IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 2 Ver. II (Feb. 2016), PP 28-35
www.iosrjournals.org

To Assess the Impact Catfish Farm Effluents on Water Quality of Majidun Stream, South-West, Nigeria

Omofunmi O.E.[1],J.K[2.]. Adewumi., A.F[2]. Adisa., and S.O[3] .Alegbeleye.
[1]*Department of Agricultural and Bio-Environmental Engineering, YABATECH, Lagos, Nigeria*
[2.] *Department of Agricultural Engineering, Federal University of Agriculture Abeokuta, Nigeria.*
[3.] *Department of Fisheries and Aquaculture, Federal University of Agriculture, Abeokuta, Nigeria.*

Abstract: *There has been a great concern about the level of safety of surface waters, especially in developing countries where there is an exponential increase in water pollution and borne diseases. The aim of this study was to assess the effect of catfish effluents on water quality of stream where five catfish farms are localized. Water samples were taken on monthly basis, 20cm below water surface from water that receives effluent from surrounding fish ponds. Water quality indicators like dissolved oxygen, biochemical oxygen demand, nitrate, nitrite, water temperature, ammonia and pH were examined in sampled water accordance with the APHA standards.The average value of water quality indicators examined for the stream at effluents discharged site and Non-effluents discharged site indicated that Water temperature (24.6 ± 0.2, 24.2 ±0.1), pH (7.29±0.30, 7.30±0.10), Dissolved oxygen (6.90±0.4, 7.07±0.1 mg/l), Total Ammonia(0.40±0.04, 0.27±0.01), Total Nitrogen(3.77±0.26, 2.34±0.16 mg/l), Total Phosphorus(3.59±0.11, 2.80±0.02 mg/l) and BOD_5 (3.51±0.24, 2.46±0.21 mg/l) at ($p \geq 0.05$) respectively. There were significant differences ($p \geq 0.05$) between values obtained at effluents discharged and non-effluents discharged sites, indicating that improper discharges of catfish effluents into environment resulted in environmental contamination*

Keyword*: Assessment**,** Catfish, Effluent**,** Impact, Nutrient, Stream, Water quality*

I. Introduction

Fish rearing is an integral part of an Agricultural sector. Though seems emergent, it has been in existence for centuries, consisting effective ways of culturing, growing, harvesting, preservation and marketing of fish. Jeje, (1992) found that Nigerians aquaculture industry product like fish and shrimps that is gradually replacing animal meat as a source of dietary protein and business hub for teeming million youth. The most commonly grown fish *Clarias gariepinus*, Adekoya *et al*., (2006),

There are numerous publications on the subject of catfish pond effluents such as Tucker, 2000; Boyd et al., 2000; Tucker, et al., 2002 and Tucker and Hargreaves, 2008. These studies were mostly conducted over short periods of time and in experimental ponds. It is difficult to draw conclusions from these studies because the quality of catfish pond effluents varies with location, season, farm management practice, amounts of overflow after rains, and amounts of water drained during harvest. Draining effluent discharged during harvest has a greater potential for causing pollution than overflow from ponds after rains (Boyd 2003; Schwartz and Boyd, 2004). Effluents released during pond harvest are most concentrated in pollutants because of resuspension of sediment by seining efforts. Impact of catfish effluent on water quality depends on methods of drained, amounts of water drained during harvest and concentration of the effluents. About 20 to 30 percent of nitrogen and phosphorus applied in feed is recovered in fish at harvest (Boyd and Tucker, 1998). Water in catfish ponds usually has higher concentrations of nitrogen, phosphorus, organic matter and biochemical oxygen demand than natural surface waters in the vicinity (Boyd et-al, 2000). Researchers likes Boyd, (2005); Boyd et-al, (2008) and Boyd and Robinson, (1990) reported that concentrated aquatic animal production (CAAP) facilities such as hatchery and fish ponds to mention few are major sources of wastewater effluent that contain high level of oxygen demanding waste, producing objectionable odour in the receiving adjacent streams which most fish farmer consider an ease waste disposal methods. However, indiscriminate disposal of untreated wastewater from fish pond on streams results in over- enrichment of water body with nutrients causing eutrophication harmful to the aesthetic value of water body, preventing sunlight penetration and decay of algae weeds which add odorous compound to the aquatic system.

Stream is a mobile system, one of the water bodies in which its contents could be influenced by geographic soil conditions, sources of aquifers, climatic conditions and anthropogenic sources. In water bodies the water currents, eddies and waves influence the distribution of constituents especially in streams and estuaries. The inflow and outflow system possessed by the stream enable it to dilute the pollutants from inlet point and thereby transport them down the stream, but the effects are not localized as what is obtained in stationary water body such as lake or pond. The negative effects of pond effluents on the receiving stream and land has been reported Boyd (2001a, 2001b, 2003, 2005) ranging from offensive odour, lowering dissolved oxygen, impairment to water bodies rendering it unfit for domestic, industrial and agricultural purposes.

