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Original Article

Water quality and proximate analysis of *Eichhornia crassipes* from River Nun, Amassoma Axis, Nigeria

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Abstract
Surface water harbors several useful aquatic plants. *Eichhornia crassipes* is an invasive plant found in several aquatic ecosystems in the Niger Delta including rivers, creeks and creeklets. This study investigated the physicochemical and proximate composition of *Eichhornia crassipes* from River Nun, Amassoma axis, Nigeria. Standard analytical methods were employed for both water quality and proximate analysis. Results showed that the physicochemical properties ranged from 6.910 – 7.350 (pH), 25ºC (temperature), 0.000 – 0.017 mg/l (salinity), 10.333 – 34.333mg/l (total dissolved solid), 25.700 – 40.533 NTU (turbidity), 0.903 - 3.333 mg/l (total hardness), 3.4333 – 5.466 mg/l (total suspended solid), 33.167 – 68.000 µS/cm (conductivity), 0.500 – 3.466 mg/l (chloride), 0.566 – 0.866 mg/l (sulphate), 0.117 – 0.394 mg/l (nitrate), 0.800 – 2.333mg/l (calcium), 0.333 – 0.816mg/l (potassium), 0.533 – 1.310mg/l (sodium), 0.390 – 1.466 mg/l (magnesium), 0.023 – 0.463 mg/l (iron) and 0.003 – 0.023 mg/l (manganese). Proximate composition including moisture content, ash, protein, lipid, fiber and dry matter ranged from 82.733 – 87.760%, 6.216 – 7.700%, 3.656 -5.036%, 1.836 -3.023%, 5.700 – 7.166% and 12.283 -17.300% respectively. Analysis of variance showed that there were significant variations ($P<0.05$) in all the parameters across the sample batches. The proximate composition of *Eichhornia crassipes* from River Nun provide vital information that indicates that the plant could be used for the production of value added products such animal feeds and purification of water.

1. Introduction

Much of the coastal areas of the southern Nigeria are wetland. A wetland is an area characterized by marsh, fern, peat and water bodies that are either standing or flowing [1]. Wetland is essential due to their role in economic, social and ecological development [1, 2]. Due to changes in environmental condition i.e sea rise and precipitation, the coastal communities are under threat.

Also, as a result of the presence of several water bodies including rivers, creeks and creeklets in the wetland region, it is a home to several macrophytes which are reported to adapt to life in anoxic environments [1]. In addition, wetland provides habitats for fisheries, wildlife and important medicinal plants [1]. Some aquatic macrophytes found in Nigeria include water hyacinth (*Eichhornia crassipes*), water lily (*Nymphaea lotus, N. maculate*), Water lettuce (*Pistia stratiotes*), salvinia (*Salvinia nymphellula*), and water velvet (*Azolla pinnata var africana*), fern (*Dryopteris filixmas*), sword fern (*Nephrolepis biserrata*), false fiddle (*Hydrolea palastris*) duckweed (*Lemna paucicostata*) [3]. These macrophytes are obligate wetland plants i.e occurring at estimated probability of about 99% and 1% in wetland and non-wetland conditions respectively.

They constitute nuisance/obstruction on the water ways where they impede transportation and fishing. In Bayelsa state where rivers, creeks and creeklets abound, these macrophyes are available and they have perpetually remained underutilized. One of such macrophyes is *Eichhornia crassipes*, a freshwater weed belonging to the pontederiaceae family. *Eichhornia crassipes* is an invasive, free floating and stoloniferous perennial herb native to South America especially to tropical and sub-tropical regions [4, 5]. *Eichhornia crassipes* is also known to have a major ecological and socio-economic effect [6].

In Nigeria, surface water (fresh water) is a source of potable water [7,8]. The occurrence of *Eichhornia crassipes* in large amount could degrade or affect the water quality with regard to its physicochemical properties. Vidya and Girish [9] reported that *Eichhornia crassipes* is a noxious aquatic weed that could pollute fresh water ecosystem. This could also lead to changes in the aquatic plant and animal community. This is probably due to reduction of oxygen and light penetration in the water. Hence it can be used as bioindicator in environmental studies [10].

The nuisance constituted by *Eichhornia crassipes* could be prevented through its harvesting and utilization. *Eichhornia crassipes* produces several natural products due to the biomolecules and secondary metabolites they exhibit in biological system; hence they can have been utilized in several sectors including human therapy, veterinary, agriculture [11]. Authors have reported the potentials of *Eichhornia crassipes* in animal feed production [6,12–14], composting, vermin-composting and Biofertilizer [4,9,11,15,16]. Due to the protein content and other useful minerals such as amino acids and vitamins, it has been successfully used in the formulation of fish feed 14, 17 – 19], goat feed [20,21]. In Bayelsa state, Central Niger Delta, River Nun is a major river in the region that habors *Eichhornia crassipes*. The proximate composition of *Eichhornia crassipes* in relation to the physicochemical properties of water where they grow in River Nun is scanty in Literature, hence the need for this study.

