

## PAPER 108 – IMPACT OF FISH FARMING ON THE WATER QUALITY OF RIVER CHANCHAGA, MINNA

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### **ABSTRACT**

This study aimed to assess the impact of effluent discharge from aquaculture fish farm on the water quality of a nearby receiving River Chanchaga Minna (9° 35' 00" N, 6° 35' 00"E) in Niger State. Some physiochemical water quality parameters of the effluent receiving stream were determined at seven selected sites, above and below the effluent discharge point into the stream to assess the effluent impact on the water body. The water quality parameters investigated include (water temperature, true color, turbidity and transparency), chemical parameters (pH, conductivity, TDS, total alkalinity, total hardness, ammonia and DO), major ions (Ca<sup>2+</sup>, Mg<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup>), nutrient compound and heavy metals. Water samples were collected for: both rainy and dry season and analyzed in the laboratory using standard analytical methods. The effluent discharge from the investigated fish farm had a significant negative impact on the water quality of the receiving River and the indicator parameters comprised of ammonia, color and alkalinity.

**KEYWORDS:** Aquaculture, Water Quality, Nutrients, River, Wastewater, Environment.

## **1. INTRODUCTION**

### **1.1 Background of the Study**

Aquaculture plays an important role in the development of many national economies and a key role in the socio-economic resilience of rural areas, potentially offering valuable and skill-based employment opportunities and, in some cases, stabilizing the economic base of otherwise fragile communities (Edwards 1999; Muir 1999; Haylor and Bland 2001). Fish production is very important for many reasons. Fish is one of the most stable food items for man as it provides a rich source of essential protein for human consumption. carbohydrate diet, like in Africa (FAQ, 2005).

The common of discharge fish farming effluents among the local fish farmers in Nigeria are land disposal and dilution technique. Disposal effluent into a body of water or watercourses is known as disposal by dilution. There has been great concern about the level of safety of surface and underground waters, especially in developing countries (Nigeria) where there is an exponential increase in water pollution and an inefficient system of waste management. Hence, there is the need for continual research on the impact of pollution on aquatic. The toxic effects of fish pond effluents on surface water has been highlighted by Boyd (1990, 2001, 2003, 2005); Sticking, (2002); Omofunmi, (2014); Tucker and Robinson (1990), and Tomasso, (2002), that it produces offensive odour, impacts negatively on the aesthetic value of adjacent rivers. Characterization of fish farming effluents and quantification of their environmental impacts in aquaculture provides required information for effective waste management systems generation, collection, transportation, storage, treatment and ultimate disposal which are not currently coordinated in Nigeria. Almost all the fish farmers were not treating their effluents before discharging into the environment. Pond pisciculture affects the chemical composition of the water; depending on the season, species and size of fish stock (Boyd and Tucker 1998; Brune et al; 2003; Quant et al; 2009; Sidoruk, Assessing the impact of fish farming on the water quality of river Chanchaga. I. To determine the physico-chemical water quality parameters of the effluents receiving River. II. To determine the level of concentration of water quality parameters at each station of the river. III. To determine the causes of the environmental problem associated with flow through land-based fish farming facility

## **2. MATERIALS AND METHODS/METHODOLOGY/EXPERIMENTAL PROCEDURE**

## 2.1 DESCRIPTION OF THE STUDY AREA

The investigated water body is River Chanchaga is located at the southern part of Minna, Niger State capital, and lies between latitudes 9° 35' 00" N and longitudes 6° 35' 00" E. The study area is predominantly underlain by the pre-cambrian basement complex rocks. The climate of the area is characterized by two distinct seasons: rainy season (may- October) and dry season (Nov-April) and it is warm throughout the year with average monthly temperature in the range of 28°C and 35°C while the relative humidity is in the range of 85 and 95%.

River Chanchaga servers as a major natural water source upon which members of the riparian communities depend, domestic water supply and some socioeconomic activities.

