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RESEARCH ARTICLE

DRY SEASON IDENTIFICATION 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 dry season (March- April) of 2013 in the floodplains of River Benue in streams, ponds, main drainage channels and marshy areas within Makurdi metropolis comprising nine (9) locations, to determine the prominent dry season aquatic macrophytes infesting these water areas, their distribution and species characteristics. Macrophyte survey was carried out based on a combination of transects. In each transect all species and ecological groups (emergent and floating-leaved plants) were recorded. A total of 31 aquatic macrophytes were identified. Of all the macrophyte species identified, those belonging to the families *Cyperaceae Onagraceae, Poaceae* and *Pontederiaceae* respectively were the dominant group found and most distributed in the sample locations. However, Water hyacinth (*Eicchornia crassipes),* was observed to be the single most distributed macrophyte specie. The percentage weed occurrence in River Benue was observed to be significantly higher ($p<0.05$) than in all the other locations. This was followed by Berbesa and Tyumugh, Agongul, University of Agriculture Annex, Katsina-ala Street, BBL, Adubu, New Bridge Abattoir and Industrial Layout. Also, in River Benue, *Eicchornia crassipes, Azolla pinnata, Cyperus difformis, Cyperus erecta, Kyllinga pumila, Pycreus lanceolatus* and *Cyperus haspan* showed the highest macrophtye abundance. At Adubu and New Bridge Abattoir *Eicchornia crassipes* was observed to have maximum Macrophyte abundance (MA) 5, Frequency of occurrence (FO) 100%, Relative abundance (RF) 26.6% and Dominace index (DI) 100%, respectively. At Makurdi Industrial Layout, even though *Eicchornia crassipes* recorded a comparatively less MA (4), the FO (100%) and DI (100%) was observed to be the same as in Adubu and New Bridge Abattoir while the RF was 57.1%. The Simpson's divertsity index (SDI) results indicated the following order: River Benue 0.92% > Berbusa 0.86% > Tyumugh 0.84% > University Agriculture Annex, Katsina-ala street 0.81% > Adubu 0.79% > Benue Bottling Company (BBL) 0.77%.

INTRODUCTION

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 *et al.,* 2012). Rivers and streams play an important role in human development and are important natural potential sources of irrigation water (Ladu *et al*., 2012). The Fresh wetlands in Nigeria are Niger delta, Niger River, Benue River, Cross river and Imo River, Ogun-Osun River, and Lake Chad. River Benue is the longest tributary of river Niger, approximately 1, 400 km (870mi) in long and is almost entirely navigable during the summer months (rainy season). As a result, it is an important transportation route in the regions through which it flows. It rises in the Adamawa Plateau of northern Cameroun, from where it flows west and through the town of Garoua and Lagdo Reservoir into Nigeria South of the Mandara mountains through Jimeta, Ibi and Makurdi before meeting the Niger at Lokoja. At the point of meeting the Niger, River Benue exceeds the Niger by volume (mean discharge by 1960: $3,400m^3$ vs $2,500m^3$) (Encyclopeadia Britanica 2014). In its first 240 km, River Benue descends more than 600m over many falls and rapids, the rest of its course being largely uninterrupted (Encyclopeadia Britanica, 2012). During flooded 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. 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. (Encyclopeadia Britanica 2012). River Benue contains rich Fadama areas (flooplains). The Fadama areas provide good fertile land for commercial vegetable, cereal

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(maize, rice, millet) 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 activities being grazing, agriculture, and fishing. This has provided gainful employment for inhabitant settlers along its fringes, yet, its habitat 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 *et al*. 2005; Dudgeon *et al*. 2006). Aquatic weed infestation of water bodies is a worldwide problem (Adesina *et al.,* 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 2001).