Water quality can be judged from physical, chemical, biological and aesthetic points of view. Physical parameters for water quality are colour, turbidity, total suspended solids, temperature, conductivity and odour. Chemical parameters are pH, dissolved oxygen (D0), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved ions and chemicals and Biological parameters are bacteria, algae, virus, coliform and other biological pathogens. Impact of catfish effluent on water quality depends on methods of drained, amounts of water drained during harvest and concentration of the effluents.

With increased interest in green environment and sustainable fish farming practices, the aquaculture industry needs to focus on ways to reduce waste through effective waste management. In Nigeria, Federal Environmental protection agency (FEPA) has not developed effluent regulations for aquaculture. Pond aquaculture was excluded from effluent limitation guidelines. There has been considerable concern over water waste especially from industries as water pollutant in Nigeria and effort has been devoted to reduce the effects in Nigeria water bodies. In Nigeria impacts of catfish farming on water quality has not been studied and data for effluent limitation and regulation are yet to be developed. The potential impact of catfish effluents on the receiving streams in the past has not been well reported, this study was aimed to assess its potential impact on water quality of stream and sources of water surrounding the fish farms in Lagos State, Nigeria. Only chemical parameters and water temperature were investigated in this study.

II. Materials And Methods

2.1 Description of the Study area.

Geographically, Lagos State is situated in the South West of Nigeria. It spans the Guinea Coast of the Atlantic Ocean for over 180km on the South, from the Republic of Benin on the West to its boundary with Ogun State in the North and East of Nigeria. It fall within longitudes 030 50`E and 030 38`E and latitudes 060 20`N and 060 18`N.The total territorial area is 3,577sq km, with about 787sq km of which twenty-two percent (22 %) is wetland area. The altitude of the State is approximately 4.6m above the sea level. It is divided into Local Government Areas and is as shown in Fig.1. The sampling station was located at Majidun Lagoon in Ikorodu division in Lagos State, Nigeria. Sampling location includes the following water bodies: stream and Canal. There was no industrial or domestic sewage that discharged to the stream. The sampling stations were S_1 to S_4 which were along the stream where the catfish discharged its effluent to. While sampling stations C_1 to C_2 which were in the canal that served as control (non-effluents discharged).Upstream site (S_1) was 40 metres before effluents discharged site (S_2) while S_3 and S_4 were 40 and 80 metres away from S_2 respectively. The sample stations and locations are presented in Table 1.

= LOCATION AREA

Figure 1: Map of Lagos State showing the study area.

2.2 Experimental Methods

Water sample were collected at approximately one month intervals beginning from July 2, 2012 at S_1 to S_4 and C_1 to C_2. Sampling continued at all stations until December 2, 2013. The required samples were collected in 250 ml glass bottle for DO and BOD, and other samples were collected in sterilized 1-litre plastic bottles for other physiochemical parameters. The air temperature was measure at an altitude of 1.6m above sea level in the morning (10.0 am) and others samples were taken at 50 cm depth of water at the same time of the day. The samples were collected during the same day and analyses were carried out the next day. Measured physico-chemical water quality parameters were water temperature, pH, dissolved oxygen, total ammonia, total nitrogen, total phosphorus and biochemical oxygen demand. All measurements were replicated four times.

Table 1: The sample stations and locations

Sample stations	Location
S1	Majidun lagoon, near ferry jetty
S2	Majidun lagoon near Omoyele street
S3	Majidun lagoon, near Abejoye street
S4	Majidun lagoon, near Agbon street
C1	Majidun canal, near police station
C2	Majidun canal, near police station

2.3 Measurements

Water physico-chemical properties measurements were taken at stations, one month intervals beginning from July 2, 2012 and ended December 2, 2013

2.3.1 Water temperature: It was measured in situ using thermometer

2.3.2 pH: The pH (Hydrogen ion concentration) value were measured directly by a pH meter by dipping the electrode into the pond water (APHA 2005).

2.3.3 Dissolved oxygen: The dissolved oxygen (DO) was determined by Winklers method. Water sample for DO were collected at each location in 100 ml DO sample bottle without agitating. The stopper was carefully removed. 1ml each of sodium iodide (Nal) solution and magnesium Sulphate (MgSO4) solution were added with aid of 1ml pipette, the stopper was replaced and the content was thoroughly mixed, 2.0 ml of concentrated Sulphuric acid (H_2SO4) was added mixture, 50 ml of the solution was titrated with 0.025N of Sodium thiosulphate ($Na_2S_2O_3$) with starch solution as indicator of the colorless end point. The dissolve oxygen (mg/l) is expressed as follows:

DO (mg/l) = ml of 0.025(N) $Na_2S_2O_3$ used x 4 (APHA, 2005).

