



# EFFECT OF IRRIGATIONAL ACTIVITIES ON WATER QUALITY OF RIVER NGADDA, MAIDUGURI – NIGERIA.

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## Abstract

*The study aimed at assessing the effect of irrigational activities on water quality of river Ngadda, Maiduguri, Borno State, Nigeria. Samples for the water quality analysis were collected biweekly for eleven months period from three sampling stations. The water qualities parameters Total Dissolved Solids (TDS), Dissolved Oxygen (DO), potential Hydrogenii (pH), phosphate, nitrate, zinc, iron and copper concentrations were analyzed using standard method in the laboratory. Temperature was measured in-situ using mercury thermometer. The mean temperature ranges from 21 – 21.2 °C during irrigational regime and 22.2 – 23 °C during non – irrigational periods, phosphate concentration ranges from 0.54 – 0.64 mg/L during irrigational regime and 0.40 – 0.45 mg/L during non – irrigational periods, nitrate concentration ranges from 0.87 – 0.90 mg/L during irrigational regime and 0.73 – 0.81 mg/L during non – irrigational periods, TDS ranges from 238.5 – 243.3 NTU during irrigational regime and 224.6 – 244.2 NTU during non – irrigational periods. The DO values for both irrigational and non – irrigational period ranges from 15.2 – 19.4 mg/L. The mean Iron concentration ranges from 0.12 – 0.21 ppm during irrigational regime and 0.31 – 0.41 ppm during non – irrigational periods. The study revealed that the irrigational activities was a seasonal potential threat to river’s water quality although there were other constant non – seasonal potential threats like effluent from Maiduguri Water Treatment Plant, Maiduguri Abattoir house, dyeing industries e.t.c. Temperature, phosphate concentration, TDS, DO, pH, zinc concentration and copper concentrations were all within the national permissible limits set by National Environmental Standards and Regulations Enforcement Agency (NESREA) whereas nitrate and iron concentrations were slightly above the set national limits. The continuous environmental compliance monitoring and enforcement outreaches by NESREA, Borno State Field Office, Maiduguri to polluters (facilities polluting the river) is gradually paying off as the concentration of phosphate, nitrate, TDS and DO reveal a great improvement from the values of previous studies.*

**Keywords:** *Non-Point Pollution, Irrigation, River Ngadda, Runoff, Water Quality*

## 1. Introduction

Human Population is believed to increase at a geometric ratio against the arithmetic ratio of agricultural production. The need to meet agricultural production target, feed the ever-increasing population and ensure food security has made government, cooperate bodies and individuals to intensify agricultural production employing strategies such as irrigational agriculture (Verma and Agarwal, 2008).

Irrigational agriculture though seems to solve the challenges of shortages of perishable agricultural products and ensuring food security, while its challenges include from soil erosion, waterlogging, increase in salinity, contamination of the underground water and surface water through infiltration and runoffs. Runoffs from irrigational sites into surface water bodies may be diluted with chemicals, such as pesticides, fertilizers and sewage used in irrigational farms in developing nations like Nigeria, these can affect the water quality of the river (Bwala, 2019; Govind, 2012; Verma and Agarwal, 2008).



The movement of water with or without contaminants on soil surface occurs when water is added to soil surface more than it can percolate into the soil (Lilly-Rose *et al*, 2016; Luke and Fleming, 2010; Shunsuke *et al*, 2009; Ingjerd *et al*, 2006). The physical characteristic of soil such as moisture content, texture, topography and vegetation cover can influence the rates and durations of runoff, (Ron, 2012).

The insurgency in Northeastern, Nigeria and particularly Borno State has displaced more than one million persons, merging multiple communities in Maiduguri, mounting pressure on land, food and shelter. Over the years there is an observe increase in irrigational farming along the bank of river Ngadda which may result to water quality deterioration. Altering the environmental parameters of the aquatic ecosystem (River Ngadda) may disrupt the aquatic bio – resource, leading to migration, reduction in productivity and subsequently death of some of the aquatic organisms inhabiting the river (Syed, 2011; Akan *et al*, 2013). Irrigational activities along the bank of the river is a seasonal activity unlike the continuous industrial and domestics activities releasing effluents into the river such as sludge from the Maiduguri Water Treatment Plant, effluent from Maiduguri Abattoir house and local dyeing industries and also solid waste dumping along the river bank. Among the many activities that may pollutes the river, impacting on the water quality, only irrigational activity is seasonal and as such it's easier to isolate the impact of the irrigational activities from other non – seasonal activities since they are always active and impacting on the water quality continuously (Syed, 2011; Bwala, 2016).

