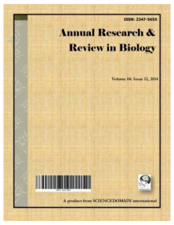

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The Impact of Catfish Farming on Water Quality of Stream in Lagos State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This paper advocates habitat conservation and ecological studies with special reference to the physico-chemical characteristics of Majidun stream. The aim of this study was to assess the potential impact of catfish *(Clarias gariepinus)* effluents on water quality of stream where five catfish farms are localized. The constituents monitored include water temperature, specific conductance, turbidity, total suspended solids (TSS), total alkalinity, total hardness and chloride. Monthly samples were taken from upstream (S_1) and the catfish farm effluents discharged site (S_2) and downstream ($S_{3,}$ S_4) for six months. Physical and chemical properties of water samples were determined in accordance with the American Public Health Association standards. Data were analysed using descriptive statistics and analysis of variance. The mean values water quality parameters for the stream at effluents discharged site and Non-effluents discharged site indicated that they contained: Water temperature (24.6±0.2, 24.2±0.1), Specific conductance (408.6±44.3, 358.4±22.4 mho/cm), Turbidity (27.5±10.3, 21.3±4.2 NTU), TSS (27.1±12.6, 19.3±5.5 mg/l), Total Alkalinity (24.6±8.6, 18.6±5.8 mg/l), Total hardness (29.8±14.2, 22.1± 0.02 mg/l) and Chloride (20.5±4.5, 14.3±2.8 mg/l) respectively and were significantly different ($p \leq 0.05$). If the present conditions continue for a long period, Majidun stream may soon become ecologically unbalance to the aquatic ecosystem.

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Keywords: Catfish; effluents; Lagos state; stream; water quality.

1. INTRODUCTION

The catfish industry play very important role in Nigeria aquaculture industry as the largest segment of aquaculture in the Nigeria. Most catfish are grown in the southern part of Nigeria, and the industry is economically important to several others states [1]. The most popular species that have proved desirable for culture in Nigeria are the *Clarias gariepimus*, Heteroclarias sp, and Heterobranchus species [2].

There are numerous publications on the subject of catfish pond effluents. 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. Researchers likes [3,4,2,5-8]. [9,10] reported that concentrated aquatic animal production (CAAP) facilities produce a variety of pollutants that may be harmful to the aquatic environment when discharged in significant quantities such as total suspended solids (TSS) and nutrients. Water temperature was the environmental parameter having the greatest effect on fish. Turbidity is produced by dissolved and suspended substances, such as clay particles, humic substances, silt, plankton, coloured compounds to mention few. Boyd [11-14] highlighted the effects of turbidity which are as follows:

- It limits light penetrations
- It prevents the growth of rooted aquatic plants.
- Inhibits the development of food phytoplankton Blooms
- It clogs the gills of small fish and invertebrates.
- It smothers fish eggs, it limits light penetrations; preventing the growth of rooted aquatic plants.

Alkalinity of water is a measure of its capacity to neutralize acids, in other words, to absorb hydrogen ions without significant pH change. The higher the alkalinity more stables the water against pH changes. Total alkalinity does not have a direct effect on fish, but waters having a total alkalinity below 30 mg/l were considered poorly buffered against pH changes [15]. A total alkalinity range of 20-400 mg/l has been considered satisfactory for most aquaculture purposes [16-18,14].

Some countries have developed standards and criteria for aquaculture effluents; they require permits for discharging ponds effluents into natural water and effluents characteristics must comply with specifications set forth in the permit. Both public and private fish farms in Nigeria have been increased year by years as a result of government intervention. The needs for pond effluents are of necessity for environmental preservation and maintenance of aesthetic values. The effects of pond effluents are highlighted by [19,4,12,20] as follows: It produces offensive odour, impacts on aesthetic value of the environment, reduces dissolved oxygen, pollutes water body and introduces diseases. The potential impact of aquaculture effluent on natural waters is eutrophication of the receiving water, rather than a direct toxic effect on animal or plant.

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. 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. In water bodies the water currents, eddies and waves influence the distribution of constituents especially in streams and estuaries.

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. Symptoms of poor water quality are unacceptable pH, nitrite, ammonia, alkalinity, low dissolved oxygen levels and fluctuating water temperatures [20]. Total suspended solids (TSS) are a common measure of water quality and refer to all suspended particulate matter in the water column. High TSS is indicative of poor water quality [21]. Increased nutrient loading from fertilizers may lead to TSS that is predominately living organic matter in the form of bacteria and algae [22].