2. Materials and Methods

2.1 Study Area

Amassoma town is host community to the Niger Delta University. The town has a land mass of < 30 km² and is situated about 40 km West of Yenagoa, the Bayelsa State capital on the banks of the River Nun and in the heart of the rainforest of South-south Nigeria [5]. The town is located between latitudes 4°15'' to 4°50''N and longitude 6°50'' to 7°50''E [5]. Prior to the establishment of the university, the town was a typical riverine community whose economic activities include fishing, lumbering land and water transportation [22]. Waste disposal system is a major problem in the study area. Resident of the community disposes their wastes; solid and liquid municipal wastes into the surface water. The people also defecate on pier toilet systems built on the river banks [23].

2.2 Sampling Stations

Five sampling stations/points were established with a distance of about 300 meters apart in the Amassoma axis of the Nun River. A triplicate sampling was carried out thrice in batches of two weeks intervals. The sampling was carried out between the Months May and June, 2014.

2.3 Sample Collection

The water sample was collected with the aid of sampling container of approximately 1 liter by volume. The water hyacinth samples were collected at the point where the water samples were collected. The collected samples were then labeled at the point of collection, preserved and stored in ice boxes and then transported to Laboratory.

2.4 Water hyacinth sample preparations

Sample of the water hyacinth were collected comprising of the root, stem and leaves using jute bags. The water hyacinth samples were washed and the water allowed draining out. Thereafter they were dried under the sun light, before transferring the oven at temperature of 100ºC. The samples were then blended together (i.e leaves, stem and roots) and preserved in sterile Ziploc bag prior to proximate analysis.

2.5 Physicochemical and heavy metal analysis

The physico-chemical parameters such as pH (pH meter, Model: HANNA HI 9820), conductivity, total dissolved solids and salinity (multimeter Model: HANNA Instrument: HI 9820), temperature (Extech 407510A) and turbidity (HANNA HI 93414) were analyzed *in-situ*. Total hardness, nitrate, chloride, sulphate, total suspended solid, calcium, magnesium, sodium and sulphate were analyzed using the scheme of Ademoroti [24]. The heavy metals (iron and manganese) were analyzed using Atomic Absorption Spectrophotometer (AAS) (APHA 301A) (model: 5100 PC, Perkin-Elmer, Boston, USA) [25].

2.6 Proximate Analysis

The proximate parameters of the *Eichhornia crassipes* including protein, lipid, ash, fiber, moisture and dry matter were analyzed using the guide provided by AOAC [26].

2.4 Statistical analysis

SPSS software version 16 was used to carry out the statistical analysis. A one-way analysis of variance was carried out at P = 0.05, and Post Hoc was carried out using Student Newman Keul's (SNK) Test. The relationship between the physicochemical parameters of the water was carried using Pearson's correlation matrix.

3. Results and discussion

Table 1 and 2 presents the physicochemical properties and metals (light and heavy metals) respectively of River Nun at Amassoma axis, Nigeria. While the Pearson's correlation coefficient (r) matrices for the analyzed parameters are presented in Table 3.

3.1 pH: The pH of water sample is nearly neutral ranging from 6.910 – 7.350. However, there no significant variation (P>0.05) between batch III, but variation (P<0.05) occurs across the three batches. pH show significant positive correlation (P < 0.01) with chloride, sulphate, total hardness, calcium, magnesium, sodium and potassium and negatively correlate (P < 0.01) with salinity, conductivity, total dissolved solid, nitrate, total suspended solid and iron (Table 3). The variation could be attributed to the type and amount of wastes containing acidic materials deposited in the river prior to sampling. But due to dilution effects the toxicity of wastes discharged into the water fades away. The pH results of this study is close to of river Nun at Amassoma axises reported in 2005 as 6.94 [5] and 7.105 in 2007 [7]. However, the pH shows similarity with previous reports; 5.25 and 5.93 at dry and wet season from Minichnda stream in Rumuokwurushi, Port Harcourt [27], 6.5 – 6.9 from River Olosun, Ibadan, Oyo State [28], 7.4 – 7.57 (dry season i.e December, January and February) and 6.9 – 7.33 (wet season i.e April, May and June) of Epie creek [29], 7.4 – 7.5 at Tombia Bridge Construction across Nun River [30]. Basically, these reports indicate that Nun River has not changed much within the last 10 years with regard to acidity.

