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RAINY SEASON IDENTIFCATION AND SPECIES CHARACTERISTICS OF AQUATIC MACROPHYTES IN THE FLOODPLAINS OF RIVER BENUE AT MAKURDI

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ABSTRACT

A survey experiment was conducted during the rainy season (June to August) of 2013 in the floodplains of River Benue in streams, ponds, main drainage channels and marshy areas within Makurdi metropolis to determine the prominent aquatic macrophytes infesting these areas and their distribution during the rainy season. Macrophyte survey was carried out based on a combination of transects (WISER, 2011. A total of 10 aquatic macrophytes were identified, representing 8 families. Submerged macrophytes were observed to be absent in all the sample locations. Significant differences ($p<0.05$) were observed on percentage weed occurrence in all the sample locations surveyed. At Adubu, and Abattoir macrophyte abundance (MA), relative frequency (RF) and dominance index (DI) were observed to be 100% each compared to the other locations while MA and DI were observed to be 100% and RF of 57.1% respectively at Industrial layout. This was followed by River Benue (MA=97.9%, RF=67.2%, DI=97.9%), University of Agriculture Annex, Katsina-ala street (MA=91.7%, RF29.7%, DI=183%), Berbesa (MA=72.7%, RF=34.8%, DI=43.6%). No macrophyte diversities were observed at Abattoir and Adubu had the least (0.0). To mitigate both the infestations of macrophytes therefore requires appropriate identification and possibly, enduring control approach(es) that may as well enhance greater water use.

Keywords: Rainy Season**,** Aquatic Macrophytes, Riparian Population, Species Characteristics, Benue Floodplains

INTRODUCTION

Aquatic ecosystems are critical components of the global environment. They provide a variety of services for human populations, including water for drinking and irrigation, recreational opportunities and habitat for economically important fisheries (Poff Brinson &Day, 2002). The Action Plan for Fisheries and Aquaculture in Africa (NEPAD, 2005) recognized the vital contributions of inland and marine fisheries to food security, poverty reduction and economic development in the African continent. Aquatic macrophytes by their explosive and inhibitory characteristic to these attributes (food security, poverty reduction and economic development in the African continent) are capable of suppressing or preventing sustainable development among the riparian populations especially in Africa where most of these riparian inhabitants are essentially subsistent farming and fishing communities.

Freshwater bodies (such as River Benue) 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).

Rivers have always been the most important freshwater resources. Along the banks of rivers ancient civilizations have flourished and still most of the developmental activities are dependent on rivers (Vyas,Yousuf,Bharos & Kumar, 2012). Rivers and streams play an important role in human development and are important natural potential sources of irrigation water (Ladu *et al*., 2012). Rivers support vast biodiversity of flora and fauna which provide food and shelter to aquatic organisms. The Fresh wetlands in Nigeria are Niger delta, Niger River, Benue River, Cross river and Imo River, Ogun-Osun River, and Lake Chad.

The Benue River is the longest tributary of river Niger, about 1,083 km in length. It rises in northern Cameroon as the Bénoué at about 1,340 m and, in its first 240 km descends more than 600m over many falls and rapids, the rest of its course being largely uninterrupted (Encyclopeadia Britanica 2012). During flood periods its waters are linked via the Mayo-Kebbi tributary with the Logone, which flows into Lake Chad. Below the Mayo-Kebbi the river is navigable all year round by boats drawing less than 0.75 m and by larger boats for more restricted periods. A considerable volume of imports (particularly petroleum) is transported by river, and cotton and peanuts (groundnuts) are exported in the same way from the Chad region between Yola and Makurdi. The Benue River is joined by the Gongola, and it then flows east and south for about 480 km.

River Benue contains rich Fadama areas. The Fadama area (flooplains) provides good fertile land for commercial vegetable, cereal (maize, rice,) and cassava production and livestock grazing respectively. Local fishing activities are also carried out daily. The flood plains of River Benue is one of the richest areas in the State for its land, recreation and water resources, with the key commercial sectors being grazing, agriculture, forestry and fishing. This has provided gainful employment for inhabitant settlers along its fringes, yet, its habitats and biodiversity are recognized to be under serious threat by aquatic weed infestation, like in many others at global level (Revenga and Kura 2003; Leveque, Balian & Martens. 2005; Dudgeon *et al*. 2006). A floodplain is a valley or floor adjacent to a river that is (or was historically) inundated periodically by flood waters

(CEC, 2002).Aquatic weed infestation of water bodies is a worldwide problem (Adesina, Akinyemiju & Moughalu, 2011). Aloo *et al*., (2013) reported that aquatic weeds are higher plants that grow in water or in wet soils. They usually occur along the shores of water bodies like dams, lakes and along rivers and river mouths. Aquatic plants develop explosively large population only when the environrnent is altered either physically or through the introduction of pollutants (Okayi and Abe 2000). They may 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, Boumo,VanG-roenedael &Bornette, 2008). Aquatic macrophytes are either adapted to continuous supplies of water or are at least, tolerant to waterlogged soil conditions for substantial periods of time and perpetuate their life cycle in still or moving water or on inundated or non-inundated hydric soils (Donald, 1996), a phenomenon achieved by only 2% of the 360,000 angiosperm species (Cook, 1990) and are associated with open water or wetlands of shallow water (CEC, 2002).