The potential impact of catfish form effluents on water resources is not well studied in Nigeria. Therefore, procedures for regulating, controlling and monitoring the environmental impacts of fish farmer are not well established. The lack of site-specific data on the effluent quality of farms and on their impacts on receiving water bodies is a major constraints on the establishment of such regulatory measures and adaptation of appropriate waste management systems. The aim of this study was to assess the potential impact of catfish effluents on water quality of stream where five catfish farms are localized.

2. MATERIALS AND METHODS

2.1 Site Description

Geographically, Lagos State is situated in the South Western of Nigeria. It spans the Guinea Coast of the Atlantic Ocean for over 180 km 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 of 3,577 sq km, about 787 sq km or twenty-two percent (22%) is wetland area. The altitude of the State is approximately 4.6 m 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.

2.2 Experimental Procedures

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 1.6 m 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

Fig. 1. Map of Lagos State showing the study area

collected during the same day and analyses were carried out the next day. Measured physico-chemical water quality parameters were water temperature, Specific conductance, Turbidity, TSS, Total hardness and Chloride. 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 at 16 cm depth of water.

2.3.2 Total suspended solid (mg/l)

50 ml of samples through pre – weighted glass fibre paper dried for 30 minutes and weighed again. The suspended solid content of the sample is the difference in the weight of filters. For a given sample location, the experiments were repeated three times and average reading were taken [23].

2.3.3 Specific conductance

20 ml of water sample was put into Erlenmeyer flask and 80ml of distilled water was added. The mixture was placed on shaker for one hour and then filter through Whatman No.1 filter paper. The conductivity electrode was washed with distilled water and rinsed with standard KCL solution. EC was determined by dipped the conductivity meter into the solution. The conductance is expressed n mmhos / cm [23].

2.3.4 Turbidity (mg/l)

Turbidity was determined by Jackson's turbidity. Water sample was put into calibrated glass tube which recorded the depth of the water [23].

2.3.5 Alkalinity (mg/l)

100 mml of water sample was put into conical flask. 3 drops of phenolphthalein indicator was added. Alkalinity of water sample was measured by titrated with 0.02N of Sulphuric acid.

2.3.6 Alkalinity (mg/l)

0.02 of H_2SO_4 used X 1000/ ml of water sample [23].

2.3.7 Hardness (mg/l)

100 ml of water sample was put in a conical flask. 1 ml of Ammonia buffer and 6 drops of Eriochrome Black T indicator to the flask Wine red colour was developed and then titrated with standard EDTA solution till the colour changed from wine red to blue.

Hardness (mg/l): ml of EDTA used X N X 1000 / ml of water sample [23].

2.3.8 Chloride (mg/l)

20 ml of water sample was put into a porcelain dish by pipette and same amount of distilled water into a second dish for a colour comparison. 1 ml of potassium chromate indicator was added to each dish. Standard silver nitrate solution was added to the sample by burette drops by drops by drop with simultaneous gentle stirring with a glass rod till the color changed reddish

Chloride (mg/l): (ml of $AgNO_3$ used – 0.02) X 500 / ml of sample [23].

2.4 Data Analysis

Physical and chemical properties of soil samples were determined in accordance with the American Public Health Association Standards [23]. Data were analyzed using descriptive statistics. Means of each parameter was compared using Duncan`s multiple range test. The statistical inference was made at 0.05 (5%) level of significance.

3. RESULTS

The water quality variables measured were presented in Table 2 and Figs. 2, 3, 4, 5, 6, 7 and 8 respectively.

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

	Sample stations		
Parameters	**Upstream (S_1)**	**Downstream (S_2- S_4)**	**Control (C1–C2)**
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)
Specific conductance (µmhos/cm)	335.9±26.6a (323.4 – 390.1)	408.6±38.6b (321.3–489.2)	358.4±22.4c (291.8–390.8)
Turbidity (NTU)	20.7±5.2a (16.2 – 24.6)	27.5±10.3b (18.4–38.4)	21.3±4.2a (14.4–26.6)
Total suspended solid (mg/l)	15.8±6.8a (14.3 -20.8)	27.1 ±12.6b (16.2–37.8)	19.3±5.5a (12.6–23.8)
Total hardness (mg/l)	20.8±4,8a (16.9 – 24.3)	29.8 ±14.2b (20.1–40.8)	22.1 ±6.8a (17.9–26.4)
Total Alkalinity (mg/l)	18.3±4.4a	24.6±8.6b	18.6±5.8a
Chloride (mg/l)	13.4 ±2.8a (8.6 – 18.6)	20.5±4.5b (14.3–28.6)	14.3±2.8a (9.9–18.8)

Values are means of four replicates (n = 4) in all Treatment; DAT- Months of discharged
Results presented are means 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)