## 2 SAMPLING PROGRAM

Water samples for analysis was collected four times from each sampling station comprising two times in the dry season an two times in the rainy season. Sampling at each station was carried out at a fixed time of the day from about 0800h to 1800 h of each sampling date. At each sampling station, water samples were taken just below the water surface using uncontaminated 2.5-L plastic bottles.

## 3 LABORATORY ANALYSIS

The analyses was carried out within the holding time of each parameter, according to applicable standard methods (APHA 1995, 1998; Golterman et al. 1978; Willis and Savory 1995) the impact was determined by comparing the water quality of the unimpacted stations (A-B) with that of the impacted stations (E&F) as well as by comparing the latter stations with reference water (Stations G) and the Nigerian Standard for Drinking Water Quality (NSDWQ) and WHO Adequate quality control and quality

## 4 RESULTS AND DISCUSSION

**Table 1. Mean values of water quality parameters of the investigated Chanchaga River compare**

Parameter	USS	EPP	EDP	ISS	RWB	ANOVA	
	(A-B)	(C)	(D)	(E&F)	(G)	F	P
<i>Channel characteristics</i>							
River channel depth (cm)	19.78 (±1.92)	NA	33.93 (±2.66)	28.4 (±2.29)	NA	30.91	1.37E-05***
River channel width (cm)	66.2 (±27.16)	NA	411.0 (±22.06)	298.68 (±25.73)	NA	38.62	2.96E-06***
<i>Hydro-physical</i>							
Water temp. (°C)	26.46 (±0.32)	30.0 (±1.04)	28.0 (±0.82)	28.04 (±0.35)	30.0 (±2.7)	8.088	1.95E-03***
True color (Pt.Co.mg/L)	9.99 (±7.02)	60.91 (±8.63)	59.96 (±9.23)	53.64 (±13.0)	0.0 (±0.0)	8.73	7.33E-03***
Turbidity (NTU)	18.89 (±2.80)	40.86 (±7.23)	38.75 (±8.9)	33.05 (±3.5)	10.2 (±3.5)	9.18	1.02E-03***
<i>General chemical</i>							
pH	6.58 (±0.22)	7.96 (±0.4)	7.10 (±0.2)	7.20 (±0.09)	6.40 (±0.1)	4.66	1.90E-02***

