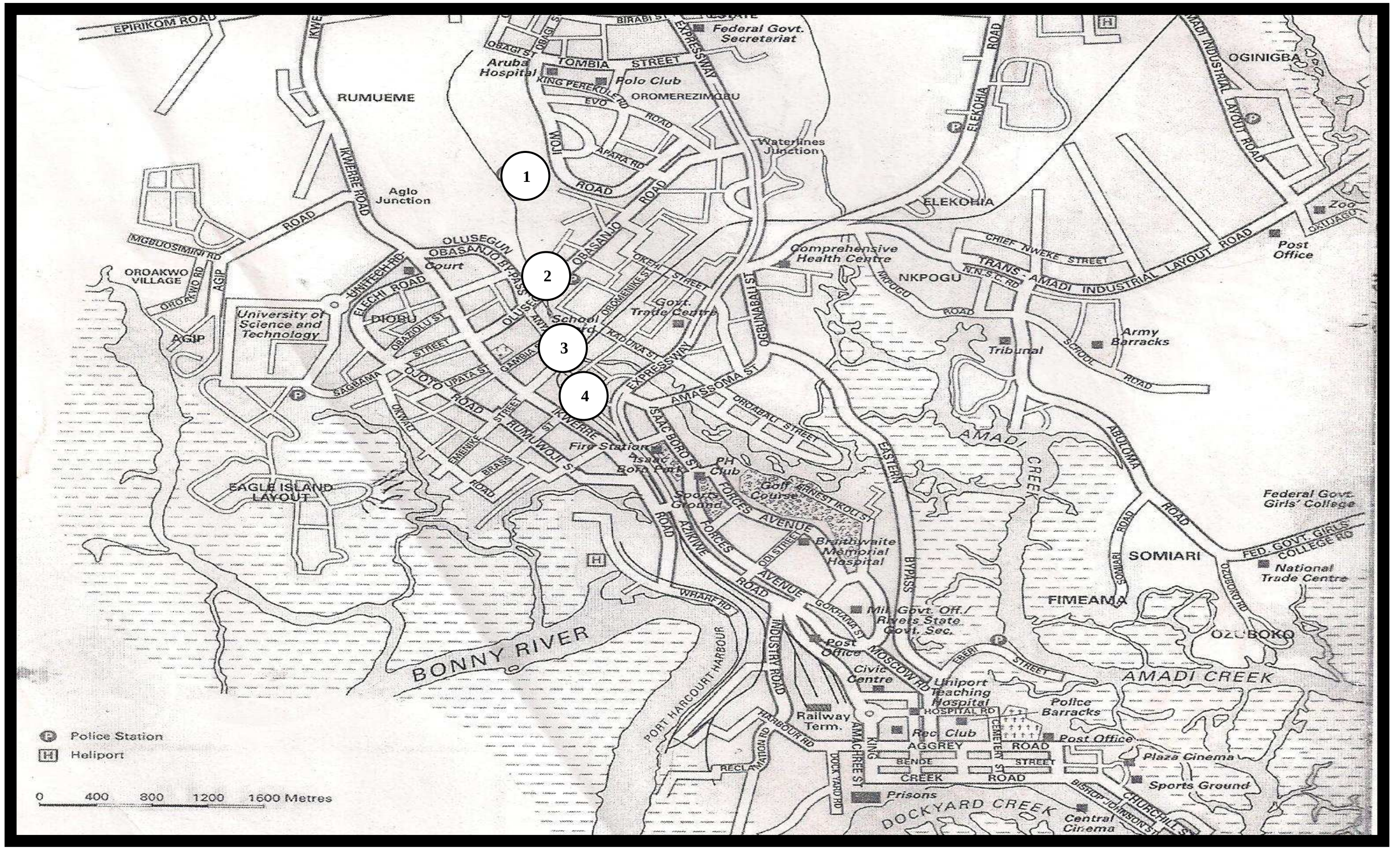

Fig. 1: Map of Port Harcourt Metropolis Showing the sampling stations.
Source: Rivers state Ministry of Land and Housing

