IMPECTS OF CATFISH EFFLUENTS ON WATER QUALITY PARAMETERS OF MAJIDUN STREAM, SOUTH-WEST, NIGERIA

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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 water-borne diseases. The aim of this study was to assess the effect of catfish pond effluents on water quality of stream water where five catfish farms were located. Water samples were taken on monthly basis, 20 cm of below water surface from the streams that receive effluents from neighboring fishponds. Water quality indicators like dissolved oxygen, biochemical oxygen demand (BOD₅), nitrate, nitrite, water temperature, ammonia and Hydrogen ion Concentration (pH) were examined in the sampled waters in accordance with the American Public Health Association standards. The average values of water quality indicators examined at effluents and non-effluents discharged sites of the stream indicated that water (24.6 ± 0.2, 24.2 ±0.1), (7.29±0.30, 7.30±0.10), (6.90±0.4, 7.07±0.1 mg/l), (0.40±0.04, 0.27±0.01), (3.77±0.26, 2.34±0.16 mg/l), (3.59±0.11, 2.80±0.02 mg/l) and (3.51±0.24, 2.46±0.21 mg/l) at (p≥0.05) respectively for temperature, pH, dissolved oxygen, total ammonia, total nitrogen, total phosphorus, and BOD₅. They were significant differences (P<0.05) excepts temperature and pH, between values obtained at effluents discharged and non-effluents discharged sites, indicating that improper discharges of catfish pond effluents could resulted into environmental contamination

Keyword: Catfish pond effluents, Stream waters, water quality, environmental pollution, South-West Nigeria

1. 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) reported that Nigerians aquaculture industry products like fish and shrimps is gradually replacing animal meat as a source of dietary protein and the business hub for teeming million youth. The most commonly cultured is African Clarias (Clarias gariepinus) (Adekoya et al., 2006). There are numerous publications on the catfish pond effluents (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 logical 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. Reprehensive handling of fishpond effluents during fish harvesting is environmentally unfriendly with serious decline in biodiversity than overflow from fishponds after rainfall events (Boyd, 2003; Schwartz and Boyd, 2004). Effluents released during fish harvesting are highly polluted due to suspended of sediment by seining efforts. The effects of continuous suspension catfish effluent on fresh water quality depends on methods of drainage, amounts of water drained during the harvesting and the concentration of pollutants in the effluents. About 20 to 30 % of nitrogen and phosphorus applied during feeding are observed 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). Some studies those conducted by 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 are major sources of wastewater effluent that contain high level of oxygen demanding waste, and also producing objectionable odour in the receiving adjacent streams which most fish farmer consider an ease means of waste disposal methods. However, indiscriminate disposal of untreated wastewater from fish ponds into streams could result in over enrichment of water body with the dissolved nutrients, thereby causing eutrophication. This is could dwindle the aesthetic value of the water body, prevents sunlight penetration and promote decay of aquatic algae thereby making the water to stink.

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 had been 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 by Boyd (2001a, 2001b, 2003, 2005) ranging from offensive odor, lowering dissolved oxygen, impairment to water bodies rendering it unfit for domestic, industrial and agricultural purposes. Stream water can be judged from physical, chemical, biological and aesthetic points of view. Physical parameters for water quality are color, turbidity, total suspended solids, temperature, conductivity and odor. Chemical parameters are pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved ions and chemicals and biological parameters are bacteria, algae, virus, coliform and other biological pathogens. With increased interest in green environment and sustainable fish farming practices, the aquaculture industry needs to focus on ways to reduce water-quality deterioration, and general environmental pollution through effective waste management techniques. In Nigeria, the Federal Environmental Protection Agency (FEPA) has not been developed regulations for effluent from pond aquacultures. There has been considerable concern over waste waters especially from industries as water pollutants in Nigeria and effort has been devoted to reduce the effects in Nigerian water bodies. In Nigeria impacts of disposing waste water from catfish farming ponds on the quality of surface water bodies has not been studied and data on 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 effect on water quality of surface water bodies surrounding the fish farms in Lagos State, Nigeria.

2. Materials and Methods
2.1 Description of the Study area.
Geographically, Lagos State is situated in the South West of Nigeria that, 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 falls within longitudes 03°50’E and 03°38’E and latitudes 06°20’N and 06°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 4.6 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.

