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Some soil parameters concerning macrophyte abundance along the Manatee habitat along River Benue, Nigeria

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Abstract

Some soil parameters as well as the aquatic flora along river Benue were analyzed.The results indicated that ten plants were identified as manatee food plants and these include; *Cynodon, dactylon, Digitaria horizontalis, Eichornia crassipes, Ipomea aquatica, Vossia cuspidata, Viteveria flavibarbis, Quisqualis indica, Polygonium acuminatum, Pistia stratiotes and cardiospermun halicacabum, the most palatable species were Vossia cuspidata, Viteveria flavibarbis, Digitaria horizontalis, Eichornia crassipes* in *decreasing order.* There was significant differences in the pH value of soils in the four sampling stations. The pH value for Abinsi (6.50) and Makurdi (6.68) were not significantly different from those of Gbaji (7.70) and Gbajimba (7.68). This is interesting in that the gradient along the river would have indicated otherwise. The potassium content of the soil in the four sampling stations did not indicate any significant differences as well as the phosphorus content of the soil. The potassium content of the soil ranged from 2.74Mg/kg in Makurdi to 2.78Mg/kg in Abinsi while the phosphorus content was between 0.46 Mg/kg for Gbaji to 0.72Mg/kg in Abinsi. The soil Nitrogen content indicate significant differences in the four sampling stations in the study area. The value in Abinsi (3.74Mg/kg) and Gbajimba (4.10Mg/kg) are significantly different from those of Gbaji (5.12mg/kg) and Makurdi (4.22Mg/kg) and Abinsi-Gbajimba and that of Gbaji. The soil parameter in the four sampling stations relate with the plant species richness of the stations and agrees with the report of FAO (2018) that soils and vegetation have a reciprocal relationship.

Keywords: Soil, macrophytes, manatee River Benue

Introduction

West and Central Africa contain a variety of suitable habitats for Manatees ranging from large and small rivers, coastal estuaries, freshwater and saltwater lagoons, shallow quiet coastal bays, lakes and reservoirs. Like *T. manatus, T. senegalensis* inhabits practically every accessible habitat (Dodman *et al.*,2008). They have been observed or recorded from coastal areas, estuarine lagoons, large rivers that range from brackish to fresh water, freshwater lakes and the extreme upper reaches of rivers above cataracts. In general, their habitat requirements seem to be similar to *T. manatus* and require sheltered water with access to food and freshwater (Reep and Bonde 2008, Marsh *et al.*, 2012).West African Manatees feed primarily on vegetation, and over 70 species of plants have been documented to date as Manatee food throughout their range (Akoi, 2004, Ogogo *et al*., 2013, Keith Diagne 2014). Some of the species more commonly observed being eaten by Manatees include: *Vossia* sp., *Eichornia crassipes, Polygonum sp., Crinum natans, Nymphea sp., Cyperus papyrus, Cymodocea nodosa, Ceratophyllum demersum, Azolla sp., Echinochloa sp., Lemna sp., Myriophyllum sp., Pistiastratioties, Rhizophora sp, and Halodule wrightii.* In countries including Senegal (Keith Diagne 2014), Cameroon and Sierra Leone (Reeves *et al.*, 1988),

Healthy soils are crucial for ensuring the continued growth of natural and managed vegetation, providing feed, fibre, fuel, medicinal products and the ecosystem services such as climate regulation and oxygen production (FAO, 2015). Soils and vegetation have a reciprocal relationship. Fertile soil encourages plants growth by providing plants with nutrients, acting as a water holding tank, and serving as the substrate to which plants anchor their roots. In return, vegetation, tree cover and forest prevent soil degradation and desertification by stabilizing the soil and nutrient cycle. Tropical ecosystem is known to have the highest plant biodiversity on the planet (Nadeau and Sullivan, 2015). The Amazonian tropical forest can support life for up to and even more than 280 tree species per hectare (Wright, 2002).