Aquatic macrophytes are important components of freshwater ecosystems because they enhance the physical structure of habitats and biological complexity, which increases biodiversity within littoral zones (Estevez, 1998; Wetzel 2001; Agostinho, Gomes & Pelicice. 2007, Pelicice, Thomaz & Agostinho. 2008). They are an important part of the aquatic food web of water bodies as they play an important role in aquatic systems worldwide because they provide food and habitat to fish, wildlife and aquatic organisms (Gross, 2003). Lembi (2003) summarized problems associated with excessive aquatic plant density as follows: Impairment or prevention of recreational activities such as swimming, fishing, and boating, excessive densities and biomass can also result in stunted fish growth and overpopulation of small-bodied fishes because the production of too much vegetative cover prevents effective predation of small fish by larger fish, excessive aquatic plant growths decrease localized dissolved oxygen levels, which can cause fish kills. Oxygen levels are affected by the Diel cycle of photosynthesis (oxygen levels are high during the day) and respiration (night-time oxygen levels are depleted). If plant biomass is excessive, night time respiration by aquatic plants can consume most of the dissolved oxygen in the water within the macrophyte beds to levels less than 1-2 mg/L.

Since 1984, aquatic weeds, especially Water hyacinth (*Eicchornia crassipes)* and Cattail (*Typha* spp.) have increasingly invaded and spread in Nigeria’s major rivers, streams and lakes (Ofoeze and Akinyemiju, 2002, Avav *et. al*, 2010). *Typha* infestation is a major problem of water resource management in the wetlands of the Chad Basin, Hadejia-Jama’are and the Sokoto-Rima river basins in the northern states of Nigeria (Bdliya, Barr & Fraser, 2006). Water hyacinth was first observed on River Benue at Makurdi in 1988 (Avav, Personal Communication).

In Nigeria, aquatic weed infestation in inland waters is increasing geometrically (Uka, Chukwuka & Daddy, 2007). The spread is augmented by anthropogenic activities like the use of fertilizers and organic manures in farming and dumping of wastes in water bodies and channels. Aquatic weeds respond to the high level of nutrient in urban, industrial and municipal wastewater (Baret and Farno, 1982). Aquatic macrophyte identification has been reported by many authors to be the first and one of the most critical prelude to effective control. To ensure that control is effective, sustainable and leads to economic development of the riparian communities, congnized must be made of the approach of FAO, (1997) that sustainable development must include management and conservation of natural and resource base (such as River Benue and its floodplains) in such a manner that ensures the attainment of continued satisfaction of human needs. Such sustainable satisfaction and development in the agricultural and fisheries sector should conserve land, water, plant and animal resources in environmentally non-degrading and technically appropriate economically viable and socially acceptable manner. Therefore, this study was carried out to identify the prominent aquatic macrophytes during the rainy season and their density, distribution and to determine the anthropogenic activities that augment the spread of aquatic weeds in the flood plains of the River Benue.

MATERIALS AND METHODS

A survey was conducted during the rainy season (June to August) of 2013 in the floodplains of River Benue in the streams, ponds, main drainage channels and marshy areas within Makurdi metropolis (River Benue with an area of 4249585. 935m^2 and 433 sampling points), Adubu (with area of 164,636. 405m^2 and 17 sampling points), Berbesa (with area of 26, 115.382m^2 and 11 sampling points), Tyumugh (with area of 7,294. 422m^2 and 3 sampling points), Agongul (with an area of 23,759.601m^2 and 8 sampling points), New Makurdi Bridge Abattoir (with an area of 155,811.547m^2 and 16 sampling points), Katsinal-ala Street Makurdi (with an area of 132,735.657m^2 and 12 sampling points), Benue Brewery Limited (BBL) (with an area of 45,515. 212m^2 and 15 sampling points) and Makurdi Industrial Layout(11,183.010m^2 and 4 sampling points), to determine the prominent aquatic macrophytes infesting these areas and their distribution.

Macrophyte survey was carried out based on a combination of transects (WISER, 2011). The method consisted of establishing transects (sectors) perpendicular to the shoreline, with a length covering the complete depth range of the macrophyte occurrence in the streams, ponds, main drainage channels and marshy areas, to estimate the quantitative and maximum colonization depth of each species identified within the transects. In each transect all species and ecological groups (emergent and floating-leaved plants) were recorded. Transects were marked out using tall pegs, measuring tape and a handheld GARMIN product Global Positioning System (GPS), (Model GPS MAP 76 CSx), (Hugh, 2002). Water depth was determined using a calibrated deep stick. The GPS unit was used to provide coordinates for the grid (all the locations) which consisted of 544 sites, all laid out at equal spacing of either 50 meters or 100 meters apart, between all points to ensure complete coverage and to locate sampling sites while in the field. The shape of the water bodies and the size of the littoral zone were the two factors used to determine the number of sites/points and their spacing (Swenson, Homan & Turyk., 2008).