## 2. Materials and Methods

### 2.1 Study Area

Maiduguri is the capital of Borno State, Nigeria, which lies on latitude  $11^{\circ} 51' 42''$ N and longitude  $013^{\circ} 09' 35$ E and located within the northern Sudan Savannah with a distinct dry and wet (rainy) season. The town has an annual mean temperature of  $37^{\circ}$ C and two (2) main river systems (Nggadabul and Nggada Rivers) which met and continue to flow as River Ngadda in a circular pattern around the city as shown in **Fig 1** (Bukar *et al*, 2016; Bwala, 2019). Water from the river is used for domestic, industrials and agricultural (irrigation) activities. The river receives runoff from the irrigational farmlands during irrigational activities and constantly (during both irrigational and non – irrigational periods) receive effluent from the Maiduguri Water Treatment Plant, Maiduguri Abattoir House and dyeing industries located beside the river bank. The immigration of people into the city as a result of the Boko Haram crisis has mounted pressure on the land use along the bank of river, increasing the number of irrigational farmlands which may subsequently pollute the river through runoffs from the irrigational sites. (Adeniyi and Yusuf, 2007; Haruna and Anthony, 2011 Syed, 2011). The irrigational activities along the bank of the river accelerates and became intensified from 2014 as the result of increase in the demand of perishable crops caused by the demographic changed witnessed as the result of the insurgents taking over about 14 of the 27 local governments in Borno State with over one million Internally Displaced Person's (IDP), Maiduguri has about six (6) major IDP camp (Noorah, 2016; John *et al*, 2015; Kajidu *et al*, 2015).

#### 2.1.1 Sampling

The river was divided into three (3) different sampling stations based on the irrigational activities along the bank of the river as shown in **Table I**.

### 2.2 Methodology

#### 2.2.1 Water Quality Assessment

Samples for water quality assessment were collected at the three (3) sampling stations during both irrigational and non – irrigational activities. Surface water temperature was determined using mercury thermometer at the sampling stations. Water samples were collected for phosphate, nitrate, Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and potentia Hydrogenii (pH), Zinc (Zn), Copper (Cu) and Iron (Fe) biweekly for eleven (11) months period



covering both irrigational (November, 2018 – April, 2019) and non – irrigational (September – October, 2018 and May – July, 2019) periods. Samples collected were transported in ice to the laboratory for further water quality analysis by standard methods (APHA 2005); (Usman et al, 2016; Noorah, 2016; Gwana et al, 2017) with slight modification.

Temperature ( $^{\circ}\text{C}$ ) was measured using mercury thermometer in-situ, while Dissolved Oxygen (mg/L) using Winkler's titration method, Total Dissolved Solids (NTU), phosphate (mg/L) and nitrate (mg/L) were analyzed using Agilent Tech. (4210 MPAES), pH was also determined using pH Mettler Toledo. Furthermore Zn (ppm), Cu (ppm), Fe (ppm), were also analyzed using Atomic Absorption Spectrometer (AAS) using standard method of Water analysis by APHA, (2005) at National Agency for Food and Drug Administration Control (NAFDAC), Maiduguri laboratory.

### 3. Result and Discussion

The result of the study was shown in **Figure 2** and **Table II**.

