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Sustainable Fisheries and Diversity in River Fete, Benue State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author ROO designed the study, involved in the sample collection, analysis, and proof read the first draft. Author BTI carried out and managed the experiment and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The fish diversity of River Fete, Benue State, Nigeria was investigated monthly between January to December, 2016 to determine its status, management strategies as well as providing a base line data for monitoring anthropogenic changes prompted by human induced factors and river aging. Fish samples were collected from artisanal fisher men using cast nets, lift nets and traps. Two way ANOVA was used to analyze the result using GLM procedures of the statistical analysis system (SAS). The result showed that 28 fish species belonging to 23 families were recorded from the river. The family Cichlidae dominated the fish population of the river followed by Mormyridae and Bagridae which were both represented by four species each. Other families such as Claridae, Cyprinidae, Citharinidae and Mockokidae were represented by two species. About six families identified recorded only one species of fish, these include; Characidae, Malapteruridae, Gymnarchidae, Centropomidae, Lepidoserinidae and Osteoglosidae. Significant variations were observed in the fish diversity by season and stations with most of the species being highly abundant in wet season. The hydrology, water residence time, precipitation, evaporation and bedrock chemistry were some of the factors identified to influence the variations. H. niloticus and

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Barbus occidentalis were two fish species found to be endangered and which need conservation. Various management strategies such as stocking of indigenous fish species, implementation of fishing regulations, periodic limnological monitoring and adoption of best limnological – mediated management practices were suggested for effective utilization and sustainable exploitation of the river water and its resource.

Keywords: Fish; fish diversity; River Fete.

1. INTRODUCTION

Water is essential for all socio-economic development and for maintaining healthy ecosystems; however freshwater sources have experienced increased stress due to ever rising demand and degenerate use, as well as by growing pollution worldwide [1]. The water quality of a river is influenced by the catchment characteristics with various imposed pollution loads. The pollution loads imposed on a river system consists of three components, direct/point wastewater discharge, diffuse/non – point contribution in seepage and runoff water from the catchment and back ground contribution from natural sources [2].

These three aspects must be considered in catchment water quality management plan.

Urbanization in Benue state has resulted in rural-urban migration since 1980 resulting in development of informal settlements with inadequate or no waste disposal facilities [3]. The high rate of untreated effluent discharges into River Benue (which forms tributary with River Fete) at Makurdi is alarming coupled with some rural dwellers that use the river as their toilet while some people use the same river as their main source of drinking water calls for attention.

River Fete consists of rich Fadama areas and is endowed with some macrophytes. The Fadama area provides good fertile land for subsistence vegetable production and livestock grazing. Local fishing activities are also carried out. Fish growth depends on water quality in order to boost its production. Water physico–chemical parameters are known to affect the biotic component of an aquatic environment in various ways [4]. The important characteristics of River Fete to its riparian owners can never be over emphasized and also the damage done to its quality by man and animals call for more attention to study, protect and preserve the river and its valuable resources such as fishes, shrimps, crabs, phytoplankton, zooplankton and macrophytes.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, Makurdi is bounded by longitudes 8^0 30''E and latitudes 7^0 48.5N. The climate of Makurdi is tropical climate with distinct rainy and dry seasons. The annual rainfall ranges from 700mm per annum to 1100mm per annum while the mean annual temperature ranges from 22.18^0C to 33.25^0C. The area has guinea savannah vegetation, characterized by woodland which has given way to grassland due to frequent bush burning.

River Fete cuts across Gwer East and Makurdi Local Government Area of Benue State. The River has its starting point at Igbor hills in Gwer East Local Government Area to Mbaku community where it empties into River Benue. It passes through a major Federal high way linking Benue State and Kogi state at Adaka community in Makurdi, Makurdi Local Government.

2.2 Sampling Procedures

The study was carried out for a period of twelve (12) months. Five sampling stations (A, B, C, D and E) were located on the River. The sites were selected at strategic but easily accessible places based on the presumption that there is a measurable problem at that location along the river. On the five sites chosen, the water quality, and plankton diversity were assessed on monthly bases.

2.3 Fish Sampling

Fish species composition was estimated from fish samples collected from the fishermen after landing. The fishes were identified, enumerated and sorted into family and species. Each fish was counted. The fishes were caught by the fishermen using gill nets, cast nets and lift nets of various mesh sizes ranging between 4.80cm to 16 12cm. Fishing activities were carried out on dugout canoes. Wire mesh Traps and raffia palm traps set at various sites of the river where there was low water current were also used to capture

fishes. The fishes were identified to species level using keys from [5].

