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ASSESSMENT OF PHYSICOCHEMICAL PARAMETERS AND BACTERIAL QUALITY OF SELECTED FISH POND EFFLUENTS IN OWO METROPOLIS

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Abstract

The present study investigated the physicochemical properties and microbiological quality of different concrete and earthen fish pond effluents in Owo. The physicochemical parameters were assessed using standard chemical methods while the microorganisms were isolated using the pour plate method and the isolates were identified using some biochemical tests. The results of the physicochemical analysis showed that the temperature of the fishpond water ranged from 27.38±0.05 to 27.85±0.02, pH ranged from 6.31±0.01 to 6.79±0.01, turbidity (2.42±0.02 to 13.70±0.00 NTU), conductivity (32.57±0.01 to 307.10±0.04µS/cm), dissolved oxygen (8.24±0.01 to10.27±0.04 mg/L), Biological Oxygen Demand (4.88±0.03 to 6.78±0.02 mg/L). Nitrate in this study ranged from (1.18 to 1.37mg/L), sulphate from (0.29±0.20 to 1.69±0.02 mg/l) and phosphate from (1.01±0.00 to 4.08±0.15mg/L). Total bacteria count (TBC) was highest in the concrete pond at Okedogbon (5.28±0.07 x10^5 cfu/ml) and lowest in the earthen pond (1.26±0.58 x 10^5 cfu /ml). TCC and TEC ranged from 18.2±0.05 to 52.5±0.25 × 10^5 cfu /ml and 2.1± 0.00 to 2.8±0.03 ˣ x 10^5cfu /ml) respectively with earthen pond recording the lowest in TEC and nil in TCC. Similarly, earthen pond recorded the least in both Salmonella/Shigella (1.2±0.05^{a}x 10^5cfu/ml) and Vibrio cholerae (1.0±0.00x 10^5CFU cfu /ml) counts. The presence of pathogenic bacteria especially E. coli and Salmonella spp can lead to the transmission of waterborne diseases. The study recommended that urgent measures are needed to ensure appropriate fish management and prevention of transmission of potential pathogens which are important in the part of the food safety plan and general environmental safety.*

Keywords: Physicochemical, Bacteria, Pathogens, Fishpond, Effluent, Safety

Introduction

The farming of aquatic organisms is referred to as aquaculture. It is one of the major fast-growing sectors in global food production and a source of animal protein in Nigeria and the world today. To fully bring aquaculture to the desired level, four production challenges have been identified. These challenges are; management of the pond, water quality, feeding of the stock in the pond, fish seeds provision, and pond construction. The first two challenges, water quality management and fish feeding, affect each other. According to Filbrun, Reynolds and Culver (2013), excessive feeding of the stocks decreases production efficiency and yields; this affects the water quality which in turn affects the performance of fish in the pond by causing hypoxia. It is accepted that good water quality is needed to maintain viable aquaculture production as opined by Alam and Al-Hafedh (2016). Its quality is one of the most overlooked aspects of good management until it affects fish production or causes risk to human health. Poor water quality can result in low profit, low product quality, and potential human risk.

Shoko, Limbu, Mrosso and Mgaya (2014) believed that production is reduced when the water contains contaminants that can impair development, growth, and reproduction, or even cause mortality to the cultural species. To have successful aquaculture, there is a need for healthy fish and proper water quality management as a deficiency in any variable will reduce the growth and affect the health of the fish.

Over the years, aquatic pollution has been a major environmental concern globally. The increase in human population, civilization, industrialization, and increasing anthropogenic activities have contributed greatly to aquatic pollution in developing countries (Siyanbola, Ajanaku, James, Olugbuyiro and Adekoya 2011). Chemical pollution as a result of untreated effluent discharges and inadequate waste management and disposal appears to be the major sources of aquatic pollution in developing countries. Earlier studies have shown that less than 10% of industries in developing countries treat their effluents before being released into the nearby streams or rivers (Adewoye, Salami and

Taiwo, 2010). A large number of chemical pollutants due to their persistence in the environment and accumulation over time have been reported to impair water quality, making it unsuitable for aquatic life, domestic recreation, and industrial purposes (Taiwo *et al*., 2012).