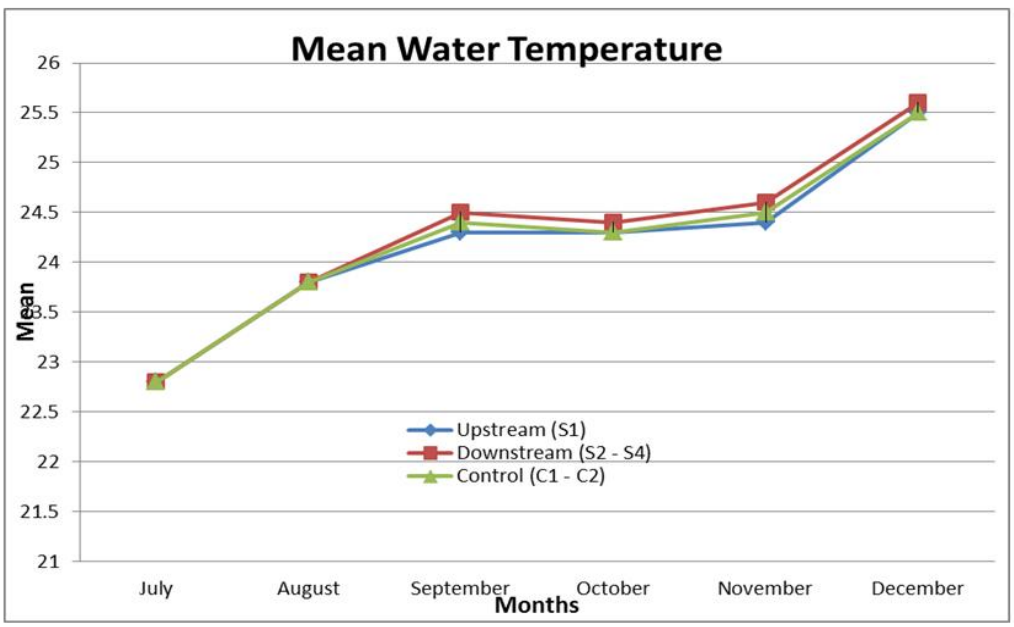

Fig. 2. Monthly water temperatures at station S_1 and monthly means for water temperature at stations (S_2 to S_4) and control streams (C_1 to C_2)

4. DISCUSSION

4.1 Water Temperature

Average water temperatures were quite similar among the three categories of the stations as shown in (Fig. 2). Lowest temperatures ranged from 22.7°C to 22.8°C and highest were 25.5°C to 25.7°C. There was no difference in grand means for water temperature among the stations (Table 2). The increase in water temperature was less than 2.8°C rise that allowed in streams classified for fish and wildlife propagation [3,11].

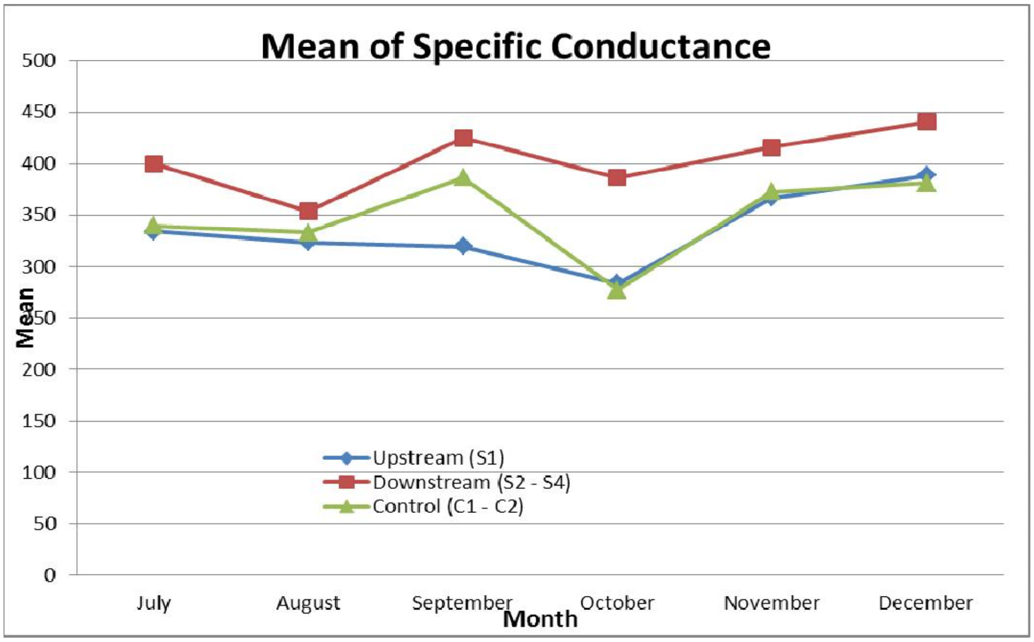

Fig. 3. Monthly specific conductance at station S_1 and monthly means for specific conductance at stations (S_2 to S_4) and control streams (C_1 to C_2)