2.2 Sample Collection

Water samples were collected from streams and canals in which only effluents from catfish ponds are discharged. The sampling stations along the stream were labeled S\textsubscript{1} to S\textsubscript{4}, while sampling stations along canal were labeled C\textsubscript{1} to C\textsubscript{2} that served as control (non-effluents discharged). All the sampling stations were spaced 40 m apart.

The sample stations and locations are presented in Table 1.

![Study Area](image)

Figure 1: Map of Lagos State showing the study area

2.3 Experimental Methods

Water sample were collected at approximately one-month intervals beginning from July 2, 2012 at S\textsubscript{1} to S\textsubscript{4} and C\textsubscript{1} to C\textsubscript{2}. Sampling continued at all stations until December 2, 2013. Four samples were collected in 250 ml glass bottle for Dissolve oxygen (DO) and biological oxygen demand (BOD), and other samples were collected in sterilized 1-litre plastic bottles for other physiochemical parameters. The water temperature was measured at depth of 0 cm, 30 cm and 60 cm and the samples were kept inside refrigerator. The samples were collected during the same day and analyses were done the next day. The measured physiochemical water quality parameters include water temperature, pH, DO, total ammonia, total nitrogen, total phosphorus and BOD. All sample collections were replicated four times.

<table>
<thead>
<tr>
<th>Sample Stations</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Majidun lagoon, near ferry Jetty</td>
</tr>
<tr>
<td>S2</td>
<td>Majidun lagoon near Omoyele street</td>
</tr>
<tr>
<td>S3</td>
<td>Majidun lagoon, near Abejoye street</td>
</tr>
<tr>
<td>S4</td>
<td>Majidun lagoon, near Agbon street</td>
</tr>
<tr>
<td>C1</td>
<td>Majidun canal, near police station</td>
</tr>
<tr>
<td>C2</td>
<td>Majidun canal, near police station</td>
</tr>
</tbody>
</table>
2.4 Sample measurements
The parameters measured include water temperature, pH, total nitrogen (TN), total ammonia (TNH₃), total phosphorus (TP), dissolved oxygen (DO) and biological oxygen demand (BOD₅).

2.4.1 Water temperature:
It was measured in situ using thermometer.

2.4.2 pH:
The pH value was measured directly by a pH meter by dipping the electrode into the pond water (APHA, 2005).

2.4.3 Total Nitrogen (TN) and Total Ammonia (TNH₃):
Total nitrogen and total Ammonia were determined by the Kjeldahl method (APHA, 2005).

2.4.4 Total Phosphorus (mg/l):
Total phosphorus was measured using a spectrophotometer (APHA, 2005).

2.4.5 Biochemical oxygen demand (BOD₅):
The BOD was determined by Winkler’s method (APHA, 2005).

2.4.6 Dissolved oxygen (DO):
The dissolved oxygen (DO) was determined by Winker’s method (APHA, 2005).

2.5 Data Analysis
The SPSS software package 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.

3. Results and Discussions
The grand mean water qualities concentration for catfish effluent at various sample stations are presented in Table 2.

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

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>SAMPLES STATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream (S₁)</td>
<td>Downstream (S₂– S₄)</td>
</tr>
<tr>
<td>Water temperature (°C)</td>
<td>24.2±0.1a (22.8 – 25.5)</td>
</tr>
<tr>
<td>pH (standard units)</td>
<td>7.32±0.20a (7.18 – 7.48)</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/l)</td>
<td>7.11 ±0.2a (6.99 – 7.24)</td>
</tr>
<tr>
<td>Total ammonia (mg/l)</td>
<td>0.26±0.02a (0.11 – 0.36)</td>
</tr>
<tr>
<td>Total nitrogen (mg/l)</td>
<td>2.40 ±0.13a (2.1 – 2.9)</td>
</tr>
<tr>
<td>Total phosphorus (mg/l)</td>
<td>2.58 ±0.06a (2.16 – 3.51)</td>
</tr>
<tr>
<td>Biochemical oxygen demand (mg/l)</td>
<td>2.30±0.18a (1.5 – 3.8)</td>
</tr>
</tbody>
</table>
Values are means of four replicates (n = 28) in all sampling; 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 (S₁), downstream
(S₂ to S₄) and control stream (C₁ to C₂) without catfish discharged effluents. Means indicated by
the same letter did not differ (P ≥ 0.05) according to Duncan’s multiple range test (horizontal
comparisons only).

3.1 Water Temperature
Average water temperatures were quite similar among the three categories of the stations as shown
in Figure 2. Lowest temperatures ranged 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 is less than 2.8°C rise that allowed in streams classified for fish and
wildlife propagation (Boyd, 2000b).