Conductivity ( $\mu\text{S}/\text{cm}$ )	76.11 ( $\pm 9.36$ )	74.65 ( $\pm 6.36$ )	84.85 ( $\pm 3.88$ )	87.41( $\pm 3$ .13)	19.80 ( $\pm 1.99$ )	13.49	1.07E-04***
TDS (mg/L)	45.48 ( $\pm 5.68$ )	48.1 ( $\pm 16.2$ 2)	50.32 ( $\pm 1.91$ )	51.79 ( $\pm 2.03$ )	11.66 ( $\pm 1.3$ )	12.78	1.5E-04***
Alkalinity (mg/L $\text{CaCO}_3$ )	24.85 ( $\pm 2.72$ )	78.1 ( $\pm 15.2$ 2)	62.1 ( $\pm 17.22$ )	58.43 ( $\pm 6.8$ )	31.1 ( $\pm 4.4$ )	12.19	2.01E-04***
Total hardness (mg/L $\text{CaCO}_3$ )	48.95 ( $\pm 5.14$ )	42.5 ( $\pm 3.07$ )	44.5 ( $\pm 4.07$ )	45.98 ( $\pm 4.4$ )	40.0	0.26	0.769
Ammonia, $\text{NH}_3$ (mg/L)	0.17 ( $\pm 0.05$ )	2.12 ( $\pm 0.45$ )	1.625 ( $\pm 0.375$ )	1.53 ( $\pm 0.40$ )	0.0 ( $\pm 0.0$ )	1.22	2.90E-03***
DO (mg/L)	5.43 ( $\pm 0.55$ )	2.38 ( $\pm 0.35$ )	3.38 ( $\pm 0.55$ )	4.1 ( $\pm 0.55$ )	5.5 ( $\pm 1.24$ )	1.60	0.22
<b>Major ions</b>							
$\text{Ca}^{2+}$ (mg/L)	7.67 ( $\pm 0.81$ )	5.28 ( $\pm 2.0$ )	6.38 ( $\pm 1.0$ )	8.50 ( $\pm 1.28$ )	2.8 ( $\pm 1.2$ )	3.908	3.34E-02**
$\text{Mg}^{2+}$ (mg/L)	2.44 ( $\pm 0.33$ )	0.96 ( $\pm 0.20$ )	1.48 ( $\pm 0.40$ )	2.29 ( $\pm 0.56$ )	1.24 ( $\pm 0.2$ )	1.007	0.380
$\text{Na}^+$ (mg/L)	5.25 ( $\pm 0.26$ )	6.86 ( $\pm 0.35$ )	6.61 ( $\pm 0.25$ )	6.50 ( $\pm 0.2$ )	3.10 ( $\pm 0.2$ )	33.74	7.92E-08***
$\text{K}^+$ (mg/L)	2.74 ( $\pm 0.26$ )	5.91 ( $\pm 0.24$ )	5.10 ( $\pm 0.22$ )	5.31 ( $\pm 0.21$ )	0.85 ( $\pm 0.06$ )	63.7	1.49E-10***
$\text{Cl}^-$ (mg/L)	5.54 ( $\pm 0.55$ )	8.02 ( $\pm 0.46$ )	7.03 ( $\pm 0.39$ )	6.88 ( $\pm 0.48$ )	1.7 ( $\pm 0.3$ )	14.07	8.06E-05***
$\text{SO}_4^{2-}$ (mg/L)	2.26 ( $\pm 0.38$ )	8.23 ( $\pm 1.23$ )	7.43 ( $\pm 1.53$ )	6.50 ( $\pm 1.03$ )	0.49 ( $\pm 0.32$ )	12.63	1.61E-04***
$\text{HCO}_3^-$ (mg/L)	29.9 ( $\pm 3.3$ )	82.43 ( $\pm 22.1$ 2)	74.52 ( $\pm 20.66$ )	70.1 ( $\pm 8.2$ )	37.37 ( $\pm 5.34$ )	12.14	2.07E-04***
<b>Nutrient compounds</b>							
$\text{NO}_3^-$ (mg/L)	1.57 ( $\pm 0.89$ )	4.5 ( $\pm 1.20$ )	3.5 ( $\pm 0.89$ )	1.63 ( $\pm 0.54$ )	0.0 ( $\pm 0.0$ )	0.023	0.095
$\text{NO}_2^-$ (MG/l)	0.09 ( $\pm 0.05$ )	1.36 ( $\pm 0.40$ )	0.26 ( $\pm 0.80$ )	0.13 ( $\pm 0.4$ )	0.0 ( $\pm 0.0$ )	0.309	0.584
$\text{PO}_4^{3-}$ (mg/L)	0.34 ( $\pm 0.14$ )	0.56 ( $\pm 0.81$ )	0.51 ( $\pm 0.29$ )	0.495 ( $\pm 0.14$ )	0.31 ( $\pm 0.26$ )	0.383	0.685
<b>Heavy metals</b>							
$\text{Hg}^{2+}$ (mg/L)	0.03 ( $\pm 0.006$ )	0.127 ( $\pm 0.01$ )	0.03 ( $\pm 0.006$ )	0.026 ( $\pm 0.002$ )	0.005 ( $\pm 0.005$ )	3.349	0.051

Mn <sup>2+</sup> (mg/L)	1.39 (±0.15)	2.55 (±0.19)	1.55 (±0.19)	1.59 (±0.09)	1.63 (±0.19)	0.830	0.448
Fe <sup>2+</sup> (mg/L)	1.87 (±0.13)	2.01 (±0.59)	2.12 (±0.49)	2.45 (±0.26)	2.39 (±0.30)	2.257	0.125
Cu <sup>2+</sup> (mg/L)	0.054 (±0.02)	0.032 (±0.04)	0.054 (±0.03)	0.067 (±0.02)	0.134 (±0.08)	1.384	0.269
Zn <sup>2+</sup> (mg/L)	0.147 (±0.09)	0.492 (±0.07)	0.292 (±0.21)	0.182 (±0.09)	0.178 (±0.084)	0.00	0.956