#### 3.1 Temperature ( $^{\circ}\text{C}$ )

The mean temperature ranges from 21 – 21.2  $^{\circ}\text{C}$  during irrigational regime and 22.2 – 23  $^{\circ}\text{C}$  during non – irrigational periods as indicated in **Table II**. The temperature is within the national permissible limit has set by the National Environmental Standards and Regulations Enforcement Agency (NESREA). Atmospheric (air) temperature of the area may have effect on the surface water temperature of the river (Livingstone and Lotter, 1998). Surface water temperature of any aquatic ecosystem is influenced by the complex heat budget. Traditionally, it is has been argued that ambient air temperature directly influences the surface water temperature, in a recent model formulated by Piccolroaz, *et al.*, (2013), incorporated other variables like water density, seasonal variation and depth of the river in determining and influencing the surface water temperature of an aquatic environment. In view of all that has been mentioned so far, one may suppose that the temperature of the river to be high during the irrigational period as the atmospheric temperature of the area is high (34 – 44  $^{\circ}\text{C}$ ) but since other variables such as the depth of the river, rate of flow etc. may also plays role in influencing the surface water temperature, the river recorded high temperature values during non – irrigational regimes.

Another interesting reason might be the formation of a micro-climate as the result of vegetation (irrigated crops) near the river bank. A published result by Ali *et al.*, (2014) indicates that in the periods before the acceleration and the intensification of irrigational activities along the river bank, temperature during the dry season (irrigational period) were high in Lagos bridge which is near Sampling Station B and in Gwange Bridge near Sampling Station A. The irrigated crops might have formed a micro-climate within the study period resulting in the decreased temperature during the study period.

#### 3.2 Phosphate (mg/L)

**Table II** shows the mean phosphate concentrations for both irrigational and non – irrigational regimes in the sample stations. The phosphate concentration ranges from 0.54 – 0.64 mg/L during irrigational regime and 0.40 – 0.45 mg/L during non – irrigational periods. The concentration of phosphate is within NESREA permissible limits in all the sampling stations, although the level of concentrations was high during the irrigational period (0.64, 0.58 and 0.54 mg/L respectively) in all the three (3) sample stations. The increase in phosphate concentration during the irrigational regime maybe attributed to irrigational runoff in to the river and reduced water level due high rate of evaporation in the period (Bukar *et al.*, 2016, Govind, 2012; Verma and Agarwal 2008).

Deborah *et al.*, (2017) work on the same parameter in sampling Station A, in January, March and May, 2013 and revealed that the mean phosphate concentration was high during the irrigational regime, although there weren't much irrigational activities in the periods of their study. Similarly, Ali *et al.*, (2014) studied same parameter in Sampling Station B and C from the periods of April, 2012 – March, 2013 as and revealed that the mean phosphate concentration was high during the irrigational regime, although also there weren't much irrigational activities in their study periods. The results from both studies were higher than this current study and even more surprising as there were not much irrigational activities in their study periods. This suggest that the environmental compliance



monitoring and enforcement outreach by the personnel of NESREA is gradually paying off as though there was increased in phosphate concentration during Irrigational regime in the study period but it was lower than studies conducted prior to acceleration and intensification of irrigational activities along the bank of the river (Deborah *et al*, 2017; Ali *et al*, 2014)

### 3.3 Nitrate (mg/L)

The mean nitrate concentrations as revealed in **Table II**, ranges from 0.87 – 0.90 mg/L during irrigational regime and 0.73 – 0.81 mg/L during non – irrigational periods. The level of concentration of nitrate was above the national permissible limits (0.08 mg/L) set by NESREA in the two (2) different regimes. The level of concentration was higher during the irrigational (0.90, 0.87 and 0.87 mg/L respectively) than the non – irrigational (0.81, 0.75 and 0.73 respectively) periods in all the three (3) different sample stations. Irrigational runoffs containing dissolve nitrates compound in pesticides and fertilizers may have attributed to the increased in nitrate during the irrigational periods (Haruna and Anthony, 2011; Syed, 2011; Verma and Agarwal, 2008).