2.3.4 Nitrogen, Nitrite, Nitrate and Ammonia: 100 ml of filtered water sample was collected in Kjeldahl flask fitted with distillation unit. 1g of Magnesium oxide (MgO) was added and distillation started; 25 ml of distilled was collected. 1g of devards alloy was added to the remaining volume of the flask and distillation started again. 25 ml of distilled was taken into two separate Nessler tubes and 0.5 ml Nessler reagent was added to each tube. The mixed solution started developing colour. This colour after 10-15 minutes was matched against colour discs of a Nesslenizer (BDH Nesslenizer). Nitrogen content (mg/l) is expressed as follows:

N, NO_2, NO_3 and NH_3 (mg/l) = umber of matchng division of the standard dics × 100 × 0.01 (APHA, 2005).

2.3.5 Phosphorus (mg/l): 50 ml of filtered water sample was put in a nessler tube. 2 ml of sulphomolybdic acid and 5 drops of stannous chloride solution were added. The mixtures were mixed thoroughly. The developed blue colour after 3-4 minutes was compared with nesslenizer standard colour discs. The phosphate content (P_20_5) in ppm is expressed as follows:

Phosphate (mg/l) = disc reading for 50mm × 2 × 0.01 (APHA, 2005).

2.3.6 Biochemical oxygen demand (BOD_5): The BOD was determined by Winkler's method.

Water sample for BOD were collected at each location in 100 ml BOD bottles without agitating. The initial DO content is determined as stated; stopper was carefully removed. 1ml each of sodium iodide (Nal) solution and magnesium Sulphate ($MgSO_4$) solution were added with aid of 1ml pipette, the stopper was replaced and the content was thoroughly mixed, 2.0 ml of concentrated Sulphuric acid (H_2SO_4) was added mixture, 50ml of the solution was titrated with 0.025N of Sodium thiosulphate ($Na_2S_2O_3$) with starch solution as indicator of the colorless end point. After 5 days, incubated bottles, DO was determined using the above procedure

The BOD_5 (ppm): Initial DO of sample – DO of sample after 5 day X 100 /ml of percentage of sample added (APHA 2005).

2.4 Data Analysis

SPSS program version 17.0 was used for statistical analysis. Monthly data were converted to mean values (±standard error) for comparison, Mean values of each parameter measured upstream, downstream and control canal were compared using Duncan`s multiple range test. The statistical inference was made at 0.05 (5%) level of significance.

III. Results And Discussions

Table 2: Grand mean water qualities concentration measured for catfish effluent discharged at 1, 2, 3, 4, 5 and 6 DAT at various sample stations

Parameters	Upstream (S_1)	Downstream (S_2- S_4)	Control (C_1–C_2)
	Sample stations		
Water temperature (0C)	24.2±0.1a (22.8 – 25.5)	24.6±0.2a (22.8 – 25.7)	24.2 ±0.1a (22.7 – 25.5)
pH (standard units)	7.32±0.20a (7.18 – 7.48)	7.29±0.30b (7.01 -7.50)	7.30±0.10a 7.13 – 7.47)
Dissolved Oxygen (mg/l)	7.11 ±0.2a (6.99 – 7.24)	6.90±0.4b (6.04 – 7.22)	7.06 ±0.1a (6.66 – 7.25)
Total ammonia (mg/l)	0.26±0.02a (0.11 – 0.36)	0.40±0.04b (0.28 – 0.63)	0.27±0.01a (0.13 – 0.40)
Total nitrogen (mg/l)	2.40 ±0.13a (2.1 – 2.9)	3.77 ±0.26b (2.1 – 5.3)	2.34±0.16a (1.8 – 3.2)
Total phosphorus (mg/l)	2.58 ±0.06a (2.16 – 3.51)	3.59 ±0.11b (2.90 – 4.81)	2.80±0.02a (2.16 – 3.62)
Biochemical oxygen demand (mg/l)	2.30±0.18a (1.5 – 3.8)	3.51±0.24b (2.1 – 5.2)	2.46±0.21a (1.8 – 3.2)

Values are means of four replicates (n = 4) in all Treatment; DAT-Months of discharged Results presented are mean values of each determination ± standard error means (SEM) minimum and maximum values (in parentheses) for water quality parameters in upstream (S_1), Downstream (S_2 to S_4) and control stream (C_1 to C_2) without catfish discharged effluents. Means indicated by the same letter did not differ ($P \geq 0.05$) according to Duncan`s multiple range test (horizontal comparisons only)

