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Full Length Research Paper

Impact of Nonpoint Source Pollutant Loadings From Irrigation Sites on River Ngadda, Maiduguri – Borno State

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The study was aimed at examining the impact of nonpoint source pollutant loadings from irrigation sites on the physico – chemical water quality and biodiversity of river Ngadda, Maiduguri, Borno State, Nigeria. Water samples was collected biweekly for the period of six months from four sampling stations. The physico – chemical qualities (total nitrogen (TN), ammonium ($NH4^+$), total phosphorus (TP), total organic carbon (TOC), total dissolved solids (TDS), turbidity (Tur) and total suspended solids (TSS)) were determined using standard methods described by APHA, (2005); Gwamna et al, (2017) with slight modification. A 40µm mesh size standard plankton net was used to filter 20l (4L x 5) of kicked and grabbed sample of water for phytoplankton examination which was preserved with 4% formalin and transported to the laboratory for determination of phytoplankton using drop and count method with the aid of key. Capture and recapture method was employed to determined the relative abundance of fish species using Lincoln index. 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 26^0C – 28^0C. A total of seven (7) classes and sixteen (16) species of phytoplankton were identified in all the four (4) different sampling stations. A total of four (4) families and ten (10) species of fishes were identified in the sampling stations. The study revealed that irrigation runoff adversely impact fish community of river Ngadda, hence the need for period monitoring to ensure the safety and health standard of this aquatic ecosystem.

Keywords: Non-Point Pollution, Irrigation, River Ngadda

I. INTRODUCTION

Agricultural runoffs as a whole is one of the major nonpoint sources of pollution into surface waterbodies causing the deterioration of water quality and affecting the aquatic biodiversity, (Verma and Agarwal, 2008; Shunsuke *et al*, 2009; Harris, 2012). The nonpoint pollution from irrigational sites involves runoff water into streams, rivers and lakes together with chemicals, such as pesticides and fertilizers which changes the physico – chemical parameters of such aquatic environment thereby influencing the abundance and distribution of the aquatic bio – resource, (Bwala, 2019; Govind, 2012; Verma and Agarwal 2008)

Surface runoff is a hydrological process at the origin of phenomena such as soil erosion, floods out of rivers, mudflows, debris flows and can cause major damage, (Lilly-Rose *et al*, 2016; Harris,2012; Verma and Agarwal 2008; Ingjerd *et al*, 2006). Runoff is the movement of water and with any contaminants on soil surface which occurs when irrigation, rain or snow melt adds water to a surface faster than it can percolate into the soil (Lilly-Rose *et al*, 2016; Luke and Fleming, 2010; Shunsuke *et al*, 2009; Ingjerd *et al*, 2006).

Soil characteristic such as soil moisture content, soil texture, topography (slope or grade of the site) and vegetation cover affect rates and durations of runoff, (Ron, 2012). Land use and physico – chemical characteristics of a site influences the quantity and quality of runoff of that site (Ron, 2012; Syed, 2011; Luke and Fleming, 2010; Verma and Agarwal 2008).

The insurgency in North eastern, Nigeria and particularly Borno State has displaced more than one million persons and Maiduguri, the Borno State capital being a major city of refuge to the displaced individuals with over six (6) major Internally Displaced Person's (IDP) camps has witnessed a rapid change in population, land use and economic activities resulting intense irrigational activities along the bank of river Ngadda.

Various activities which takes place along the river bank such as farming, fishing, forestry, construction, urban development and land pollution (indiscriminate solid waste disposal) may result to water quality problems, adversely changing the physico – chemical parameters of aquatic ecosystem and this dynamism may disrupt the aquatic bio resource, leading to migration, reduction in productivity and subsequently death (Syed, 2011; Akan *et al*, 2013)

This paper is aimed at examining the impact of the intense irrigational activities on the physico – chemical parameters of River Ngadda and its biodiversity.

II. Study Area

Maiduguri is the capital and the largest city in Borno State, Nigeria which is located on latitude 11^0 51' 42''N and longitude 013^0 09'' 35E and lies within the northern Sudan Savannah with a distinct dry and wet (rainy) seasons. The town has an annual mean temperature of 37^{0}C. The town has two (2) main river systems (Nggadabul and Nggada Rivers) which met and continues to flow as River Nggada; 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 which 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).