2.4 Statistical Analysis

Statistical analyses of the results were done in the department of fisheries and aquaculture, university of agriculture Makurdi, Benue state, Nigeria using Gentat software. Two way analysis of variance (ANOVA) at 0.05 probability level was used to test for the effect of variation due to sampling error, sampling stations, seasons and fish abundance by family.

3. RESULTS AND DISCUSSION

3.1 Fish Species Composition in River Fete

A total of 28 species belonging to 23 families (Tables 1 and 2) were recorded from the river. The family Cichlideae dominated the fish population of the river in terms of fish abundance. Six species in the family were identified. The family Mormyrideae and Bagridae were both represented by 4 species each. Other families such as Clariidae, Cyprinidae, Citharinidae and Mockokidaee were represented by two species. About six families identified recorded just one species of fish; these were, Characidae, Malapteruridae, Gymnarchidae, Centropomidae, Lepidoserinidae and Osteoglosidae. The result of the ANOVA shows that little variation in fish abundance exists among the station A – D.

This is evident in the fact that most of the means representing the stations carry the same superscript. Station E, however stood out, dominating in all the species recorded. Where differences exist among the stations, they are either significant ($p<0.05$) or highly significant ($p<0.01$).

The fish composition of River Fete was similar to other small rivers in Nigeria. The number of fish species and families recorded in this study was higher than the records of [6] on Oyun Reservoir at the university of Ilorin main campus. The number was however lower than the record of [7] on Asa reservoir located on Asa river, which along with Ogun river forms part of the extensive river network system in Kwara state, Nigeria. The dominance by the family cichlidae is in line with what obtained in many Rivers and reservoirs in Nigeria [8,9,10,11]. The dominance of this family in terms of species diversity and number could be explained by the presence of large amount of phytoplankton and zooplankton which serve as food for them, their prolific breeding capabilities and their adaptation to lacustrine conditions of the river. The same reasons could also account for the high number of *Tilapia zilli* which was the predominant species in the river. Ita [12] reported the dominance of *T. zilli* in Eleyele reservoir, while Omotosho [6] and Balogun [11] revealed *Sarotherodon galilaeus* as the dominant fish in Ogun mini dam at the university of Ilorin and Kangimi reservoir in Kaduna respectively. Absence of effective predators to checkmate the prolific breeding ability of the family and its species might have also contributed to their high number. *T guntheri* which was the least abundant among the cichlids in the river was in disagreement with that of Omotosho [6] who recorded *Hemichromis faciatus* as the least abundant species among the cichlids in Ogun mini dam.

The family mochockideae also recorded high number of species most of which were obtained during the rainy season (Tables 3 and 4). This might be due to their diverse feeding habit [7], low predation and good spawning ground in the river for their breeding. *Heterotis niloticus* was the only species in the family osteoglossidae was the least abundant in river Fete. Araoye [7] has also listed the family as the least abundant in Asa reservoir. The reason for their low species diversity and abundance could be as a result of their low breeding rate and over exploitation of the species. The greatest threat to their existence could be extinction, thus the fish could be tagged a threatened species in the Fete River. This is more so when the catches of the family is declining yearly. *H niloticus* might become endangered species since it has only one species constituting the family. It is therefore imperative to gear conservative efforts to the species in order to preserve the species from becoming extinct with time. Lae [13] has listed the species among the endangered species and reported the declining and disappearance of the species from catches. Ita [12] have also reported the decline of *H. niloticus* from the river system of Nigeria and advocates for their conservation.

The family cyprinidae also recorded high number especially the dry season (Tables 5 and 6). This may not be far from their likeness for shallow waters. According to Balogun [11], Cyprinidae was found to have a preference for shallow water

bottom and was dominant in the shallow water bottom of kangimi reservoir. The population of *Barbus occidentialis* in the Fete River in particular could not be said to be high. In actual sense, the species could be described as threatened and could be included on the list of endangered species in the river. This is due to its declining population density according to catches, its rarity in the river as well as listing as one of the threatened fish species of the world [14].