Interestingly, Deborah *et al*, (2017) study the same parameter in sampling Station A, in January, March and May, 2013 and their findings revealed that the mean nitrate concentration was higher than the current study during the irrigational regime, although there weren't much irrigational activities in their study periods. Similarly, Amos and Joshua, (2014) and Ali *et al*, (2014) studied the nitrate concentration in April, 2012 – March, 2013 in sampling station B and C and provided an insight into the water quality in respect to nitrate concentration before the increased in irrigational activities along the bank of the river and also before full compliance monitoring and enforcement outreaches by staff of NESREA to facilities polluting the river. Although the findings of the current study revealed that nitrate concentration were high across all the sampling stations during irrigational period but previous studies suggests much higher concentrations in years prior to the accelerated irrigation farming along the river bank (Deborah *et al*, 2017; Amos and Joshua, 2014; Ali *et al*, 2014), this further suggest that the continuous environmental compliance monitoring and environmental law enforcement campaigns by the NESREA Borno state field office is gradually reflecting on the water quality though there is need to still monitor the irrigational activities along the river bank as nitrate concentration was high during the period.

### 3.4 Total Dissolved Solids (NTU)

The result from **Table II** above shows the mean TDS values for both irrigational and non – irrigational periods in the three (3) sample stations. The mean TDS ranges from 238.5 – 243.3 NTU during irrigational regime and 224.6 – 244.2 NTU during non – irrigational periods. The values of the TDS were above the national permissible limit (150 NTU) as set by NESREA. TDS was high during the irrigational (239.3, 243.3 and 238.5 NTU respectively) than the non – irrigational (244.2, 227.0 and 224.6 NTU respectively). This can be due to surface runoffs from irrigational farmlands along the river bank and reduced volume of water in the period (Syed, 2011; Akan *et al*, 2013; Ingjerd *et al*, 2006).

Furthermore, previous studies by Ali *et al*, (2014) and Amos and Joshua, (2014) conducted in 2012 – 2013 and revealed a contradictory result in sampling station B and C before the acceleration and the intensification of irrigational activities along the river bank during dry season (irrigational period). The season for the sampling can be attributed as the cause of variation in the data of the two studies. This further suggests that irrigational activities along the river bank affect the TDS of the river.

### 3.5 Dissolved Oxygen (mg/L)

**Table II** above reveals the mean DO values for both irrigational (19.4, 18.8 and 18.6 mg/L respectively) and non – irrigational (15.2, 15.8 and 16.5 mg/L respectively) period in all the three (3) sample stations. The mean DO values were within the NESREA permissible limits (Minimum 4.0 mg/L). The mean DO values were low during irrigational (19.4, 18.8 and 18.6 mg/L respectively) period suggesting that there might be high oxygen utilization activities in the river during the period (Usman *et al*, 2016; Gwana *et al*, 2017; Causapé *et al.*, 2004).

Surprisingly, previous studies by Deborah *et al*, (2017) and Ali *et al*, (2014) indicates much lower DO in years prior to the intensification of irrigational activities along the river bank. This further suggests that there was an



improvement in the water quality over the years as a result of the continuous government monitoring the activities of polluters through the Federal Ministry of Environment (FMEnv) and its agent (NESREA).

### 3.6 *potentia Hydrogenii (pH)*

The mean pH values vary slightly in both the two regimes of the three (3) sample stations. Table II above shows the pH values for both irrigational (7.8, 7.7 and 7.8 respectively) and non – irrigational (7.6, 7.6 and 7.4 respectively) period. The mean pH of the aquatic ecosystem is within NESREA permissible limits (6.5 – 8.5). The pH value was high during the irrigational (7.8, 7.7 and 7.8 respectively) period, a possible explanation for this is that since nitrate, phosphate and other elements were high during the irrigational period, this might have affected the water chemistry of the aquatic environment by slightly increasing the pH values. Runoffs from irrigational sites and other chemical reactions in the water may be the reason why the pH values changed slightly during the irrigational periods (Lilly-Rose *et al*, 2016; Luke and Fleming, 2010; Shunsuke *et al*, 2009; Ingjerd *et al*, 2006).

The pH of the current study is consistent with those of Ali *et al*, (2014); and Amos and Joshua, (2014) who concluded that the river is alkaline, although Ali *et al*, (2014) reported a weak acidic water pH in Sampling C.