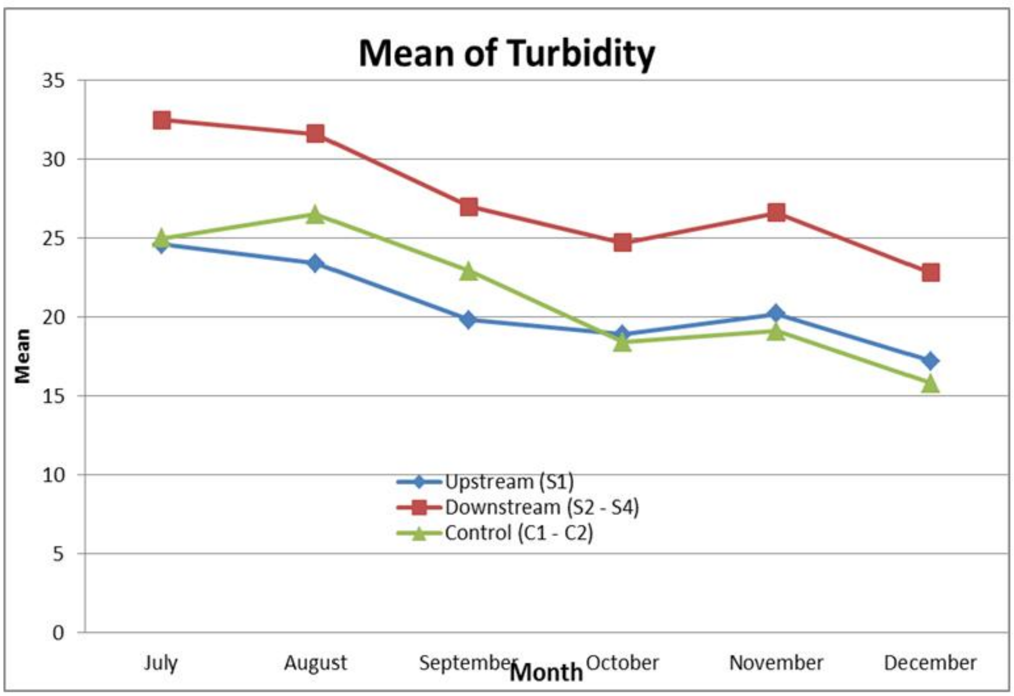

Fig. 4. Monthly turbidity at station S_1 and monthly means for turbidity at stations (S_2 to S_4) and control streams (C_1 to C_2)

