Full Length Research Paper

An investigation of the microbiological and physicochemical profile of some fish pond water within the Niger Delta region of Nigeria

Njoku, O. E.*, Agwa, O. K. and Ibiene, A. A.

Department of Microbiology, Faculty of Biological Sciences, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Rivers State, Nigeria.

The microbial profile of some concrete and earthen fish ponds within the Niger delta region was evaluated. The results of physico-chemical properties of the water samples showed that alkalinity values were significantly higher in concrete ponds (99.7±47.1 to 150±69.7) than (18±6.9 to 24±14.5 mg/L) in earthen ponds. Electrical conductivity values varied significantly between the ponds with (200±84.1 to 290±74.9 μs/m) in concrete ponds and (18±6.9 to 24±14.5 μs/m) in earthen ponds. Sulphate concentrations were higher in concrete ponds (0.25±0.36 to 1.53±14.9 mg/L) than (0.25±0.36 to 0.4±0.77 mg/L) in earthen ponds. The mean total heterotrophic bacteria count was higher in concrete ponds (6.5×10^5 to 7.4×10^5 cfu/ml) than in earthen (6.3×10^5 to 6.5×10^5 cfu/ml) ponds. The mean fungal count ranged from 2.11×10^5 to 2.25×10^5 cfu/ml in concrete pond and (1.8×10^5 to 2.4×10^5 cfu/ml) in earthen ponds. The bacterial genera isolated from the ponds were *Escherichia coli*, *Staphylococcus* sp., *Aeromonas* sp., *Streptococcus* sp., *Salmonella* sp., *Vibrio* sp., S*higella* sp., *Proteus* sp., *Pseudomonas* sp., *Klebsiella* sp. *Enterobacter* species occurred only in concrete pond, while *Serratia species* occurred in earthen ponds. The fungal genera isolated from both the concrete and earthen ponds were *Aspergillus* sp., *Penicillum* sp. and *Cladosporium* sp. The genera, *Fusarium* sp. and *Mucor* sp were isolated only from earthen ponds. The study revealed that the ponds were grossly contaminated with pathogenic microorganisms which poses a risk to human health, thus of significant public health concern.

Key words: Heterotrophic bacteria, fish ponds, fungal isolates, pathogens, physico-chemical properties.

INTRODUCTION

Fish and its products are very important to human population all over the world. According to the Food and Agricultural Organization (2002), most of the world's population (56%) derives at least 20% of its animal protein intake from fish. This is because fish is the preferred source of much desired animal protein as compared to poultry, beef, mutton or pork. It is compara-tively cheaper and highly acceptable with little or no religious bias which gives it advantage over other proteins (Philips, 2004).

In Niger Delta Region, fish pepper soup is one of their best delicacies leading to higher demand for fish in the region. This gave rise to the increasing number of fish farms in the region in order to meet the demand for fish

*Corresponding author. E-mail: ogadinma_njoku@yahoo.com.

and also offset the scarcity of fish gotten from the wild environment.

Fishes are reared in different culture media or controlled environment which could be ponds (concrete or earthen), vats (wooden or fiber glass) and plastics (Osawe, 2004). Among these culture systems, concrete and earthen ponds are widely used (Ezenwa, 2006). Earthen pond culture system has been the conventional method of fish culture in Nigeria, until recently; concrete tanks culture system is gaining grounds as land become costly, scarce and readily unavailable (Onome and Ebinimi, 2010). Research has shown that a higher number of fish farmers use concrete ponds (73%) as compared to 27% using earthen ponds in Nigeria (Ugwumba, 2010). Fishes cultivated in these controlled environments has been found to be contaminated by microorganisms (pathogenic and opportunistic organisms) (Fafioye, 2011; Nguyen et al., 2007). This contamination has been attributed to questionable water quality and high stocking densities (Okpokwasili and Ogbulie, 1998). The feed used for the fish in these ponds contain organic materials and introduces a wide variety of microorganisms into the ponds (Okpokwasili and Ogbulie, 1999).