In River Benue and BBL Macrophytes were investigated in two depth zones (0-1 m, 1-2 m), using a canoe to move from one point to another (Toivonen and Huttunen 1995, Heegaard *et al*. 2001). Movement by the canoe was achieved by slowly paddling through areas that supported aquatic macrophytes, recording all macrophytes present based on visual observations (Capers, Selsky,Bugbee & White.,2009), while for Adubu, Berbesa, Tyumugh, Agongul, New Makurdi Bridge Abattoir, University of Agriculture Annex Katsinal-ala Street, and Makurdi Industrial Layout, the depth zone investigated was restricted to only one (0.4-1m) mainly due to the shallow and stagnant water conditions of these areas which depths could not sustain a canoe, and involved physically moving from one point to another. This was achieved by moving perpendicular from the shoreline to just beyond the maximum depth of aquatic plant growth throughout to measure plant densities and population composition (species identification) in quadrats placed in regular intervals along the line. These quadrats were 1 square meter (Primer, 2005). Macrophyte abundance was estimated based on the WISER, (2011) and five-point Kohler Scale (1978), (from 1 – Rare species to 5 – Dominant species). The modified method of mycrophyte collection by Wood (1975) was used. The method involved collection of plant species with their flowers, seeds and roots by hand collection around the lakes.

The weeds which could not be identified on site were collected by hand and samples placed in a 250µm mesh net and all sediments removed from the sample by washing in the water at the point where the samples were collected (Mormul, *et al.*, 2010), specimens were covered with wet paper sheets and placed in a sealed plastic bag, kept cold in a cooler box and transported to the Crop and Environmental Protection Laboratory of Federal University of Agriculture, Makurdi, where for identification, (Lynch, 2009; Mormul, *et al.*, 2010).

Macrophytes were identified and classified according to their life forms because each life form colonizes and uses water and sediment resources quite differently and different life forms occupy distinct positions in the water column (free floating, and emergent), have different access to light and nutrients, sediment and/or water column (Mormul, *et al.*, 2010). An identification of the macrophytes was carried out using *A Handbook of West African Weeds* by Akobundu and Agyakwa (1987), Western Weeds: *A Guide to the weeds of Western Australia by* Hussey *et al.*, (2007), MCIAP, (2007), National Pest Plant Accord, http://www.biosecurity.govt.nz/nppa, (2008), *A Field Guide to Common Aquatic Plants of Pennsylvania* (2009) and *Biology and Control of Aquatic Weeds: Best Management Practices* by Gettys *et. al*., (2009).

Equipment(s) for Survey

1. Boat, suitable for local conditions, with appropriate safety equipment from National Inland Waterways Authority (NIWA), Makurdi office
2. Ropes and anchors
3. Global Positioning System (GPS)
4. Rakes with extendable rod for sampling submerged weeds
5. Floating rope and/or measuring tape
6. Sticks for transect marking
7. Calibrated dip stick for measuring depth of plant growth.
8. 250µm mesh net
9. Cooler box

Data collection

Parameters observed were; Data were collected on the following parameters

- Surface area (m^2) of the water bodies
- Altitude of the Benue River (m)
- Start- point depth (m) using a calibrated dip stick
- End-point depth (m) using a calibrated dip stick

Floristic Inventory: Based on a list of species present, observations and/or sampling from the shore or a boat (Palmer, Bell & Butterfield. 1992, Toivonen and Huttunen 1995, Heegaard *et al*. 2001). The taxonomic composition was taken on;

- ***Distribution and Vegetation*** (mapped at the peak of the vegetation season (June-August) using the Global Positioning System for mapping purposes (Jäger*et*, Pall & Dunmfarth, 2004, Ciecierska, 2008).
- ***Macrophyte Abundance*** **(MA)** measured using a descriptive scale (Rare, Occasional, Frequent, Abundant, Dominant, using the Kohler scale of 1 to 5, where 1= Rare and 5= Dominant, (WISER, 2011 and Kohler, 1978).
- ***Frequency of occurrence***: The frequency of occurrence (**FO**) value is a measure of the percent of the points sampled that had vegetation. This parameter measured the proportion of points where each species was present and was calculated as (s/N)*100, where **s** is the number of points where the species is present and **N** is the total number of points surveyed (LARE-TIER II, 2010).
- **Relative frequency: (RF)** Relative frequency allows us to see what the frequency of a macrophyte specie is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled to the total of all plants sampled (Williamson and Kelsey, 2009).
- ***Dominance index:*** **(DI)** This measure combined frequency of occurrence and relative abundance into a dominance value that characterized how dominant any species was within the macrophyte community. This was calculated as:

((Σra-z)/(N*rmax))*100, where r was the abundance score for a species at each point, summed from points numbered from a to z, rmax was the theoretical maximum abundance score of 5, and N was the total number of points surveyed (LARE-TIER II, 2010; Williamson and Kelsey, 2009).

- ***Maximum number of species per point***: The highest number of species collected at any point.
- ***Mean number of species per point***: The average number of all species collected per sampling point. This is calculated as the number of all species collected at each point summed for all points and divided by the total number of points (i.e., ((Σsi-j)/N), where s is the total number of species at each point, summed from points numbered i to j, and N is the total number of points surveyed).
- **Simpson's diversity index (SDI)**: quantifies biodiversity. It measures the probability that two individuals randomly selected from a sample belong to the same species or some other species (diversity of the plant community), Where D = Simpson's Diversity, n= the total number of organisms of a particular species, N=the total number of organisms of all species. This value can range from 0 to 1.0. The greater the value, the more diverse the plant is (Williamson and Kelsey, 2009; CEN 2003).

It is expressed as $D = \frac{1-\Sigma n(n-1)}{N(N-1)}$

Aquatic vegetation analysis was confined to the assessment of species abundance, frequency of occurrence, relative abundance, dominance index and Simpson's Diversity Index. GenStat statistical tool (Discovery Edition 4), was used to carry out a One-way analysis of variance (ANOVA) as outlined by Wood (1975) to test for significant differences in macrophyte number in the rainy season and between or among the locations surveyed (Idowu and Gadzama, 2011).