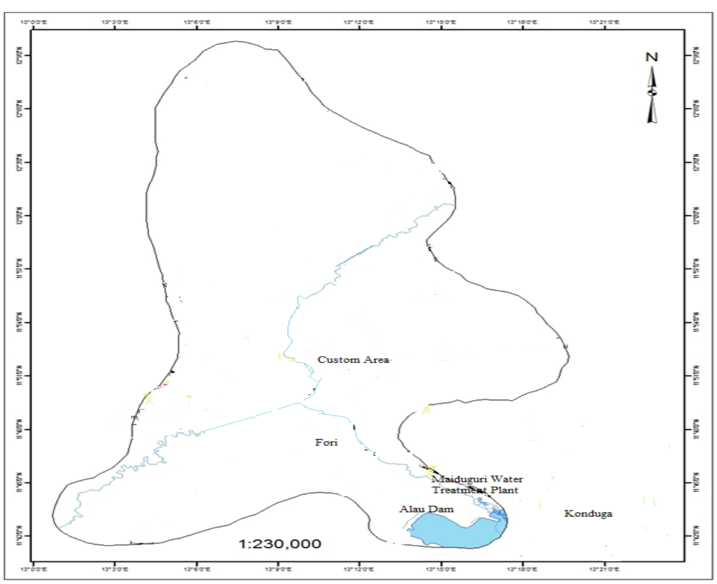

Figure 1: Map of Maiduguri Metropolis showing the sampling Stations
Source: Sharah, (2020)

III. SAMPLING

The river was sampled into four (4) different stations based on the irrigational activities along the bank of the river.

Table 1.1 Sampling Stations

S/N	STATION	LOCATION	GPS COORDINATE	ACTIVITIES/REMARK
4	**A**	Up Stream Close to Alau Dam	N11^0 44' 11.8'' E013^0 11' 38.0''	✓ Non-Irrigated Site.
1	**B**	Beside Water Treatment Plant	N11^0 47' 28.1'' E013^0 11' 33.8''	✓ Irrigation sites ✓ Topography: Sloppy
2	**C**	Fori ward	N11^0 48' 10.2'' E013^0 10' 18.9''	✓ Domestic uses ✓ Irrigation sites ✓ Topography: Sloppy
3	**D**	Custom Area	N11^0 51' 29.8'' E013^0 11' 01.0''	✓ Irrigation sites ✓ Topography: flat ✓ Wastewater from abattoir

IV. EXPERIMENTATION

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 Station B - D a monitoring station was established at the edge of the rill erosion at the entering point to the river.

Water Quality Assessment

Samples for water quality assessment 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.

Determination of Phytoplankton Relative Abundance

Water sample for the phytoplankton were collected at each sampling station using kick and then grab sampling techniques. Kick Sampling technique involves stirring a body of water which creates disturbance to the benthos periphyton community, thereby making them to come-up to the surface for easy collection with grab sample collection technique.

A 40µm mesh size standard plankton net was used to filter 20l (4L x 5) of the grab sample, and then filled into air tight 120ml well labeled sampling bottles at each station and preserved with 4% formalin within two (2) minutes of collection and then taken to the laboratory for analyses using the drop-count method with microscope and plankton identification manual and keys, (NIO, 2004).

Relative abundance (%Ra) was determined using the formula

$$\%\text{Ra} = \frac{n(100)}{N}$$

, cited in (George et al, 2012).

Where **n** = total number of plankton under consideration

N = total number of all the species of the plankton group

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

Cited in FSC, (2016)

V. Result and Discussion

Mean Physico – chemical parameters

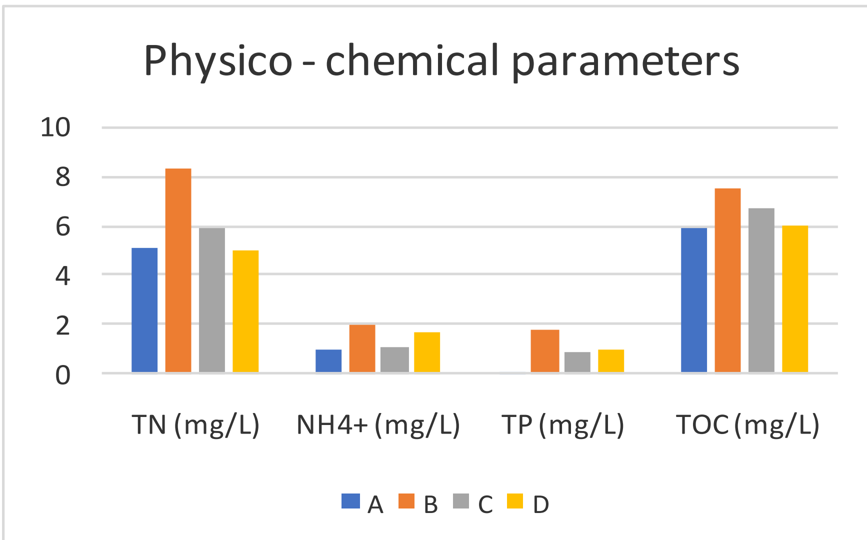

Figure 1: Physico – Chemical Parameters (TN, NH4+, TP and TOC) of the sampling Stations