Among the constraints of fish farming is the high cost of feeding, which resulted to the use animal manure to augment conventional feed in countries like China, India and also in Nigeria. However, organic manure also leads to the release of high concentration of opportunistic and pathogenic microorganisms into the ponds which are of public health concerns. According to Omojowo and Omojosola (2013), their presence in fish intended for human consumption may constitute a potential danger not only in causing disease but could act as reservoirs of antibiotic resistance organisms leading to treatment failures and high cost of treatment when improperly cooked fish is consumed. Fish is in direct contact with micro flora in the environment and the opportunistic pathogens already present in the water may invade the host under stress and undesirable water quality conditions. It is therefore, important to understand the micro flora associated with fish culture environment, since the microbial flora of a cultivated fish is a reflection of its aqueous environment (Erondu and Ayanwu, 2005). It is therefore significant to evaluate and compare the microbial quality and physiochemical parameters of some fish ponds within the Niger Delta region of Nigeria.

MATERIALS AND METHODS

Study area

The study area is within the Niger Delta region of Nigeria and lies between latitude 4-6°N and longitude 5-8°E. The region is characterized by high biodiversity, characteristic swamp, water ways, vast plains and mangrove forest. The farms combine fish production and livestock production, thus they operate integrated fish production having both concrete and earthen fish ponds stocked with tilapia and catfish.

Sample collection

Water samples were aseptically collected from the ponds biweekly using sterile screw capped bottles. Composites samples were obtained by collecting at different sampling points (four sides of the pond) and 10-15 cm depths from the water surface. The water samples were transported to the laboratory in an ice-packed container for microbiological and physiochemical analysis.

Isolation of total heterotrophic bacteria and fungi

Ten-fold serial dilution of the pond water samples were prepared aseptically in sterile physiological saline up to 10^{-5} and 0.1 ml aliquot of each dilution was inoculated on dried nutrient agar and Sabouraud dextrose agar (Oxiod Limited. Wade Road. Basingstoke Hampshire United Kingdom) plates, in triplicate using the spread plate technique for enumeration of total heterotrophic bacteria count and fungi count, respectively. The nutrient agar plates were incubated at 35°C for 24 h under aerobic condition, while the Sabouraud plates were incubated at room temperature for five days. Plates containing 30-300 bacterial colonies were selected and counted. The number of colony forming units per ml (cfu/ml) was calculated by multiplying the number of colonies per dilution factor. The fungi isolates were identified using lactophenol cotton blue stain while the bacterial isolates were identified using series of biochemical reactions. Cfu/ml = number of colonies per ml plated /total dilution factor.

### Enumeration of total coliform

The most probable number (MPN) was adopted in the determination of the total coliform bacteria using MacConkey broth (Sigma-Aldrich, 3050 Spruce Street St. Louis, MO.) and the five tubes techniques. All positive tubes from the MPN tubes were sub-cultured on an EMB agar (Titan Biotech. Azadpur, New Delhi, India) plates in duplicate and incubated at 35°C for 24 h.

Isolation of *Salmonella/Shigella*

The *Salmonella/Shigella* agar (SSA) (Oxiod limited, Wade Road. Basingstoke Hampshire United Kingdom) was prepared according to the manufacturer's instructions and 0.1 ml aliquot of each water sample was transferred onto the surface of dried sterilized SSA plate. The plates were inoculated in triplicate and incubated at 37°C for 24 – 48 h. Thereafter, pure cultures were obtained by sub-culturing onto freshly prepared SSA plates and pure colonies were identified using biochemical reactions for example, motility indole – urea- tryptophan deamination test (MIUTDA), triple sugar iron test and o-nitrophenylbeta D-galactopyroside test (ONGP).

Isolation of *Vibrio* species

The thiosulphate citrate bile salt agar (TCBS) (Acumedia Neogen. Lasher Place, Lasing, USA.) was prepared and poured onto sterilized Petri dishes. On solidification, 0.1 ml of each pond water sample previously enriched in alkaline peptone water was transferred unto the dried agar plate in duplicate using a 1 ml pipette and spread evenly with a sterile hockey stick. It was incubated at 35°C for 24 – 48 h. After incubation, *Vibrio* colonies were enumerated for *Vibrio* count and identified using biochemical reactions.
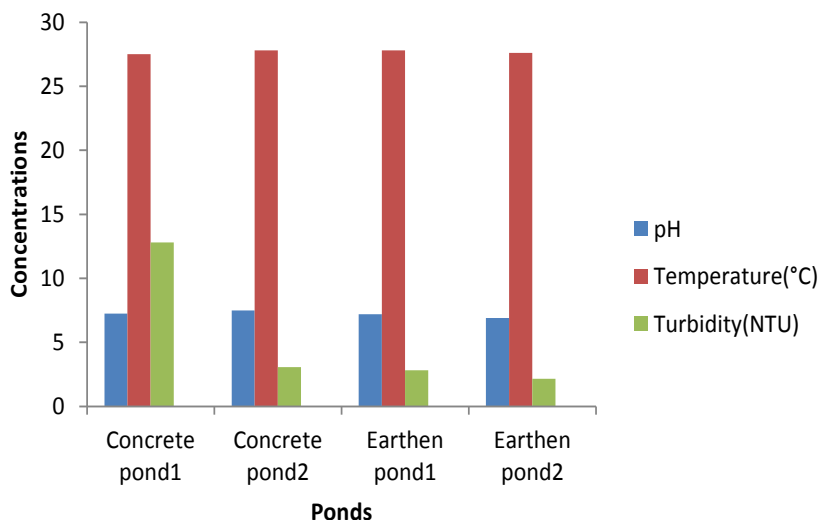
Figure 1. Concentration of pH, temperature and turbidity within the ponds.

