Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 19 Number 4 (October 2020) pp. 18 - 23

ISSN 1119-7455

MANAGEMENT OF AQUATIC PLANTS AND THEIR CONTRIBUTIONS TO FISHERIES PRODUCTION IN IKERE-GORGE, ISEYIN, OYO STATE, NIGERIA

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ABSTRACT

Aquatic plants are important in freshwater ecosystems. They provide food, shelter, spawning and nursery grounds for fish. They are usually found at the littoral parts of freshwater ecosystems. The abundance, distribution and diversity of aquatic plant of Ikere-gorge, Iseyin, Nigeria were examined between January 2017 and December 2018. There are twelve fishing villages in Ikere-gorge and four villages were randomly selected. Aquatic plants were sampled and collected with the help of hired fishermen. The collected aquatic plant samples were identified at the Forest Herbarium of the Forestry Research Institute of Nigeria with appropriate keys. This work identified 13 families and 23 species of aquatic plants. Cyperaceae family recorded the highest (4) number of individual species while Salvinia molesta had the highest abundance in all the sampling sites. The ecological classification of the aquatic plants showed that 14 species are emergent; 7 species floating and 3 species submerged. Site C had the most abundance (9220) of aquatic plants, followed by site D (8490), site B (8130) and site A (7940). The gamma (γ) and beta (β) diversities were 23 and 0.01 respectively. The alpha (α) diversity included Dominance (0.08), Simpson (0.92) and Shannon-Wiener (2.72) respectively. These results show that Salvinia molesta and Najas guadalupensis are the most and least abundant aquatic plants in Ikere-gorge respectively; which may be due to their ecological status. Moreover, management of aquatic plants is an integral part of fisheries management for sustainable fisheries. Therefore, their management is essential for the maintenance of aquatic biodiversity.

Key words: aquatic plants, diversity, emergent, floating, submerged

INTRODUCTION

According to USAID (2015), freshwater diversity includes the species that depend upon freshwater ecosystems for one or more components of their life cycles, including plants, insects, amphibians, reptiles, fishes, crustaceans, mammals, and birds. Likewise, CBD (2016) explained that freshwater biodiversity is simply biodiversity associated with inland waters. But since all terrestrial animals and plants depend on fresh water, the boundaries between aquatic and terrestrial are blurred. At the species level, inland water biodiversity generally includes all life forms that depend upon inland water habitat for things other than simply drinking (or transpiration in plants). Besides the obvious life living within water itself (e.g., fish), this also includes many "terrestrial" species of animals (e.g. waterbirds), semi-aquatic animals (e.g. hippopotamus, crocodiles, beaver) and plants (e.g. flooded forest, mangroves, vegetation associated with the margins of water bodies). The majority of amphibians, for example, breed in fresh water. Cook (1990) defined aquatic plants as plants with photosynthetic parts that are permanently or temporarily submerged or floating in water and visible to the human eye. Aquatic plants are important components of the aquatic ecosystem especially freshwater ecosystem contributing to the aquatic biodiversity. Moderate abundance of aquatic plants in the freshwater ecosystem supports fish production; they provide shelter or habitat, spawning ground and even food for some fish species and other aquatic organisms (Dienye, 2015). Valley *et al.* (2004) explained the importance and functions of aquatic plant for fish population and productive fisheries. Aquatic plants support primary production, stabilizing sediments, maintaining water clarity, and providing quality habitat for zooplankton, macro invertebrates, and numerous fish species.

Please cite as: Ajagbe S.O., Soaga J.A., Olunloyo A.A., Odewo S.A. and Udaghe O.M. (2020). Management of aquatic plants and their contribution to fisheries production in Ikere-gorge, Iseyin, Oyo State, Nigeria. *Agro-Science*, **19 (4),** 18-23. DOI: https://dx.doi.org/10.4314/as.v19i4.4

However, aquatic plants may become a nuisance and a challenge to the management of freshwater ecosystem causing economic as well as ecological losses by adversely affecting the aquatic ecosystem, (Narasimha and Benarjee, 2016). Studies on aquatic plants are rare, especially on aquatic plants of Ikere-gorge. This study is important to give baseline information on species composition, abundance and diversity of aquatic plants in Ikere-gorge. This information is vital to the management of aquatic plants and improves their provision of habitats, food items and recruitment grounds for aquatic organisms.