3.2 Temperature

The spatial spreading of temperature over the water is prejudiced by; amount of insulation received and nature of surface water however the temperature of the water in this study are in the order of 25ºC, being similar (P>0.05) in batch I and batch III samples and varying (P<0.05) with batch II samples. The temperature in this study is slightly lower than 27.250 ºC reported in 2007 by Agedah *et al.* [7]. Other authors have reported temperature in the range of; 28.7 – 30.5ºC (dry season) and 27.3 – 29.3ºC (wet season) in Epie creek in Yenagoa metropolis, Bayelsa state [29], 30.22ºC and 29.88 ºC for dry and wet season respectively at Minichnda stream [27], 26 - 27ºC from River Olosun, Ibadan, Oyo State [28], 26.9 – 28.7 ºC, 26 ºC value at Tombia Bridge Construction across Nun River [30]. The slight variation in temperature from this study with previous studies could be attributed to the season of sampling and environmental condition as well as the relative humidity of the days.

3.3 Salinity

Salinity is a measure of salt concentration of the water and in this study it ranged from 0.000 – 0.017 mg/l, being significantly the same (P>0.05) in batch II and III and varies (P<0.05) with batch I. Salinity shows positive significant correlation at P<0.01 with conductivity, total dissolved solid, nitrate, Total suspended solid, magnesium, iron and manganese and at P<0.01 with calcium, and also show negative correlation at P<0.01 with turbidity and at P<0.05 with sodium. The salinity is lower than the concentration 7.25 mg/l of the river in 2005 reported by Nyananyo *et al.* [5], but comparable to salinity of 0.010 ‰ in 2007 reported by Agedah *et al.* [7]. Also, salinity slightly higher than the value of this study has been reported. Allison and Otene [27] reported 0.01 mg/l and 0.04 mg/l as salinity concentration of water from Minichnda stream during dry and wet season respectively The decline in the salinity of River Nun at Amassoma axis could be attributed to increased anthropogenic activities in the study area, which could have wash off due to dilution effects.

Table 1: Physico-chemical characteristics of Nun River, Amassoma Axis,

Batch	Sampling points	pH	Salinity, mg/l	TemperatureºC	Conductivity, µS/cm	Turbidity, NTU	Total Dissolved Solid, MG/L	Nitrate , mg/l	Chloride, mg/l	Sulphate, mg/l	Total Suspended Solid, mg/l	Total Hardness, mg/l
1	A	7.290±0.493bc	0.000±0.000a	25.433±0.218ab	34.333±0.333a	38.266±0.333d	16.800±0.416bc	0.149±0.033a	2.200±0.057cd	0.650±0.028ab	3.533±0.176a	3.266±0.066hi
	B	7.240±0.012bc	0.000±0.000a	25.833±0.033b	33.1667±0.166a	37.8333±0.333d	10.333±0.166a	0.117±0.005a	2.150±0.028cd	0.853±0.020b	3.500±0.057a	3.000±0.057efg
	C	7.293±0.039bc	0.000±0.000a	25.500±0.057ab	35.000±1.732a	38.733±0.333de	16.333±0.333b	0.124±0.003a	1.900±0.057c	0.573±0.033a	3.800±0.057ab	3.066±0.033ghi
	D	7.243±0.026bc	0.000±0.000a	25.766±0.066ab	34.666±2.333a	37.833±0.333d	17.666±0.666b	0.152±0.033a	2.266±0.066d	0.720±0.100ab	3.433±0.166a	3.066±0.033ghi
	E	7.293±0.046bc	0.000±0.000a	25.433±0.266ab	33.000±1.000a	37.600±0.577d	16.666±0.666bc	0.153±0.033a	2.133±0.133cd	0.566±0.066a	3.466±0.233a	3.333±0.133i
2	A	7.300±0.057bc	0.013±0.003b	25.433±0.033ab	44.000±1.527b	40.333±0.202f	21.433±0.296e	0.220±0.005ab	2.800±0.057e	0.866±0.044b	4.233±0.088bcd	2.866±0.033ef
	B	7.350±0.035c	0.013±0.003b	25.533±0.033ab	44.333±1.452b	38.500±0.288d	21.833±0.333e	0.219±0.033ab	3.466±0.145f	0.8630.017b	4.600±0.115cde	2.833±0.033ef
	C	7.316±0.032bc	0.010±0.000b	25.300±0.057a	48.000±0.577bc	40.533±0.176f	24.333±0.2403g	0.220±0.000ab	3.100±0.057d	0.786±0.050ab	4.466±0.088cde	2.700±0.115e
	D	7.350±0.035c	0.013±0.003b	25.333±0.033ab	42.666±1.201b	39.666±0.440ef	19.683±0.176d	0.233±0.033ab	2.766±0.088e	0.863±0.060b	4.266±0.145bcd	2.266±0.088d
	E	7.140±0.035b	0.010±0.000b	25.533±0.033ab	49.666±0.881c	38.766±0.088de	19.400±0.230d	0.214±0.031ab	2.600±0.173e	0.770±0.041ab	4.133±0.088bc	2.700±0.152e
3	A	6.963±0.017a	0.017±0.003b	25.500±0.057ab	68.000±0.577d	25.700±0.152a	34.333±0.240c	0.394±0.033d	0.766±0.088ab	0.560±0.017a	5.466±0.145h	1.016±0.044ab
	B	6.950±0.035a	0.013±0.003b	25.633±0.033ab	56.000±0.577c	28.533±0.202b	27.166±0.120b	0.287±0.033bc	0.740±0.020ab	0.756±0.020ab	4.700±0.152def	0.903±0.003a
	C	6.916±0.068a	0.010±0.000b	25.366±0.120ab	43.333±0.881b	28.633±0.145b	22.233±0.145ef	0.337±0.008cd	0.500±0.057a	0.700±0.041ab	5.100±0.057fgh	1.483±0.044c
	D	6.906±0.046a	0.010±0.000b	25.733±0.033ab	45.333±0.881bc	30.533±0.120c	23.200±0.251f	0.288±0.003bc	0.920±0.019b	0.566±0.044a	5.270±0.065gh	1.200±0.057b
	E	6.910±0.065a	0.013±0.003b	25.433±0.033ab	45.666±2.027bc	29.436±0.031b	23.100±0.100f	0.327±0.034bcd	0.766±0.088ab	0.660±0.041ab	4.916±0.068efg	1.166±0.066ab