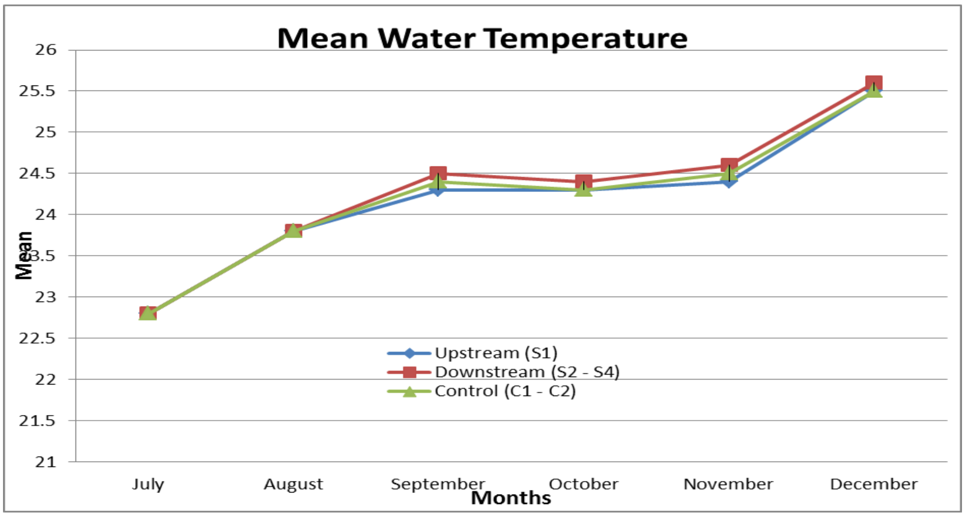

Fig.2: Monthly water temperatures at station S_1 and monthly means for water temperature at stations (S_2 to S_4) and control streams ($C_1$to C_2).

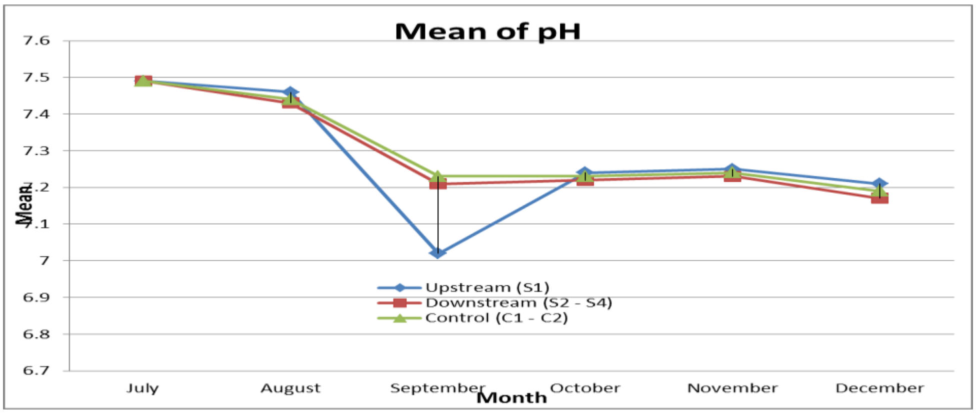

Fig. 3: Monthly pH at station S_1 and monthly means for pH at stations (S_2 to S_4) and control streams ($C_1$to C_2)

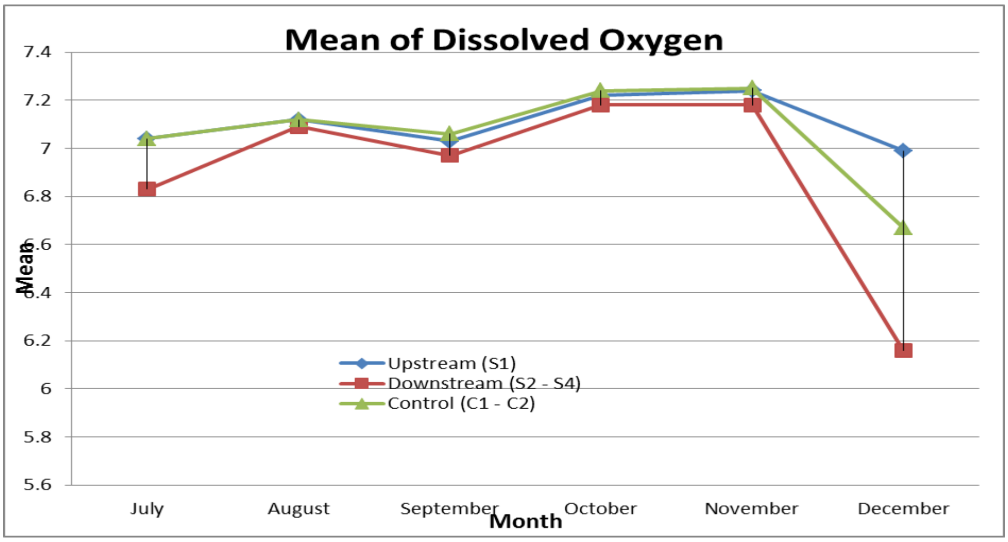

Fig.4: Monthly dissolved oxygen at station S_1 and monthly means for dissolved oxygen at stations (S_2 to S_4) and control streams ($C_1$to C_2)