The bacteria flora of the fish depicts the level of bacteria in the water environment. Soon *et al*. (2014) opined that the fish bacterial flora is shown by the bacteriological quality of the water. This in turn plays a vital role in diseases spreading in farmed fish, the fact that must be well known by the fish farmers who should understand the importance of maintaining the proper bacteriological water quality of the pond. They become pathogenic when conditions such as temperature changes, dietary, hormonal stresses, and other physiochemical parameters are favourable for the development of pathogenesis, the condition that fishes are cultured in may be potentially stressful (Garcia-Mendoza *et al*., 2019).

Water quality for aquaculturists refers to many characteristics of water that affect the survival, reproduction, and growth of the desired organism being reared. According to Boyd (2003), the water quality variable generally means the components of water that must be present for the best possible growth of aquatic organisms. As noted by Bhatnagar and Devi (2013), water quality is made up of physical (temperature, density) chemical (pH, conductively, nutrients), and biological (bacteria, plankton, and parasites) which influence the use of water in fish culture purposes.

Fish cultivation in a restricted environment is usually contaminated by microorganisms (pathogenic and opportunistic organisms). Huicab-Pech *et al*. (2016) attributed this contamination to questionable water quality and stocking densities. According to Ikpi and Offem (2011), microorganisms contribute a significant fraction of importance in the aquatic ecosystem and they have been observed to be among the factors that cause the emergence of infectious diseases in the practice of aquaculture. Therefore, the primary aim of this study was to assess the physicochemical parameters and microbiological quality of fish pond effluents in the Owo metropolis.

Materials and Methods

Study Area: Owo is the headquarters of Owo Local Government Area of Ondo State. It is situated in the South – West geopolitical zone of Nigeria. All the fish ponds water sampled were located in the area. They were also constructed to standard.

Collection of Fish Pond effluent Samples: The samples were collected randomly from five ponds for the microbial counts and physicochemical parameters. The samples were collected in white plastic containers. They were previously sterilized with 70% alcohol and rinsed with distilled water. At the ponds, the containers were rinsed twice with the pond water before being used to collect the samples. Thereafter, they were transported to the Microbiology Laboratory of the Science Laboratory Technology Department, Rufus Giwa Polytechnic, Owo for further processing.

Physicochemical Parameters Analysis: The pH and temperature of the samples were determined on-site using a hybrid pH and thermometer electrode (Suntex model sp-701) (APHA, 2005). Turbidity was determined using a turbidimeter (Nach model 2100N) and recorded in units known as Formation Turbidity Unit (FTU). Conductivity and total dissolved solids (TDS): The conductivity was determined using a conductivity meter (Labtech model 648) and recorded in µs/cm and the total dissolved solids (TDS) ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium that contribute to the dissolved solids in water were determined using the formula: TDS = 0.5 × Conductivity. The total suspended solid (TSS) was determined using a spectrophotometer (Hach 3900). Readings were taken and recorded in mg/l. Dissolved oxygen (DO) and biological oxygen demand (BOD) were done using the method described by APHA (2005) while nitrate, sulphate, and phosphate were assessed using a spectrophotometer.

Microbial Analysis

Samples of the pond water were serially diluted in ten folds. Total viable heterotrophic aerobic plate counts were determined by plating in duplicate, using the pour plate technique. Molten nutrient agar, Salmonella- Shigella agar, Thiosulphate Bile Citrate Salt agar, MacConkey agar and Eosin Methylene Blue agar at 45 ^{0}C were poured into the Petri dishes containing 1mL

of the appropriate dilution for the isolation of the total heterotrophic bacteria, Salmonella-Shigella, *Vibrio cholerae*, coliforms and *Escherichia coli* respectively. They were swirled to mix and colony counts were taken after incubating the plates at 35 ºC for 24 hours. Characterization was done using the cultural, morphological, and biochemical characteristics of the colonies based on the criteria of the Bergey's Manual of Determinative Bacteriology (Akinnibosun, Omonigho and Oyetayo, 2020).

Results and Discussion

The results of the analysis of the fish pond water samples effluents from different concrete fish ponds are shown in Tables 1-3. The mean values of the physicochemical parameters effluents from different concrete fish ponds in Owo are presented in Table 1. The water pH is vital because it affects the solubility and availability of nutrients, and how they can be utilized by aquatic organisms in the ponds mostly fisheries (Osawe, 2007). The pH levels of the collected fish pond water in this study in Owo were between 6.31±0.01 to 6.79±0.01. All the samples were slightly acidic with Earthen Pond (6.31±0.01) being the most acidic amongst all the samples. This result falls within the FEPA regulatory limit of 5.0 to 9.0 for optimum fish production and is in agreement with the study of Okonkwo *et al.* (2008). The result also revealed that the pH of water samples from the earthen pond was significantly lower than the pH of samples in concrete ponds.