### 3.7 *Zinc (ppm)*

The mean concentration of zinc was within the national limit (5.0 ppm) as set by NESREA in both regimes of the three (3) sample stations. The mean zinc concentration during the irrigational (0.0, 0.1 and 2.9 ppm respectively) regime is lower than the non – irrigational (0.9, 0.6 and 2.9 ppm respectively), which suggest that irrigational activities have no or less impact on the aquatic ecosystem. (Ali *et al*, 2014; Harris, 2012; Haruna and Dami, 2011). Amos and Joshua, (2014) reported an increased in the mean zinc concentration of sampling station B and C during dry season when there were no much irrigational activities going on along the river bank. This suggests a general increased in the concentration of zinc in the river in all sampling stations except sampling station A (during irrigational period) although irrigational activities have little or no effect on the concentration. This result is difficult to explain, but it might be related to other underlying chemical factors capable of affecting the water chemistry.

### 3.8 *Copper (ppm)*

**Table II** above indicates the mean level of concentration of copper in the river. The concentration of copper was within the national limit (2.0 ppm) as set by NESREA in both regimes of the three (3) sample stations. The mean copper concentration in sample station A and C were high during the irrigational (0.21 and 0.22 ppm respectively) than the non – irrigational (0.20, and 0.21 ppm respectively), while it reverses in sample station B in which non – irrigational (0.31 ppm) was greater the irrigational (0.10 ppm) this suggest other activities along the river bank and in the river itself might have impacted on the copper concentration other than just the irrigational activities (Noorah; 2016; Ali *et al*, 2014; Harris, 2012; Govind, 2012; Haruna and Dami, 2011; Verma and Agarwal 2008).

Previous studies conducted by Amos and Joshua, (2014) revealed that copper concentration was high in sampling station B and C when there were no much irrigational activities along the river bank. This further suggests that irrigational activities have little or no effect on the copper concentration in the river.

### 3.9 *Iron (ppm)*

**Table II** above shows the mean Iron concentration for both irrigational and non – irrigational regimes in the sample stations. The mean Iron concentration ranges from 0.12 – 0.21 ppm during irrigational regime and 0.31 – 0.41 ppm during non – irrigational periods. The mean concentration of Iron is slightly above NESREA permissible limits (0.30 ppm) in all the sampling stations during non – irrigational period (0.34, 0.31 and 0.41 ppm respectively) in all the three (3) sample stations. The increase in zinc concentration during the non – irrigational regime is somewhat surprising and contrary to expectation although in aquatic ecosystem an array of factors plays together to influence the concentration and availability of an element, therefore the level of zinc concentration in the river may not be affected by the irrigational activities along the river bank (Bukar *et al*, 2016, Govind, 2012; Verma and Agarwal 2008).

Amos and Joshua, (2014) reported a much lower concentration of iron in sampling station B and C during the study period there were no much irrigational activities along the river bank, which may suggest that the irrigational activities might have impacted on the iron concentration but surprisingly, a contradictory result was unveiled in the current study, a situation that calls for further studies.

