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► **To cite this version:**

Mathias Bwala. Impact of Irrigational Runoff on Fish Biodiversity in River Ngadda, Maiduguri – Borno State. Nigerian Journal of Pure and Applied Sciences, 2021, pp.3981 - 3988. 10.48198/njpas/20.b04 . hal-03265205

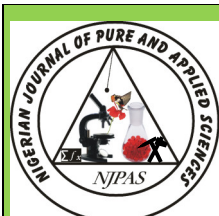
HAL Id: hal-03265205

<https://hal.science/hal-03265205v1>

Submitted on 19 Jun 2021

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<http://dx.doi.org/10.48198/NJPAS/20.B04>

IMPACT OF IRRIGATIONAL RUNOFF ON FISH BIODIVERSITY IN RIVER NGADDA, MAIDUGURI – BORNO STATE

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ABSTRACT

Irrigation is a dry season agricultural activity that was known to man for centuries. Agricultural runoff has been identified as the major nonpoint sources of pollution into surface waterbodies which changes the physico – chemical parameters thereby impacting on the biodiversity of such ecosystem. River Ngadda receives pollutants from the irrigational sites along the river bank. The study was aimed at assessing the impact of irrigation on fish biodiversity in river Ngadda, Maiduguri, Borno State, Nigeria. The objectives of the study were to determine the physico – chemical parameters and examine the fish biodiversity of the river. The river was divided into 4 sampling Stations. Water samples was collected biweekly for the period of 6 months from 4 sampling stations. The physico – chemical qualities (total nitrogen (TN), ammonium (NH_4^+), total phosphorus (TP), total organic carbon (TOC), total dissolved solids (TDS), turbidity (Tur) and total suspended solids (TSS) were determined using standard methods. Capture and recapture method was employed to determine the relative abundance of fish species using Lincoln index. The mean Total Nitrogen (TN) ranges from 5.02 mg/L – 8.31mg/L, mean ammonium (NH_4^+) ranges from 0.93mg/L – 2.01, mean Total phosphorous (TP) ranges from 0.07mg/L – 1.81mg/L. mean Total Organic Carbon (TOC) ranges 5.87mg/L – 7.45mg/L, mean Turbidity (Tur) ranges from 27mg/L – 31mg/L, mean Total Dissolved Solids (TDS) ranges 198NTU – 298NTU, mean Total Suspended Solids ranges from 34mg/L – 47mg/L and mean surface water Temperature ranges from 26°C – 28°C. A total of 4 families and 10 species of fishes were identified in the sampling stations.

Keywords: Non-Point Pollution, Irrigation, River Ngadda

Introduction

Irrigation is a dry season agricultural farming practice that was known to man for centuries. Irrigation as an agricultural practice involves the controlled supply of water needed by crops for their growth and survival. Generally, agricultural runoff as being identified as the major nonpoint sources of pollution into surface waterbodies which changes the physico – chemical parameters

of such aquatic environment thereby affecting the biodiversity inhabiting that particular aquatic environment (Verma and Agarwal, 2008; Shunsuke *et al*, 2009; Harris, 2012). Irrigational runoff drill into streams, rivers and lakes along with diluted chemicals, such as pesticides and fertilizers deteriorating the water quality, impacting on the aquatic ecosystem via influencing

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the abundance and distribution of the aquatic bio – resource, (Verma and Agarwal 2008; Govind, 2012; Bwala, 2019).

Land use and physico – chemical characteristics of soil as been identified as key factors in regulating the quantity and quality of runoff in a site (Ron, 2012; Syed, 2011; Luke and Fleming, 2010; Verma and Agarwal, 2008).

The insurgency in North eastern, Nigeria and particularly Borno State with an estimated one third of its population displaced. The State capital, Maiduguri became the major city of refuge to the displaced individuals (<https://www.unicef.org/nigeria>). The town has witnessed a rapid change in population, land use and economic activities resulting in intense irrigational activities along the bank of river Ngadda.

Pollution from the various activities which takes place along the river bank such as irrigation farming, urban development and land pollution (indiscriminate solid waste disposal) may result in water quality deterioration, changing the physico – chemical parameters of aquatic ecosystem. This dynamism may disrupt the aquatic ecosystem, leading to migration, reduction or increase in productivity, booming in some species and resulting to death in others (Syed, 2011; Akan *et al*, 2013).

The study was aimed at assessing the impact of irrigational activities on fish biodiversity in river Ngadda, Maiduguri, Borno State, Nigeria.