Same alphabets along the column is not significant difference (P>0.05) according to Student Newman Keul's (SNK) Test; Mean ± Standard error, (n=3)

3.4 Total dissolved solid

The concentration of total dissolved solid ranged from 10.333 – 34.333mg/l, being significantly different (P<0.05) from the sampling points across the batches. Total dissolved solid show positive relationship at P<0.01 with nitrate, total suspended solid, iron, manganese and negatively correlate with chloride, total hardness, sodium and potassium. Again, the variation could be due to the amount of solid matter deposited into the water from the various locations across the batches. The total dissolved solid in this study is comparable to the concentration of 28.180mg/l of the water at Amassoma axises in 2007 as reported by Agedah *et al.* [7]. The total concentration of dissolved solid found in River Nun in this study is lower than the values previously reported in surface water of Epie creek in Yenagoa metropolis in the range of 55 - 62 mg/l (dry season) and 33 – 37.33 mg/l (wet season) [29], 62.1 – 67.9 mg/l at Tombia Bridge Construction across Nun River [30], 457 – 540.13 mg/l from River Olosun, Ibadan, Oyo State [28]. However, total solid dissolved solid are materials that could have dissolved in the water sample. These are indications of high dilution in the surface water and the current intensity of the river, hence majority the solid materials deposited into the water body do flow out and dissolve.

3.5 Turbidity

The turbidity level ranged from 25.700 – 40.533 NTU, being significantly different (P<0.05) from the sampling points across the batches. Turbidity shows positive significant correlation (P<0.01) with chloride, sulphate, total hardness, calcium, magnesium, sodium and potassium, but negatively correlate with total dissolved solid, nitrate, total suspended solid and at P<0.05 it negatively correlate with iron (Table 3). The variation could be attributed to the different anthropogenic activities going on in the water during sampling. A high turbidity of 117 NTU was reported from the river in 2007 [7]. However, the turbidity of the water in this study is slightly higher than that of Epie Creek in Yenagoa metropolis, which was reported in the range of 11.67 – 19.67 NTU (dry season) and 16.67 – 28.00 NTU (wet season) [29] and relatively far higher than the value of 5.29 – 6.68 NTU from River Olosun, Ibadan, Oyo State [28], 0.05 NTU and 7.00 NTU during dry and wet season respectively from Minichnda stream [27] and 5 – 64 NTU at Tombia Bridge Construction across Nun River [30]. The higher turbidity of the water in this study is a reflection of clay nature of the environment, discharge of all forms of anthropogenic materials into the water bodies.