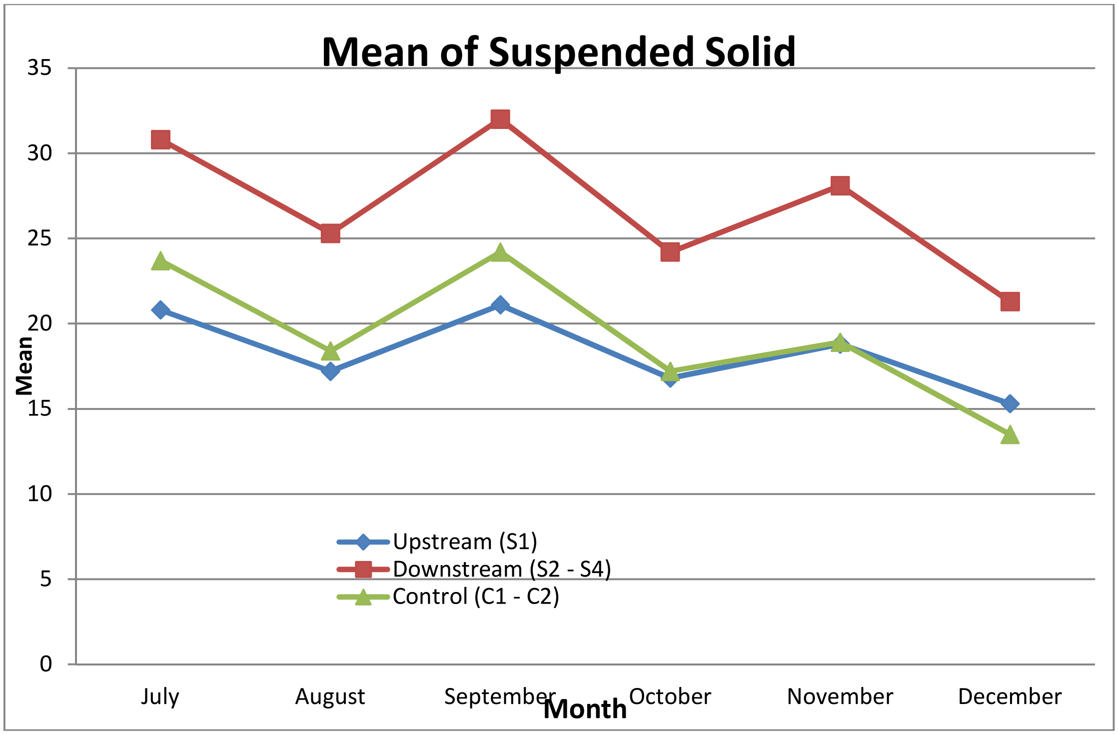

Fig. 5. Monthly total suspended solids at station S_1 and monthly means for total suspended solids at stations (S_2 to S_4) and control streams (C_1 to C_2)

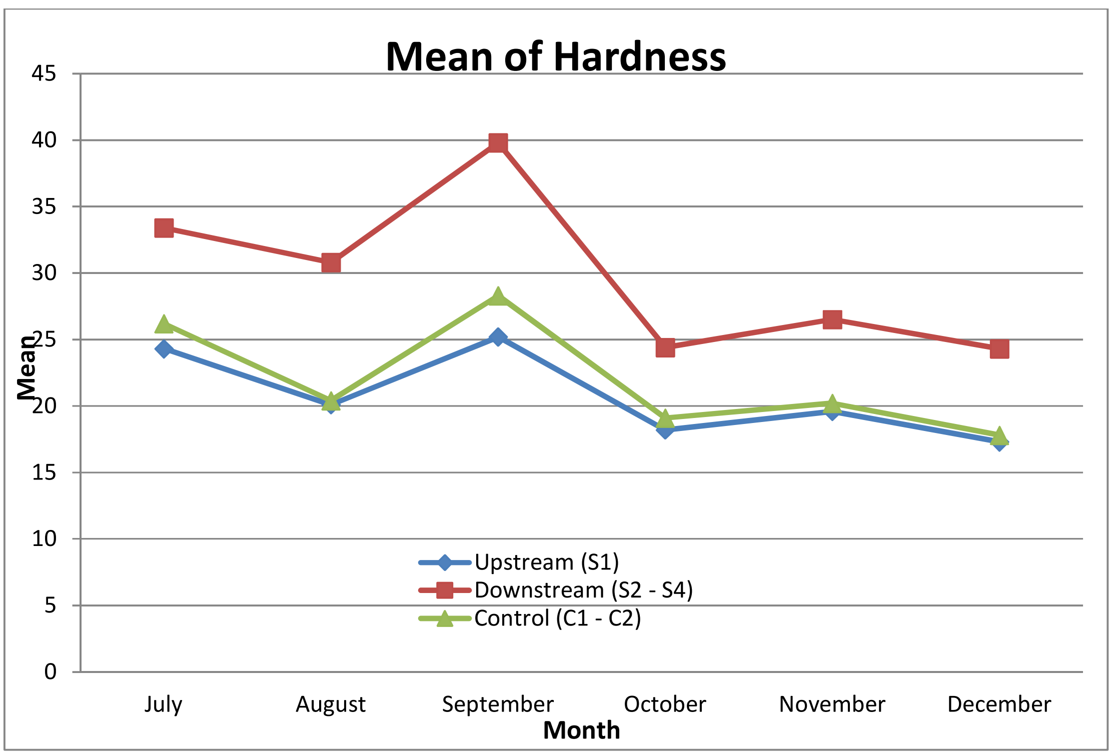

Fig. 6. Monthly total hardness at station S_1 and monthly means for total hardness at stations (S_2 to S_4) and control streams (C_1 to C_2)