The family claridae is among the most important and commercially fished. The two species of the family occurring in this river *C. gariepinus* and *C. anguilaris* are among the fishes highly sought after by fishermen. Overfishing of the species could be responsible for their fair abundance in the river. This occur as a result of the use of unregulated mesh size fishing nets which caught a lot of juveniles thereby hampering the growth of the species to adult size. The absence of high number of adult *Clarias sp* to check the prolific reproductive ability of the cichlids precludes a desirable population balance between carnivores and prey in the river. A similar scenario in the prey-carnivore relationship has been pointed out earlier by Omotosho [6] in Ogun mini dam. According to Swingle [15] a balance in population is one in which the ratio of forage to carnivorous (F/C) species ranges between 4:1 to 10:1, and believed that a ratio of between 3:1 and 6:1 as most desirable in balance range.

Table 1. Fish diversity of River Fete at the different sampling Stations

Fish Taxa	Sampling sites					P-Value
	A	B	C	D	E	
Mormyridae						
Mormyrus rume	10.33±1.24^{b}	8.00±1.09^{b}	11.25±1.61^{b}	12.17±1.55^{b}	16.83±1.84^{a}	<0.01
Petrocephalus bovei	7.25±1.33^{b}	7.25±1.93^{b}	8.83±1.29^{b}	10.25±1.07^{b}	15.33±1.19^{a}	<0.01
Mormyrops deliciousus	6.50±1.69^{c}	9.67±1.57^{bc}	8.66±0.73^{bc}	10.41±0.67^{ab}	14.08±1.52^{a}	<0.01
Gnathonemus cyprinoides	8.08±1.43^{b}	9.08±1.86^{b}	9.00±1.98^{b}	9.58±1.83^{b}	15.58±2.04^{a}	0.04
Cichlidae						
Hemichromis faciatus	22.58±2.95^{a}	14.83±3.11^{b}	17.42±2.55^{b}	18.75±2.19^{b}	30.00±4.27^{a}	<0.01
Hemichromis bimaculatus	21.33±3.66	17.58±3.62	21.92±3.29	20.75±2.79	31.25±3.39	0.05
Tilapia zilli	26.42±3.75^{b}	24.08±3.43^{b}	24.00±3.25^{b}	23.25±2.79^{b}	35.83±3.29^{a}	<0.01
Oreochromis niloticus	20.92±2.75^{b}	21.92±2.14^{b}	25.67±3.87^{b}	19.67±3.86^{b}	38.67±4.52^{a}	<0.01
Sarotherodon galilaeus	15.17±1.50^{b}	14.92±2.47^{b}	17.08±2.15^{b}	18.42±3.32^{b}	30.08±3.22^{a}	<0.01
Tilapia guntheri	14.33±2.13^{b}	20.00±1.73^{b}	13.83±1.80^{b}	18.08±1.99^{b}	27.33±3.44^{a}	<0.01
Clariidae						
Clarias gariepinus	15.75±1.99^{bc}	14.08±2.27^{c}	19.08±1.20^{bc}	20.75±2.41^{ab}	26.00±1.72^{a}	<0.01
Clarias anguillaris	18.92±1.87^{b}	19.33±1.93^{b}	18.17±1.72^{b}	19.00±1.91^{b}	28.50±1.48^{a}	<0.01
Bagridae						
Auchenoglanis biscutatus	13.00±2.34^{b}	16.75±2.02^{b}	17.58±1.42^{b}	18.50±2.32^{b}	26.17±2.00^{a}	<0.01
Bagrus docmac	11.42±1.76^{b}	11.42±1.69^{b}	13.33±1.64^{b}	13.00±2.64^{b}	21.75±2.18^{a}	<0.01
Bagrus bayad	10.50±1.71^{b}	11.17±1.59^{b}	9.92±1.61^{b}	12.92±2.07^{ab}	17.25±2.13^{a}	<0.01
Clarotes laticeps	7.08±1.35^{b}	10.25±1.86^{b}	9.50±1.53^{b}	10.33±1.32^{b}	17.25±2.22^{a}	<0.01
Cyprinidae						
Labeo senegalensis	4.00±1.26^{b}	5.50±1.78^{bc}	8.17±1.36^{bc}	9.92±2.19^{ab}	13.33±2.18^{a}	<0.01
Barbus occidentalis	5.75±1.85^{bc}	4.08±1.15^{c}	6.00±1.37^{bc}	9.67±1.79^{ab}	13.25±2.12^{a}	<0.01