3.6 Total hardness

The concentration of total hardness ranged from 0.903 - 3.333 mg/l, being significantly different (P<0.05) from the sampling points across the batches. Total hardness shows positive relationship at P<0.01 with calcium, sodium, potassium, and at <0.01 with magnesium and also negatively correlate (P<0.05) with iron (Table 3). The hardness of the water is an indication of the ability of the water to tolerate high soap concentration. The low total hardness could be due to the type of anthropogenic activities of the water during sampling period and the current intensity of the surface water as well as the period of study. The period of sampling in this study is characterized by high rainfall resulting to dilution of the surface water.

3.7 Total suspended solid

The concentration of total suspended solid ranged from 3.4333 – 5.466 mg/l, being significantly different (P<0.05) from the sampling points across the batches. Total suspended solid shows positive significant relationship (P<0.01) with calcium, sodium and potassium and at P<0.01 with magnesium, also it negatively correlate (P<0.05) with iron (Table 3). Previous study from surface water in Ibadan has reported a concentration of 116.95 to 147.40 mg/l as the total suspended solid [28]. The low total suspended solid in the water at Amassoma Axis could be attributed to the dilution effects.

3.8 Conductivity

The conductivity ranged from 33.167 – 68.000 µS/cm, being significantly different (P<0.05) from across the batches. However, no significant variation (P>0.05) exist between the sampling points in batch I. conductivity shows positive correlation (P<0.01) with total dissolved solid, nitrate, total suspended solid, iron and manganese and negatively correlate with turbidity, total hardness, sodium and potassium (Table 3). A lower conductivity of 0.30 µS/cm was reported from the Nun River at Amassoma axis in 2005 [5]. But in 2007, Agedah *et al* [7] reported conductivity of 28 µS/cm, which is comparable to the findings of this study. Generally, high conductivity value have been reported in surface water in the range of; 78.33 – 89.33 µS/cm (dry season) and 47.73 – 54.00 µS/cm (wet season) from Epie creek in Yenagoa metropolis [29], 105.05µS/cm and 169.32µS/cm during dry and wet season respectively from Minichnda stream [27]. The magnitude of conductivity is a useful indication of the total concentration of the ionic solutes.

3.9 Chloride

The concentration chloride ranged from 0.500 – 3.466 mg/l, being significantly different (P<0.05) from the sampling points across the batches. Chloride shows positive correlation (P<0.01) with sulphate, total hardness, calcium, magnesium, sodium, potassium and shows negatively relationship with total suspended solid (Table 3). The concentration of chloride in the surface water is comparable previous reports in the range of; 1.65 – 4.62 mg/l (dry season) and 3.62 – 4.28 mg/l (wet season) [29] and 3.74 mg/l and 0.22 dry and wet season respectively from Minichinda stream [27]. High concentrations of chloride give a salty taste to water. Generally due to the low salinity, it reflects on the chloride concentration of the water. Chloride depends on the associated cations such as sodium, potassium and calcium chloride etc. the low chloride is as a result of the current level of the water and dilution.

3.10 Sulphate

The level of sulphate in the water ranged from 0.566 – 0.866 mg/l, being significantly different (P<0.05) from the sampling points across the batches. Sulphate shows positive significant relationship (P<0.01) with potassium, sodium, calcium, total hardness. A previous study from Epie creek in Yenagoa metropolis has indicated a sulphate concentration of 1.98 – 2.66 mg/l and 2.22 – 6.27 mg/l for dry and wet season respectively [29]. Nyananyo *et al*. [5] reported no sulphate in River Nun at Amassoma axises. Sulphate occurs naturally in numerous minerals and is used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition. The concentration of sulphate in this study is low to cause laxative effects to biological organisms that reside in the water and its intended users.

3.11 Nitrate

The level of nitrate in the water ranged from 0.117 – 0.394 mg/l, being significantly different (P<0.05) from the sampling points across the batches. Nitrate positively correlate (P<0.01) with total suspended solid and iron and at P<0.05 with manganese, it also shows negative relationship (P<0.01) with chloride, sulphate total hardness, sodium and potassium (Table 3). Nitrate is an organic form of nitrogen. Nitrate is found naturally in the environment and is an important plant nutrient. It is present at varying concentrations in all plants and is a part of the nitrogen cycle. The concentration of nitrate in this study is comparable to previous reports in the range of; 0.237mg/l [5], 0.02 – 0.27 mg/l and 0.14 – 0.28 mg/l for dry and wet season respectively from Epie creek Yenagoa metropolis Nigeria [29], 0.32 – 4.15 mg/l from Tombia Bridge Construction across Nun River [30]. The presence of nitrate in surface water is as a result of discharge of organic materials into the water, which is a common practice to the inhabitant of the sample collection areas. Surface water nitrate concentrations can change rapidly owing to surface runoff of organic matter during soil erosion, uptake by phytoplankton and other aquatic herbs and denitrification by bacteria.