MATERIALS AND METHODS

Study Site

Ikere-gorge is a multipurpose dam located at Ikere village, about 28 km, North East of Iseyin in Oyo State. Ikere-gorge is located between longitude 8°10' and 8° 20'N and latitude 3° 40' and 3° 50'E (Figure 1). Along the bank of the dam are distributed forest and savanna trees and aquatic grasses and shrubs. The dam experiences frequent current as a result of wind that blows on it from time to time. Sometimes, the current results to wave action which spreads across the dam and it could be violent particularly during the raining season (Kehinde and Ayoade, 2012). Ikere-gorge took its source from Sepeteri about 40 km to Ikere through Asamu and Alagbon. Ikere-gorge has Ogun River as its major tributary and River Amaka, River Oowe and River Owu as its minor tributaries.

There are 12 fishing villages in Ikere-gorge. Four sampling sites were selected from Ikere-gorge using stratified random sampling method. The fishing villages were divided into four strata for easy access according to their geographical location and proximity to each other. From each sampling site, one fishing village was chosen randomly for sampling to make a good representation. The selected sampling sites (fishing villages) included Site A Asamu (N 8º 13' 54.828" E 3º 47' 00. 696"), Site B Agatu (N 8º 09' 51. 972" E 3º 44' 57.642"), Site C Spillway (N 8º 11' 53.760" E 3º 44' 51. 810") and Site D Irawote (N 8º 14' 01. 170" E 3º 42' 47. 802"). The locations of the sampling sites and other fishing villages were documented using global positioning system (GPS). The selected sampling sites were sampled for four days consecutively in the first week of every month for a period of 24 months (January 2017 to December 2018).

Sampling, Preservation and Identification of Aquatic Plant Species

Aquatic plants were assessed by taking the inventory of floating, emergent and submerged plants of the dam. The sampling method of Adesina *et al.* (2011) was adopted for this study. Sampling plots were established in each fishing village. A 10 x 10m plot was laid to facilitate a complete littoral and open water plant species data collection. A fisherman was employed in each of the selected fishing village for the collection of the aquatic plants located in the dam. The samples were collected by moving the canoe slowly through the littoral zone of the water in a zigzag manner. Submersed species and emergent species found along the shore of the dam were collected. The depth of the water was also observed. Aquatic plants were collected in the dam with their flowers, seeds and roots by hand and sampling rakes. These samples were rinsed and preserved using plant press. They were later taken to the Forestry Research Institute of Nigeria for proper identification. Identification of aquatic plant species was done using identification keys such as: Akobundu and Agyakwa (1998) and web based manual. GPS was used to take the locations where the aquatic plant samples were collected.

Data Analysis

Relative Density

It is the proportion contribution of individual aquatic species to the total population in the sample. It was computed with the formula:

$$RD = Si/N \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1);$$

where RD is relative density, *Si* is population of individual species, and *N* is total population of species.

Frequency of Occurrence

This is the number of plots individual aquatic plant species was recorded among the sampling plots. Hence, it was calculated using the formula of Lare-Tier II (2010):

$$S/N \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where S is the number of points where the specie is present, and *N* is the total number of plots surveyed.

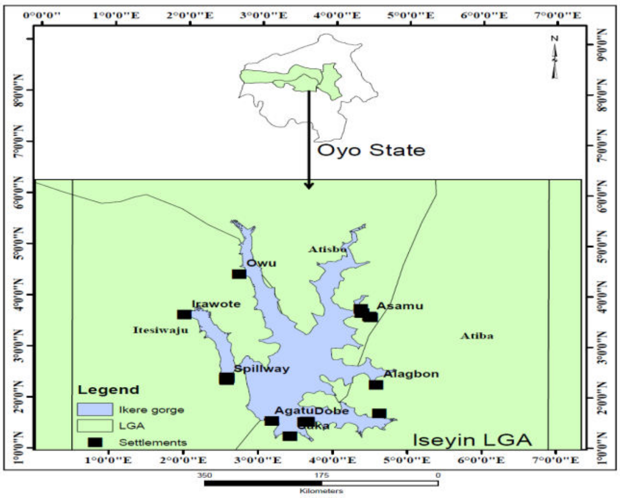

Figure 1: Map of Ikere-Gorge (showing some fishing villages), Iseyin, Oyo State, Nigeria