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 *et al.,* 2008). The 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 *et al*., (2007); Pelicice *et al*. (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. Other problems associated with excessive plant growth include provision of stagnant habitat ideal for mosquito breeding; certain algae can impart foul tastes and odors to the water, and can produce substances toxic to fish and wildlife. Plants impede water flow in ditches, canals, and culverts and cause water to back up, deposition of dead organic matter can cause the gradual filling in of water bodies, nutrients, particularly organic carbon and phosphorus, released from senescent plants into the water can result in algal blooms, excessive growth can lower property values and decrease aesthetic appeal, and invasion of nonnative plants (i.e., invasive species) can cause shifts in community structure and function that may negatively impact native animal and plant species. 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 *et. al,* 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 *et. al*, 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 (Barret and Farno, 1982). Therefore, this study was carried out to identify the prominent dry season aquatic macrophytes 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 dry season (March- April) of 2013 in the floodplains of River Benue in 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 (area of 164,636. 405m^2 and 17 sampling points); Berbesa (area of 26, 115.382m^2 and 11 sampling points); Tyumugh (area of 7,294. 422m^2 and 3 sampling points); Agongul (area of 23,759.601m^2 and 8 sampling points); New Makurdi Bridge Abattoir (area of 155,811.547m^2 and 16 sampling points); Katsinal-ala Street Makurdi (area of 132,735.657m^2 and 12 sampling points); Benue Bottling Company (BBL) (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 (Figure 1), all laid out at equal spacing of either 50 meters or 100 meters apart, between all points to ensure thorough 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 *et al.,* 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 *et al.,* 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 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, for identification, (Lynch, 2009; Mormul, *et al.,* 2010). The modified method of macrophyte 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.

Macrophytes were identified and classified according to their life forms (Crow and Hellquist 2006), 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 (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 used for the 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 collected

Parameters observed were;

- 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 *et al*. 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 al.* 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 macrophyte specie is, compared to 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). The relative frequency of all plants will add to 100%.

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).

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 $D = 1 - \frac{\Sigma n(n-1)}{N(N-1)}$

Aquatic vegetation analysis was confined to the assessment of species abundance, frequency of occurrence, relative abundance, dominance index and Simpson's Diversity Index.