Materials and Methods

Study Area

Maiduguri is the capital and the largest city in Borno State, Nigeria. It is located on latitude 11° 51' 42''N and longitude 013° 09' 35E and lies within the northern Sudan Savannah with distinct dry and wet (rainy) seasons. The town has an annual mean temperature of 37°C. The town has two (2) main river systems (Nggadabul and Nggada Rivers) which met and continue to flow as River Ngadda; both rivers are freshwater bodies which are

remarkable for their circular shape (Bukar *et al*, 2016; Bwala, 2019).

Water from the river is used for irrigation, human consumption, domestic purposes and various industrial activities and the river receives runoff from the irrigated sites and effluent from Maiduguri Water Treatment plant, abattoir and dyeing industries located beside the river bank. This calls for systematic environmental monitoring to ensure the safety and health of the aquatic environment, (Adeniyi and Yusuf, 2007; Haruna and Anthony, 2011; Syed, 2011).

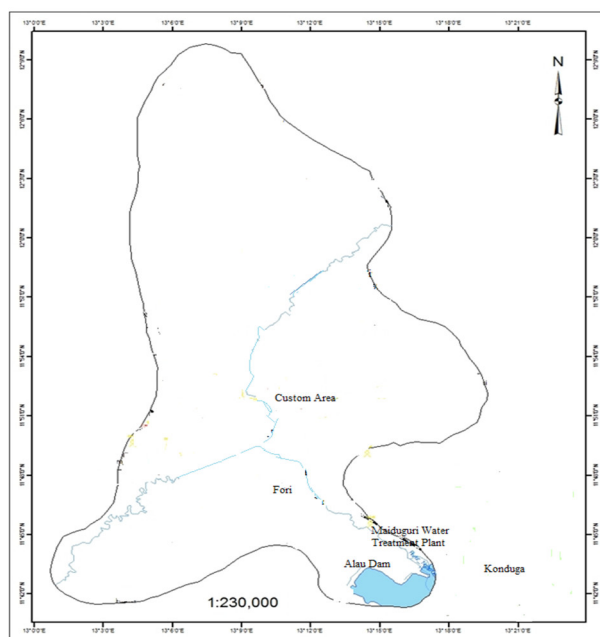


Fig 1: Map of Maiduguri Metropolis showing the sampling Stations. (Sharah, 2020)

Sampling

The river was divided into 4 different stations based on the irrigational activities along the bank of the river. A handheld Global Positioning System (GPS) device (GPSMAP 76CX) was used to obtain coordinates on all the sampling stations.

Table 1: Sampling Stations

S/N	STATION	LOCATION	GPS COORDINATE	ACTIVITIES /REMARK
1	A	Up Stream Close to Alau Dam	N11° 44' 11.8'' E013° 11' 38.0''	✓ Non-Irrigated Site.
2	B	Beside Water Treatment Plant	N11° 47' 28.1'' E013° 11' 33.8''	✓ Irrigation sites ✓ Topography: Sloppy
3	C	Fori ward	N11° 48' 10.2'' E013° 10' 18.9''	✓ Domestic uses ✓ Irrigation sites ✓ Topography: Sloppy
4	D	Custom Area	N11° 51' 29.8'' E013° 11' 01.0''	✓ Irrigation sites ✓ Topography: flat ✓ Wastewater from abattoir

Drainage Flow Monitoring

During irrigation events, pumping machine was used to irrigate the farmlands and some return to the river again as surface irrigation runoff with observable minor rill erosion. At Sampling Stations B - D a monitoring station was established at the edge of the rill erosion at the entering point to the river.

Determination of Physico – chemical parameters

Samples for determination of physico – chemical parameters were taken at the sampling stations from the point where the pumping machine was used to drain water and a representative sample from the monitoring station. Water surface temperature was determined using mercury thermometer at the sampling stations. Water samples were collected for analysis of total nitrogen (TN), ammonium (NH₄⁺), total phosphorus (TP), total organic carbon (TOC), total dissolved solids (TDS), turbidity (Tur) and total suspended solids (TSS). A composite auto – sampler was installed at each sampling station to collect samples at intervals (biweekly) during irrigation seasons (November, 2018 – April, 2019). Samples collected were transported in ice to the

laboratory for further water quality analysis by standard methods (APHA 2005); (Usman *et al*, 2016; Gwana *et al*, 2017) with slight modification.