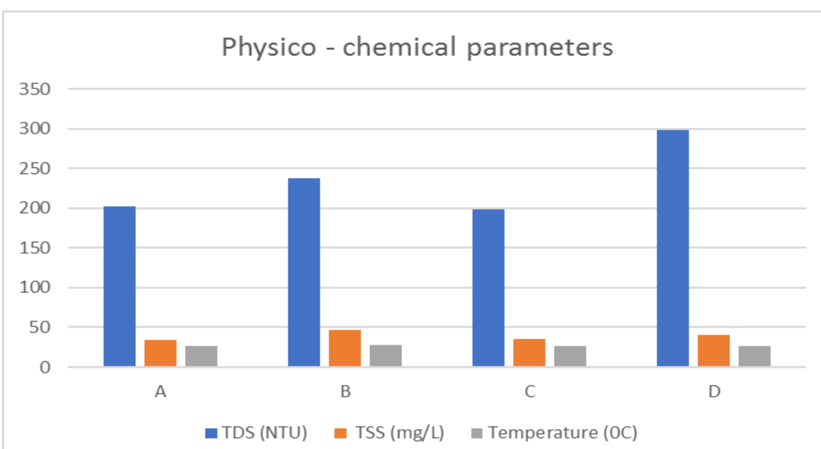

Figure 2: Physico – Chemical Parameters (TDS, TSS and Temp.) of the Sampling Stations

Table 2: Mean Physico – chemical parameters

Station	TN (mg/L)	$NH4^+$ (mg/L)	TP (mg/L)	TOC (mg/L)	Tur (mg/L)	TDS (NTU)	TSS (mg/L)	Temperature (^{0}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

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^{0}C – 28^{0}C.

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^{0}C), it is worthy of note that this station is also receive 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 (Bwala, 2019; Gwana *et al*, 2017; Akan *et al*, 2013).

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 while Sampling Station D was a flat irrigated zone which recorded the highest TDS 298NTU and receive wastewater from Maiduguri abattoir. The values are slightly above NESREA permissible limits, (NESREA, 2011)

Table 3: Distribution of Phytoplankton

S/N	CLASS	A	B	C	D	TOTAL
A	**CHLOROPHYCEAE**					
1	*Pteromonas*	1	5	2	1	9
2	*Ankistrodemus*	-	-	2	1	3
3	*Batryococcus*	7	3	5	-	15
4	*Spirogyra*	19	29	24	17	89
5	*Ulothrix*	-	1	1	4	6
6	*Microspora*	-	11	-	1	12
7	*Cladophora*	-	-	-	4	4
	TOTAL	**27**	**49**	**34**	**28**	**138**
B	**CRYPTOPHYCEAE**					
8	*Crytomonas*	7	9	1	3	20
	TOTAL	**7**	**9**	**1**	**3**	**20**
C	**CHRYSOPHYCEAE**					
9	*Synura*	-	1	1	1	3
10	*Uroglena*	1	-	1	21	23
	TOTAL	**1**	**1**	**2**	**22**	**26**
D	**CYANOPHYCEAE**					
11	*Chroococcus*	14	6	-	1	21
	TOTAL	**14**	**6**	**0**	**1**	**21**

Table 3: Continue						
E	**EUGLENOPHYCEAE**					
12	*Euglena*	11	13	15	2	41
13	*Phacus*	7	12	-	9	28
	TOTAL	**18**	**25**	**15**	**11**	**69**
F	**RHODOPHYCEAE**					
14	*Asterocytis*	7	11	7	10	35
	TOTAL	**7**	**11**	**7**	**10**	**35**
G	**BACILLARIOPHYCEAE**					
15	*Melosira*	6	9	-	-	15
16	*Pinnularia*	-	-	1	3	4
	TOTAL	**6**	**9**	**1**	**3**	**19**

Table 3 above revealed a total of seven (7) classes and sixteen (16) species of phytoplankton which were identified in all the four (4) different sampling stations.