Diversity Indices

Aquatic diversity was determined by different diversity indices using Palaeontological Statistics (PAST) and *R* statistical package (Odulate *et al*., 2017; Hammer *et al.,* 2001).

i. Shannon-Weiner Diversity Index (Mörsdorf, 2015):

$$H = -\Sigma Pi \ln Pi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where *H* is Shannon-Weiner index (the uncertainty of species identity), *Pi* is ni/N, *ni* is number of individuals of each species in the sample, and *N* is total number of individuals of all species in the sample.

ii. Simpson's Dominance Index (Hossain *et al*., 2012):

$$\lambda = \sum p_i^2 \quad \lambda = \frac{\Sigma ni(ni-1)}{N(N-1)} \quad \ldots\ldots\ldots (4)$$

The value of **λ** ranges between 0 and 1. When λ is0, it signifies infinite (maximum or highest) diversity, but 1 signifies no diversity in the population.

iii. Simpson's Index of Diversity (D), also called Gini coefficient.

$$D = 1 - \frac{\Sigma ni\,(ni-1)}{N(N-1)} = 1 - \lambda \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Likewise, the value of D is between 0 and 1. When D is 0, it signifies no diversity in the population, but 1 is infinite (highest or maximum) diversity.

RESULTS

This study identified 13 families and 23 species of aquatic plants in Ikere-gorge, Iseyin, Oyo State, Nigeria. Cyperaceae family recorded the highest (4) number of individual species. They are *Carex autro-africana, Cyperus dives, Rynchospora corymbosa* and *Scirpus articulatus*. Nymphaeaceae and poaceae family recorded 3 individual species of aquatic plants each. They were *Nymphaea caerulea, Nymphaea lotus* and *Nymphaea nouchalia* (Nymphaeaceae); while family Poaceae were *Echinochloa pyramidalis, Andropogon tectorum* and *Phragmites australis*. The families of Convolvulaceae, Onagraceae and Ploygonaceae had two species each, while the families of Araceae, Ceratophyllaceae, Fabaceae, Hydrocharitaceae, Salviniaceae and Sphenocleaceae had one species each (Table 1). Likewise, Table 1 and Figure 2 show that 58% of the aquatic plants reported were emergent amounted, 29% are floating and 13% are submerged.

The results show that a floating macrophyte; *Salvinia molesta* had the highest abundance in all the sampling sites. But *Najas guadalupensis* was observed to have the least abundance with relative density of 0.27. Moreover, the abundance of other aquatic plants was diverse in the sampling sites. In site A, the most abundant aquatic plants were *Potamogeton schweinfurthii, Andropogon tectrum, Phragmites australis* and *Echinochloa pyramidalis*.

Table 1: Checklist of species composition of aquatic plants of Ikere-Gorge, Iseyin

Family	Plant species	Common name	Ecology
Araceae	*Pistia stratiotes*	Water lettuce	Floating
Ceratophyllaceae	*Ceratophyllum demersum*	Hornwort	Submerged
Convolvulaceae	*Ipomoea aquatica*	Water spinach,	Emergent
	Ipomoea asarifolia	Ginger leaf	Emergent
Cyperaceae	*Carex autro-africana*	Cat's tail sedge	Emergent
	Cyperus dives	Giant sedge	Emergent
	Rynchospora corymbosa		Emergent
	Scirpus articulatus		Emergent
Fabaceae	*Neptunia oleracea*	Water mimosa	Floating
Hydrocharitaceae	*Najas guadalupensis*	Water nymph	Submerged
Nymphaeaceae	*Nymphaea caerulea*	blue lotus	Floating
	Nymphaea lotus	White lotus	Floating
	Nymphaea nouchalia	Blue lotus	Floating
Onagraceae	*Ludwigia decurrens*	Upright primose	Emergent
	Ludwigia stolonifer	Creeping ludwigia	Floating
Salviniaceae	*Salvinia molesta*	Water varing	Floating
Polygonaceae	*Persicaria senegalensis*		Emergent
	Polygonum senegalense		Emergent
Sphenocleaceae	*Sphenoclea zeylanica*	Wedgewort	Emergent
Poaceae	*Echinochloa pyramidalis*	Antelope grass	Emergent
Poaceae	*Phragmites australis*	Common weed	Emergent
Poaceae	*Andropogon tectrum*	Horse grass	Emergent
Potamogetonaceae	*Potamogeton schweinfurthii*	Pondweed	Submerged