In Ecuador, 1,104 tree species were found having an area of 25ha. This high plant diversity is essential for the survival of several living organisms that thrive in this area. It is thought that high plant biodiversity is related to stable high temperature, high humidity which favor the growth of a large number of plant species. Waide *et al.,* (1999) reviewed the relationship between plant productivity and species richness in boreal forest, tropical forest and aquatic ecosystems. They concluded that trends are variable and the relationship between plant biodiversity and productivity may vary according to different habitats and can also be influenced by other biotic and abiotic

factors. In a study carried out by Janssens *et al.,* (2000) on the relationship between plant biodiversity and different soil chemical factors. They found a positive relationship between plant biodiversity (richness and diversity) and the concentration of potassium and phosphorus in soil.No relationship was found between plant biodiversity and other factors such as nitrogen and calcium concentration, pH, and other organic contents. Tilman *et al.,* (2006) investigated the effects of species richness and diversity on ecosystem productivity. They found that nitrogen was more available to plants roots in plot with higher species richness and diversity due to the reduction of Nitrogen leaching loss in soil, thereby increasing ecosystem productivity at the same time. Nadeau and Sullivan, (2015) worked on the relationship between plants biodiversity and soil fertility and reported a linear regression analysis which indicated that plant species richness was negatively related to

potassium content in soil.Therefore, the number of plant species declines as the concentration of level of K increases. On the other hand, there was no relationship between K content and species richness for either herb or shrub communities. No relationship was found between K concentration in soil and Shannon-Wiener species diversity of herbaceous plants. Their study on the whole indicated that plant species was found to be **inversely** related to soil K, ca and P contents and soil fertility index. Other studies have also supported that some kind of relationship exist between plant species richness and availability of soil nutrients. This study therefore, looks at the abundance hence availability of food plants to manatees along River Benue, Nigeria.

Material and methods

Study Area

The study covers a section of the River Benue system which is about 462km in length from Gbajimba town in Guma Local Government Area of Benue State to Lokoja in Kogi State Nigeria. (Fig 1). The area lies within latitude 07^0 49ˆN and 07^0 52'N and longitude 08^0 36ˆE and 08^0 40ˆE. The major tributaries of the River Benue along this area include Rivers Guma, Katsina-Ala, Mu, and Gwer. Several settlements are found all along this area, the major ones being, Gbajimba, Makurdi and Abinsi. The River Benue takes its origin from the Adamawa highlands in the Western Cameron and it is the largest tributary to the River Niger which its confluences with at Lokoja, Kogi State. River Benue enters Nigerian a few kilometers East of Yola in Adamawa State, flowing westwards for a distance of about 780km before joining River Niger at Lokoja. It flows through

Adamawa, Taraba, Benue and Kogi State and has several tributaries. Unlike other major African Rivers, the River Benue flows free of rapids and waterfalls.

Climate

The study area has distinct dry and wet seasons of tropical climate. The Tropical maritime air mass blows across the Atlantic brings rain to the area. The rainy season last from April to October and is between 1,250m-1440m. The tropical Continental air mass blows through the Sahara Desert brings dry harm tan winds. The dry season is from November to March of the next year. The monthly temperature is between 28.5^{0}C to 36^{0}C and may rise to as high as 38^0 in March to April.