3.12 Exchangeable Cations

Exchangeable cations are positively charged ions found in water and they include Calcium (Ca^{2+}), potassium (K^{+}), Sodium (Na^{+}) and magnesium (Mg^{2+}) in the water ranged from 0.800 – 2.333mg/l, 0.333 – 0.816mg/l, 0.533 – 1.310mg/l and 0.390 – 1.466 mg/l respectively, being significant different ($P<0.05$) from the sampling points across the batches in the four parameters. Calcium significantly show positive correlation ($P<0.01$) with manganese, potassium, magnesium and calcium; magnesium correlate positively ($P<0.01$) with sodium and potassium and at $P<0.05$ with manganese. Sodium shows positive and negative correlation ($P<0.01$) with potassium and manganese respectively, while potassium significantly show positive and negative correlation ($P<0.05$) with manganese and iron respectively Calcium and magnesium are divalent while sodium and potassium are monovalent. Nutrient availability and nutrient leachability depend on the relative proportions of the monovalent and divalent cations. Hence, the low exchange cations indicate that the water is classified as soft water and low in some pollution indicators. This is an indication that aquatic plants such as water hyacinth has taken up most of these nutrients for their growth. Previous study by Izonfuo and Bariweni [29] has respectively reported the concentration of cation for dry and wet season as 5.47 – 7.53 mg/l and 3.20 – 4.84 mg/l (calcium), 2.29 – 3.6 mg/l and 1.77 – 2.98 mg/l (magnesium), 3.27 and 5.27 mg/l and 2.27 – 3.36 mg/l (sodium). The result from this study is relatively lower than previous study. This could be attributed to prolonged anthropogenic activities in the area during sampling.

Table 2: Metallic properties of River Nun, Amassoma Axis, Nigeria

Batch	Sampling points	Calcium	Magnesium	Sodium	Potassium	Iron	Manganese
1	A	1.400±0.115b	0.540±0.017abc	1.233±0.088efg	0.620±0.041bcd	0.023±0.006a	0.010±0.000abc
	B	1.390±0.030b	0.533±0.033abc	1.116±0.060def	0.650±0.057cde	0.023±0.003a	0.010±0.000abc
	C	1.500±0.1000bc	0.666±0.066cd	0.953±0.033cd	0.693±0.074cde	0.023±0.003a	0.003±0.003a
	D	1.400±0.100b	0.616±0.066bcd	1.000±0.000cde	0.533±0.066abc	0.026±0.003a	0.010±0.000abc
	E	1.616±0.166c	0.590±0.030bcd	1.100±0.057def	0.683±0.039cde	0.033±0.003a	0.013±0.003abcd
2	A	2.333±0.202e	1.073±0.046e	1.233±0.088efg	0.866±0.044e	0.046±0.003ab	0.023±0.003d
	B	2.100±0.057de	1.466±0.044g	1.090±0.030def	0.783±0.039de	0.035±0.005a	0.010±0.000abc
	C	1.846±0.069cd	1.000±0.000e	1.310±0.048fg	0.786±0.052de	0.047±0.004ab	0.016±0.003bcd
	D	2.333±0.0.088e	1.050±0.028e	1.310±0.041g	0.816±0.044de	0.053±0.008ab	0.016±0.003bcd
	E	2.133±0.088de	1.233±0.088f	1.000±0.000cde	0.666±0.088cde	0.463±0.031d	0.016±0.003bcd
3	A	1.366±0.145b	0.600±0.088bcd	0.566±0.088a	0.333±0.033a	0.233±0.033c	0.020±0.000cd
	B	1.300±0.057b	0.750±0.057d	0.533±0.033a	0.433±0.028ab	0.110±0.005ab	0.013±0.003abcd
	C	0.800±0.0416a	0.390±0.028a	0.796±0.029bc	0.360±0.041a	0.133±0.033b	0.006±0.003ab
	D	1.266±0.088b	0.450±0.028ab	0.836±0.031bc	0.390±0.030a	0.133±0.033b	0.010±0.000abc
	E	1.300±0.057b	0.556±0.029abcd	0.693±0.088ab	0.433±0.033ab	0.133±0.033b	0.013±0.003abcd

Same alphabets along the column is not significant difference (P>0.05) according to Student Newman Keul's (SNK) Test; Mean ± Standard error, (n=3)