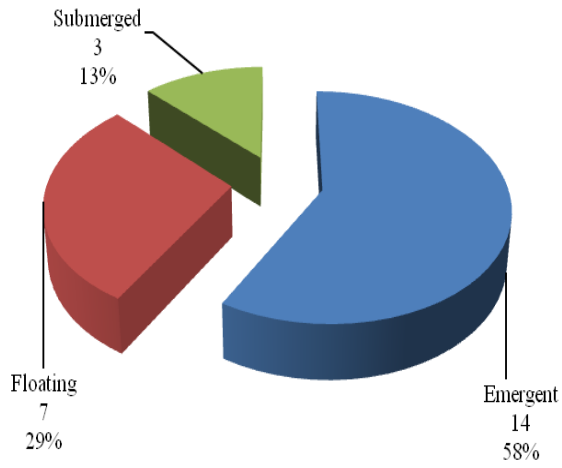

Figure 2: Ecological status of aquatic plants in Ikere-gorge, Iseyin, Oyo State, Nigeria

In site B, the most abundant aquatic plants were *Echinochloa pyramidalis, Phragmites australis, Andropogon tectrum* and *Ludwigia stolonifer*. In site C, the most abundant aquatic plants were *Echinochloa pyramidalis, Ludwigia stolonifer, Scirpus articulatus* and *Cyperus dives*. In site D, the most abundant aquatic plants were *Echinochloa pyramidalis, Ludwigia stolonifer, Cyperus dives* and *Andropogon tectrum* (Table 2). Likewise, Table 2 shows that only *Neptunia oleracea* had 50% frequency of occurrence, while *Ipomea aquatica*, *Ceratophyllum demersum*, *Carex autro-africana*, *Percicaria senegalensis*, *Sphenoclea zeylanica*, and *Najas guadalupensis* had 75% of frequency of occurrence and other aquatic plants had 100% of frequency of occurrence in Ikere-gorge.

Emergent and submerged aquatic plants in the littoral zone are identified in Ikere-gorge as spawning and nursery grounds for fish. They provide suitable shelter for fish fry, fingerlings and juvenile; because water current is moderated by the aquatic plants. Likewise, leaves, stems and fruits of some aquatic plants like *Nymphaea* spp. are edible for both fish and man (Plate 1). Therefore, herbivorous and omnivorous fish such as Cichlidae and Clariidae usually come to the littoral zone to forage. Occasionally, some predatory fish also come to prey on these fish. This also provides opportunity for fisher folks to set their traps (fishing gears) under these aquatic plants to catch (Plate 2). Therefore, as the fish grow and mature they migrate out of the littoral zone.

Table 2: Spatial abundance of aquatic plants of Ikere-gorge, Oyo State, Nigeria

Plant Species	Site A	Site B	Site C	Site D	Ikere	RD	FO (%)
Salvinia molesta	1020	960	1430	1370	4780	14.15	100
Echinochloa pyramidalis	1120	860	960	1060	4000	11.84	100
Scirpus articulatus	680	620	720	580	2600	7.70	100
Phragmites australis	730	860	520	490	2600	7.70	100
Ludwigia stolonifer	510	680	760	640	2590	7.67	100
Andropogon tectrum	380	820	650	610	2460	7.28	100
Cyperus dives	560	510	720	630	2420	7.16	100
Pistia stratiotes	380	470	490	510	1850	5.48	100
Potamogeton schweinfurthii	330	460	520	420	1730	5.12	100
Rynchospora corymbosa	440	340	470	390	1640	4.85	100
Nymphaea nouchalia	310	290	420	380	1400	4.14	100
Nymphaea lotus	310	350	380	320	1360	4.03	100
Nymphaea caerulea	330	280	250	290	1150	3.40	100
Polygonum senegalense	150	120	210	170	650	1.92	100
Ludwigia decurrens	110	140	160	210	620	1.84	100
Ipomoea asarifolia	110	100	140	50	400	1.18	100
Ipomoea aquatica	130	80	160	0	370	1.10	75
Ceratophyllum demersum	150	110	0	80	340	1.01	75
Carex autro-africana	130	0	50	80	260	0.77	75
Persicaria senegalensis	0	50	90	70	210	0.62	75
Sphenoclea zeylanica	50	0	30	70	150	0.44	75
Neptunia oleracea	0	0	40	70	110	0.33	50
Najas guadalupensis	10	30	50	0	90	0.27	75
Total	7940	8130	9220	8490	33780	100.00	