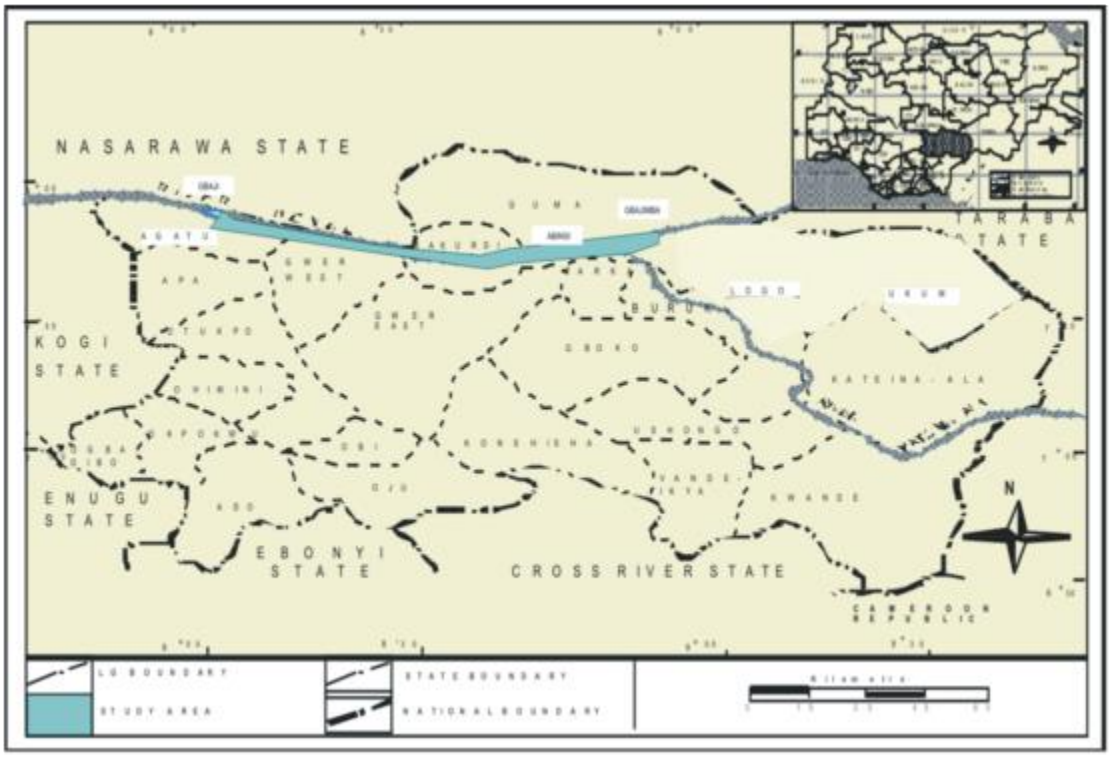

Figure 2. Map showing River Benue, Nigeria Source**:** Geological survey office Makurdi (2016)

Topography

The area generally lies at about 100m above the sea level and experiences annual flooding. The banks of the Benue River is thus filled with rich alluvial soils which is now utilized for dry season farming of vegetables, fruits and rice.

Data Collection

During the two years of survey, between 2015 to 2016,40 transects, each 500m long were laid in the 462Km stretch of the River Benue. To facilitate the selection of suitable sites for laying the transects, the sampled area was divided into four zones of similar length viz: Gbajimba, Abinsi, Makurdi and Gbaji. The selected sites gave a wide spatial coverage and reflected the range of habitats in each zone. Ten transects of 500metres length were laid on each side of the bank of the river in each zone, and manatee signs were searched for freshly grazes aquatic plants. Sampling was carried out once every month for three days since it takes three days to thoroughly sample one zone. A plant Taxonomist identified all the aquatic plants encountered in each zone and their abundance noted. To determine the soil parameters along the shoreline of the river, one sample each was dug to a depth of 50cm using a soil auger. The following soil parameters were measured; pH, Potassium, Nitrate, phosphorus and Temperature using an electronic NICE soil testing kit ISO 9001. This was carried out once at the four sample zones.

Results

Table 1. Frequency of Occurrence and Percentage Composition of Plant Species in the four stations along River Benue.

Scientific names	Gbajimba		Abinsi		Makurdi		Gbaji		SD
	Freq	%	Freq	%	Freq	%	Freq	%	
Ageratum conyzoides	24	0.76	0	0	0	0	24	0.62	13.86
Alchornia laxiflora	0	0.00	82	1.89	0	0	0	0.00	41.00
Alternanthera halicacabum	48	1.53	0	0.00	0	0	0	0.00	24.00
Alternanthera sessilis	0	0.00	0	0.00	0	0	12	0.31	6.00
Amaranthus spinosus	0	0.00	9	0.21	0	0	0	0.00	4.50
Calapogonium mucoides	0	0.00	0	0.00	8	0.19	0	0.00	4.00
Cardiospernum halicacabum	0	0.00	102	2.35	312	7.28	0	0.00	147.08
Celosia argenta	15	0.48	15	0.35	0	0.00	32	0.83	13.08
Celosia leptostachya	8	0.25	0	0.00	0	0.00	0	0.00	4.00
Ceruana pratensis	24	0.76	7	0.16	0	0.00	34	0.88	15.54
Cissus ibuerisis	14	0.45	0	0.00	12	0.28	38	0.98	15.92
Cola laurifolia	12	0.38	0	0.00	0	0.00	5	0.13	5.68
Combretum aculcatum	12	0.38	0	0.00	0	0.00	24	0.62	11.49
Cynodon dactylon	5	0.16	32	0.74	255	5.95	230	5.95	130.20