Table 2: NESREA permissible limits of some physico – chemical parameters for fisheries and recreation quality criteria standards

S/N	Physico – chemical parameter	Fisheries and recreation quality criteria standards
1	NH ₄ ⁺	0.05 (mg/L)
2	TSS	0.25 (mg/L)
3	TDS	18 (NTU)
4	Turbidity	15 (mg/L)
5	Temperature	≤40 (°C)

Source: NESREA, 2011

Determination of Fish Relative Abundance

Capture and recapture method was employed to determine the relative abundance of fish. A representative sample was preserved with 40% alcohol and transported to the laboratory for species identification (Portt *et al.*, 2016). The Lincoln Index was used to estimate the fish population size.

Population =

$$\frac{\text{Total number of fish in 1st Sample} \times \text{Total number of fish in 2nd sample}}{\text{Number of marked fish in 2nd sample}}$$

(FSC, 2016)

Results and Discussion

The results of the study were presented in tables below and shows that most of the parameters measured were above the national permissible limits as set by the National Environmental Standards and Regulations Enforcement Agency (NESREA).

Table 3 presents the mean physico – chemical parameters of river Ngadda. The results indicates that Total Nitrogen (TN) ranges from 5.02 mg/L – 8.31mg/L, ammonium (NH₄⁺) ranges from

0.93mg/L – 2.01, Total phosphorous (TP) ranges from 0.07mg/L – 1.81mg/L. Total Organic Carbon (TOC) ranges 5.87mg/L – 7.45mg/L, Turbidity (Tur) ranges from 27mg/L – 31mg/L, Total Dissolved Solids (TDS) ranges 198NTU – 298NTU, Total Suspended Solids ranges from 34mg/L – 47mg/L and Temperature ranges from 26°C – 28°C.

It can be seen from Table 3 that Sampling Station A been an unirrigated zone has the lowest NH₄⁺ (0.93mg/L), TP (0.07mg/L) and TSS (34mg/L). Station B is a sloppy irrigated zone with observable rill erosion as a result of surface runoff and has the highest TN (8.31mg/L), NH₄⁺ (2.01mg/L), TP (1.81mg/L), TOC (7.45mg/L), TSS (47mg/L) and Temperature (28°C), it is worthy of note that this station also received a point source pollutant from Maiduguri Water Treatment Plant (sludge discharge) coupled with nonpoint source pollutant from the densely irrigated sites along the river bank affects the water chemistry, this agrees with (Akan *et al*, 2013; Gwana *et al*, 2017; Bwala, 2019).

Sampling Station C, has the highest mean turbidity (31mg/L) with a relatively high TN (5.87mg/L), TOC (6.69mg/L) was sloppy irrigated zone similarly, Sampling Station D was a flat irrigated zone which recorded the highest TDS 298NTU and receive wastewater from Maiduguri abattoir. The values of NH₄⁺, TDS and TSS are all above NESREA limit in all sampling stations (NESREA, 2011).

Table 4 presents the relative abundance of fish biodiversity in river Nggada. The results revealed a total of four (4) different families and ten (10) distinct species of fishes were identified in the sampling stations.

From Table 4, it can be seen that Station A has the highest relative abundance of fish (115.3), with the highest relative abundance of class *Cichlidae* (38.7), *Characidae mochokidae* (28.4) and surprisingly zero (0) presence of class *Cyprinidae osteoglossidae*. It was an unirrigated zone, with less

anthropogenic activities and interference having the less mean TSS (34mg/L), TP (0.07mg/L) and NH₄⁺ (0.93mg/L) which may have favoured the growth and development of the fish species in the sampling (Portt *et al*, 2006; Harris, 2012). *Tillapia zillii* (73.7), *Alestes nurse* (81.2) and *Clarias gariepinus* (20.2) are the most abundant species, this agrees with Akan *et al*, (2013); Mshelia *et al*, (2015); Gwana *et al*, (2017).

Similarly, Table 4 revealed that Sampling Station D has the lowest relative abundance of fish species (34) using the Lincoln index, with relatively high abundance of class *Cyprinidae osteoglossidae* (4). The sampling station apart from being a flat irrigated land also receives point source pollutants (effluent) from the Maiduguri abattoir and has the highest TDS 298NTU and relatively high TSS (41mg/L), Tur (39mg/L), TP (1.01mg/L) and surface water Temp. (27°C) which may have adversely affected the abundance and distribution of fish species in the sampling station.