RESULTS AND DISCUSSION

Figures 1 and 2 present maps of the study areas and locations on satellite image, respectively

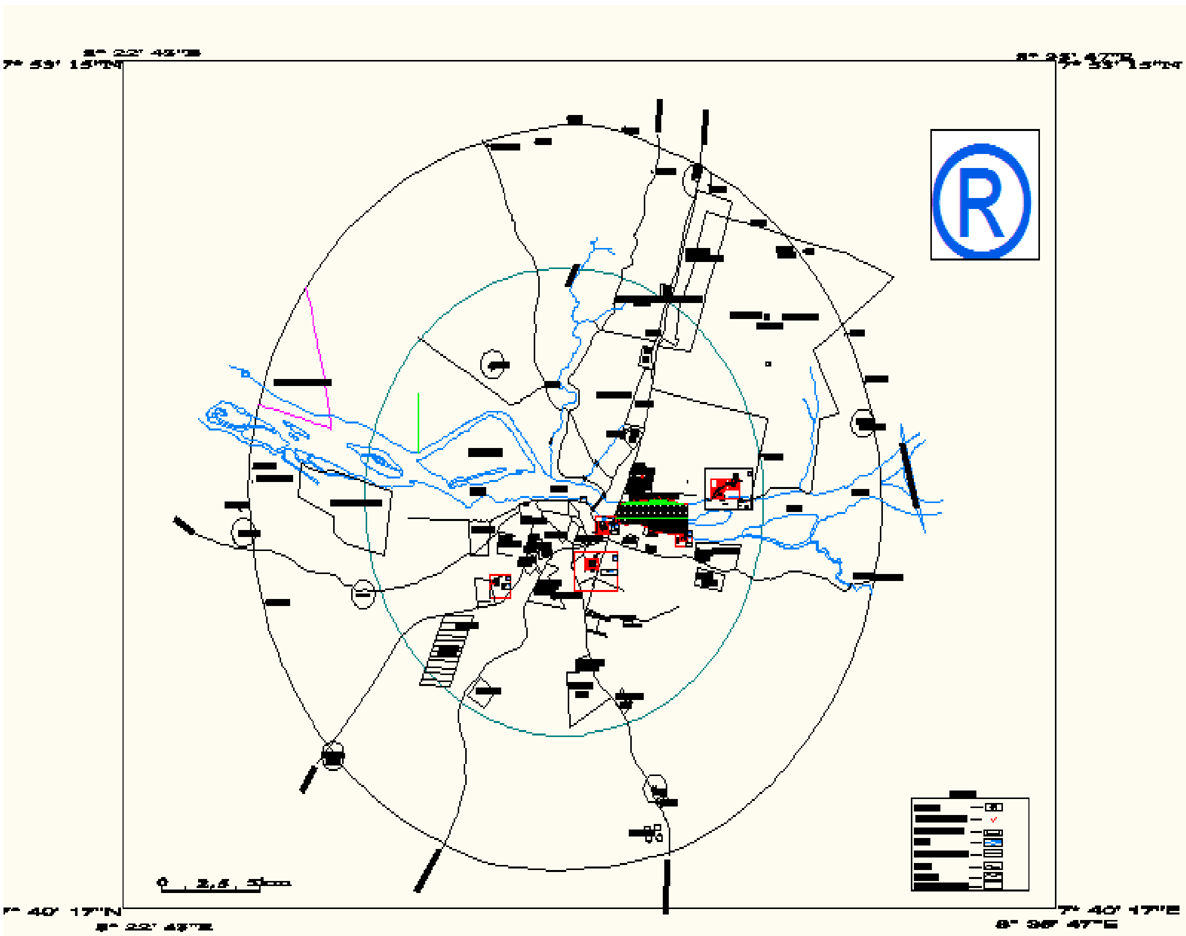

Figure 1. Map of Makurdi Showing Study Area

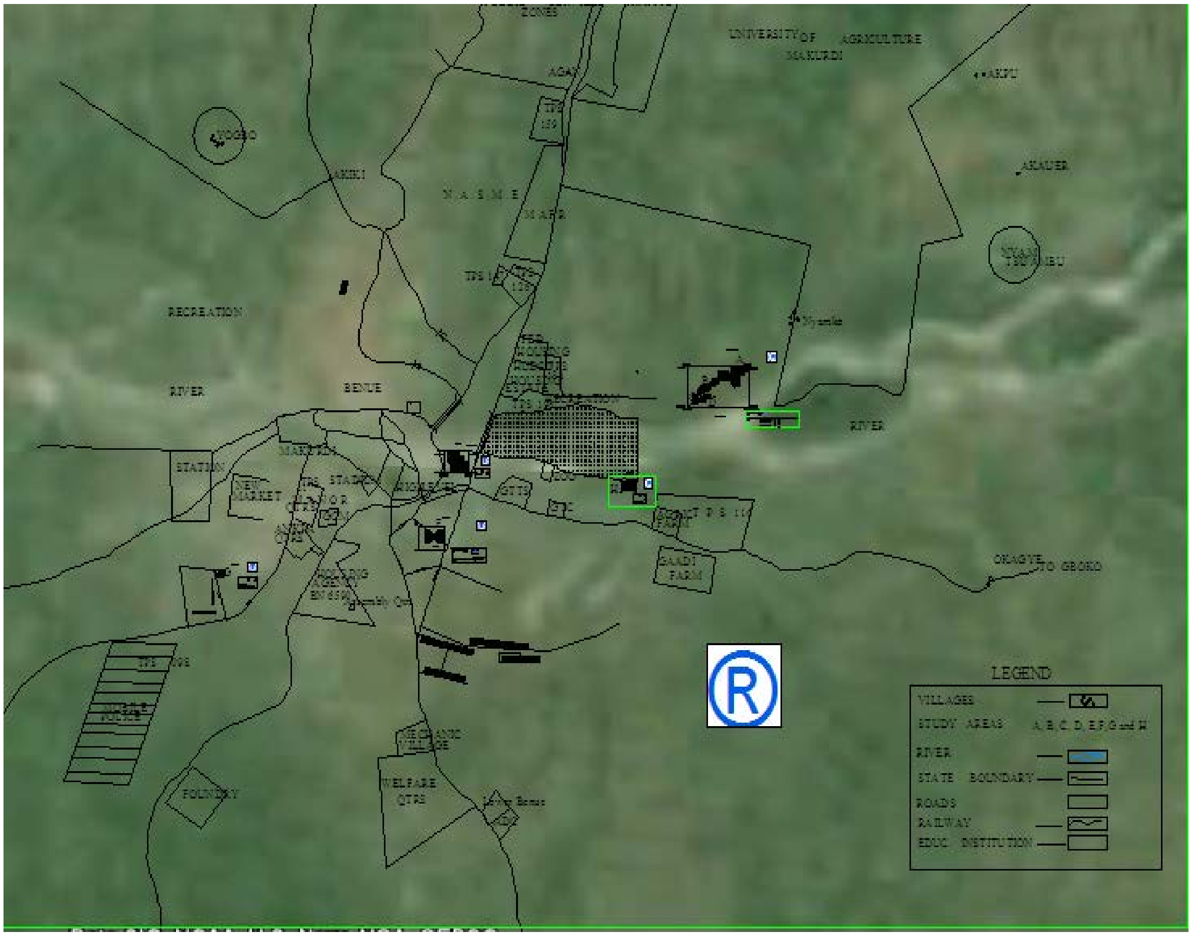

Figure 2. Showing Study Locations On Satellite Image

A total of 10 aquatic macrophytes were identified (Table 1), representing 8 families. Submerged macrophytes were observed to be absent in all the sample locations. Whereas, the absence of submerged macrophytes in Adubu, Tyumugh, Berbesa, New Bridge Abattoir, University of Agriculture Annex, Katsina-ala Street and Industrial Layout may be attributed to the dense mats of *Eicchornia crassipes* which may have inhibited or prevented light penetration into the bottom depths of the water (Uka *et al.*, 2009; Gross, 2003) and the turbid nature of water in these waters (UNEP, 2008) their absence in River Benue and BBL may be attributed to the sandy soil nature which are also very poor in organic matter content such that rooting, support and nutrient supply to submerged macrophytes may not have been possible or too limited to ensure the emergence or growth of submerged macrophytes. The number of macrophytes identified during the rainy season (10) may be regarded as being small however their mere presence shows changes in the physical, chemical and biological conditions brought about by the uncontrolled flow of nutrients from urban, agricultural and industrial centers eroded from watersheds (Gutiérrez, Saldana & Huerto, 1994; Mandal, 2007).