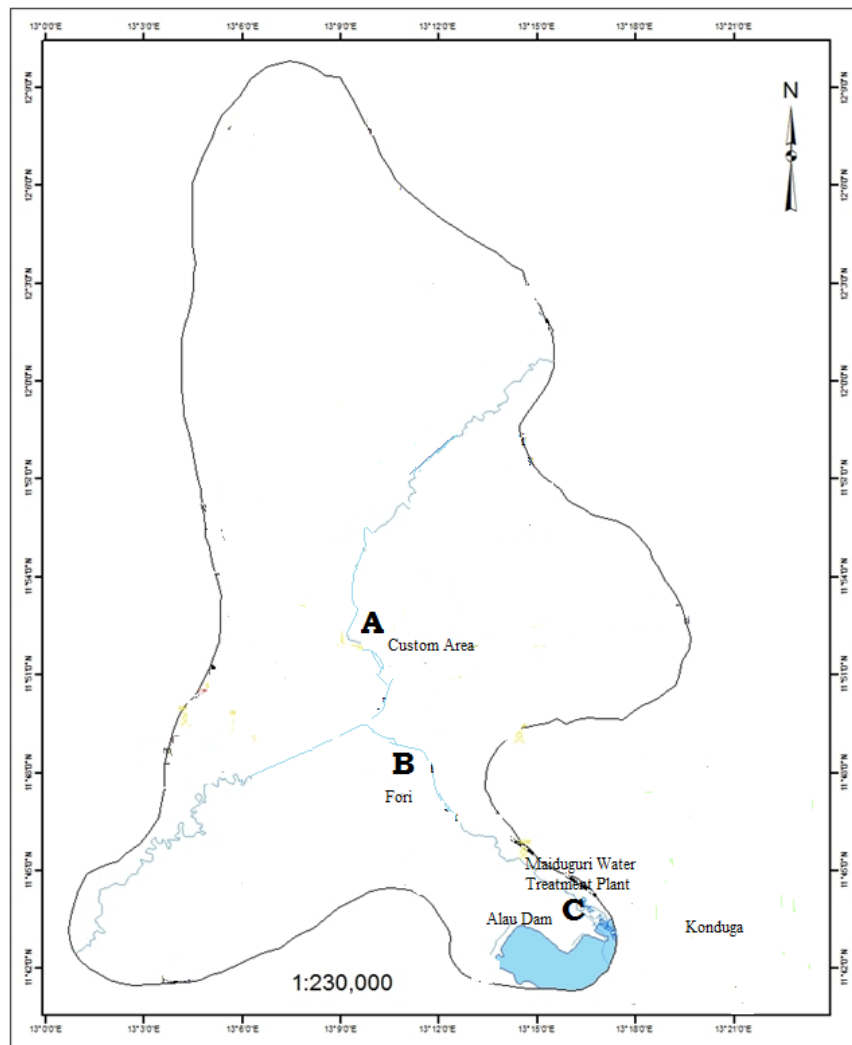
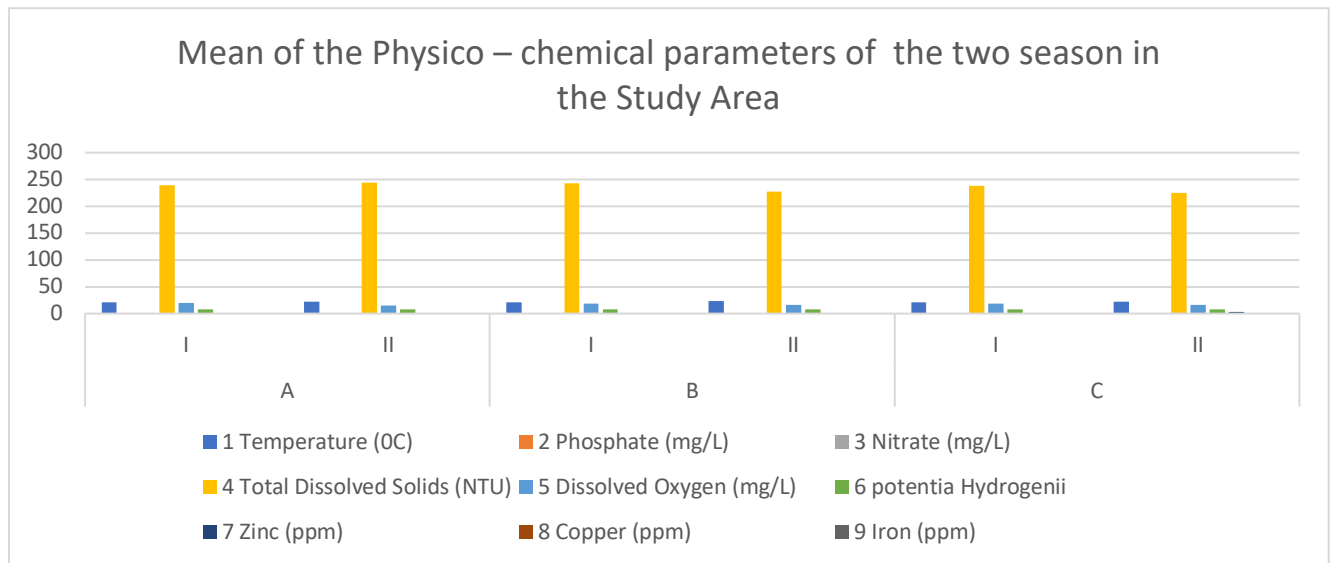