Identification of bacterial isolates

The cultural, morphological and biochemical characteristic of the respective isolates were compared with the criteria in Bergey's manual of Determinative Bacteriology (1994). The biochemical test used in the identification and characterization of the isolates include: Gram staining, motility, indole production, methyl red – Voges proskauer, citrate utilization, oxidase, catalase, coagulase and sugar fermentation test.

Physico-chemical analysis of water samples

The water samples from the different ponds were examined for physico-chemical characteristics using standard procedures of the American Public Health Association (APHA). pH was measured *in situ* using a Phillips model of PW 9418 Ph meter after it has been calibrated with standard buffer 7. Temperature and conductivity was measured using Hach conductivity meter Model (CO150). The Winkler's iodometric titration method was adopted for dissolved oxygen determination, biochemical oxygen demand was detemined using the 5 days approach, while chemical oxygen demand was measured using Walkley and Black (1934) dichromate reflux condenser. Alkalinity was done by titrating 100 ml of samples with 0.02 ml of HCl solution using methyl orange as indicators, sulphate was determined using the barium chloride (turbidimetric) method, while the spectrophotometric method at 555 nm UV visible light PC UNICO 2102 USA was used in the determination of nitrite. Ammonia and phosphate were measured using Nessler reaction and ascorbic acid method, respectively.

Statistical analysis

Results collected were subjected to analysis of variance and the least significant difference (LSD) test was used to separate differences between means at 5% level of confidence.

RESULTS

The physico-chemical parameters of the water samples of the four ponds are presented in Figures 1 to 4. The

parameters did not vary significantly within the ponds except for alkalinity, **(**99.7±47.1 to 150±69.7) which was higher in concrete ponds than in earthen ponds (18±6.9 to 24±14.5 mg/L). Conductivity values were higher in concrete ponds (200±84.1 to290±74.9 μs/m) than in earthen ponds (18±6.9 to 24±14.5 μs/m), sulphate was found to be higher in concrete ponds (0.25±0.36 to 1.53±14.9 mg/L) than in earthen ponds (0.25±0.36 to 0.4±0.77 mg/L). All the parameters were within the range that supports fish production except ammonia which was above the limit specified by the FAO for aquaculture. The microbial count did not vary significantly between the ponds (Table 1).

Total heterotrophic bacteria count was highest in concrete pond 1 ($9.5x10^5$ cfu/ml) and lowest in earthen pond 2 ($3.6 x10^5$ cfu/ml). Fungal count was also highest in concrete pond 1($5.5x10^5$ cfu/ml) and lowest in earthen pond1 ($1.2x10^5$). *Salmonella/Shigella* count was highest in earthen pond 1 ($8.5x10^5$) and lowest in concrete pond 1 ($1.0x10^5$cfu/ml). *Vibrio* count was higher in concrete pond 2 ($8.3x10^4$ cfu/ml) and lowest in concrete pond 1 ($1.0x10^5$ cfu/ml), while total coliforms was highest in concrete pond 1 (94 mg/100 ml) and lowest in earthen pond 2 (2 mg/100 ml). Bacteriological analysis of the water samples showed twelve different genera (Table 2) which are *Escherichia coli, Staphylococcus* sp*., Salmonella* sp*., Shigella* sp*., Aeromonas* sp*., Vibrio* sp*., Pseudomonas* sp*., Proteus* sp*., Enterobacter* sp*., Klebsiella* sp*., Serattia* sp. and *Streptococcus* sp. *Enterobacter* sp. occurred only in concrete ponds 1 and 2, *Serattia* sp. occurred only in earthen pond 1, *Proteus* sp. and *Streptococcus* sp. occurred in all the ponds except earthen pond 2, while others occurred mainly in all the ponds.