S/N	Scientific name	Common name	Life form	Family	Density (m^2)	Macrop hyte Abund Ance	Sample Site(S)	Location Frequency of Occurrence (%)	Relative Fre Quency (%)	Diversity index (%)
		1		**River Benue (433 Sample Sites)**						
1	*Eicchornia crassipes* (Mart.)Solms-Laub	Water hyacinth	Floating	Pontederiaceae	56	4	401	92.6	11.3	74.1
2	*Azolla pinnata* R.Br. var. *africana* (Desv.)	Water velvet	Floating	Azollaceae	51	4	351	81.0	9.9	64.8
3	*Cyperus difformis* Linn.	Nil	Emergent	Cyperaceae	54	4	322	74.4	9.0	59.5
4	*Cyperus erecta* [schumach.] Mattf & Kuk.	Nil	Emergent	Cyperaceae	48	3	300	69.3	8.4	41.6
5	*Kyllinga pumila* Michx.	Nil	Emergent	Cyperaceae	51	4	298	68.8	8.4	55.1
6	*Pteridium esculentum*	Bracken	Emergent	Dannstaedficeae	13	2	84	19.4	2.4	7.8
7	*Polygonium lanigerum* R.Br. *africanum* Meisn.	Lady's thumb	Emergent	Polygonaceae	08	1	38	08.8	1.1	1.8
8	*Rorippa nasturtum-aquaticum*	Water cress	Emergent	Brassicaceae	04	1	42	9.7	1.2	1.9
9	*Ludwigia abbysimia* A.Rich	Water primrose	Emergent	Onagraceae	38	2	38	8.8	1.1	3.5
10	*Scleria naumanniana* Boek.	Nil	Emergent	Cyperaceae	44	3	277	64.0	7.8	38.4
11	*Eleocharis calva*	Spike Rush	Emergent	Cyperaceace	25	2	86	19.9	2.4	7.9
12	*Limnocharis flava*	Yellow burhead	Emergent	Limnocharita- ceae	46	3	287	66.3	8.1	39.8
13	*Pycreus lanceolatris* (Poir.) C.B.Cl.	Nil	Emergent	Cyperaceae	59	4	355	82.0	10.0	65.6
14	*Cyperus haspan*	Nil	Emergent	Cyperaceae	62	4	303	70	8.5	56.0
15	*Ludwigia decurrens* Walt.	Water primrose	Emergent	Onagraceae	28	3	286	66.1	8.0	39.6
16	*Salvina Nymphellula* Desv.	Salvinia	Floating	Salvianiaceae	08	1	40	9.2	1.1	1.8
17	*Anredera cordifolia*	Madeira vine		Bassellacea	05	1	21	4.8	0.6	1.0
18	*Myriophyllum aquaticum*	Parrot Feather milfoil	Emergent	Haloragaceae	04	1	32	7.4	0.9	1.5
		2		**ADUBU (17 Sample Sites)**						
1	*Eicchornia Crassipes* (Mart.)Solms-Laub	Water hyacinth	Floating	Pontederiaceae	74	5	17	100	26.6	100
2	*Cyperus difformis* Linn.	Nil	Emergent	Cyperaceae	66	4	12	70.5	18.8	56.5
3	*Kyllinga pumila* Michx.	Nil	Emergent	Cyperaceae	55	4	14	82.4	21.9	65.9
4	*Pycreus lanceolatus* (Poir.) C.B.Cl.	Nil	Emergent	Cyperaceae	57	4	11	64.7	17.2	51.8
5	*Leptochloa caerulescens* Steud.	Nil	Emergent	Paoceae	33	3	10	58.8	15.6	35.3
		3.		**INDUSTRIAL LAYOUT (4 Sample Sites)**						
1	*Eicchornia crassipes* (Mart.) Solms-Laub	Water hyacinth	Floating	Pontederiaceae	70	5	4	100	57.1	100
2	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	52	4	3	75	42.9	60
		4		**BERBESA (11 Sample Sites)**						
1	*Eicchornia crassipes* (Mart.) Solms-laub	Water hyacinth	Floating	Pontederiaceae	71	3	6	54.5	12	32.7
2	*Sacciolepis africana* Hubb. & Snowden	Nil	Emergent	Poaceae	41	3	5	45.5	10	27.3
3	*Ludwgia decurrens* Walt.	Water primrose	Emergent	Onagraceae	43	3	5	45.5	10	27.3
4	*Ludwigia hyssopifolia* (G.Don) Exell	Water primrose	Emergent	Onagraceae	39	4	8	72.7	16	58.2
5	*Heliotropium indicum* Linn.	Cock's comb	Emergent	Boriginaceae	22	2	4	36.4	08	14.5
6	*Pistia stratiotes* Linn.	Water lettuce	Floating	Araceae	80	2	4	36.4	08	14.5
7	*Azolla pinnata* R.Br. var. *africana* Desv.	Water velvet	Floating	Azollaceae	58	3	6	54.5	12	32.7
8	*Cardiospermum helicacabum*	Balloon vine	Emergent	Sapindaceae	08	2	4	36.4	08	14.5
9	*Myriophllum aquaticum*	Parrot feather milfoil	Emergent	Haloragaceae	05	4	8	72.7	16	58.2