It can also be noted from the Tables 3 and 4 accordingly, that Sampling Station B, has a total relative abundance of fish species (86.9) using the Lincoln index, with zero (0) presence of *Heterotis niloticus species in the class Cyprinidae osteoglossidae*. The station has the highest TN (8.31mg/L), NH₄⁺ (2.01mg/L), TP (1.81mg/L), TOC (7.45mg/L), TSS (47mg/L) and Temperature (28°C), and receives a point source pollutant from Maiduguri Water Treatment Plant (sludge discharge) and also its bank is densely irrigated which may have charge the station with nonpoint source pollutant, this agrees with (Akan *et al*, 2013; Gwana *et al*, 2017; Bwala, 2019). This suggests that the class *Cichlidae* (28.1) and *Characidae mochokidae* (27.4) are tolerant species, while the class *Claridae* (4.2) and *Cyprinidae osteoglossidae* (2) as indicator species.

It can be seen from the results that Sampling Station D, has the highest TDS (298 NTU) and relatively high TSS (41 mg/L) and Tur (29 mg/L), and the lowest relative abundance of fish species (34) using

the Lincoln index. This suggest that the physico – chemical parameters may have effect on the fish abundance and distribution. There might have been some dissolve metals that might have inhibited the growth and survival of the fish species, impacting adversely on their abundance and distribution in the sampling station. The abundance and distribution of

fish species is impacted by the dynamism of the physico – chemical characteristic of the river, as the data is slightly lower than the findings of Mshelia *et al.*, 2015 and Gwamna *et al.*, 2017.

Table 3: Mean Physico – chemical parameters of the Sampling Stations

Stations	TN (mg/L)	NH ₄ ⁺ (mg/L)	TP (mg/L)	TOC (mg/L)	Tur (mg/L)	TDS (NTU)	TSS (mg/L)	Temperature (°C)
A	5.12	0.93	0.07	5.87	29	203	34	27
B	8.31	2.01	1.81	7.45	27	238	47	28
C	5.87	1.09	0.92	6.69	31	198	35	26
D	5.02	1.72	1.01	5.98	29	298	41	27
NESREA Standards	-	0.05	-	-	15	18	0.25	≤40

Table 4: Relative Abundance of Fish (*Lincoln Index*)

S/N	FAMILY	A	B	C	D	TOTAL
A	<i>CICHLIDAE</i>					
1	<i>Tillipia zillii</i>	34.6	25.1	12	2	73.7
2	<i>Oreochromis niloticus</i>	2.1	2	0	0	4.1
3	<i>Himechromis bimaculatus</i>	2	1	1	0	4
Total		38.7	28.1	13	2	
B	<i>CLARIDAE</i>					
4	<i>Clarias gariepinus</i>	12	2	5.2	1	20.2
5	<i>Clarias ngularis</i>	4.2	3.2	18.6	4	30
Total		14.2	4.2	23.8	5	
C	<i>CYPRINIDAE OSTEOGLOSSIDAE</i>					
6	<i>Labeo senegalensis</i>	0	2	2.1	2	6.1
7	<i>Heterotis niloticus</i>	0	0	3	2	5
Total		0	2	5.1	4	
D	<i>CHARACIDAE MOCHOKIDAE</i>					
8	<i>Synodontis nigrita</i>	1.2	2	3.1	0	6.3
9	<i>Synodontis eupterus</i>	2	2.4	4.1	1	9.5
10	<i>Alestes nurse</i>	25.2	23	21	12	81.2
Total		28.4	27.4	28.2	13	
E	<i>OTHER FAMILY</i>					
11	<i>Other Species</i>	32	24.2	23	10	89.2
GRAND TOTAL		115.3	86.9	93.1	34	329.3

Conclusions

The irrigational runoffs into river Ngadda is an emerging ecological concern with the sky rocking irrigational activities along the river bank. The Physico – chemical parameters of the river are slightly above NESREA permissible limited, which calls the need for systematic monitoring of this aquatic ecosystem.

The findings indicate that the classes *Cichlidae* and *Characidae Mochokidae* are less disturbed and more tolerant to the changing physico – chemical parameters and has such can be consider as “tolerant species” in river Ngadda as against *claridae*) and *Cyprinidae osteoglossidae* which are more affected by the aquatic environmental dynamism and can be said to be the “Indicators species” of river Ngadda.

Acknowledgement

I will like to appreciate the staff and management of NESREA Borno for granting me the permission to use some of its facilities and acknowledge Mr. Charles Joshua Sarah (NESREA, Borno State Coordinator) for ensuring the quality of this study. I wish to also acknowledge NAFDAC, Maiduguri for subsidizing the cost of analysis and other logistics.

Competing interests

Authors have declared that no competing interests exist.

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