![Figure 2: Monthly water temperatures at station S₁ and monthly means for water temperature at
stations (S₂ to S₄) and control streams (C₁ to C₂)](image-url)

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 alkaline. The upstream (S₁) had higher pH level than downstream and control
stream The pH of stream water tended to increase between downstream (S₂ – S₄) and control
stations (C₁ – C₂) indicating that effluents from pond was basic in reaction relative to normal
stream flow from downstream. The upstream (S₁) usually had slightly higher pH than water at
(S₂). However, the difference pH concentration between upstream (S₁) and downstream (S₂ - S₄)
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 (2004) 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)

The 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). The DO concentration at ($S_2$) 6 mg/l which exceeded stream standard of 5.0 mg/l. DO concentrations in unpolluted water normally ranges0 between 8 and 10 mg/l and concentrations below 5 mg/l do adversely affect aquatic life (Rao, 2005). DO for drinking purpose is 6 mg/l whereas for sustaining fish and aquatic life is 4-5 mg/l (Rao, 2005). DO concentrations for all the stations were adequate for maintenance of biological function.
3.4 Total Ammonia (TA) and Total Nitrogen (TN)

The monthly trend of total ammonia and total nitrogen concentrations were as presented in Figures 5 and 6 respectively. The peak of total ammonia and nitrogen concentrations of 0.63 mg/l and 5.3 mg/l were reached at downstream (S₂) respectively. The decline in total ammonia along the downstream (S₂ – S₄) was the result. 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 ≥0.05) between downstream station and other stations (Table 2). The ammonia concentration exceeded the recommended level ≥0.05 mg/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.

![Mean of Ammonia](chart)

**Fig.5:** Monthly concentration of ammonia at station S₁ and monthly means for ammonia at stations (S₂ to S₄) and control streams (C₁ to C₂)

![Mean of Nitrogen](chart)

**Fig.6:** Monthly concentration of total nitrogen at station S₁ and monthly means for total nitrogen at stations (S₂ to S₄) and control streams (C₁ to C₂)
3.5 Total Phosphorus Concentration

Total phosphorus concentrations were fluctuated at all stations as shown in Figure 7. The peak value 5.3 mg/l was at downstream station (S2). The decline in total phosphorus concentrations at station (S3 – S4) was likely due to uptake of what by aquatic plants and adsorption by sediment. The grand means of phosphorus was significantly different (P ≥ 0.05) among the stations (Table 2). The phosphorus concentrations at all the stations were greater than recommended value (2.0 mg/l), for domestic consumption (WHO, 2004) which was due to the catfish effluent. The high phosphorus load associated with the higher phosphorus content of catfish effluent in the study area. Phosphorus loads could be reduced by use of low-pollution feed and better-feed management.

Figure 7: Monthly concentration of total phosphorus at station S1 and monthly means for total phosphorus at stations (S2 to S4) and control streams (C1 to C2)

Figure 8: Monthly concentration of biological oxygen demand at station S1 and monthly means for biological oxygen demand at stations (S2 to S4) and control streams (C1 to C2)
3.6 Biochemical Oxygen Demand (BOD₅)
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 (S₁) and ranged from 2.1 mg/l to 5.2 mg/l at downstream (S₂ – S₄). There was clear trend in concentration among the station Peak of biochemical oxygen demand was observed at S₂. Grand means for biochemical oxygen demand did not differ between the upstream station and control station. There was significant difference (P ≥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 (S₂ – S₄) with control canal (C₁ – C₂) allows the best evaluation of the effect of catfish farming on water quality. These findings corroborate earlier works (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.

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

1. Stream had distinctly different water quality between upstream station (S₁) above the outflow of catfish farm effluents station (S₂) and the downstream stations (S₃ – S₄) below the outflow of catfish farm effluents station (S₂).
2. The major differences occur in pH, total ammonia, total nitrogen, total phosphorus and biochemical oxygen demand.
3. These differences were related to catfish farm effluents and runoff caused by the flood in the area.
4. Catfish pond effluents have elevated in concentrations of nitrogen, ammonia, biochemical oxygen demand and phosphorus than stream waters into which they were discharged.
5. 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

References
Adekoya, BB, Ayansanwo, TO, Idowu, AA., Kudoro, OA. and Salisu, AA. 2006. Inventory of Fish Hatcheries in Ogun State, Ogun State Agricultural development programme, Abeokuta., pp. 194 - 200