Key

(1)	Sampling Station 1	-	Abacha Road
(2)	Sampling Station 2	-	Olu-Obasanjo Road
(3)	Sampling Station 3	-	Afam Street
(4)	Sampling Station 4	-	Okija Street

RESULTS

The macrophyte composition of Nta-wogba stream (Table 1) indicated that *Einochloa pyramidalis* recorded the maximum density (1988.00 No. /m^2) and the *Ludwigia decurrens* the minimum (8.00 No/m^2). In Abacha road (station 1) *Diplazum sammattii* had the highest (74.07 no/m^2) abundance. At Abacha Road the highest value was observed in *budungia decurrens,* while I*pomoea aquatica, Aneilema beninse* and *Alternathera sessilis* were absent (Table 1). In Olu-Obasanjo Road (station 2) the order of abundance was *C. difformins* > *E. pyramidalis* >. *B iecurrens* > *D. samattii* > *I. aquatica*. While Alternanthera *sessilis* has the lowest abundance species (0.00), in Afam street (station 3), *Ipomoea aquatica* has the highest value (44.64) while the lowest value (11.11) were observed in *Diplazum sammattii*. In Okija street (station 4) the highest value (48.21) was observed in *Ipomoea aquatica* and *ludwigia decurrens* has the lowest (0.00) (Table 1).

The physico-chemical parameters along Nta-Wogba stream indicated that the pH ranged between 7.53±0.68 (station 4) and 7.70 ± 0.82 9 station 3) . The minimum value (95.11±22.40 μ/cm) of conductivity was observed in station 1, while the highest (236.12±28.68μ/cm) was recorded in station II. The turbidity increased downstream with the highest value (11.66/m) at Olu-Obasanjo Road. Alkalinity ranged from 21.44±2.6mg/l (Abacha Road) to 40.97±2.5mg/l (Olu-Obasanjo Road). The mean values of salinity were the same in all the stations. The temperature ranged between 28.94^{0}C (station 3) and 29.72^{0}C (Abacha Road). The nitrate concentration was highest 92.21±1.11 mg/l) in station 3 and the lowest 0.71 ± 0.10 (Olu-Obasanjo Road). The phosphate level increased downstream with the highest value (2.91±0.27mg/l) observed in station 4. The mean values of sulphate were within the same range (8.00-8.24 mg/l) except Abacha Road. The maximum ammonium ion value 0.20 mg/l was recorded at Abacha Road while the lowest (0.09 mg/l) was recorded at Afam Street.

The total dissolved solids (TDS) increased steadily across the four stations. Dissolved oxygen level was within the range of 3.21 ± 1.11 (Afam Street) and 6.12 ±1.12 (Abacha Road). Biological oxygen demand had the lowest value 51.78 ± 3.10 (Abacha Road) and the highest, (171.28 ± 21.16) in station 4 (Okija Street)

The Pearson correlation revealed that pH and Alkalinity correlated negatively with all the macrophytes while conductivity was positively correlated with all the macrophytes. The turbidity was positively correlated with all the macrophytes except *Cyperus difforms* ($p < 0.025$). The salinity and temperature were positively correlated with all the macrophytes. The nutrients which are nitrates, ($N0_3$) phosphates (P_{04}), sulphates (S_{04}), and ammonium (NH_4) were all positively correlated with the macrophytes and significant at ($P<0.05$) level. (Table 3)

The mean squares from ANOVA between physicochemical variables in relation to months, station and aquatic macrophytes were shown in table 4. The F-test of mean square of the interactions between the water quality parameter and the aquatic macrophytes were significant ($P<0.001$) in nitrates (NO_3^-) phosphates (PO_4^-), sulphates (SO_4^-), and ammonium (NH_4^+) levels, for conductivity, turbidity, dissolved oxygen and biological oxygen demand were significant at ($P< 0.01$), temperature and total dissolved solids were significant at ($P < 0.05$), while salinity, alkalinity and pH were not significant (Table 4).