Table 3: Pearson's correlation matrix of the physicochemical parameters of Nun River, Amassoma Axis

	pH	Salinity	Temp.	Conductivity	Turbidity	TDS	Nitrate	Chloride	Sulphate	TSS	TH	Calcium	Magnesium	Sodium	Potassium	Iron	Manganese
pH	1																
Salinity	-0.361**	1															
Temperature	-0.102	-0.196	1														
Conductivity	-0.488**	0.736**	-0.096	1													
Turbidity	0.879**	-0.404**	-0.110	-0.596**	1												
TDS	-0.519**	0.711**	-0.219	0.915**	-0.653**	1											
Nitrate	-0.653**	0.700**	-0.201	0.755**	-0.737**	0.809**	1										
Chloride	0.864**	-0.159	-0.138	-0.351**	0.915**	-0.411**	-0.532**	1									
Sulphate	0.371**	0.232	-0.062	-0.019	0.430**	-0.172	-0.093	0.538**	1								
TSS	-0.673**	0.720**	-0.127	0.744**	-0.722**	0.796**	0.820**	-0.525**	-0.184	1							
TH	0.846**	-0.615**	-0.035	-0.720**	0.892**	-0.744**	-0.797**	0.784**	0.225	-0.851**	1						
Calcium	0.595**	0.255*	-0.237	0.015	0.667**	-0.083	-0.171	0.784**	0.574**	-0.215	0.415**	1					
Magnesium	0.490**	0.346**	-0.163	0.190	0.535**	0.074	-0.079	0.737**	0.588**	-0.052	0.290*	0.812**	1				
Sodium	0.775**	-0.313*	-0.193	-0.545**	0.875**	-0.547**	-0.530**	0.821**	0.428**	-0.571**	0.752**	0.627**	0.412**	1			
Potassium	0.779**	-0.114	-0.234	-0.390**	0.858**	-0.437**	-0.497**	0.857**	0.431**	-0.502**	0.701**	0.758**	0.641**	0.778**	1		
Iron	-0.442**	0.379**	0.002	0.547**	-0.300*	0.351**	0.435**	-0.212	-0.056	0.374**	-0.336*	0.080	0.184	-0.350**	-0.283*	1	.
Manganese	0.017	0.494**	-0.243	0.453**	0.052	0.385**	0.294*	0.189	0.237	0.107	-0.105	0.490**	0.338*	0.140	0.252*	0.266*	1

Temp: Temperature; TDS: Total dissolved Solid; TSS: Total Suspended Solid; TH: Total Hardness

**Correlation is significant at the 0.01 level (1 tailed)

*Correlation is significant at the 0.05 level (1 tailed)

N=45; n=3

3.13 Iron and Manganese

The concentration of iron and manganese from the River Nun ranged from 0.023 – 0.463 mg/l and 0.003 – 0.023 mg/l respectively. There was significant difference ($P<0.05$) among the sampling points across the sample batches between the two parameters. The concentration of iron in this study is comparable to an author report. The Iron concentration significantly correlated ($P<0.05$) with manganese. Nwidu *et al.* [22] reported iron concentration in the range of 0.05 – 0.10 mg/l from River Nun. Iron is a major element found in the Niger Delta environment. But its low concentration in the aquatic ecosystem could due to dilution effects of the river. Basically, iron concentration is a reflection of the acidity of the water (pH). This is in agreement with the pH of the water. Typically, iron and manganese are need by biological system in trace amount, hence their concentration in the water is adequate for the growth of aquatic plants such as *Eichhornia crassipes* and is below the permissible limit that it could pose danger to biological organisms.

Table 4 presents the proximate composition of *Eichhornia crassipes* from Nun River. The moisture content, ash, protein, lipid, fiber and dry matter ranged from 82.733 – 87.760%, 6.216 – 7.700%, 3.656 -5.036%, 1.836 -3.023%, 5.700 – 7.166% and 12.283 -17.300% respectively. Basically there is significant variation ($P<0.05$) among the various sampling points across the batches apart from the ash content of batch I. The variation in the proximate analysis may be attributed to the level of organic materials absorbed by the *Eichhornia crassipes* in the water.