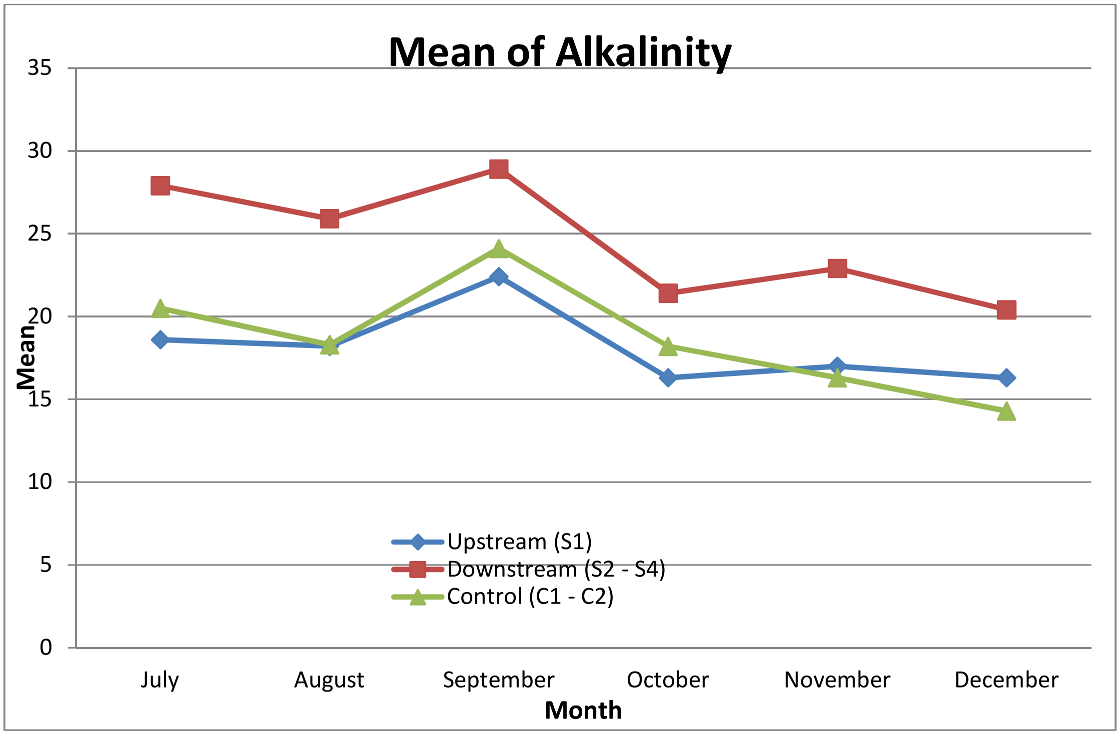

Fig. 7. Monthly total alkalinity at station S_1 and monthly means for total alkalinity at stations (S_2 to S_4) and control streams (C_1 to C_2)

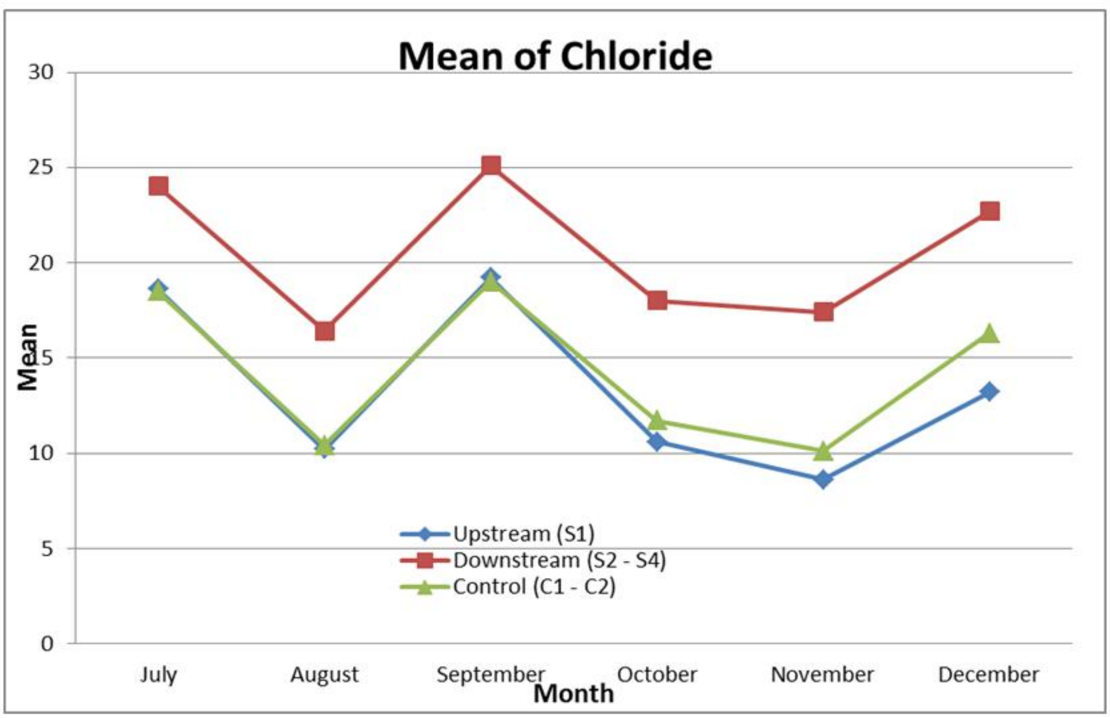

Fig. 8. Monthly chloride at station S_1 and monthly means for chloride at stations (S_2 to S_4) and control streams (C_1 to C_2)