The fungal genera isolated are presented in Table 3 and they include *Aspergillus* sp., *Penicillum* sp*., Cladosporium* sp*., Mucor* sp. and *Fusarium* sp*.
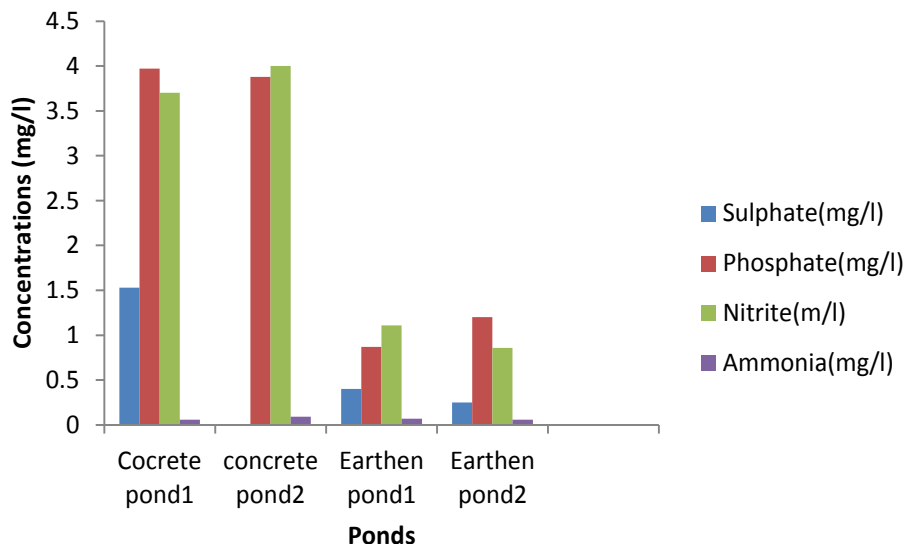
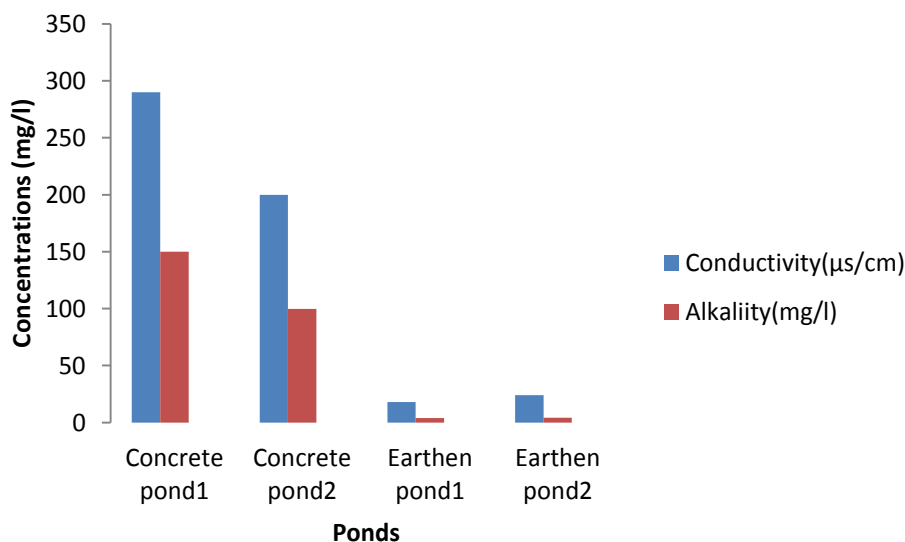**Figure 2.** Concentration of sulphate, phosphate, nitrite and ammonia.

Figure 3. Concentration of conductivity and alkalinity.