Means on the same row with different superscript are statistically significant (p<0.05);
ns = not significant

Table 2. Fish diversity of River Fete at the different sampling Stations

Fish Taxa	Sampling sites					P-Value
	A	B	C	D	E	
Citharinidae						
Citharinus citharus	6.50±1.68^{b}	8.75±1.82^{ab}	7.83±1.95^{ab}	7.75±2.07^{ab}	13.42±2.48^{a}	0.04
Citharinus latus	7.25±2.09^{b}	8.42±2.68^{ab}	9.25±2.08^{ab}	10.75±2.50^{ab}	15.17±2.67^{a}	0.04
Mochokidae						
Synodontis schall	6.00±1.55^{b}	7.33±1.75^{b}	7.25±1.90^{b}	8.08±1.50^{b}	14.75±1.97^{a}	<0.01
Synodontis nigrita	9.00±1.78^{ab}	10.00±1.80^{ab}	7.16±0.83^{b}	9.00±1.69^{ab}	13.83±2.29^{a}	0.04
Characidae						
Alestes nurse	8.08±2.31^{b}	6.92±1.64^{b}	9.00±1.37^{b}	10.33±2.18^{ab}	15.17±1.97^{a}	0.03
Malapteruridae						
Malapterurus electricus	6.08±1.65^{b}	7.17±1.69^{ab}	7.67±1.73^{ab}	10.75±2.56^{ab}	13.08±2.97^{a}	0.04
Gymnarchidae						
Gymnarchus niloticus	8.50±2.31^{a}	7.67±2.41^{a}	7.33±2.12^{a}	7.92±2.44^{a}	11.08±2.90^{a}	0.82^{ns}
Centropomidae						
Lates niloticus	5.08±1.73^{b}	5.83±1.90^{b}	6.58±2.18^{b}	8.00±2.54^{ab}	10.08±3.12^{a}	0.04
Lepidosirenidae						
Protopterus annectans	6.33±2.06^{a}	5.83±2.28^{a}	6.17±2.37^{a}	6.92±1.91^{a}	9.75±3.01^{a}	0.73^{ns}
Osteoglossidae						
Heterotis niloticus	5.00±2.23^{a}	4.33±1.90^{a}	4.58±2.09^{a}	3.58±1.64^{a}	5.83±2.52^{a}	0.95^{ns}

Means on the same row with different superscript are statistically significant (p<0.05); ns = not significant

Table 3. Fish diversity indices of River Fete, Benue State, Nigeria

Fish Taxa	Biodiversity indices				
	Shannon-Weiner H	Simpson 1-D	Berger-Parker D	Margalef	Species Richness
Mormyridae					
Mormyrus rume	3.96	0.98	0.04	8.85	59.00
Petrocephalus bovei	3.92	0.98	0.04	8.94	58.00
Mormyrops deliciousus	3.95	0.98	0.04	8.93	58.00
Gnathonemus cyprinoides	3.47	0.97	0.04	5.45	35.00
Cichlidae					
Hemichromis faciatus	3.94	0.98	0.05	8.28	60.00
Hemichromis bimaculatus	2.95	0.94	0.07	3.37	20.00
Tilapia zilli	4.09	0.98	0.03	7.99	60.00
Oreochromis niloticus	3.96	0.98	0.05	8.05	60.00
Sarotherodon galilaeus	3.95	0.98	0.05	8.37	60.00
Tilapia guntheri	3.99	0.98	0.05	8.40	60.00
Clariidae					
Clarias gariepinus	3.84	0.98	0.03	8.28	60.00
Clarias anguillaris	3.86	0.98	0.03	8.37	60.00
Bagridae					
Auchenoglanis biscutatus	3.99	0.98	0.04	8.42	60.00
Bagrus docmac	3.92	0.98	0.04	8.45	58.00
Bagrus bayad	3.93	0.98	0.04	8.78	59.00
Clarotes laticeps	3.91	0.98	0.05	8.95	59.00
Cyprinidae					
Labeo senegalensis	3.72	0.97	0.06	7.91	50.00
Barbus occidentalis	3.72	0.97	0.07	8.14	51.00