**Table 2. Mean values of water quality parameters of the investigated Chanchaga River compare with WHO and NSDWQ standard**

Parameter	USS	EPP	EDP	ISS	RWB	WHO	NSDWQ
	(A-B)	(C)	(D)	(E&F)	(G)		
Water temp (°c)	26.46	30.00	28.00	28.04	30.00	12-15	Ambient
True color (P6.CO.mg/L)	9.99	60.91	59.96	53.64	0.00	15	15
Turbidity (NTU)	18.89	40.86	38.75	33.05	10.20	5	5
Ph	6.58	7.96	7.10	7.20	6.40	6.5-8.5	6.5-8.5
Conductivity (HIS/CM)	76.11	74.65	84.85	87.41	19.80	400	1000
TDS (mg/L)	45.48	48.10	50.32	51.79	11.66	500	500
Alkalinity (mg/L cab D3)	24.85	78.10	62.10	58.43	31.10	300	-
Total hardness mg/L ca cd3	48.95	42.50	44.50	45.98	40.00	500	150
Ammonia, NH <sub>3</sub> (mg/L)	0.17	2.12	1.63	1.53	0.00	0.2	-
DO (mg/L)	5.43	2.38	3.38	4.10	5.50	6	5.0
Ca <sup>2+</sup> (mg/L)	7.67	5.28	6.38	8.50	2.80	75	75
Mg <sup>2+</sup> (mg/L)	2.44	0.96	1.48	2.29	1.24	30	20
Na <sup>2+</sup> (mg/L)	5.25	6.86	6.61	6.50	3.10	50	200
K <sup>+</sup> (mg/L)	2.74	5.91	5.10	5.31	0.85	20	-
CL <sup>-</sup> (mg/L)	5.54	8.82	7.03	6.88	1.7	200	250
SO <sub>4</sub> <sup>2-</sup> (mg/L)	2.26	8.23	7.43	6.50	0.49	250	100
HCO <sub>3</sub> <sup>-</sup> (mg/L)	29.9	82.43	74.52	70.1	37.37	125-250	-
NO <sub>3</sub> <sup>-</sup> (mg/L)	1.57	4.5	3.5	1.63	0.0	50	50
NO <sub>2</sub> <sup>-</sup> (mg/L)	0.09	1.36	0.26	0.13	0.0	50	0.2
PO <sub>4</sub> <sup>3-</sup> (mg/L)	0.34	0.56	0.51	0.495	0.31	0.5	0.5
Hg <sup>2+</sup> (mg/L)	0.03	0.27	0.03	0.026	0.005	0.001	0.001
Mn <sup>2+</sup> (mg/L)	1.39	2.55	1.55	1.59	1.63	0.1-0.5	0.2
Fe <sup>2+</sup> (mg/L)	1.87	2.01	2.12	2.45	2.39	0.1	0.3
Cu <sup>2+</sup> (mg/L)	0.05	0.032	0.05	0.07	0.13	1	1
Zn <sup>2+</sup> (mg/L)	0.15	0.492	0.29	0.18	0.18	5	3

**Keys**

USS: unimpacted sampling station EPP: effluent point from pond EDP: Effluent discharge point  
ISS: impacted sampling station RWB: reference water body WHO: world health organization  
NSDWQ: Nigeria's standard drinking water quality NA: not applicable