RD: Relative Density; FO: Frequency of Occurrence

Plate 1: Contribution of aquatic plants to provision of food in Ikere-gorge, Iseyin, Oyo State

Plate 2: Aquatic plants providing shelter for fish and fishing ground for fisher folks in Ikere-gorge, Iseyin, Oyo State, Nigeria

Table 3: Diversity indices of aquatic plants of Ikere-gorge, Iseyin, Oyo State, Nigeria

	Site A	Site B	Site C	Site D	Ikere
Individuals	7940	8130	9220	8490	33780
Gamma	23	23	23	23	23
Beta (β_P)	0.12	0.12	0.12	0.12	
Beta (β_D)	0.91	0.91	0.91	0.91	
Taxa_S	21	20	22	21	23
Dominance_D	0.08	0.08	0.08	0.08	0.08
Simpson_1-D	0.92	0.92	0.92	0.92	0.92
Shannon_H	2.75	2.71	2.75	2.72	2.76
Evenness_e^H/S	0.74	0.75	0.71	0.73	0.69

Table 3 shows the diversity indices of aquatic plants in Ikere-gorge. The results show that gamma (γ), proportional and differentiation diversity were 23, 0.10 and 0.91 respectively. The alpha diversity for site A, site B, site C and site D were 21, 20, 22 and 21 respectively. Likewise, Table 4 shows the values of other alpha diversity indices. It shows that dominance and Simpson indexes were constant at all sites; dominance is 0.08 and Simpson index was 0.92. Shannon Wiener for site A and site C was 2.75, while site B and site D were 2.71 and 2.72 respectively. The Evenness for site A, B, C and D were 0.74, 0.75, 0.71 and 0.73 respectively.

DISCUSSION

Aquatic plants provide shelter, spawning ground; security and food for aquatic organisms especially fish. This study identified *Nymphaea* spp. as an edible aquatic plant. Narasimha and Benarjee (2016) reported that aquatic plants serve as a good source of food to mankind and animals (including water birds) and for aquatic wildlife conservation practices. Okayi *et al*. (2013) reported that aquatic macrophytes may serve as food for fish, shelter to fish, serve as spawning ground, provide food and shelter to water fowls, improve aesthetic values, and provide materials for curative therapy as ethnobotanic. Pinese *et al*. (2015) observed that aquatic plants allow the emergence of a variety of niches and microhabitats, supporting a highly diverse zooplankton community around them.

This study identified 23 species belonging to 13 families of aquatic plants in Ikere-gorge, Iseyin, Oyo State, Nigeria. Dienye and Olopade (2017) identified 20 species of aquatic plants representing 13 families in Oyan Lake, Ogun State, Nigeria. Dienye (2015) reported 10 families of macrophyte (12 species) in New Calabar River, Niger Delta. Narasimha and Benarjee (2016) recorded 25 macrophytes from littoral and sub-littoral zones of the tank at four stations in Nagaram tank of Warangal district, Telangana State. Ghosh and Biswas (2015) recorded 45 genera of macrophytes in Ganga River Basin. Likewise, this study showed that Cyperaceae family recorded the highest (4) number of individual species. This is in agreement with Dienye and Olopade (2017) who reported that Cyperaceae and Poaceae families had the highest species with four species each in Oyan Lake, Ogun State, Nigeria. Also, Dienye (2015) that Cyperaceae had the highest species with three species in New Calabar River, Niger Delta, Nigeria.

Cyperaceae family can be found in almost all types of habitats with exception of few as Antarctica (Košnar, 2013). Although, this study identified Cyperaceae family as emergent aquatic plants, it can also be found in freshwater ecosystem as floating and submerged aquatic plants. This is due to their capacity to absorb excess nutrients especially phosphorus and nitrogen and become often dominant. They play an important role in primary productivity and support hydrological cycle. They provide habitats for faunal diversity. Their fruits and, sometimes, shoots and tubers are important food for many aquatic and amphibious animals. Likewise, they are used in weaving mats, baskets, screens, and even sandals because of their strong, fibrous stems and leaves (Mishra *et al*., 2016; Encyclopaedia Britannica 2013). In addition, Mishra *et al*. (2016) identified other ecological functions perform by Cyperaceae family. They stabilize water flow and control erosion. They develop and produce peat and peat soil. They can be used as health indicator in wetlands; recycling nutrients; removing sediments and heavy metals. The presence of heavy metals in freshwater ecosystem affects physiological and metabolic activities of fish. Idowu *et al*. (2020) identified *Oreochromis niloticus* as one of fish affected by heavy metals.