Table 1: Physicochemical Properties of effluents from different concrete fish ponds in Owo

Parameter	Okedogbon	Okeogun	Ijebu	Earthen
pH	6.68±0.12	6.42±0.00	6.79±0.01	6.31±0.01
Temperature	28.02±0.07	28.72±0.03	27.85±0.02	27.38±0.05
Turbidity (NTU)	13.70±0.00	11.62±0.20	12.03±0.02	2.42±0.02*
Conductivity (µs/cm)	274.09±0.25	307.10±0.04	285.37±0.03	32.57±0.01*
Total dissolved Solid (mg/l)	15.22±0.05	14.25±0.08	14.07±0.01	8.89±0.10*
Total Suspended Solid (mg/l)	16.77±0.01	13.92±0.58	15.88±0.03	7.28±0.02*
Dissolved Oxygen	9.12±0.01	8.92±0.18	8.24±0.01	10.27±0.04
Biological Oxygen Demand (mg/l)	6.19±0.03	6.31±0.00	6.78±0.02	4.88±0.03*
Sulphate (mg/l)	1.62±0.00	1.58±0.01	1.69±0.02	0.29±0.20*
Nitrate (mg/l)	3.61±0.10	4.07±0.02	4.31±0.00	1.05±0.03*
Phosphate (mg/l)	4.08±0.15	3.72±0.01	3.58±0.05	1.01±0.00*

Values are Mean±SEM and those followed by * across rows are significantly different at P<0.05

Temperature is an essential parameter in water. It affects the chemical and physicochemical characteristics of the environment as well as the organisms in the pond. The temperature profile of the fishpond water samples examined during this study ranged from 27.38±0.05 –28.72±0.03 which were within the FEPA recommended range of 20–35 °C. The temperature recorded for earthen ponds had the lowest temperature cause of the nature of the material the pond was made than those of concrete (28.02±0.07, 28.72±0.03 and 27.85±0.02) for Okedogbon, Okeogun, and Ijebu respectively. Though generally the temperature of all the ponds are of good factor for proper rearing of fish as recommended scientifically. The findings in this study are similar to the reports of Okonkwo *et al.* (2008) who reported 28 to 29 °C.

Turbidity is the result of several factors including suspended soil particles, planktonic organisms, and humic substances produced through decomposition of organic matter (Garcia-Mendoza *et al.,* 2019). The turbidity value obtained in the concrete pond samples (13.70±0.00, 11.62±0.20 and 12.03±0.02 NTU) for Okedogbon, Okeogun and Ijebu respectively are higher than that of Earthen pond (2.42±0.02* NTU) which falls within the range limit by WHO (10 NTU) that supports aquatic life while the other ponds are slightly above the permissible limit. This could be a result of debris or unwanted substances hovering on the surface of the ponds in Okedogbon, Okeogun, and Ijebu. Turbidity hinders the penetration of sunlight in the pond making it difficult for aquatic habitats to receive the positive effect of light (Alam and Al-Hafedh, 2016).

Conductivity is widely used as an index of ionic concentration in the water as well as an approximation of total dissolved solids. The study showed a conductivity range of 32.57±0.01* - 307.10±0.04µS/cm which is within the regulatory

limit of 20-1500 µS/cm and thus suitable for fish production. The findings from this study differ from those of Soon *et al.* (2014) who reported a conductivity value of 0.012 -0.017 µS/cm. This could be a difference between locations and seasons of study.

The Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) in this study ranged from 8.89±0.10 - 15.22±0.05mg/Land 7.28±0.02 - 16.77±0.01 mg/L respectively. Earthen ponds scored the lowest value for both TDS (8.89±0.10 mg/L) and TSS (7.28±0.02 mg/L) compared to those of concrete ponds from Okedogbon, Okeogun, and Ijebu respectively. Even though the values were within the regulatory limit of 50 mg/L (FEPA, 2019), the earthen ponds' samples performed better by scoring the lowest TDS and TSS values. This could be attributed to regular partial water changes in the sampled fish ponds that help to dilute wastes and algae-promoting nutrients. The total dissolved solids and total suspended solids are very useful parameters describing the chemical constituents of the water and can be considered as a general of edaphic relations that contribute to productivity within the water body (Herrera *et al.,* 2019). The presence of these parameters may be as a result of the fish feed and runoff.