Table 4: Proximate composition of Water hyacinth from River Nun on Amassoma Axis, Nigeria

Batch	Sampling points	Moisture, %	Ash, %	Protein , %	Lipid , %	Fiber, %	Dry matter, %
1	A	86.780±0.057f	7.550±0.066f	4.560±0.011de	2.300±0.057bc	6.300±0.057cd	13.286±0.056c
	B	87.300±0.057g	7.600±0.057f	4.720±0.011ef	2.046±0.017ab	5.753±0.020ab	12.666±0.145ab
	C	86.350±0.028e	7.596±0.041f	4.486±0.052d	1.836±0.039a	6.033±0.033bc	14.166±0.088d
	D	87.533±0.033gh	7.683±0.033f	5.033±0.016g	2.170±0.090bc	5.833±0.033ab	12.336±0.168a
	E	86.726±0.088f	7.700±0.030f	5.013±0.008g	2.450±0.028c	6.500±0.100d	13.283±0.029c
2	A	84.503±0.029b	6.216±0.031a	3.656±0.014a	2.480±0.005c	5.570±0.015a	15.560±0.011f
	B	84.756±0.008c	6.243±0.026a	3.663±0.021a	2.333±0.024c	5.700±0.028a	15.256±0.014e
	C	85.600±0.057d	6.766±0.088bc	4.166±0.120bc	3.366±0.202e	6.033±0.033bc	14.400±0.115d
	D	82.733±0.120a	7.433±0.260ef	4.066±0.044b	2.860±0.041d	6.466±0.120d	17.300±0.208g
	E	86.766±0.044f	7.046±0.026cd	3.800±0.041a	3.023±0.014d	5.800±0.057ab	13.266±0.044c
3	A	87.633±0.088h	6.816±0.088bc	4.326±0.176cd	2.500 ±0.115c	7.166±0.120e	12.633±0.088ab
	B	87.690±0.030h	6.620±0.083b	4.350±0.028cd	2.400±0.057c	6.533±0.088d	12.353±0.054a
	C	87.333±0.088g	7.200±0.115de	4.796±0.078fg	2.026±0.021ab	6.266±0.145cd	12.666±0.145ab
	D	87.760±0.011h	7.453±0.029ef	4.900±0.030fg	2.496±0.057c	6.016±0.012bc	12.283±0.029a
	E	87.300±0.208g	6.870±0.041bc	5.036±0.027g	2.500±0.057c	6.536±0.039d	12.803±0.029b

Same alphabets along the column is not significant difference (P>0.05) according to Student Newman Keul's (SNK) Test; Mean ± Standard error, (n=3)

The result of proximate analysis is in agreement to previous studies and is an indication that it could be used for the formulation of livestock feeds. Akinwande *et al*. [12] reported the proximate analysis of *Eichhornia crassipes* as 90.16, 10.01, 22.75 and 14.98 g/100g DM for moisture content, crude protein, crude fibre and ash respectively. Saha and Ray [14] reported the moisture content, crude protein, lipid and ash content of water *Eichhornia crassipes* as 82%, 9.85%, 2.1% and 4.0% respectively. Igbinosun *et al*. [19] and Sotolu [18] reported the proximate composition of leave and petioles of water hyacinth to include dry matter 14.70% (leave) and 7% (petioles), ash 12.40% (leave) and 19.85% (petioles), crude protein 22.76% (leave) and 9.6% (petioles), crude fiber 15% (leave) and 22% (petioles) and 4.82% (leave) and 1.29% (petioles). Olele [31] reported the proximate composition of *Eichhornia crassipes* from Onah lake, Nigeria as 48.65% (moisture content), 6.70% (ash), 21.65% (crude fiber) and 13.90% (crude fiber). On the formulation of fish feed perspective, Mohapatra and Patra [32] studied various composition of water hyacinth supplement to fish feed and reported that the percentage of crude protein, crude lipid, ash, moisture and crude fibers in the formulated fish diet ranged from 33.12-40.12%, 5.2-8.5%, 11.03-13%, 2.2-3.9% and 4.9-8.3% respectively and the highest percentage of crude protein (40.12%) was recorded at 0% replacement of *Eichhornia* feed and the least (35.82%) was at 45% replacement. Similarly, Sotolu [17] and Solotu and Sule [33] has reported that the proximate composition of water hyacinth plant mean and leave meal values respectively as 24.17% and 28.20% (crude protein), 2.37% and 4.70% (crude lipid), 19.62% and 14.79% (crude fiber), 11.35% and 7.03% (ash). Hence, *Eichhornia crassipes* from River Nun could also be used for other uses in animal feed production due to its proximate composition.

4. Conclusion

Eichhornia crassipes is a free floating plant with inflated leaves and adventitious root system for adaptation in the aquatic ecosystem. This study evaluated the physicochemical parameters of River Nun and the proximate composition of *Eichhornia crassipes* from same river. The study found that the proximate analysis is rich in protein, ash, lipid and dry matter and thus it could be used for production of value added good as livestock feed. While, the low physicochemical properties of the water apart from turbidity, also suggest that *Eichhornia crassipes* can be used for phytoremediation of toxic substances in the water as well as nutrient uptake.

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