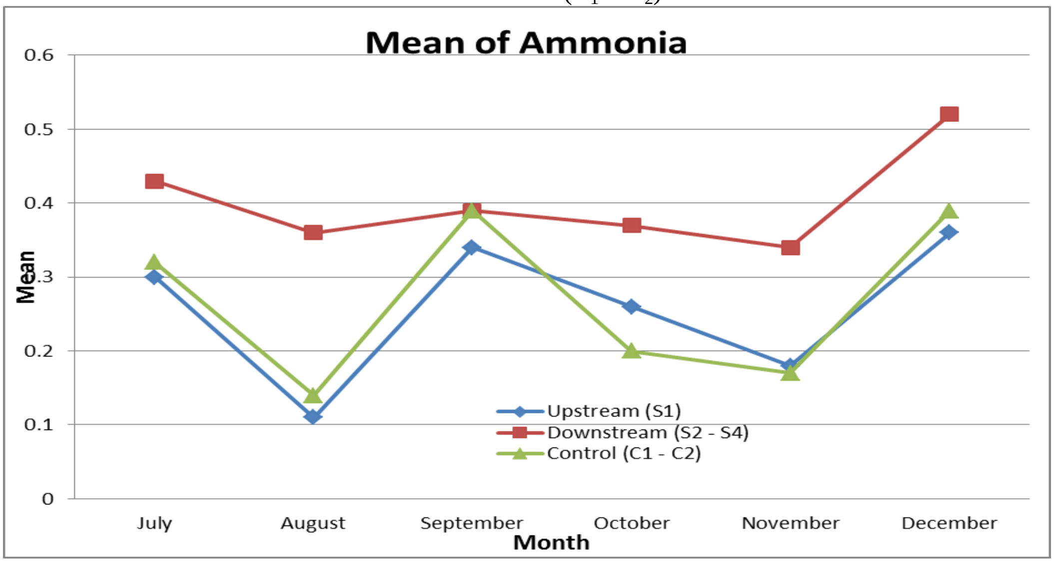

Fig.5: Monthly ammonia at station S_1 and monthly means for ammonia at stations (S_2 to S_4) and control streams ($C_1$to C_2)

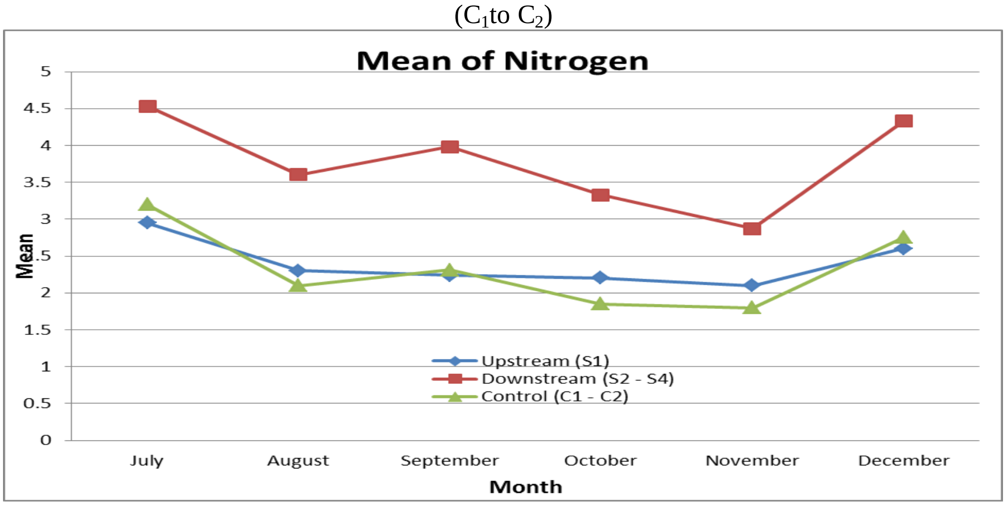

Fig.6: Monthly total nitrogen at station S_1 and monthly means for total nitrogen at stations (S_2 to S_4) and control

streams ($C_1$to C_2)