Dissolved Oxygen (DO) is affected by the photosynthetic activity and aeration rate thus; dissolved oxygen value is a vital factor. It is usually high in winter and low during summer. This is due to low atmospheric temperature in winter (high level of dissolved oxygen) and high metabolic rate of organisms (Morris, 2013). In this study, it is found to be highest in the earthen ponds (10.27±0.04) than those of Concrete ponds from Okedogbon, Okeogun, and Ijebu (9.12±0.01, 8.92±0.18 and 8.24±0.01 respectively). These findings were supported by the findings of Atema, (2008) which were in the same range. In low dissolved oxygen levels, organic matter would start to decompose.

The BOD in the earthen ponds may be attributed to the presence of organic matter while the lower values on the ponds could be due to little or no organic matter degradation. The biological oxygen demand obtained in this study did not vary significantly within the ponds except in earthen which was lesser than others. Biological Oxygen Demand (BOD) values in this study varied from 4.88±0.03* - 6.78±0.02 mg/L. BOD values were within the permissible limit (1-20mg/L). The findings are similar to Taiwo *et al.* (2012) who reported BOD of 3.2 and 4.36 mg/L.

Sulphate concentration in the ponds varied from 0.20±0.29 - 1.69±0.02 mg/l with the earthen pond significantly lower than the concrete ponds which are at $P<0.05$ significantly different. These values are significantly lesser than that of Wurts (2010) who reported 42.46-57.36mg/l. He suggested the use of detergent and soaps by residents which got into the water body may be responsible for the high value of sulphate. Thus, the sulphate value of ponds from this study are in the safe range.

Nitrate is produced by autotrophic Nitrobacter combining oxygen with nitrite in the bio-converter and to the walls of the pond. Whereas ammonia and nitrite are toxic to fish, nitrate is essentially harmless. The level of nitrate in the pond water should be controlled to avoid causing eutrophication (Bhatnagar and Devi, 2013). Nitrate in this study ranged from 1.05±0.03 to 4.31±0.00 mg/L with the highest recorded in the concrete pond (4.31±0.00 mg/L) from Ijebu and the lowest in the earthen pond (1.05±0.03 mg/L). The presence of nitrate could be from the fish feed and surface water runoff. Nitrate is the result of nitrification and is very important to plants. Nitrate is naturally controlled through routine water change and consumption by plant algae (Cole, Arnold, Watten and Krise, 2001).

Phosphate also ranged from 1.01±0.00 - 4.08±0.15 mg/L with the highest observed in the concrete pond from Okedogbon (4.08±0.15 mg/L) and lowest in earthen (1.01±0.00 mg/L). Phosphate is the main nutrient for algae. The phosphate level must not exceed 0.03-2.00 mg/L as recommended by Bhatnagar and Devi (2013). Even the smallest increase can trigger an excessive growth of algae leading to eutrophication. As seen, the phosphate levels from this study exceeded this limit and should be controlled to avoid eutrophication of the ponds (Richard, 2012; Eze and Okpokwasili, 2010). This high level of phosphate obtained may be introduced into the pond through fish feed when the pond is filled with water that contains phosphate or through surface water runoff. This could also be from the building materials used in the construction of the pond that can also release minerals containing phosphate into the pond water. Algae have been observed to store phosphate in their organs and when they die, they release the previously absorbed phosphate

into the water which can trigger the growth of new algae. It is virtually impossible to remove phosphate naturally from pond water. Phosphate and, therefore, algae are the main problems in artificial ponds (Durborow, Crosby and Brunson, 2001).

Table 2: Mean Bacterial counts of effluents from different concrete fish ponds in Owo

Parameter	Okedogbon	Okeogun	Ijebu	Earthen
TBC (x10^5 cfu/ml)	4.86±0.58^c	5.28±0.07^c	3.78±0.10^b	1.26±0.58^a
Salmonella-Shigella (x 10^5 cfu/ml)	2.9±0.01^b	3.2±0.05^b	2.8±0.02^b	1.2±0.05^a
Vibrio cholerae (x 10^5 cfu/ml)	1.9±0.02^b	1.3±0.01^a	1.4±0.02^a	1.0±0.00^a
Coliforms (cfu/100ml)	52.5±0.25^c	47.2±0.09^c	29.6±0.07^b	18.2±0.05^a
Escherichia coli (x 10^5 cfu/ml)	2.1±0.00^b	2.8±0.03^b	2.5±0.00^b	0.00±0.00^a