		5.		**TYUMUGH (3 Sample Sites)**							
1	*Pteridium esculentum*	Nil	Emergent	Dannstaedficea-e	18	3	1	33.3	8.3	20.0
2	*Azolla pinnata* R.Br. var. *africana* (Desv.)	Water velvet	Floating	Azollaceae	48	3	1	33.3	8.3	20.0
3	*Kyllinga pumila* Michx.	Nil	Emergent	Cyperaceae	50	4	2	66.7	16.7	53.3
4	*Nymphae lotus*	Water lily	Floating	Nymphaeceae	66	2	1	33.3	8.3	13.3
5	*Ludwigia decurrens* Walt.	Water primrose	Emergent	Onagraceae	30	3	1	33.3	8.3	20.0
6	*Ludwigia hyssopifolia* (G.Don.) Exell	Water primrose	Emergent	Onagraceae	30	4	2	66.7	16.7	53.3
7	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	22	3	1	33.3	8.3	20.0
8	*Cardiospermum heliocacabum*	Balloon vine	Emergent	Sapindaceae	08	1	1	33.3	8.3	6.7
9	*Myriophyllum aquaticum*	Parrot feather milfoil	Emergent	Haloragaceae	06	4	2	66.7	16.7	53.3
		6.		**AGONGUL (8 Sample Sites)**						
1	*Pteridium esculentum*	Nil	Emergent	Dannstaedficeae	40	4	5	62.5	22.7	50.0
2	*Mariscus longibracteatus* Cherm.	Nil	Emergent	Cyperaceae	56	3	4	50.0	18.2	30.0
3	*Heliotropium indicum* Linn.	Cock's comb	Emergent	Boranginaceae	23	3	4	50.0	18.2	30.0
4	*Sphenoclea zeylonica* Gaertn.	Nil	Emergent	Sphenocleaceae	16	3	4	50.0	18.2	30.0
5	*Melochia corchorifolia* Linn.	Nil	Emergent	Sterculiaceae	14	2	3	37.5	13.6	15.0
6	*Cardiospermum heliocacabum*	Ballon vine	Emergent	Sapindaceae	06	1	2	25.0	9.1	5.0
		7.		**UNIVERSITY OF AGRICULTURE ANNEX, KATSINA-ALA STREET (12 Sample Sites)**						
1	*Eicchornia crassipes* (Mart.)Solms-Laub	Water hyacinth	Floating	Pontederiaceae	78	5	11	91.7	20.8	91.7
2	*Nymphae lotus* Linn.	Water lily	Floating	Nymphaeceae	62	4	9	75.0	17.0	60.0
3	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	67	3	8	66.7	15.1	40.0
4	*Pontederia cordata*	Pickerelweed	Emergent	Pontederiaceae	30	4	9	75.0	17.0	60.0
5	*Pistia stratiotes*	Water lettuce	Floating	Araceae	76	4	9	75.0	17.0	60.0
6	*Salvinia nymphellula* Desv.	Salvinia	Floating	Salviniaceae	38	3	7	58.3	13.2	35.0
		8.		**NEW BRIDGE ABATTOIR (16 Sample Sites)**						
1	*Eicchornia crassipes* (Mart.) Solms-Laub	Water hyacinth	Floating	Pontederiaceae	78	5	16	100	44.4	100
2	*Kyllinga pumila* Michx.	Nil	Emergent	Cyperaceae	44	3	8	50.0	22.2	30.0
3	*Kyllinya erecta* [schumach.] Var. *erecta*	Nil	Emergent	Cyperaceae	38	3	8	50.0	22.2	30.0
4	*Ipomea aquatica* Forsk.	Water spinach	Emergent/Floating	Convolvulaceae	03	2	4	25.0	11.1	10.0
		9		**BENUE BREWERY LIMITED (15 Sample Sites)**						
1	*Polygomium lanigerum* R.Br. var. *africanum*	Knotweed	Emergent	Polygonaceae	50	4	11	73.3	17.2	58.7
2	*Nymphae lotus* Linn.	Water lily	Emergent	Nymphaeceae	33	3	8	53.3	12.5	32.0
3	*Sphenoclea zeylonica* Gaertn.	Nil	Emergent	Sphenocleaacea	21	4	11	73.3	17.2	58.7
4	*Melochia corchorifolia* Linn.	Nil	Emergent	Sterculiaceae	07	3	10	66.7	15.6	40.0
5	*Heliotropium indicum* Linn.	Cock's comb	Emergent	Boranginaceae	26	4	12	80.0	18.8	64.0
6	*Persicaria decipens*	Slender knotweed	Emergent	Polygonaceae	54	4	12	80.0	18.0	64.0