\*Significant;  $P < 0.05$

\*\*Highly significant;  $P < 0.01$

\*\*\*Very highly significant;  $P < 0.001$

**Table 3. ANOVA statistics of Seasonal variations in the water Quality parameters of Chanchaga River.**

Parameter	Dry season samples	Rainy season samples	ANOVA statistics	
	Mean $\pm$ SE	Mean $\pm$ SE	F	P
pH	6.53( $\pm$ 1.05)	7.64( $\pm$ 1.65)	10.43	0.015
TDS (mg/L)	36.15( $\pm$ 3.86)	50.56( $\pm$ 5.54)	4.55	0.043
Water temp. ( $^{\circ}$ c)	30.0( $\pm$ 3.24)	26.46( $\pm$ 2.41)	5.35	0.023
Turbidity (NTU)	18.34( $\pm$ 2.90)	29.09( $\pm$ 3.72)	5.188	0.031
Phosphate, PO <sub>4</sub> <sup>2-</sup> (mg/L)	0.72( $\pm$ 0.13)	0.08( $\pm$ 0.03)	22.79	6.1E-05***
Manganese, Mn <sup>2+</sup> (mg/L)	1.20( $\pm$ 0.09)	1.82( $\pm$ 0.06)	32.34	5.5E-06***
Iron, Fe <sup>2+</sup> (mg/L)	1.91( $\pm$ 0.18)	2.48( $\pm$ 0.18)	4.79	0.0379*
Dissolve Oxygen (mg/L)	5.43( $\pm$ 1.05)	3.38	8.56	0.035
Mercury, Hg <sup>2+</sup> (mg/L)	0.55( $\pm$ 0.17)	0.02( $\pm$ 0.003)	9.98	0.004**
Nitrate NO <sub>3</sub> (mg/L)	1.57( $\pm$ 0.12)	3.5( $\pm$ 1.62)	18.62	0.046
Ammonia (mg/L)	2.12( $\pm$ 0.15)	0.17( $\pm$ 0.45)	5.21	0.041
Alkalinity (mg/L calco3)	78.1( $\pm$ 15.32)	58.85( $\pm$ 12.3)	25.31	0.024

\* Significant;  $P < 0.05$

\*\*Highly significant;  $P < 0.01$  \*\*\*Very highly significant;  $P < 0.001$  SE-Std Error

#### 4 DISCUSSION

The results of the investigated physicochemical parameters in the sampling stations are presented in **Table 1 and 2** Generally most of the investigated parameters were of higher concentrations in the impacted section than in the unimpacted section, while the other parameters were higher in the unimpacted section than in the impacted section of the effluent receiving stream. Also a general pattern of progressive decrease in concentrations of investigated parameters (except DO, Cu<sup>2+</sup>, Fe<sup>2+</sup> and Mg<sup>2+</sup>) was observed from the point of effluent discharge (Station D) into the stream to the last impacted sampling station F. according to Chapman (1992), effluent discharge would be deemed to impact a stream if the concentration of a given physicochemical variable is higher in the effluent or just below its point of discharge and decreases significantly with increasing distance downstream.

#### 5. CONCLUSIONS

This study characterized some physico-chemical water quality parameters of the effluent receiving river chanchaga were determined at seven selected sites, above and below the effluent discharge point Table 1. The seven sampling stations comprised two stations (A-B) located upstream effluent discharge point (station D), effluent point from the ponds (Station C), two stations (E and F) located downstream of station D, while the seventh station (Station G) was a closed-by reference groundwater source.

The water quality parameter revealed the level of the mean concentrations of turbidity, true color,  $\text{NH}_3$ ,  $\text{PO}_4^{3-}$ ,  $\text{Mn}^{2+}$ ,  $\text{Fe}^{2+}$ , and  $\text{Hg}^{2+}$  were above the FEPA (1991) effluent limitation standards. The difference between the water qualities of impacted and unimpacted stretches of the effluent receiving stream was significant ( $P < 0.05$ ) for more than half of the parameters. All the investigated parameters (except total hardness, DO and  $\text{Hg}^{2+}$ ) were higher in the impacted section than in the unimpacted section, thus indicating the negative impact on the receiving stream. The effluent qualities varied among the investigated parameters and decreased (except DO,  $\text{Fe}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Hg}^{2+}$ ) gradually from the outpour downstream. The pronounced increase

in ammonia, major ions and nutrient compounds indicated that the discharge from the fish farm is both inorganic and organic. The effluent discharge from the investigated fish farm had a significant negative impact on the water quality of the receiving River and the indicator parameters comprised of ammonia, color and alkalinity.

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