Cyperus imbricatus	56	1.78	135	3.11	0	0.00	84	2.17	56.30
Digitaria horizontalis	345	10.99	320	7.38	680	15.86	382	9.88	167.45
Eichornia colona	21	0.67	0	0.00	0	0.00	0	0.00	10.50
Eichornia crassipes	200	6.37	420	9.68	510	11.89	250	6.46	144.80
Elusine indica	25	0.80	0	0.00	0	0.00	32	0.83	16.70
Ethulia conyzoides	8	0.25	0	0.00	0	0.00	0	0.00	4.00
Euphorbia heterophylla	32	1.02	0	0.00	0	0.00	28	0.72	17.40
Ficus aspemtolia	12	0.38	8	0.18	0	0.00	20	0.52	8.33
Haliotropium hispidata	0	0.00	0	0.00	0	0.00	16	0.41	8.00
Haliotropium strigosum	6	0.19	0	0.00	0	0.00	0	0.00	3.00
Heliotropium indicum	10	0.32	28	0.65	0	0.00	0	0.00	13.20
Ipomea aquatic	230	7.33	320	7.38	181	4.22	342	8.84	75.70
Ipomea hetrotricha	0	0.00	0	0.00	8	0.19	41	1.06	19.53
Ludwigia abysisinia	24	0.76	24	0.55	0	0.00	38	0.98	15.78
Ludwigia dedurens	8	0.25	6	0.14	0	0.00	41	1.06	18.48
Ludwigia suffruticosa	12	0.38	0	0.00	22	0.51	0	0.00	10.63
Luffa cylindrical	52	1.66	220	5.07	438	10.21	24	0.62	190.47
Mimosa pigra	210	6.69	495	11.41	680	15.86	140	3.62	251.47
Mucuna poggiei	8	0.25	0	0.00	0	0.00	30	0.78	14.18
Nicotiana rustica	0	0.00	12	0.28	0	0.00	0	0.00	6.00
Oldenlandia capensis	0	0.00	8	0.18	0	0.00	0	0.00	4.00
Panicum pansum	0	0.00	18	0.42	0	0.00	0	0.00	9.00
Panicum repens	0	0.00	8	0.18	51	1.19	0	0.00	24.46
Paspalun conjugatum	23	0.73	8	0.18	0	0.00	15	0.39	9.81
Paullinia pinnata	12	0.38	12	0.28	18	0.42	14	0.36	2.83
Physalis angulate	18	0.57	32	0.74	12	0.28	10	0.26	9.93
Pistia straitiotes	0	0.00	0	0.00	0	0.00	56	1.45	28.00
Polygonium lavigerum	130	4.14	0	0.00	120	2.80	162	4.19	70.96
Polygonium pulchrum	0	0.00	7	0.16	0	0.00	48	1.24	23.07
Polygonium salicifolium	0	0.00	200	4.61	0	0.00	0	0.00	100.00
Pycreus flareceus	0	0.00	0	0.00	38	0.89	0	0.00	19.00
Quisqualis indica	26	0.83	0	0.00	42	0.98	32	0.83	17.93
Rottboellia cochinchinensis	0	0.00	0	0.00	0	0.00	18	0.47	9.00
Sesbania brispinosa	12	0.38	413	9.52	18	0.42	0	0.00	201.64
Setaria barbata	20	0.64	0	0.00	0	0.00	0	0.00	10.00

Setaria bispinosa	0	0.00	0	0.00	0	0.00	18	0.47	9.00
Sorghum arundinaceum	820	26.12	620	14.30	520	12.13	882	22.81	169.20
Sparagonophous spuraganophora	6	0.19	0	0.00	0	0.00	0	0.00	3.00
Spigelia authelia	5	0.16	0	0.00	0	0.00	22	0.57	10.44
Stachytarpheta indica	16	0.51	0	0.00	42	0.98	0	0.00	19.82
Striga hermontheca	12	0.38	8	0.18	0	0.00	31	0.80	13.15
Tephrosia bracteolate	12	0.38	0	0.00	0	0.00	0	0.00	6.00
Torenia thoursii	10	0.32	40	0.92	0	0.00	20	0.52	17.08
Tridax procumbens	24	0.76	28	0.65	14	0.33	21	0.54	5.91
Viteveria flavibarbis	320	10.19	180	4.15	97	2.26	250	6.46	95.49
Vossia cuspidate	252	8.03	520	11.99	210	4.90	401	10.37	142.17
Total	3139	100	4337	100	4288	100	3867	100	554.22

Table 2. The ten aquatic plants utilized as food by Manatees along River Benue, Highly utilized XXXX, Moderately utilized XXX, poorly utilized XX

Plant scientific Name	**Level of utilization**
Cynodon, dactylon	*xx*
Ipomea aquatic	xx
Quisqualis indica	*xx*
Polygonium acuminatus	*xx*
Pistia stratiotes	xx
Cardiospermun halicacabum	*xx*
Vossia cuspidata	*xxxx*
Viteveria flavibarbis	*xxx*
Digitaria horizontalis	*xx*
Eichornia crassipes	*xx*