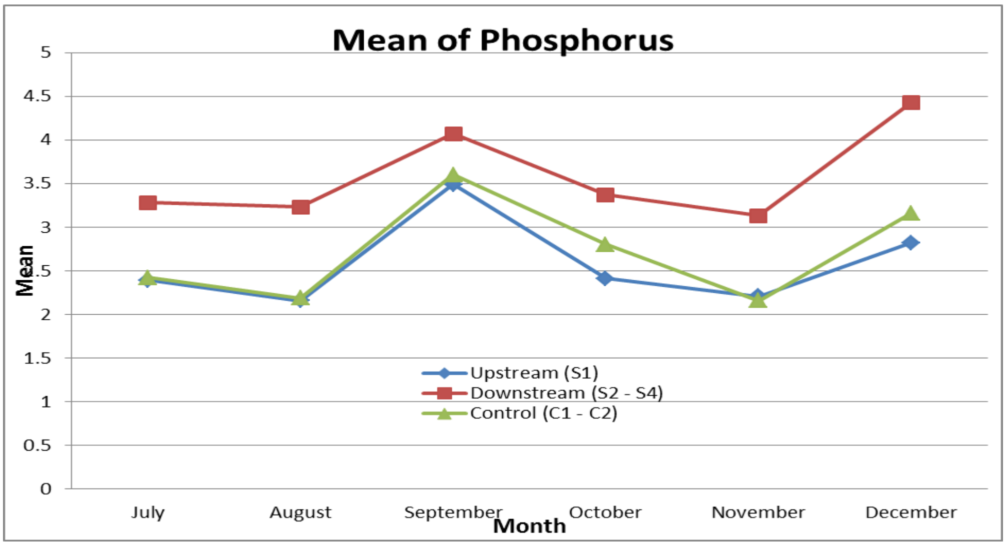

Fig.7: Monthly total phosphorus at station S_1 and monthly means for total phosphorus at stations (S_2 to S_4) and control streams ($C_1$to C_2)

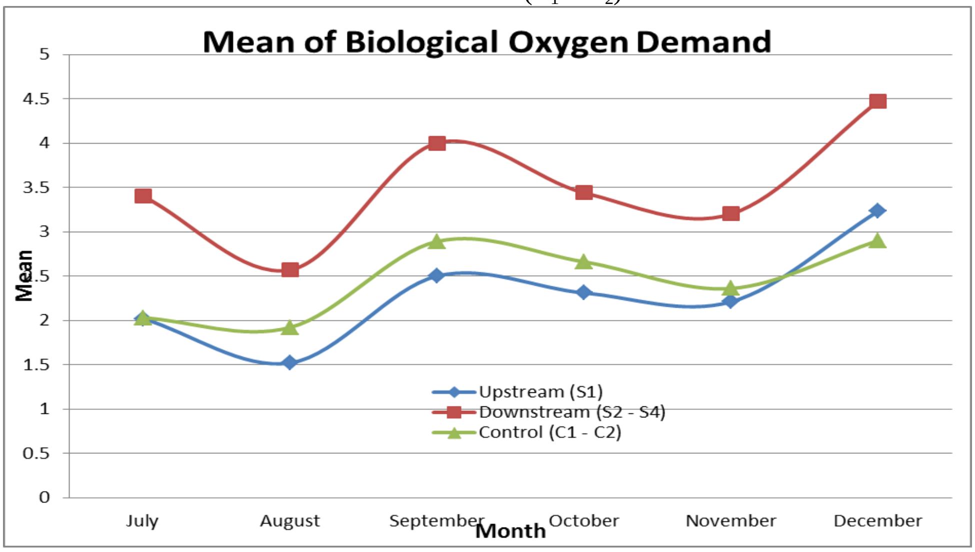

Fig.8: Monthly biological oxygen demand at station S_1 and monthly means for biological oxygen demand at stations (S_2 to S_4) and control streams ($C_1$to C_2)

3.1 Water Temperature

Average water temperatures were quite similar among the three categories of the stations as shown in figure 2. Lowest temperature ranged from 22.7^{O}C to 22.8 ^{O}C and highest were 25.5 ^{O}C to 25.7 ^{O}C .There was no difference in grand means for water temperature among the stations (Table 2).The increase in water temperature is less than 2.8^{O}C rise that allowed in streams classified for fish and wildlife propagation (Boyd,2000b).

3.2 pH of Water

The trend of pH at monthly intervals was presented in figure 3. The lowest pH value ranged from 7.01 to 7.13 and the greatest ranged from 7.47 to 7.50 among the stations. This indicated that the stream originated in alkalinity soils. The upstream (S_1) had higher pH concentration than downstream and control stream The pH of stream water tended to increase between downstream (S_2 – S_4) and control stations (C_1 – C_2) indicating that effluents from pond was basic in reaction relative to normal stream flow from downstream. The upstream (S_1) usually had slightly higher pH than water at (S_2). However, the difference pH concentration between upstream (S_1) and downstream (S_2 - S_4) was probably related to inputs from catfish effluents. There was no difference in grand means pH between upstream and control stream (Table 2) .Generally, the obtained pH values fell within the World Health Organization standard of 7.0 to 8.5 and the water quality ranged between 6.5 to 8.5 for drinking water and water meant for full contact recreation, respectively (WHO ,2004).