4.2 Specific Conductance

Specific conductance trend for the stations were presented in Fig. 3 increase from 390.1 mhos/cm at S_1 to 489.2 mhos/cm at S_2. The specific conductance increase was related to downstream be due to increases in total hardness and total alkalinity concentrations. The downstream (S_2) had the highest monthly averages for specific conductance compared to other stations. There was significant difference ($p \geq 0.05$) among the grand means for all the stations (Table 2). Specific conductance is an indicator of mineralization and salinity or total salt in a water sample. The FEPA acceptance limit for specific conductance in domestic water supply is 70 mhos/cm. This limit was exceeded in the receiving water body. Thus the parameter gave concern and it could make the water unsuitable for direct domestic use.

4.3 Turbidity and Total Suspended Solids

The averaged turbidity of the stream increased from 24.6 (NTU) at upstream to 38.4 (NTU) at downstream and declined to 26.6 (NTU) at control stream (Fig. 4).The similar pattern was observed in the total suspended solids with values of 20.8 mg/l at upstream (S_1) to 37.8 mg/l at downstream (S_2 – S_4) and 23.8 mg/l at control stream (C_1 – C_2) (Fig. 5). Turbidity and total suspended solid concentrations fluctuated in downstream, but concentrations of these two variables often were greatest at station 2 (S_2). The grand means of turbidity and total suspended solids were significant difference ($P \geq 0.05$) between downstream and other stations (Table 2). Peak turbidity and total suspended solids concentrations at all the stations were 38.4 (NTU) and 37.8 mg/l respectively. The peak turbidity values exceeded the limit for this variable in streams classified for fish and wildlife propagation [3,11].

4.4 Total Hardness and Total Alkalinity

Total hardness and total alkalinity concentrations exhibited considerable temporal fluctuation Figs. 6 and 7 respectively. The upstream station and control station had similar concentrations of these two variables while downstream station especially (S_2) tended to have highest concentration. The minimum values for total hardness and total alkalinity were 16.9 mg/l and 15.0 mg/l respectively. While the maximum values were 40.8 mg/l and 31.4 mg/l respectively. The two values lower than the range of recommended values 50 – 300 mg/l and 50 – 200 mg/l for total water hardness and total alkalinity for catfish production [12,13]. Grand means of total hardness and total alkalinity concentrations were differ between downstream and other stations (Table 2). There is no standards for total hardness and total alkalinity for stream [3,11], but the small increases in these two variables did not raise pH significantly.

4.5 Chloride Concentration

The trend of chloride concentrations at stations were presented in Fig. 8. It is exhibited similar trends of change over time at each station. Chloride concentration rose from 8.6 mg/l at S_1 to 28.6 mg/l at S_2. The grand means chloride concentration at downstream station significant difference ($P \geq 0.05$) from other stations (Table 2). The chloride concentration was due the nature of the soil in the area. The means chloride concentration at each station was closed to the recommended value 20.0 mg/l [24] for water usage.

Grand means for selected stations data in Table 2 suggest that stations (S_2 –S_4) differ from the reference stream with respect to most water quality variables. Moreover, upstream station (S_1) was similar in concentration to control stations (C_1- C_2) for several variables which is the reflection of reference stream characteristics. The effluent discharged station (S_2) and downstream stations (S_3 – S_4), however, appeared to have greater concentration of specific conductance, turbidity, total suspended solids, total hardness, total alkalinity and chloride than upstream and control stations. The changes in water quality variables between stations (S_1) and (S_2 – S_4) are depicted in Table 2. There were differences in water quality variables except water temperature among these sampling stations. Total alkalinity and total hardness concentrations were higher as a result of liming the ponds where effluent source derived. Greater specific conductance was caused by the increases in alkalinity and total hardness, while suspended solids and turbidity were caused by the effluent and overland flood from the surrounding wooden area. This study agreed with [25] and [3,11] that catfish farming had measurable impacts on stream water quality.

5. CONCLUSIONS AND RECOMMENDATIONS

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 turbidity, total suspended solids, total hardness and total alkalinity.
- These differences were related to catfish farm effluents, the nature of the soils in the area, dead and decay of aquatic plants and runoff caused by the flood in the area.
- Catfish pond effluents tended to be higher in concentrations of n in turbidity, total suspended solids, total hardness and total alkalinity than stream waters into which they were discharged.