MA from 1-5: 1=Rare, 2=Occasional, 3=Frequent, 4=Abundant and 5=Dominant

Water hyacinth (*Eicchornia crassipes),* was observed to be the most distributed (found in 7 locations out of 9) with the highest FO of 66.7, RF=10.0, DI=60) macrophyte specie of all (31) of the identified macrophyte species (Table 2). This may be attributed to its prolific multiplication and growth habit and its ability to quickly colonize areas where it is found. Reports by Gutiérrez *et al*. (1996) have indicated that Water hyacinth is successful owing to its life cycle and survival strategies that have given it a competitive edge over other species, 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 *et al.* 2001).

Table 2. Showing macrophytes and their overall percentage frequencies and dominance index for the dry season of 2013

S/N	Scientific Names	Common Names	Frequency of Occurrence (%)	Relative Frequency (%)	Dominance Index (%)
1	*Eicchornia crassipes* (Mart.) Solms-Laub	Water hyacinth	66.7	10.0	60.0
2	*Azolla pinnata* R. Br. Var. *africana* (Desv.)	Water velvet	33.3	5.0	22.2
3	*Cyperus diffomis* Linn.	Nil	22.2	3.3	17.8
4	*Cyperus erecta* [schumach.] Mattfa Kuk.	Nil	11.1	1.7	6.7
5	*Kyllinga pumila* Michx.	Nil	44.4	6.7	33.3
6	*Pteridium esculentum*	Bracken	33.3	5.0	20.0
7	*Polygonium lanigerum* R.Br. Var. *africanum* Meisn.	Lady's thumb	22.2	3.3	13.3
8	*Rorripa nasturtium-aquaticum*	Watercress	11.1	1.7	2.2
9	*Ludwigia abyssinica* A.Rich.	Water primrose	11.1	1.7	4.4
10	*Scleria naumanniana*	Nil	11.1	1.7	6.7
11	*Eleocharis calva*	Nil	11.1	1.7	4.4
12	*Limnocharis flava*	Yellow burhead	11.1	1.7	6.7
13	*Pycreus lanceolatus*	Nil	22.2	3.3	17.8
14	*Cyperus haspan*	Nil	11.1	1.7	8.9
15.	*Ludwigia decurrens* Walt.	Water primrose	33.3	5.0	20.0
16	*Anredera cordifolia*	Madeira vine	11.1	1.7	2.2
17	*Myriophyllum aquaticum*	Parrot feather milfoil	22.2	3.3	13.3
18	*Liptochloa caerulescens*	Nil	11.1	1.7	6.7
19	*Sacciolepes Africana*	Nil	11.1	1.7	6.7
20	*Ludwigia hyssopifolia*	Water primrose	22.2	3.3	17.8
21	*Heliotropium indicum*	Cock's comb	22.2	5.0	13.3
22	*Pistia stratiotes*	Water lettuce	22.2	3.3	13.3
23	*Cardiospermum heliocacabum*	Balloon vine	33.3	5.0	6.7
24	*Nymphaea lotus*	Water lily	33.3	5.0	20.0
25	*Persicaria decipens*	Slender knotweed	44.4	6.7	22.2
26	*Mariscus longibracteatus* Cherm.	Nil	11.1	1.7	6.7
27	*Sphenoclea zeylonica*	NIL	22.2	3.3	15.6
28	*Melochia corchorifolia*	Nil	22.2	3.3	13.3
29	*Pontederia cordata*	Pickerelweed	11.1	1.7	8.9
30	*Kyllinga erecta*	Nil	11.1	1.7	6.7
31	*Ipomea aquatica* Forsk.	Water spinach	11.1	1.7	6.7

Data Analysis

GenStat statistical tool (Discovery Edition 4), was used to carry out a One-way analysis of variance (ANOVA) as indicated by Wood (1975) to test for significant differences in macrophyte number in the dry season and between or among the locations surveyed (Idowu and Gadzama, 2011).

RESULTS AND DISCUSSION

The percentage weed occurrence at River Benue was observed to be significantly higher ($p<0.05$) than in all the locations surveyed (Figure 1). This was followed by Berbesa and Tyumugh, Agongul, University of Agriculture Annex, Katsina-ala Street, BBL, Adubu, New Bridge Abattoir and the least been Industrial Layout.

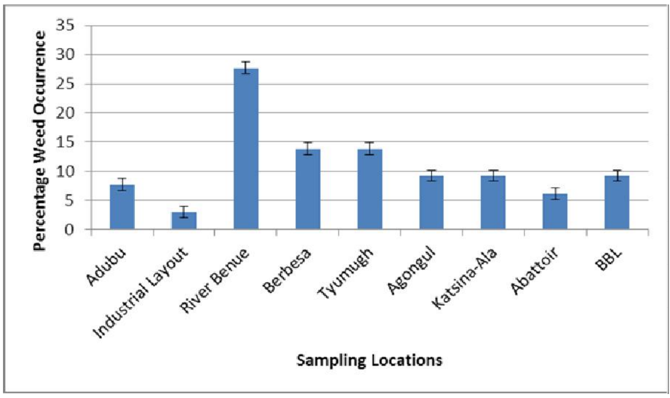

Figure 1. Showing Dry Season Percentages of Weed Occurrences in the Sampled Locations in the Floodplains of River Benue