3.3 Dissolved Oxygen (DO)

Concentration of dissolved oxygen averaged between 6.04 and 7.24mg/l, between stations S_1 and S_4 were presented in (figure 4). The lowest averages for dissolved oxygen were at downstream (S_2 – S_4) and control stream (C_1 – C_2). It has to do with the state of the organic matter downstream microbial activity has converted some of the nutrients to acids (humic acid) using dissolved oxygen and also there was more photosynthesis by aquatic plants in the upstream than downstream and control stream. There were differences in grand means for dissolved oxygen between downstream (S_2 – S_4) than other stations (Table 2) Dissolved oxygen concentration at station 2 (S_2) 6 mg/l which exceeded stream standard of 5.0 mg/l. Dissolved oxygen concentrations in unpolluted water normally range between 8 and 10 mg/l and concentrations below 5 mg/l do adversely affect aquatic life (Rao, 2005). Dissolved oxygen for drinking purpose is 6 mg/l whereas for sustaining fish and aquatic life is 4- 5 mg/l (Rao, 2005). Dissolved oxygen concentrations for all the stations were adequate for maintenance of biological function.

3.4 Total Ammonia and Total Nitrogen

The monthly trend of total Ammonia and total Nitrogen concentrations were as presented in figures 5 and 6 respectively. Peak of total Ammonia and Nitrogen concentrations of 0.63 mg/l and 5.3 mg/l were reached at downstream (S_2) respectively. The decline in total ammonia along the downstream (S_2 – S_4) was the result of nitrification. Grand means ammonia concentration was below 0.4 mg/l, which fluctuated between 0.11 mg/l and 0.63 mg/l. Total nitrogen concentration, however, was similar which was between upstream station and control station was less than 3 mg/l. Total ammonia and total nitrogen concentrations were significantly different ($P \geq 0.05$) between downstream station and other stations (Table 2).The ammonia concentration exceeded the recommended level ≥0.05mg/l (Boyd, 2001b, 2003) for all the stations. Total nitrogen was greater than the recommended value of 2.0 mg/l especially at downstream, this was due to untreated effluents and inherent property of the soil in the area.

3.5 Total Phosphorus Concentration

Total phosphorus concentrations were fluctuating at all stations shown in figure 7. The peak value 5.3 mg/l was at downstream station (S_2) .The decline in total phosphorus concentrations at station (S_3 – S_4) was likely due to uptake by aquatic plants and adsorption by sediment. The grand means of phosphorus was significantly different ($P \geq 0.05$) among the stations (Table 2). The phosphorus concentrations at all the stations were greater than recommended value (2.0 mg/l), which was due to the soil property in the area. The high phosphorus loads were associated with the higher phosphorus content of catfish feeds used and with insufficient feed management. Phosphorus loads could be reduced by use of low-pollution feed and better feed management.

3.6 Biochemical Oxygen Demand (BOD_5)

The trend for biochemical oxygen demand was as presented in figure 8.The biochemical oxygen demand ranged from 1.5 mg/l to 3.8 mg/l at upstream (S_1) and ranged from 2.1 mg/l to 5.2 mg/l at downstream (S_2 – S_4).There was no clear trend in concentration among the station. Peak of biochemical oxygen demand was observed at S_2. Grand means for biochemical oxygen demand did not differ between the upstream station and control station. There were significantly different ($P \geq 0.05$) between downstream station and other stations (Table 2). In summary, this study observed that the physical and chemical properties of water quality of the stream at effluent discharged site were altered resulting to environmental threats to the development of aquaculture in Lagos State, Nigeria. This is indicated that catfish farm effluents had a significant impact on the water quality of the stream with respect to pH, dissolved oxygen (DO), total ammonia, total nitrogen, total phosphorus and biological oxygen demand (BOD) concentrations. The comparison of water quality in downstream (S_2 –S_4) with control canal (C_1 –C_2) allows the best evaluation of the effect of catfish farming on water quality. These findings corroborate by earlier workers (Boyd et al., 2000; 2000a; 2008; Tucker, 2000 and Ozbay, 2002) that the catfish pond waters had higher concentrations of most variables than that of stream waters in the surrounding.

IV. Conclusion

The effects of catfish effluents on water quality of stream were investigated. Results of findings proved that:

- Stream had distinctly different water quality between upstream station (S_1) above the outflow of catfish farm effluents station (S_2) and the downstream stations (S_3 – S_4) below the outflow of catfish farm effluents station (S_2).
- The major differences occur in pH, total ammonia, total nitrogen, total phosphorus and biochemical oxygen demand.
- These differences were related to catfish farm effluents, the nature of the soils in the area and runoff caused by the flood in the area.