Table 3: Analysis of plant Diversity Indices along River Benue

Diversity Indices	**Stations**			
	Gbajimba	**Abinsi**	**Makurdi**	**Gbaji**
Shannon-Weiner H	2.69	2.70	2.48	2.82
Simpson 1/D	8.72	11.70	9.59	10.35
Berger-Parker D	0.26	0.14	0.15	0.22
Margalef	5.09	3.82	2.63	4.59

Species Richness	42.00	33.00	23.00	39.00

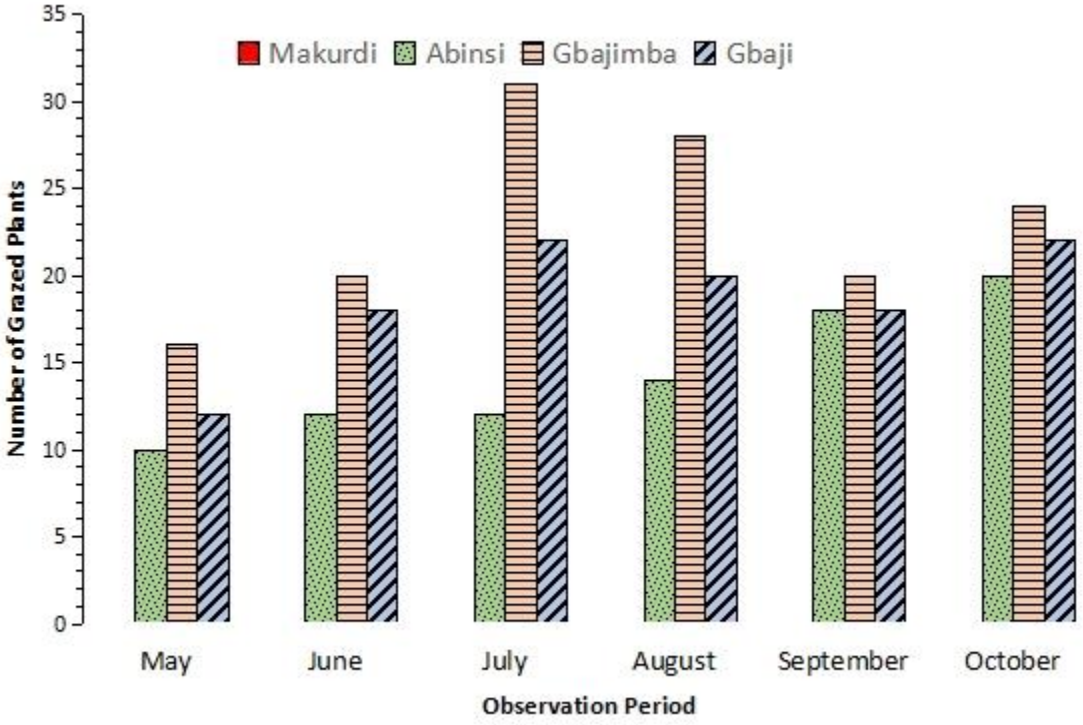

Figure 2. Number of grazed plants encountered along River Benue in the study sites**.**

Table 5. Analysis of Soil Properties along River Benue**.**

Stations	**Soil Properties**			
	pH	**Potassium Mg/Kg**	**Nitrogen Mg/Kg**	**Phosphorus Mg/Kg**
Abinsi	6.50±0.09^{b}	2.78±0.33	3.74±0.24^{b}	0.72±0.13
Gbaji	7.70±0.25^{a}	3.76±0.51	5.12±0.24^{a}	0.46±0.06
Gbajimba	7.68±0.17^{a}	3.06±0.38	4.10±0.38^{b}	0.56±0.12
Makurdi	6.68±0.30^{b}	2.74±0.37	4.22±0.41^{ab}	0.50±0.08
P-Value	*<0.01*	*0.29^{ns}*	*0.05*	*0.38^{ns}*

Means on the same column with different superscripts are statistically significant ($p<0.05$); ns = not significant.

Discussion

The result identified a total of 60 aquatic Species along the river Benue between May 2015 to April 2016, with Gbajimba station having the highest number of 43, Gbaji 40, Abinsi 34, and Makurd 23. This result closely agrees with an earlier work by Eguwmah and Iwar (2006) who identified 62 aquatic plant species with Gbajimba ranking highest with 48 species, Abinsi with 39, and Makurdi with 28 species. Most of the aquatic plants were emergent, submerged, and floating species.