The fish assemblages of rivers Fete could be described as diverse. The fish families and the species transcend all the ecological habitats and feeding structures, with herbivores species being more abundant in the river which could be traced to the preponderance of algae. Melack [16] had hypothesized that herbivorous fish are more numerous in eutrotrophic waters and that a shorter food chain leads to higher efficiency in energy transfer in the food chain. The fish composition is typical of fish assemblages of shallow rivers. The result of the fish composition and abundance in this river will help in understanding the reactions of the fishes to alteration in living conditions such as pollution and environmental changes in the river. It will

make monitoring changes and shifts in species composition and abundance easier to quantify as there is now a reference baseline data. This result could be of help in devising efficient sampling and harvesting techniques and methods for more productive fishery. It will also help in monitoring the river water quality and improve it through biomanipulation. Though the river is productive better and efficient management of the fisheries will greatly improve its productive capacity.

Table 4. Fish species diversity of River Fete

Fish Taxa	Biodiversity indices				
	Shannon-Weiner H	Simpson 1-D	Berger-Parker D	Margalef	Species Richness
Citharinidae					
Citharinus citharus	3.76	0.97	0.06	8.29	53.00
Citharinus latus	3.73	0.97	0.06	7.80	51.00
Mochokidae					
Synodontis schall	3.78	0.98	0.05	8.31	53.00
Synodontis nigrita	3.90	0.98	0.05	9.10	59.00
Characidae					
Alestes nurse	3.78	0.98	0.04	7.99	52.00
Malapteruridae					
Malapterurus electricus	3.61	0.97	0.05	6.20	40.00
Gymnarchidae					
Gymnarchus niloticus	3.89	0.98	0.07	8.75	57.00
Centropomidae					
Lates niloticus	3.33	0.96	0.05	4.78	30.00
Lepidosirenidae					
Protopterus annectans	3.29	0.96	0.06	4.82	30.00
Osteoglossidae					
Heterotis niloticus	4.04	0.98	0.04	5.92	60.00

Table 5. Seasonal variation in fish abundance of River Fete, Benue State, Nigeria

Water quality parameter	Season		df	T-Value	P-Value
	Dry	Wet			
Mormyridae					
M. rume	8.96±0.92	13.68±0.97	57	-3.51	<0.01**
P. bovei	9.44±0.98	10.03±1.02	56	-0.42	0.67
M. deliciousus	7.92±0.90	11.25±0.85	55	-2.69	<0.01**
G. cyprinoides	7.00±0.96	12.60±1.18	57	-3.67	<0.01**
Cichlidae					
H. faciatus	25.60±2.07	17.23±1.92	54	2.97	<0.01**
H. bimaculatus	27.24±2.41	19.23±1.91	56	1.58	<0.01**
T. zilli	31.72±2.28	23.14±1.92	51	2.88	<0.01**
O. niloticus	27.84±2.56	23.60±2.41	54	1.20	0.23
S. galilaeus	24.32±2.30	15.43±1.33	39	3.35	<0.01**
T. guntheri	23.32±2.18	15.42±0.99	33	3.29	<0.01**
Clariidae					
C. gariepinus	17.84±1.49	20.06±1.36	54	-1.10	0.27
C. anguillaris	18.08±1.29	22.71±1.44	54	-2.63	0.01*
Bagridae					
A. biscutatus	15.92±1.38	20.17±1.44	57	-2.13	0.03*
B. docmac	14.92±1.38	13.66±1.43	56	0.64	0.52
B. bayad	15.80±0.99	9.89±1.14	57	3.91	<0.01**
C. laticeps	12.56±1.34	9.69±1.07	50	1.67	0.10
Cyprinidae					
L. senegalensis	9.28±1.48	7.40±1.09	47	1.02	0.31
B. occidentalis	6.40±1.01	8.71±1.25	57	-1.44	0.15

** indicates statistical significance at 0.05%; ** indicates statistical significance at 0.01%*

Table 6. Seasonal variation in fish abundance of River Fete, Benue State, Nigeria