Table 4: %Ra of class of phytoplankton

S/N	***CLASS***	***A***	***B***	***C***	***D***	***TOTAL***
A	**CHLOROPHYCEAE**	19.6	35.5	24.6	20.3	**100**
B	**CRYPTOPHYCEAE**	35.0	45.0	5.0	15.0	**100**
C	**CHRYSOPHYCEAE**	3.85	3.85	7.7	84.6	**100**
D	**CYANOPHYCEAE**	66.6	28.6	0	4.8	**100**
E	**EUGLENOPHYCEAE**	26.1	36.2	21.7	16	**100**
F	**RHODOPHYCEAE**	20	31.4	20	28.6	**100**
G	**BACILLARIOPHYCEAE**	31.6	47.3	5.3	15.8	**100**
	TOTAL	**24.7**	**34.1**	**18.6**	**22.6**	**100**

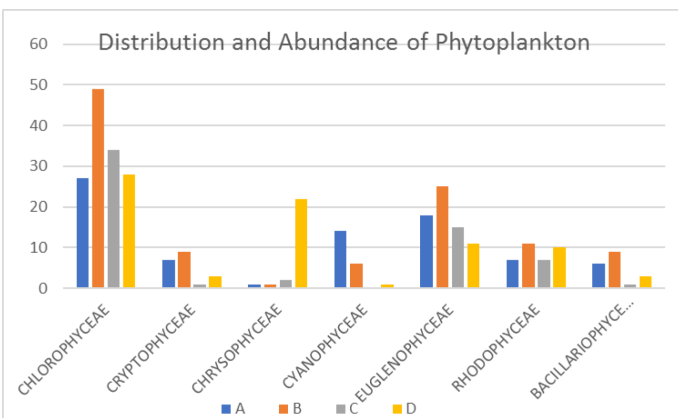

Figure 3: Distribution and Abundance of Phytoplanton

Table 4 and Figure 3 revealed that Sampling Station A recorded the highest relative abundance of class *Cyanophyceae* (66.6%), Sampling Station B has the highest relative abundance of *Chlorophyceae* (35.5%), *Cryptophyceae* (45.0%), *Euglenophyceae* (36.2%), *Rhodophyceae* (31.4%) and *Bacillariophyceae* (47.3%). This suggests that the irrigation runoff and physico – chemical characteristics of Station B favours the abundance and distribution of phytoplankton (George *et al*, 2012) as 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 (28^0C).

Surprisingly, sampling station C, recorded the lowest relative abundance of phytoplankton (18.6%) although it has the highest mean turbidity (31mg/L) with a relatively high TN (5.87mg/L), TOC (6.69mg/L) and also a sloppy heavily irrigated zone. This can be attributed to turbidity as it does not favour phytoplankton due to the fact adversely affect light penetration.

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

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

Table 4 revealed a total of four (4) families and ten (10) species of fishes identified in the sampling stations.

Station A has the highest relative abundance of fish (115.3) and it was an unirrigated zone, less disturbed with anthropogenic activities and interference which may have favour the growth and development of the fish species in the sampling (Portt *et al*, 2006; Harris, 2012). *Tillipia zillli* (73.7), *Alestes nurse* (81.2) and *Clarias gariepinus* (20.2) are the most abundant species this agrees with Gwana *et al*, (2017); Mshelia *et al*, (2015); Akan *et al*, (2013). Table 3:3 suggest that irrigation runoff adversely impact fish community of river NgaddaSampling Station D although being a flat irrigated land, receives point source pollutants (effluent) from abattoir has the highest TDS 298NTU which may have adversely affected the abundance and distribution of fish species with only 34 fish recorded using the Lincoln index.

The abundance and distribution of fish species is adversely impacted with the changing physico – chemical characteristic of the river, as the data is slightly lower than the findings of

Mshelia *et al*, 2015; Gwamna *et al*, 2017. This suggests that fish population and community composition is gradually reducing over the years.

VI. Conclusion

Nonpoint source pollutants loadings into river Ngadda is an emerging environmental issue of concern with the increasing irrigational activities along the river bank. The Physico – chemical characteristic of the river is slightly above NESREA permissible limited, (NESREA, 2011) which slightly effects the phytoplankton and fish community hence the need to monitor this aquatic ecosystem periodically.

ABBREVIATIONS

NESREA: National Environmental Standards and regulations Enforcement Agency
NAFDAC: National Agency for Food and Drug Administration Control
TN: Total Nitrogen
TP: Total Phosphorus
TOC: Total Organic Carbon
TDS: Total Dissolved Solids
Tur: Turbidity
TSS: Total Suspended Solids
IDP Internally Displaced Persons

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