Ten plants were identified as manatee food plants and these include; *Cynodon, dactylon, Digitaria horizontalis, Eichornia crassipes, Ipomea aquatica, Vossia cuspidata, Viteveria flavibarbis, Quisqualis indica, Polygonium acuminatum, Pistia stratiotes and cardiospermun halicacabum, the most palatable species were Vossia cuspidata, Viteveria flavibarbis, Digitaria horizontalis, Eichornia crassipes* in *decreasing order.* The leaves of hanging and floating plants such as *Vossia cuspidata,Viteveria flavibarbis,* and *Ipomea aquatica* were mostly preferred plant parts consumed, while in species such as *Cardiospermum halicacabum*, *Eichornia crassipes* it was the stems that were preferred food part. Grazing on aquatic vegetation was observed only during the rainy season and all grazed signs were observed on fresh vegetation and not on dead plants. Anne *et al.*, (2017) reported that Manatees in the Congo basin fed on plant species and that six are the most preferred namely, *Ipomea aquatica, Echinochloa sp, Cyperus papyrus, Ludwigia tiberosa and Saluinia molesta*. However, Ogogo *et al*., (2013) listed 15 plant species as West African Manatee food plants, while Egwali *et al.,* (2019) identified 11 aquatic plants as West African Manatee food plants. This study reveals that the preferred food plants of West African Manatee are habitat-specific. Manatees living in the mangrove habitat have different preferred food plants from those in the riverine areas.

West African Manatees are mostly sighted in the night which is the day during which they move around for their feeding. Accordingly, they are nocturnal animals. They usually move away from their place of abode to feed some distances away, even when their preferred food plants are in the close vicinity of their home

West African Manatees have for a long time been classified as herbivores. However, studies by Keith Diagne, (2014) reported that they are omnivores, eating fishes, clams and mollusks. This

may be the case along the River Benue where there are no aquatic plants sighted along the river during the dry season. Apparently, during the dry season period when there is plant food scarcity, Manatees may turn to other non-plant food or probably hibernate during the long period of the dry season, striving for low physiological activities. Grazed aquatic plants along the four sampling stations were identified through signs of grazing, however, grazing was not noticed in the Makurdi station throughout the study period. This may be due to heavy human activities carried out there such as dry-season vegetable farming, sharp sand harvesting, and intense fishing. These activities probably prevent Manatees from moving in such an area since their only means of defense is avoidance of threat factors. There were significant differences in the pH value of soils in the four sampling stations. The pH values for Abinsi (6.50) and Makurdi (6.68) were not significantly different from those of Gbaji (7.70) and Gbajimba (7.68). This is interesting in that the gradient along the river would have indicated otherwise. The potassium content of the soil in the four sampling stations did not indicate any significant differences as well as the phosphorus content of the soil. The potassium content of the soil ranged from 2.74Mg/kg in Makurdi to 2.78Mg/kg in Abinsi while the phosphorus content was between 0.46 Mg/kg for Gbaji to 0.72Mg/kg in Abinsi. The soil Nitrogen content indicates significant differences in the four sampling stations in the study area. The values in Abinsi (3.74Mg/kg) and Gbajimba (4.10Mg/kg) are significantly different from those of Gbaji (5.12mg/kg) and Makurdi (4.22Mg/kg) and Abinsi-Gbajimba and that of Gbaji. The soil parameter in the four sampling stations relates with the plant species richness of the stations and agrees with the report of FAO (2018) that soils and vegetation have a reciprocal relationship.

Conclusion

The study tried to identify Manatee food plant species along river Benue, and some soil parameters along the river. The findings of the study identified 60 aquatic plants along West African Manatee habitat in River Benue, and out of these numbers, only 10 are used as food plants by the Species. Grazed plants were not noticed during the dry season and the assertion is that either Manatee starves during this period or resort to eating fish, clams, crabs and other invertebrates as reported by Keith Diagne, (2014). Because of the heavy negative anthropogenic impact on West African Manatees along the River Benue, it is hereby recommended that:

1.Sensitization and Education of the Fishermen on the values of conserving the West African Manatee in the river be carried out in all the fishing settlements along the river.
2.Aquaculture be introduced to the Fishermen as an additional source of livelihood to prevent them from killing manatee along the river.
3.Regular monitoring of water health and other parameters be carried out to gain more information on manatee habitat along the river. This will enhance West African Manatee management along the river.
4. Proximate analysis of manatee-preferred food plants should be undertaken for captive breeding.

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