However, there was no significant difference in percentage weed occurrence between Berbesa and Tyumugh and Agongul and University of Agriculture Annex, Katsina-ala Street respectively. Peterson and Lee, (2005) observed that aquatic weed problems typically occur in clear, shallow water that is high in nutrients. The comparatively higher number of macropyhtes species in River Benue may be as a result of the river's fertility status or larger/longer size and that of its catchment and the drainage patterns and type of activities along the catchment. 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 and size, 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. Generally, the larger the watershed, the greater the inflow of nutrients. Also, this research observations found that more than at any of the locations surveyed, a lot of dry season commercial farming activities (vegetables such as pumpkin, spinach, okra and garden eggs and sugar cane respectively) were carried out along the catchment or watershed of River Benue, often, with robust applications of both organic and inorganic doses of fertilizers some of which may have eroded into the river, some of these fertilizers because of regular irrigation activities and increased grazing which increases the soil fertility status (Adesina, *et al.,* 2004). This assumption is predicated on observations that some the water used to irrigate these crops flowed back into the river together with the unused fertilizer pellets. Besides, probably because of the river's clearer water, a lot of washing of domestic items were observed along the river shores and is capable of increasing River Benue's fertility status. Further to this, a report by Peterson and Lee, (2005) indicated that if floodplains (such as observed in Berbesa, Tyumugh, Agongul, University of Agriculture annex, Katsina-ala Street, Adubu, New Bridge Abattoir and Industrial Layout) become disconnected from the main rivers because of reduced inflows, aquatic productivity and diversity may decline (Poff *et al.,* 2002). This therefore, could have been responsible for the reduced and insignificant percentage weed occurrences in these locations. Martins *et al.,* (2008) studied 18 reservoirs and found a total of 39 species in all of them. Thomaz *et al.* (2005) recorded 37 species in the Rosana Reservoir (Paranapanema River). Both reported that this number of species (39 and 37) indicated rich assemblage of aquatic macrophytes, suggesting that the floodplains of River Benue also have a rich assemblage or presence of macrophytes.

In Table 1, of all the macrophyte species identified, those belonging to the families *Cyperaceae* (7) and *Onagraceae* (3) *Poaceae* (2) and *Pontederiaceae* (2) respectively were the dominant group found and most distributed in the sample locations. This agrees with findings by Pott *et al*. (1992), Bini *et al.* (1999) and Kita and Souza, (2003) that Poaceae and Cyperaceae, which are among the best-represented families, are also the most important families in other freshwater ecosystems, while less prominent specie include *Mariscus longibrateatus, Ipomea aquatic* and *Poliginium lanigerum* (Adesina *et al.,* 2011). Results also show that during the dry season, River Benue had the highest SDI of 0.92 followed by Berbesa (0.85), Tyumugh (0.84), University of Agriculture Annex, Katsina-ala Street (0.81), Adubu and BBL (0.79) each, Agongul (0.77) and Industrial Layout (0.49) (Table 3).

Table 3. Showing Simpson's Diversity Index (SDI) for the Sampled Locations in the Dry Season of 2013

S/n	LOCATION(S)	SDI (%)	
		Dry Season	SDI (%)
1	River Benue	18	0.92
2	Berbesa	9	0.85
3	Tyumugh	9	0.84
4	University of Agriculture Annex, Katsina-ala Street	6	0.81
5	Adubu	5	0.79
6	BBL	6	0.79
8	Agongul	6	0.77
9	Industrial Layout	2	0.49

The comparatively higher SDI in River Benue, Berbesa, Tyumugh and University of Agriculture Annex, Katsina-ala Street during the Dry season implied higher macrophyte species diversity (number) and so indicated 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 lesser SDI. This according to Williamson and Kelsey, (2009) showed that River Benue (especially), has a richer and healthier or less polluted water ecosystem compared to the others.

Conclusion

A total of 31 aquatic macrophtytes representing 19 families were identified in the floodplains of River Benue during the Dry season of 2013. Submerged macrophytes were present/observed in all the nine (9) sampled locations. Water hyacinth (*Eicchornia crassipes*), was observed to be the most distributed (found in 7 locations out of 9 with the highest FO of 66.7, RF=10.0, DI=60) macrophyte specie of all (31) of the identified macrophyte species. The presence and large number of macrophyte species in the dry season may be as a result of the refuse dumps, discharge of effluents from BBL, and other anthropogenic activities in the riparian zone which have the capacity to release and discharge nutrients and the heavy irrigated farming activities carried out along the catchment of river Benue with the robust applications of both organic and inorganic doses of fertilizers which often, are eroded into the River and its floodplains. The presence of aquatic macrophytes (especially, *Eicchornia crassipes*) have indicated a dangerous and threatening trend in the rate at which invasive aquatic macrophytes are colonizing River Benue and its prominent and water rich water bodies. The water bodies are of high economic importance to the riparian populace and other stakeholders and dependents for their economic source(s) of livelihood. It is therefore very imperative to monitor and manage the influx and emergence of both the native and exotic aquatic macrophyte species in River Benue and its floodplains as most water bodies and countries which had experienced uncontrolled infestations of Water Hyacinth (Eichhornia crassipes) especially and other aquatic plants incurred heavy financial losses to their economies hence the need to very timely, nip the threats of these aquatic weed infestations.

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