DISCUSSION

The interplay between macrophytes and water quality variables represents a fundamental characteristic of river systems, which has important implications for river flow and ecological functioning (Xiao *et al.*, 2010). Although the growth and spread of macrophytes in aquatic environment is a natural phenomenon, in recent years there has been increasing concern about aquatic macrophytes and the water quality as a result of human activities such as agriculture, forestry operations, constructions activities and urbanization programmes (Collins and Walling, 2007; Wang *et al.,* 2009).

The concentration of oil, and gas and some agro-allied industries for many years in Niger Delta has resulted in the degradation of terrestrial and aquatic ecosystems in these areas. Hydro-ecosystems present itself as the terminal points where the concentration of pollutants occurred. In this vein, the monitoring of biodiversity and hydro chemical regime of streams, rivers and reservoirs are very important in the maintenance of hydro ecosystems (Cohen, 2003).

The turbidity of this stream was found to be positively correlated ($P < 0.05$) to the density of aquatic macrophyte, possibly because medium and dense macriophyte cover are characterized by a low concentration of suspended sediments hence high water transparency (Crow and Hellquist, 2000). In a situation where aquatic macrophytes density is low, such as the impact of eutrophication on water body, the turbidity becomes high, with high concentration of particles. (Kapitonova, 2002). The values of pH and alkalinity of the stream were negatively correlated with the aquatic macrophyte composition; this corroborates the findings of Carr *et al.* (2003) in Ontario Rivers. This may be due to variations of pH and alkalinity in most parts of the year.

The density of species in stations under consideration (four) in this study may be attributed to favourable environmental factors such as moderately high water temperature and high nutrient load (Carpers, 2000). The relationship between macrophytes and water temperature is positively correlated, as high temperature increased the photosynthetic activities of the macrophytes thus increasing their population. The macrophyte distribution in the stream was not in any way influenced by salinity. This is in agreement with the observation of Okayi and Abe (2001) in some reservoirs in Markurdi, Nigeria. This may be due to insignificant salinity load most especially in freshwaters.

The relationship between the nutrients (nitrate, phosphate, sulphate and ammonium ions) and macrophytes were positively correlated ($P<0.05$), an indication of the effect of nutrient load on macrophyte abundance and density as reported by Obot *et al.* (1991) in Kainji reservoir. Frankouich *et al.* (2006) reported that aquatic macrophyte distribution and growth is associated with nutrient rich environments particularly nitrate and phosphate which have been noted to favour macrophytes' growth. Further changes occur as nutrient become more available in the aquatic medium. However, under anaerobic conditions that develop in fine sediments, microbial activity tends to mineralize organic nutrients (Stutter *et al.,* 2007). Transformations and availability of phosphorus are largely controlled by the environmental conditions in the water, with pH and conductivity, of particular importance (Sagova-Marekova *et al.,* 2009). As observed by Barikpoa *et al.* (2010) in the same river, consequent of indiscriminate dumping of human and industrial waste, there is mineralization of organic matter and that the ammonia produced can be accessed by macrophytes and such trends in nutrient availability in the water can lead to increased productivity by macrophytes.

There was a negative correlation between the dissolved oxygen (DO) and biological oxygen demand (BOD), for which Cohen (2003), explained that increase in dissolved oxygen concentration was noticed with the reduction in the macrophytes cover and vice versa.

CONCLUSION

Changes in the macrophyte community a consequence of enhanced nutrients in the water body due to human activities is common place in many parts of the world. Hence, correct attribution of the cause of such changes in the flora is vital if appropriate management decisions are to be used on such evidence. The physico-chemical parameters of Nta-wogba stream were found to be related to aquatic macrophytes either positively or negatively but the nutrient levels were within the normal range for macrophytes growth. Excess nutrients can leads to eutrophication and results in macrophyte bloom. Therefore there is the need to monitor the water quality of parameters of this stream at regular intervals to determine its nutrient level in relation to the assemblage and density of macrophytes in the river system.