TABLE 1: SHOWING FLORISTIC INVENTORY OF AQUATIC MACROPHYTE IN THE BENUE FLOODPLAIN AT MAKURDI FOR THE RAINY SEASON OF 2013

S/N	SCIENTIFIC NAME	COMMON NAME	LIFE FORM	FAMILY	DS(m^2)	MA	SLS	FO	RF	DI
A		**RIVER BENUE (433 Sample Sites)**								
1	*Eicchornia crassipes*	Water hyacinth	Floating	Pontederiaceae	56	5	424	97.9	67.2	97.9
2	*Azolla pinnata*	Water velvet	Floating	Azollaceae	51	5	109	25.2	17.3	25.2
3	*Salvina Nymphellula* Desv.	Nil	Floating	Salvianiaceae	14	2	98	22.6	15.5	9.1
B		**ADUBU (17 Sample Sites)**								
1	*Eicchornia Crassipes*	Water hyacinth	Floating	Pontederiaceae	74	5	17	100	100	100
C		**INDUSTRIAL LAYOUT (4 Sample Sites)**								
1	*Eicchornia crassipes*	Water hyacinth	Floating	Pontederiaceae	74	5	4	100	57.1	100
2	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	59	4	3	75	42.9	60
D		**BERBUSA (11 Sample Sites)**								
1	*Eicchornia crassipes*	Water hyacinth	Floating	Pontederiaceae	71	3	8	72.7	34.8	43.6
2	*Ludwgia decurrens*	Water primrose	Emergent	Onagraceae	43	3	5	45.5	21.7	27.3
3	*Pistia stratiotes*	Water lettuce	Floating	Araceae	80	3	4	36.4	17.4	21.8
4	*Azolla pinnata* R.Br. var.	Water velvet	Floating	Azollaceae	60	4	6	54.5	26.1	43.6