- Catfish pond effluents tended to be higher in concentrations of nitrogen, ammonia, biochemical oxygen demand and phosphorus than stream waters into which they were discharged.

The overall impact of catfish farm effluents on the water quality of the stream could be reduced via better farm husbandry such as feed management and effluent treatment.

Stream flow should be determined and biological and physical parameters should be investigated

Acknowledgements

I acknowledge the Nigerian Institute of Oceanography and Marine Research in water analyses. I also express my profound gratitude to Mr. T. O. Sanusi the secretary of Agricultural and Bio- Environmental Engineering Department,

Reference

[1]. Adekoya,,B.B;T.O.Ayansanwo,A.A.Idowu,O.A.Kudoro and A.A. Salisu (2006). Inventory of Fish Hatcheries in Ogun State,Ogun State Agricultural development programme, Abeokuta.

[2]. American Public Health Association (APHA). 2005. Standard Methods for the water and wastewater,

[3]. American Water Works Association, Water Control Federation. Examination of Water and Wastewater, 21th Eds. Washington, DC;

[4]. Boyd,C.E. 2005. Aquaculture and water pollution.American Water Ressources. Summer Specialty Conference, snowbird, Utah.

[5]. Boyd,C.E,(1990) Water quality in ponds for agriculture.in Singh and Wheaton(CIGAR).Auburn University,Albama,Agricultural Experimental Station,Auburn.

[6]. Boyd, C. E., H. Pine, and R. Hulcher. 2008. Excess run of contribution to daily discharge frequency of channel catfish farms in Alabama. Journal of the World Aquaculture Society vol.39 pp 490-499.

[7]. Boyd, C.E (1990) Water Quality in Ponds for Aquaculture. Auburn University/Alabama Agricultural Experimentation station

[8]. Boyd, C.E.2000a. Biochemical oxygen demand in channel catfish pond water. Journal of the world Aquaculture society.

[9]. Boyd C. E. 2000b. Water quality: An introduction. Kluwer Academic Publication,Boston.

[10]. Boyd C. E. 2001a. Aquaculture and water pollution. Pg.153-157.In:D.F.Hayes and. M.Mckee (editors).Decision support systems fo water resources management.American Association,Middleburg,Virginia,USA.

[11]. Boyd, C E 2001b. Water quality standards: total ammonia nitrogen. Global Aquaculture Advocate 4(4):84-85.

[12]. Boyd, C. E. 2003. Guidelines for aquaculture effluent management at the farm level. Aquaculture 226:101-112.

[13]. Boyd,,C.E. 2005. Aquaculture and water pollution.American Water Ressources.Summer Specialty Conference, snowbird, Utah.

[14]. Boyd, C.E. and C.S. Tucker. 1998. Pond aquaculture water quality management. Kluwer AcademicPublishers, Boston, Massachusetts, USA

[15]. Boyd, C. E., J, F.Queiroz., J. Lee, M. Rowan, G. N.Whitis, and A. Gross 2000. Environmental assessment of channel catfish farming in Alabama. Journal of the World Aquaculture Society.

[16]. Ozbay, G. 2002. Studies of channel catfish Iclalurus punctatus pond effluent characteristics and treatment options. Ph.D. dissertation, Auburn University, Alabama, USA.

[17]. Rao,P.V. (2005). Textbook of Environmental Engineering, Eastern Economy Ed. Prentice Hall of India. Private limited, New Delhi.

[18]. Schwartz, M. F. and C. E. Boyd. 2004. Constructed wetlands for treatment of channel catfish / pond effluents. The Progressive Fish-Culturist, 57,255-266.

[19]. Tucker, C.S.and E.H. Robinson. 1990. Channel Catfish Farming Handbook. New York:Nostrand Reinhold Tomasso,J.R 2002.Aquaculture and the Environment in the United State.Aquaculture Society Lousiana center. Baton Rouge, Louisiana, USA..

[20]. Tucker, C. S. 2000. Characterization and management of effluents from aquaculture ponds in the southeastern United States. Southern Regional Aquaculture Center, Mississippi State University, Stoneville, Mississippi, USA.

[21]. Tucker, C. S., C. E. Boyd, J. A. Hargreaves. 2002. Characterization and management of

[22]. effluents from warm water aquaculture ponds. In: J. R. Tomasso (ed.) The

[23]. Environmental Impact of Aquaculture in the United States. United States Aquaculture Society, Baton Rouge, LA.

[24]. Tucker, C. S. and J. A. Hargreaves. 2008. Environmental best management practices for

[25]. aquaculture. Aquaculture International, 17,301-302.

[26]. World Health Organization (2004). Guidelines for Drinking water quality. 3rd Edition, WHO, Geneva 540pgs Tomasso,J.R 2002.Aquaculture and the Environment in the United State.Aquaculture Society Lousiana center. Baton Rouge, Louisiana, USA..