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Corresponding author
Akinrotimi O. A.
African Regional Aquaculture Central Nigerian Institute for oceanography and Marine Research, P. M. B. 5122, Port Harcourt Nigeria
Email: ojoakinrotimi@yahoo.com

Table 1. MACROPHYITE COMPOSITION OF NTA-WOGBA STREAM

Macrophyte species	Density (No/m^2)	RELATIVE ABUNDANCE OF SPECIES (%)			
		Station 1 Abacha Road	Station 2 Olu-Obasanjo Road	Station 3 Afam Street	Station 4 Okija Street
Echinochloa pyramidalis	1988.00	44.26	26.66	17.00	12.07
Diplazum sammatii	27.00	74.07	14.81	11.11	3.70
Aneilema beninse	400.00	0.00	32.50	22.50	45.00
Ipomoea aquatica	560.00	0.00	7.14	44.64	48.21
Cyperus difformis	170.00	0.00	52.90	41.20	5.88
Alternanthera sessilis	50.00	0.00	0.00	60.00	40.00
Ludwigia decurrens	8.00	50.00	37.50	12.50	0.00

Table 2: PHYSICO-CHEMICAL PARAMETERS OF NTA-WOGBA STREAM AT DIFFERENT STATIONS

	Sampling stations			
Parameters	1	2	3	4
pH	7.64±0.43^{a}	7.62±1.41^{a}	7.70±0.82^{a}	7.53±0.68$_{a}$
Conductivity (μ/cm)	95.11±22.40^{d}	236.11±28.68^{a}	142.66±29.12$_{c}$	187.14±32.1^{b}
Turbidity (m)	3.88±2.41^{b}	5.22±1.12^{b}	9.55±2.46^{a}	11.66±1.29^{b}
Alkalinity (mg/l)	21.44±2.6^{b}	40.97±2.5^{a}	33.98±3.01^{a}	37.06±2.42^{a}
Salinity (%)	0.02±0.01^{a}	0.02±0.01^{a}	0.02±0.01^{a}	0.02±0.02^{a}
Temperature (^{0}C)	29.71±1.21^{a}	29.30±2.12^{a}	28.94±1.68^{a}	28.9±2.41^{a}
Nitrate (mg/l)	0.86±1.01^{a}	0.71±0.10^{a}	2.21±1.11^{b}	1.81±1.14^{b}
Phosphate (mg/l)	0.58±0.12^{a}	0.47±0.11^{a}	2.74±0.89^{b}	2.19±0.87^{b}
Sulphate (mg/l)	5.20±2.11^{a}	8.24±1.86^{b}	8.00±2.41^{b}	8.12±1.35^{b}
Ammonia (mg/l)	0.20±2.11^{a}	0.10±0.02^{a}	0.09±0.02^{a}	0.19±0.01^{a}
Total dissolved solid (mg/l)	60.14±3.41+a	100.66±4.42^{b}	130.14±6.71^{b}	171.12±12.4^{b}
Dissolved oxygen (mg/l)	6.12±1.12^{a}	3.61±1.11^{a}	3.21±1.11^{a}	4.12±2.12^{a}
Biological oxygen demand (mg/l)	51.78±3.10^{b}	156.38±13.14^{a}	97.32±8.11^{b}	171.28±21.11^{a}

Means within the row with different superscript are significantly different ($P<0.05$)

TABLE 3: INTRA SPECIFIC RELATIONSHIP BETWEEN WATER QUALITY PARAMETERS AND AQUATIC MACROPHYTES.