Water quality parameter	Season		Df	T-Value	P-Value
	Dry	Wet			
Citharinidae					
Citharinus citharus	6.00±0.92	10.89±1.35	55	-2.99	<0.01**
Citharinus latus	8.52±1.68	11.34±1.45	52	-1.27	0.20
Mochokidae					
Synodontis schall	8.20±1.30	9.03±1.14	53	-0.48	0.63
Synodontis nigrita	7.48±0.68	11.46±1.23	51	-2.83	<0.01**
Characidae					
Alestes nurse	9.04±1.14	10.51±1.34	57	-0.84	0.40
Malapteruridae					
Malapterurus electricus	12.56±1.02	6.37±1.41	56	3.55	<0.01**
Gymnarchidae					
Gymnarchus niloticus	15.24±1.12	3.69±1.07	55	7.46	<0.01**
Centropomidae					
Lates niloticus	14.48±1.10	1.85±0.81	47	9.26	<0.01**
Lepidosirenidae					
Protopterus annectans	13.52±1.16	2.00±0.94	50	7.72	<0.01**
Osteoglossidae					
Heterotis niloticus	8.20±1.51	2.14±0.92	41	3.41	<0.01**

** indicates statistical significance at 0.05%; ** indicates statistical significance at 0.01%*

3.2 Seasonal Abundance of Fish Species

The seasonal abundance of fish species in the river could be attributed to a number of factors which include food availability, hydrological regime of the river, changes in physico-chemical conditions of the water and intensity of fishing activities. Ryder [17], Hoyer et al. [18] stressed that fish yield and standing crops respectively are a function of overall lake trophic status. Omotosho [6] reported that fluctuations in number observed in yearly composition of individual species is a phenomenon common to artificial reservoirs as a result of ecological changes from original lotic water body to a lacustrine environment.

The relative abundance of fish most especially those that were caught all year round irrespective of season could be due to the success of the fishes within the river. This might have been possible as a result of their high reproductive rate, high species diversity, and low predation, ability to adapt to lacustrine conditions and eat varieties of food and the availability of the food itself. The decrease noticed in seasonal abundance in population of the fish species might have been caused by fluctuation in water levels (flood regime), high rate of predation inefficiency in gill net operations, and other processes that naturally occur in rivers such as decomposition, and nutrient leaching.

4. CONCLUSION

The high productivity of the river coupled with its shallowness allowed vast assemblages and diverse species of fish to flourish in it. In order to achieve the river's maximum sustainable yield (MSY), proper and sound management based on sufficient limnological information and data to make meaningful predictive models should be undertaken. In spite of the diverse and vast assemblages of the fish species in the river, conservation efforts through numerous means need to be geared towards some declining or threatened fish species such as Heterotis niloticus in the river. This will prevent the extinction of the species and improve the fisheries of the river.

This study highlighted the need for stakeholders to be on the watch for harmful practices which may be detrimental to the fish population. The Fete River dynamics shows seasonality in its hydrology, productivity and periodicity with high water volume, plankton productivity and fish yield in the rainy season. Further understanding of this dynamics will allow the development of better ways of monitoring and managing the river and its fisheries of which the presence study has provided a base line data that was nonexistent for the river prior to this study.

Lastly, River Fete is a shallow, eutrophic and natural river with short water residence time.

Because of its shallow nature, it is subjected to rapid fluctuations in water level. These fluctuations could negatively impact on the fisheries of the river as well as its primary productivity. The influence of morphometrics and hydrological changes in river ecosystem with respect to carrying capacity for fish production has been discussed by Schiemer et al. [19]. The short water residence time becomes more critical to the river biodiversity during the dry season when water volume is at its lowest. This time corresponds to the time when so much pressure is exerted on the river through various means such as intense fishing, municipal uses of the water by the locals, excessive water withdrawal for domestic supply and other human activities.

5. RECOMMENDATIONS

Fish stock assessment should be a factor to be measured regularly. This will help in determining the reaction to the alteration in living conditions and track changes in species composition and abundance. The result of this research will form the framework for assessing further changes in the limnological and biotic parameters of River Fete.

In order to ensure high fish production and enable the river to reach or even surpass its maximum sustainable yield, stocking of river friendly species of fish should be done. Stocking of the river with fingerlings of indigenous species to enhance productivity has been emphasized in small reservoirs and lakes in Nigeria by Ita (1993). Information from the regular limnological data will aid in the stocking of the species based on the river productivity gradient.

Enforcement of strict regulations to control fishing efforts will help in obtaining high fish production in the river. This could be done by preventing over exploitation of stocks which often lead to declining stocks and extermination of species, limit the amount and type of years to be used as well as total catch. Catch and release system should be encouraged especially for threatened species. Closed areas and closed seasons should be defined and operated on the river. This will help in the conservation of species while licensing of fishermen should be done to regulate fishing activities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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