S/N	SCIENTIFIC NAME	COMMON NAME	LIFE FORM	FAMILY	DS(m^2)	MA	SLS	FO	RF	DI
	africana Desv.									
E	**TYUMUGH (3 Sample Sites)**									
1	*Pteridium esculentum*	Nil	Emergent	Dannstaedficea-e	18	3	2	37.5	33.3	66.7
2	*Azolla pinnata*	Water velvet	Floating	Azollaceae	48	3	2	37.5	33.3	66.7
3	*Nymphae lotus*	Water lily	Floating	Nymphaeceae	69	4	2	66.7	33.3	88.9
F.	**AGONGUL (8 Sample Sites)**									
1	*Pteridium esculentum*	Nil	Emergent	Dannstaedficeae	46	4	5	62.5	55.6	50.0
2	*Heliotropium indicum* Linn.	Cock’s comb	Emergent	Boranginaceae	27	3	4	50.0	44.4	30.0
G.	**UNIVERSITY OF AGRICULTURE ANNEX, KATSINA-ALA STREET (12 Sample Sites)**									
1	*Eicchornia crassipes*	Water hyacinth	Floating	Pontederiaceae	79	5	11	91.7	29.7	18.3
2	*Nymphae lotus* Linn.	Water lily	Floating	Nymphaeceae	66	4	10	83.3	27.0	66.7
3	*Pistia stratiotes*	Water lettuce	Floating	Araceae	78	4	9	75.0	24.3	60.0
4	*Salvinia nymphellula*	Salvinia	Floating	Salviniaceae	42	3	7	58.3	18.9	35.0
H.	**ABATTOIR (16 Sample Sites)**									

S/N	SCIENTIFIC NAME	COMMON NAME	LIFE FORM	FAMILY	DS(m^2)	MA	SLS	FO	RF	DI
1	*Eicchornia crassipes*	Water hyacinth	Floating	Pontederiaceae	78	5	16	100	100	100
I	**BENUE BREWERY LIMITED (15 Sample Sites)**									
1	*Polygomium lanigerum*	Knotweed	Emergent	Polygonaceae	51	4	11	73.3	34.4	58.7
2	*Nymphae lotus*	Water lily	Emergent	Nymphaeceae	36	3	9	60.0	28.1	36.0
6	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	54	4	12	80.0	37	64.0

MA Scale from1 – 5: where 1=Rare, 2=Occasional, 3=Frequent, 4=Abundant and 5=Dominant

DS = Density, MA = Macrophyte Abundance , SLS = Sample Location Site, FO = Frequency of Occurrence , RF = Relative Frequency, DI = Density Index

WQC, (2000) reported that anthropogenic sources of pollution are very serious due to increasing populations and their increasing needs while Scheffer *et al*. (2002) and Egertso,Kopaska & Downing (2004) reported that these anthropogenic changes cause eutrophication of lakes, altering aquatic vegetation species and abundance.

Earlier findings by NRC, (1992) and UNESCO, 2006) indicated that freshwater wetlands have been extensively altered by humans because of the cumulative effects of altered flow regimes, removal of timber, and deterioration of water quality due to human development and encroachment. This therefore indicates that to urgently and effectively mitigate the effects of aquatic macrophytes, there is need for their correct identification in important water-use areas (such as River Benue and its floodplains) to ensure that timely control and management strategies are initiated to regulate their presence or completely eliminate these macrophytes before they assume explosive and threatening populations that may be inimical to water use, recreation, fish and fishing and other economic activities to the riparian population. This also, agrees with the findings of Peterson and Lee, (2005) who postulated that correct macrophyte identification determines (influences) the control method to use especially if the choice of control is chemical.

Significant differences ($p<0.05$) were observed on percentage weed occurrence in all the sample locations surveyed. Percentage weed occurrence at Berbesa, Tyumugh, University of Agriculture Annex and BBL were the same but different from Industrial layout, Agongul, Adubu and Abattoir (Figure 3). Percentage Weed Occurrence at Berbesa, Tyumugh, University of Agriculture Annex and BBL can be attributed to the shallow conditions of these locations which supported/accommodated the growth of several emergent macrophytes in addition to floating macrophytes, the stagnant/limited flow regimes and detached nature of the water bodies at Berbesa, Tyumugh, University of Agriculture Annex, Industrial layout, Agongul, Adubu and Abattoir which indicated that the locations with high percentage weed occurrence were less contaminated or altered as compared to Abattoir. In Situations where water flow is slow enough (for most vascular species, less than 0.8 m s-') and the width of the water body prevents heavy shading (Berbesa, Tyumugh, University of Agriculture Annex, Industrial layout, Agongul, Adubu and Abattoir), macrophytes will become abundant (Ziglio, Siligardi & Flaim*.*, 2006). This result also indicates that the variations in Percentage Weed Occurrence may be attributed to variations in the essential nutrient (nitrogen and phosphorus) content or status in the water bodies harboring the identified macrophytes. Peterson and Lee, (2005) observed that aquatic weed problems typically occur in shallow water that is high in nutrients.