	pH	Cond	Tur	Alk	Sal	Temp	N03	P04	Sv4	NH4	TDS	DO	BOD	Epy	DSa	A.be	T.aq	Cdi	Ase	Lde
pH																				
Cond	0.41																			
Tur	0.98	0.99																		
Alk	0.30	0.47	0.31																	
Sal	0.99	0.51	0.81	0.87																
Temp	0.97	0.87	0.75	0.79	-0.89															
N03	0.91	0.32	0.65	0.41	0.99	0.91														
P04	0.90	0.412	0.51	0.46	0.77	0.86	0.61													
Sv4	-0.81	0.41	0.17	0.78	0.61	0.77	0.41	0.47												
NH4	0.72	0.71	0.32	0.99	0.98	0.66	0.21	0.31	0.32											
TDS	0.31	0.412	0.47	0.71	0.87	0.746	0.71	0.61	0.41	0.21										
DO	0.41	0.12	0.12	0.71	0.71	0.35	0.41	0.31	0.21	0.31	0.61									
BOD	0.32	0.33	0.30	0.79	0.62	0.411	0.31	0.41	0.21	0.21	0.41	-0.42								
Epy	-0.08	0.41	0.03	-0.81	-0.72	0.771	0.21	0.32	0.11	0.12	0.71	-0.72	-0.91							
DSa	-0.22	0.71	0.70	-0.91	-0.82	-0.71	0.32	0.11	0.21	0.21	0.91	-0.71	-0.72	0.71						
Abe	-0.78	0.31	0.09	0.71	-0.92	0.971	0.12	0.31	0.32	0.11	0.81	-0.68	-0.88	0.35	0.71					
T.aq	-0.86	0.42	0.47	-0.67	-0.33	0.986	0.210	0.21	0.11	0.11	0.71	-0.74	-0.91	0.61	0.81	0.31				
Cdi	-0.74	0.712	0.025	-0.866	-0.46	0.971	0.31	0.11	0.21	0.02	0.61	-0.8	0.72	0.48	0.61	0.28	0.81			
Ase	-0.67	0.33	0.01	-0.91	-0.77	0.981	0.21	0.21	0.11	0.00	0.71	-0.71	0.61	0.21	0.71	0.41	0.71	0.81		
Lde	0.75	0.42	0.12	-0.79	-0.87	0.99	0.11	0.31	0.12	0.11	0.67	-0.66	0.81	0.78	0.48	0.61	0.61	0.61	0.68	

Key: pH=Hydrogen ion; cond- conductivity; Alk-alkalinity; Sal-Salinity; Temp- Temperature; $N0^{3-}$ Nitrate; $P0^{4-}$ Phosphate; S_{04}-sulphate; NH4-Ammonium; TDS=-Total Dissolved Solids; D0- Dissolved oxygen; BOD-Biological Oxygen demand; Epy- *Einochloa pyramidalis*; Dsa-*Diplazum sammaii*; Abe-*Aneilema benniese*; Iaq- *Ipomoea aquatica; Cdi- Cyperus difforms*; Ase- *Alternathera sessilis*; Lde- *Ludwigia decurrens*

Table 4: Mean squares from analysis of variance of physico chemical parameters in relation to months, stations and Aquatic macrophytes

Source of variation	Df	pH	Conductivity	Turbidity	Salinity	Total dissolved solids	Dissolved oxygen	Biological oxygen demand	No_4^2	PO_4^2	So_4^2	NH_4^+	Alkalinity	Temperature
Month	8	0.141^{ns}	18173.3^{**}	25.3^{ns}	0.010^{ns}	8725.1^{**}	5.7^{*}	9.4^{ns}	1.5^{**}	1.8^{**}	41.0^{***}	0.004^{ns}	189.0^{*}	0.54
Location	3	0.043^{ns}	32786.0^{**}	53.1^{ns}	0.003^{ns}	16212.7^{**}	2.0^{ns}	50.0^{ns}	1.2^{***}	3.1^{**}	7.3^{***}	0.016^{ns}	$642,4^{**}$	1.20
Aquatic macrophyte	8	0.126^{ns}	1621.4^{**}	56.2^{**}	0.012^{ns}	6212.4^{**}	4.2^{**}	36.4^{**}	1.3^{***}	2.6^{***}	6.4^{***}	0.018^{***}	314.2^{ns}	1.32^{*}
Error	24	0.019	4517.5	54.8	0.006	2220.2	2.3	20.4	0.37	0.375	0.89	0.015	59.5	0.50
R^2		0.73	0.69	0.22	0.38	0.69	0.49	0.32	0.72	0.72	0.94	0.35	0.71	0.31
CV(%)		1.8	40.7	116.8	172.5	40.7	73.3	133.3	87.5	67.5	25.9	81.7	23.1	2.11

Key: *, **, *** F-test of mean square significant at p=0.05 or 0.01 or 0.001. ^{ns} = not significant