However, the conclusion was that catfish farms contaminant the stream which could lead to negative impact on stream water quality. If corrective measures are not taken, it will damage the aquatic ecosystem of the Majidun stream. The overall impact of catfish farm effluents on the water quality of the Majidun stream could be reduced via better farm husbandry, improved farm design, water filtration and treatment of the effluent before discharged into environment. Stream flow should be determined, Biological parameters and chemical parameters such as pH, DO and BOD should be investigated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jeje C. Post-larvae feeding of *Clarias gariepinus* on cultured zooplankton and Artemia diets 'Proceedings of the 10th Annual Conference of Fisheries Societ of Nigeria (FISON), Abeokuta. 16th - 20th November. 1992;129–137.
2. Adekoya BB, Ayansanwo TO, Idowu AA, Kudoro OA, Salisu AA. Inventor of fish hatcheries in Ogun State. Ogun State Agricultural development programme, Abeokuta; 2006.
3. Boyd CE. Biochemical oxygen demand in channel catfish pond water. Journal of the World Aquaculture Society; 2000a.
4. Boyd CE. Water quality standards: Total ammonia nitrogen. Global Aquaculture Advocate. 2001b;4(4):84-85.
5. Boyd CE. Aquaculture and water pollution. American Water Resources. Summer Specialty Conference, Snowbird, Utah; 2005.
6. Tucker CS. Characterization and management of effluents from aquaculture ponds in the southeastern United States. Southern Regional Aquaculture Center, Mississippi State University, Stoneville, Mississippi, USA; 2000.
7. Tucker CS, Boyd CE, Hargreaves JA. Characterization and management of effluents from warm water aquaculture ponds. In: Tomasso JR, (ed.) The Environmental Impact of Aquaculture in the United States. United States Aquaculture Society, Baton Rouge, LA; 2002.
8. Read PA, Pernandes TF, Miller KL. The derivation of scientific guidelines for best environmental practice for the monitoring and regulation of Marine Aquaculture in Europe. Journal Applied Inchthyol. 2001; 146-152.
9. Tucker CS, Hargreaves JA. Environmental best management practices for aquaculture. Aquaculture International. 2008;17:301-302.
10. Tomasso JR. Aquaculture and the environment in the United State. Aquaculture Society Lousiana Center. Baton Rouge, Louisiana, USA; 2002.
11. Boyd CE. Water quality: An introduction. Kluwer Academic Publication, Boston. In. Hayes DF. 2000b;153–157.
12. Boyd CE. Water quality standards: Dissolved oxygen. Global Aquaculture. Advocate. 2001c;4(6):70-72.
13. Boyd CE. Aquaculture and water pollution. Hayes DF, McKee M, (eds). Decision Support Systems for Water Resources. 2001d;153-157. Management, American Water Resources Association, Middleburg, Virginia.
14. Tucker CS, Robinson EH. Channel catfish farming handbook. New York: Nostrand Reinhold; 1990.
15. Boyd CE. Water quality in ponds for aquaculture. Auburn AL: Alabama Agriculture Experiment Station; 1990.

16. Boyd CE. Nitrogen, phosphorus loads vary by system, USEPA should consider system variables in setting new effluent rules. Global Aquaculture V Advocate. 2001e;4(6):84-8.
17. Boyd CE. Water quality standards: Total phosphorus. Global Aquaculture. Advocate. 2001f;4(3):70-7.
18. Boyd CE. Water quality standards: Total suspended solids. Global Aquaculture Advocate. 2001g;4(2):70-71.
19. Boyd CE. Aquaculture and water pollution. Mckee M, (editors). Decision support systems for water resources management. American Association, Middleburg, Virginia, USA; 2001a.
20. Boyd CE. Guidelines for aquaculture effluent management at the farm level Aquaculture. 2003;226:101-112.
21. Schwartz MF, Boyd CE. Constructed wetlands for treatment of channel catfish pond effluents. The Progressive Fish-Culturist. 2004;57:255-266.
22. Holdren C, Jone W, Taggart J. Managing lakes and reserviors. Lake Management society and Terrene Institution in Coop. with Official Water Assessment Watershed protection Division U.S. Environment protection Agency Madison; 2001.
23. American Public Health Association (APHA). Standard Methods for the Examination of Water and Wastewater, 16th and 17th Eds. Washington, DC; American Water Works Association, Water Control Federation; 2005
24. World Health Organization. Guidelines for Drinking water quality. 3rd Edition, WHO, Geneva. 2004;540.
25. Silapajarn O. Effects of channel catfish farming on water quality in Big Prairie Creek, west-central Alabama. Ph.D. dissertation, Auburn University, Alabama, USA; 2004.

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