Figure 1: Map of Maiduguri Metropolis showing the sampling Stations (Source: Sharah, 2020)



**Figure 2:** Mean of the Physico – chemical parameters of River Nggada, Maiduguri – Borno State, Nigeria from the Months of September, 2018 – July, 2019

*I is the irrigational regime Nov., 2018 – Apr., 2019*

*II is the non-irrigational periods Sept. – Oct., 2018 and May – July, 2019*

**Table I:** The Sampling Stations from River Nggada, Maiduguri – Borno State, Nigeria as used in this study from the Months of September, 2018 – July, 2019

S/N	STATION	LOCATION	GPS COORDINATE
1	A	Custom Area	N11 <sup>o</sup> 51' 29.8'' E013 <sup>o</sup> 11' 01.0''
2	B	Fori ward	N11 <sup>o</sup> 48' 10.2'' E013 <sup>o</sup> 10' 18.9''
3	C	Beside Water Treatment Plant	N11 <sup>o</sup> 47' 28.1'' E013 <sup>o</sup> 11' 33.8''

**Table II:** Mean of the Physico – chemical parameters of River Nggada, Maiduguri – Borno State, Nigeria from the Months of September, 2018 – July, 2019 and NESREA permissible limits

S/N	Physico – chemical parameters/Stations	A		B		C		NESREA Limits
		I	II	I	II	I	II	
1	Temperature (°C)	21	22.4	21.2	23	21.2	22.2	≤ 40
2	Phosphate (mg/L)	0.64	0.45	0.58	0.42	0.54	0.40	3.5
3	Nitrate (mg/L)	0.90	0.81	0.87	0.75	0.87	0.73	0.08
4	Total Dissolved Solids (NTU)	239.3	244.2	243.3	227	238.5	224.6	150
5	Dissolved Oxygen (mg/L)	19.4	15.2	18.8	15.8	18.6	16.5	Min. 4.0
6	potential Hydrogenii	7.8	7.6	7.7	7.6	7.8	7.4	6.5 – 8.5
7	Zinc (ppm)	-	0.9	0.1	0.6	0.2	2.9	5.0
8	Copper (ppm)	0.21	0.20	0.10	0.31	0.22	0.21	2.0
9	Iron (ppm)	0.21	0.34	0.16	0.31	0.12	0.41	0.30

*I is the irrigational regime Nov., 2018 – Apr., 2019*

*II is the non-irrigational periods Sept. – Oct., 2018 and May – July, 2019*



#### 4. Conclusion

The purpose of this current study was to examine the impact of irrigational activities on water quality of river Ngadda.

The following conclusions can be drawn from this study

- I. The irrigational activities was a seasonal potential threat to river's water quality although there were other constant potential threats like effluent from Maiduguri Water Treatment Plant, Maiduguri Abattoir house, dyeing industries etc.
- II. The irrigational activities impact on the water quality of the river and parameters such as DO, TDS, phosphate and nitrate concentrations were higher during irrigational regimes.
- III. Temperature, phosphate concentration, TDS, DO, pH, zinc concentration and copper concentrations were all within the national permissible limits set by NESREA whereas nitrate and iron concentrations were slightly above the set national limits.
- IV. Temperature of the river reduces during the study period suggesting a formation of a micro-climate as the result of vegetation (irrigated crops) near the river bank
- V. The continuous environmental compliance monitoring and enforcement outreaches by NESREA Borno State Field Office, Maiduguri to polluters (facilities polluting the river) is gradually paying off as the concentration of phosphate, nitrate, TDS and DO revealed a great improvement from the values of previous studies.

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### Abbreviations

APHA:	American Public Health Association
DO:	Dissolved Oxygen
FMEnv:	Federal Ministry of Environment
IDP	Internally Displaced Persons
mg/L:	Milligram per liter
NAFDAC:	National Agency for Food and Drug Administration Control
NESREA:	National Environmental Standards and Regulations Enforcement Agency
NTU:	Nephelometric Turbidity Unit
pH:	potentia Hydrogenii
TDS:	Total Dissolved Solids