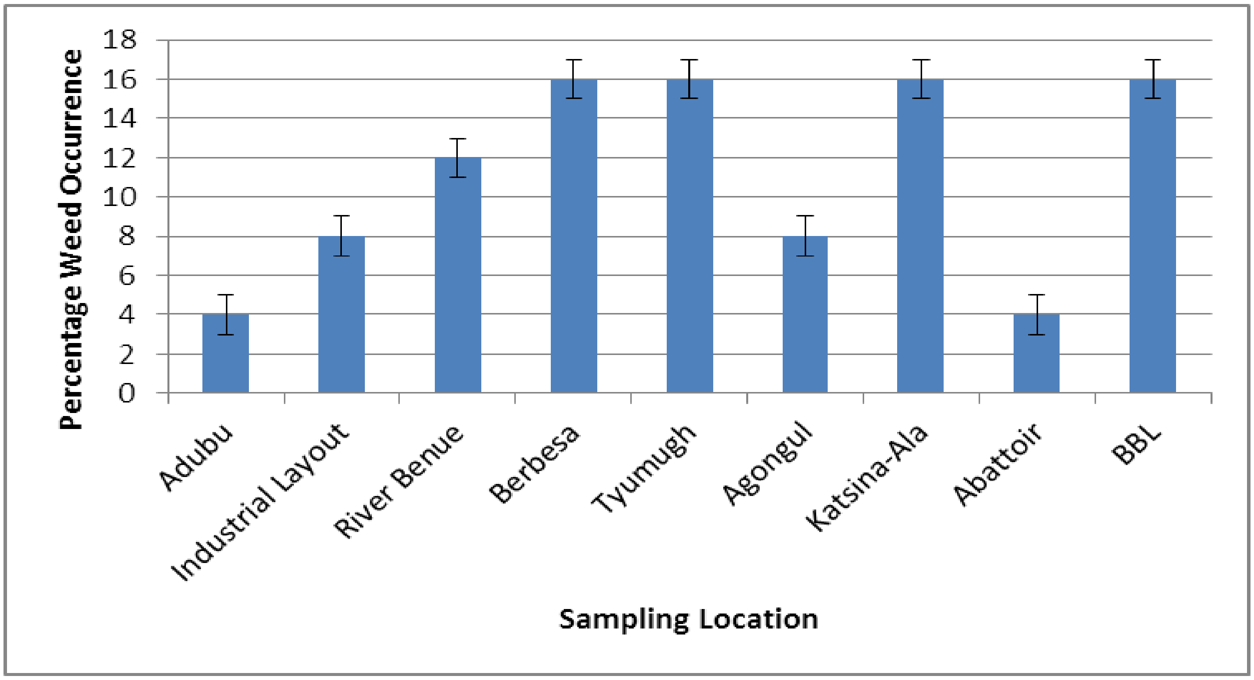

figure 3. showing percentage weed occurrence of identified macrophytes during the rainy season of 2013.

The comparatively higher number of macropyhtes species at these locations was therefore suspected to be because of their fertility status attributable to their catchment's fertility status and the drainage patterns and type of activities along the catchment (refuse dumps, effluent discharges, crop farming and fertilization, grazing, soil and sand excavation for construction works and washing). This collaborates the findings of Wandell, (2007) who reported that a lake's (or water body's) fertility and therefore its amount of aquatic plant is greatly influenced by its watershed characteristics, topography, soil fertility, drainage patterns and land use. These watershed characteristics determine the quantity of nutrients such as nitrogen and phosphorus that will be washed into the water body from land to stimulate plant growth. High percentage weed occurrence at BBL which was comparatively deeper (1-2m) was probably also complimented by nutrient sources contained in the products used in brewing (sorghum, wheat, soya beans, indoagar, lime, tetra-oxo-sulphate IV acid, hydrochloric acid, formalin, caramel, chlorine). Some of these products which are not always used up during brewing or processing are discharged into water as effluents. Other common effluents at BBL are beer from broken bottles and expired beer. These effluents are capable of causing or aggravating eutrophication which promotes increased macrophytes infestation in a water body. Although eutrophication is a natural process, human activities can greatly accelerate it by increasing the rate at which nutrients and organic substances can enter aquatic ecosystems from their surrounding watersheds. The most noticeable symptom resulting from eutrophication is the development of prolific aquatic plant growth Schmidt and Kannenberg, (1998).

Also, the findings of Idowu and Ngamarju, (2011) reported high species composition of aquatic macrophytes at Lake Alau (Nigeria) in the rainy season which they attributed to increased water level and flooding regime, which could have favored the increase in aquatic vegetation and other biological communities at these locations. Also whereas the odour of water at River Benue, Berbesa, Tyumugh, Agongul, University of Agriculture Annex and BBL were not objectionable, that at Adubu and Abattoir was observed to be objectionable, indicating complete water contamination (ph=5.7) so could have prevented other macrophytes from surviving even though, also shallow. Besides dense populations and therefore, mats of *Eicchornia crassipes* were found at Adubu and Abattoir so could have inhibited the presence or emergence of other macrophytes (Uka *et al.*, 2009; Gross, 2003), aside but in addition to the highly turbid nature of the water at Adubu (450.8) and Abattoir (406.0) compared to the other locations which ranged between 116.4-168.

The distribution and densities of *Eicchornia crassipes, Azolla pinnata* and *Salvinia nympellula* at River Benue, Makurdi Industrial Layout (*Eicchornia crassipes, Persicaria decipens*) and University of Agriculture Annex, Katsina- ala street (*Nymphae lotus*, *Pista stratiotes*) and the number of sites where these macrophytes were present were observed to be high. This may be attributed to the effects of increased soil erosion, flooding, transportation of nutrient-rich industrial and domestic sources into these areas thereby providing rich nutrients that can boost plant growth and the supply of the propagules of these plants from other sources (Obot and Mbagwu, 1988).