Salvinia molesta is a freshwater invasive species of aquatic plants. It was the most abundance aquatic plants in all the sampling sites in Ikere gorge. It has the ability to grow rapidly. It can quickly cover the entire surface of water body with a thick mat of vegetation; thereby limiting exchange of oxygen and light within the water column. This can negatively affect the biodiversity and abundance of freshwater species, including fish and submersed aquatic plants. *Salvinia molesta* invasions can alter wetland ecosystems and cause wetland habitat loss (Richard and Ramey, 2007; BioNET-EAFRINET, N.D.). *Najas guadalupensis* was observed to have the least abundance. It is a delicate plant. It can break easily. Its population is vulnerable to the movement of fish and other aquatic animals. Emergent aquatic plants are found at the littoral zone in aquatic ecosystem. They are the most visible among aquatic plants. This study identified 14 species (58%) of emergent aquatic plants. This shows relative encroachment of littoral zone and reduction of the core area of the gorge as a result of accumulation of silts and detritus from the catchments area (Ghosh and Biswas, 2015).

This is in agreement with the report of Ahmad *et al*. (2015) and Adesina *et al*. (2011). But, Dienye (2015) reported that among the 12 species sampled, 10 were grouped as emergent, two as floating and none was submerged. Ghosh and Biswas (2015) reported that emergent plants showed the largest number, followed by submerged, free floating, and rooted floating leaved in Ganga River Basin.

Though submerged aquatic plants are important in aquatic ecosystems they are the least abundant in this study. This agrees Yamaki and Yamamuro (2013). They reported that submerged plants are often scarce, nevertheless they are considered to be the most suitable refuge against predators and form of foraging habitat for small fishes; they are most preferred by fishes. Submerged plants are adapted to living with their roots submerged by water. They grow completely below water surface. They are found far from littoral zone that are dominated by emergent plants; into the core part of the lake. Submerged plants create important habitat and food sources for wildlife; they filter and trap soil and absorb nutrient. Valley *et al*. (2004) reiterated the management of submerged aquatic plants in which any alteration to submerged aquatic plants will invariably have some effect on a lake's fish community. Some floating aquatic plants identified in this study such as *Pistia stratiotes* (water lettuce) and *Ipomea aquatica* (water spinach) were also identified by Okayi *et al*. (2013). This study reported that Shannon_ H varied between 2.71 and 2.76. This is in agreement with the result of Dienye (2015) who reported Shannon Weinner of 2.72. Ghosh and Biswas (2015) reported that Shannon_H index values ranges between 0 and 5. This shows that there is moderate diversity of aquatic plants in Ikere-gorge. This is confirmed in the values of Dominance (D) and Simpson (1 – D) obtained in

this study. These values imply that the probability of picking the same species in the same population of aquatic plant in Ikere-gorge with or without replacement is 0.08. But, Ekpo *et al*. (2016) reported that Shannon-Wiener Index of aquatic macrophyte community of a riparian stream in Odot, Niger Delta, Nigeria varied between 2.29 and 2.64.

CONCLUSION

Aquatic plants are integral components of aquatic ecosystem. Their abundance, distribution and diversity are governed by the environmental variables at all levels including air, terrestrial and aquatic. *Najas guadalupensis* was observed to have the least abundance. But, an invasive species, *Salvinia molesta* was the most abundant aquatic plant in all the sampling sites in Ikere gorge. Its population must be controlled for sustainability of aquatic biodiversity of Ikere-gorge. Some of these aquatic plants are edible for fish and even human. Species composition, abundance and diversity of aquatic plants of Ikere-gorge showed their contribution to the biodiversity of the gorge. However, almost aquatic plants identified in this study provide support for fish production and improve water quality. Some of these aquatic plants are edible for fish and human being. Moreover, management of aquatic plants is an integral part of fisheries management for sustainable fisheries and they are essential for the maintenance of aquatic biodiversity in the aquatic ecosystem.

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