Values are Mean±SEM and those followed by different alphabets across rows are significantly different at P<0.05

Table 3: Distribution of Bacterial Isolates from different concrete fish pond effluents in Owo

Parameter	Okedogbon	Okeogun	Ijebu	Earthen
S. aureus	+	+	+	+
E. coli	+	+	+	+
Proteus spp	+	+	-	+
Salmonella spp	+	+	+	+
Shigella spp	+	+	+	+
Vibrio spp	+	+	+	
Klebsiella spp	+	+	+	+
Pseudomonas spp	+	+	+	+
Streptococcus spp	+	+	+	-
Serratia spp	-	-	+	-

Key: + = present, - = absence

The result of the microbiological evaluation (Table 2) of water sampled from the respective fish ponds shows that the microbial count did not vary significantly between the ponds. Total bacteria count (TBC) was highest in the concrete pond at Okedogbon (5.28±0.07x10^5cfu/ml) and lowest in the earthen pond (1.26±0.58^{a}x 10^5cfu/ml). TCC and TEC ranged from 18.2±0.05 to 52.5±0.25 x 10^5*cfu*/ml) and 2.1±0.00 ^{b} to 2.8±0.03 ^{b} x 10^5*cfu*/ml respectively with earthen pond recording the lowest in TEC and nil in TCC. Similarly, earthen pond recorded the least in both *Salmonella/Shigella* (1.2±0.05x 10^5cfu/ml) and *Vibrio cholera* (1.0±0.00x 10^5cfu/ml) counts.

Salmonella/Shigella count was higher in the concrete ponds (2.9±0.01, 3.2±0.05 and 2.8±0.02x10^5cfu/ml). Similarly, *Vibrio cholerae* was found to be higher in the concrete ponds (1.9±0.02, 1.3±0.01, and 1.4±0.02 x 10^5cfu/ml) water samples compared to the earthen pond.

The distribution of bacterial isolates from different concrete fish pond effluents in Owo is presented in Table 3. Bacteriological analysis of the water samples showed different genera which are *S. aureus, E. coli, Proteus spp, Salmonella spp, Shigella spp, Vibrio spp, Klebsiella spp, Pseudomonas spp, Streptococcus spp,* and *Serratia spp* and were all present in the sampled ponds except *Serratia spp* which was only present in the concrete sample from Ijebu and absent in other concrete ponds and earthen ponds. Also, *Streptococcus spp* was only absent in the earthen pond but present in the other pond samples while *Proteus spp* was only absent in the concrete pond from Ijebu but present in the other ponds. It can be deduced that the concrete ponds from Okedogbon, Okeogun, and Ijebu are more microbiologically contaminated than those from earthen ponds.

The diverse groups of bacteria isolated from these ponds are in line with the report of Okpokwasili and Ubah (2009) who worked on pond water suggesting that allochthonous bacteria from feed added to the ponds are the principal source of bacteria of health importance and Dabbor (2008) who reported similar organisms in the microbiological study of El-

quanter fish pond. The presence of pathogenic microorganisms especially *E. coli* and *Salmonella* spp. can lead to the transmission of waterborne diseases such as Typhoid fever, Cholera, food poisoning, and gastroenteritis (Piet, 2009) on consumption of improperly cooked fish cultivated in these ponds. The presence of *E. coli* in water or food indicates the possible presence of causative agents of many gastrointestinal diseases. *Pseudomonas* and *Staphylococcus* species have been implicated in food poisoning (Ampofo and Clerk, 2010).

Conclusion and Recommendation

The physicochemical analysis of the fish ponds showed that the values fell within the acceptable limit indicating the water quality may not harm fish health especially that of earthen ponds. However, the presence of indicator organisms as well as known pathogenic bacteria in the effluents indicates that the effluent poses a serious health risk to the environment as they may be a reservoir of these pathogens which are discharged without treatment into the surrounding water and soil. Hence, the detection of pathogenic bacteria that may be multi-drug resistant suggests the need for formulation and implementation of a code of practice for fish farmers. This is to ensure appropriate fish management and prevention of transmission of potential pathogens which is important in the part of a food safety plan and general environmental safety.

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