Eicchornia crassipes was observed to be the most distributed macrophyte species among all the identified species (found in 6 out of 9 locations). At Adubu, and Abattoir MA, RF and DI were observed to be 100% each compared to the other locations while MA and DI were observed to be 100% and and RF of 57.1% respectively at Industrial layout. This was followed by River Benue (MA=97.9%, RF=67.2%, DI=97.9%), University of Agriculture Annex, Katsina-ala street (MA=91.7%, RF29.7%, DI=183%), Berbesa (MA=72.7%, RF=34.8%, DI=43.6%). The least MA, RF and DI were observed on *Pteridium esculentum* at Tyumugh. Higher MA indicate higher population densitites while higher RF indicate the relative occurrence of a specific or individual macrophyte compared to others found at the same location. Also, higher DI indicate lower diversity (or population) of individual species in a specific location. The implication is that in the locations where MA was 100%, the population density of *Eicchornia crassipes* was optmal (maximum). At locations where RF and DI were 100% indicated that compared to other macrophyte species in those locations, the relative frequency (occurrence) of *Eicchornia crassipes* compared to other species, was maximum (no other macrophyte specie) existed. This trend was observed only on *Eicchornia crassipes* and was an indication of a proliferation of *Eicchornia crassipes* in these water ecosystems. This shows a major symptom of the water bodies' nutrient- rich status which could be attributed to the highly altered nature of the littoral zones of these locations that have brought about explosive growth of *Eicchornia crassipes*. This confirms reports by Moyo, (1997) and Mandal, (2007) that *Eicchornia crassipes*, is a weed that thrives under conditions of nutrient rich water. Mapira and Mungwini, (2005) had also reported that Rivers which passed through some urban centres were heavily polluted by wastewater resulting in eutrophication, a condition which promotes growth and proliferation of Water hyacinth. Also, Water hyacinth has been identified by the International Union for Conservation of Nature (IUCN), (2013) as one of the 100 most aggressive invasive species (Téllez *et al.* 2008) and recognized as one of the top 10 worst weeds in the world (Shanab, Shalaby, Lightfood & El-Shemy, 2010, Gichuki *et al.* 2012, Patel, 2012). Besides, *Eicchornia crassipes* is generally known to out-compete other aquatic plant species with its high invasion and colonization rate (Uka *et al.*, 2007). It produces large quantities of seeds that can survive up to 30 years and weed populations can double every 5-15 days (Denny, 1991; Masifwa, Twongo & Denny. 2001). Its floating mats cause considerable biodiversity impacts by displacing native vegetation (Petroeschevsky, 2007). Its comparatively high percentages of MA, RF and DI compared to the other species may therefore, have been as a result of its characteristic prolificacy.

Results in Table 2 present a higher SDI at Berbesa (0.74) and University of Agriculture Annex, Katsina-ala Street (0.74), followed by BBL (0.66), River Benue (0.60) and Tyumugh (0.60) Industrial Layout (0.50) and Agongul (0.47). Abattoir and Adubu had the least (0.0) .This trend indicates that Berbesa and University of Agriculture Annex, Katsina-ala Street had the highest diversity (number) or macrophyte species and so showed the probability of the individual macrophyte species at these locations varying or belonging to some other species compared to those in the other locations with lower SDI values. While at Adubu and Abattoir where SDI was 0.0 indicated that only 1 macrophyte specie existed so no diversity was observed which implied that Adubu and Abattoir were more contaminated.

Table 2. Showing Simpson's Diversity Index (SDI) for the Sampled Locations in the Rainy Season of 2013

S/n	**LOCATION(S)**	**NO. OF OBSERVED MACROPHYTES**	**SDI (%)**
1	Berbesa	04	0.74
2	University of Agriculture Annex, Katsina-ala Street	04	0.74
3	BBL	03	0.66
4	River Benue	03	0.60
5	Tyumugh	03	0.60
6	Industrial Layout	02	0.50
7	Agongul	02	0.47
8	Abattoir	01	0.0
9	Adubu	01	0.0

This assumption is based on the distribution (and infestation rate) of *Eicchornia crassipes* in these locations. Its preponderant population might have derived from these locations been generally characterized by robust anthropogenic activities (farming, refuse dumps, industrial effluents deposition (rice husks), animal dungs/wastes from the abattoir etc.) and the recycling of nutrients from dead macrophyte species within these water bodies which could have induced or triggered sustained growth so long as water was available. According to Williamson and Kelsey, (2009) this shows that Abattoir and Adubu are less healthy (polluted) water ecosystems.

CONCLUSION

A survey experiment was conducted during the rainy season (June to August) of 2013 in the floodplains of River Benue in streams, ponds, main drainage channels and marshy areas within Makurdi metropolis to determine the prominent aquatic macrophytes infesting these areas and their distribution during the rainy season. A total of 10 aquatic macrophytes were identified, representing 8 families. The identification of aquatic macrophytes in River Benue and its floodplains among which *Eicchornia crassipes* (one of the world's worst aquatic plants) was identified calls for early, appropriate and effective control strategies to mitigate the population explosion of these macrophytes and ensure sustainable socio-economic development among the inhabitant riparian population which depend on this water to earn their living either by farming, fishing or grazing their animals among other uses. This will therefore, collaborate with The Action Plan for Fisheries and Aquaculture in Africa (NEPAD, 2005) recognized the vital contributions of inland and marine fisheries to food security, poverty reduction and economic development in the African continent.

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