DISCUSSION

The result of the microbiological characteristic showed that Gram negative bacteria were dominant in the bacteria isolated from the ponds. The microorganisms isolated were *E.coli*, *Salmonella* sp. *Shigella* sp. *Pseudomonas* sp. *Proteus* sp. *Klebsiella* sp. *Vibrio* sp., *Enterobacter* sp., *Serratia* sp., *Aeromonas* sp., *Staphylococcus* sp., and *Streptococcus* sp. The coliforms isolated were an indication of the contamination of the pond water with fecal materials which may result to the presence of pathogenic organisms in fish when their concentration is above (10^4-10^6) in the skin and (10^4-10^7 cfu/g). The fecal

material may be as a result of fertilization of the ponds with animal manure which is discharged directly into the fish ponds, or excreted by the fish into the ponds (Kay et al., 2008). The presence of human pathogenic bacteria like *Vibrio* isolated from the concrete pond could be attributed to the fact that *Vibrio* spp. are regarded as indigenous bacteria in aquatic environment and naturally present in fish up to10^2-10^3 Cfu/g and multiply under favorable temperature condi-tions above 15°C. Thus, the temperature in the pond favored the growth and proliferation of *Vibrio* spp. According to Hay (2012), *Vibrio* cholera accounted for 75% of *Vibrio* associated diarrhea in some part of Niger Delta region. The presence
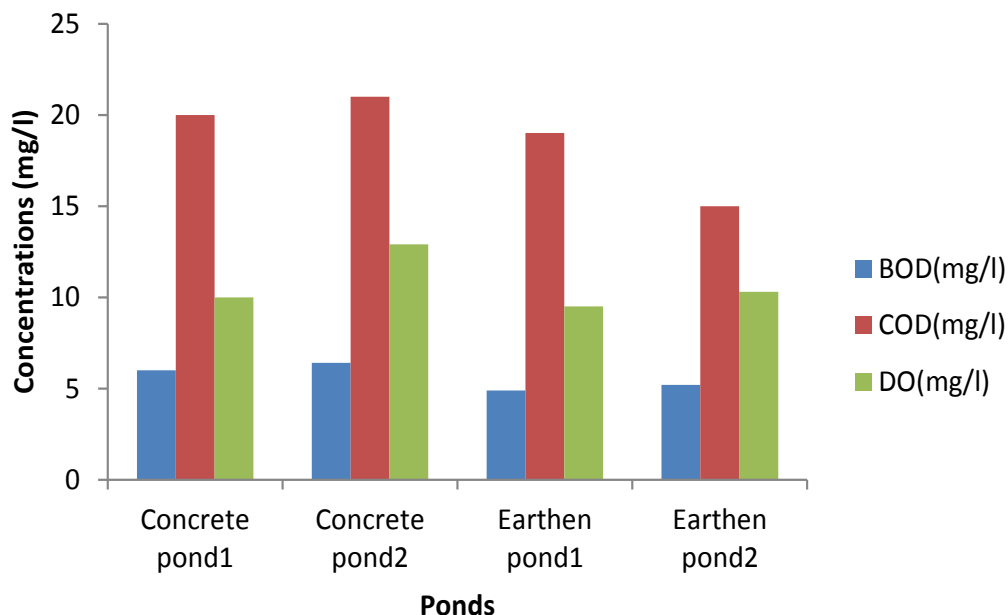
Figure 4. Concentration of BOD, COD and DO.

Table 1. Mean total heterotrophic bacteria count, fungal count, *Salmonella/Shigella* count, *Vibrio* count and coliforum count of the pond water.

	Total heterophic count (cfu/ml)	Fungal count (cfu/ml)	*Salmonella/Shigella* (cfu/ml)	Vibro count (cfu/ml)	Total coliform count (cfu/100ml)
Concrete Pond 1	6.5×10^5	2.11×10^5	3.2×10^5	4.9×10^4	59.6
Concrete Pond 2	7.4×10^5	2.5×10^5	1.9×10^5	5.9×10^4	21.0
Earthen Pond 1	6.4×10^5	1.8×10^5	3.1×10^5	5.1×10^4	23.0
Earthen Pond 2	6.3×10^5	2.4×10^5	1.7×10^5	4.9×10^4	70.3

of pathogenic microorganisms especially *E. coli, Salmonella, Shigella* and *Vibrio* can lead to the transmission of water borne diseases such as, typhoid fever, cholera, food poisoning and gastroenteritis (Piet, 2009) on consumption of improperly cooked fish cultivated in these ponds or through contact with the contaminated fish and water. The diverse groups of bacteria isolated from these ponds are in line with the report of Okpokwasili and Ogbulie (1999) who worked on pond water suggesting that allochthonous bacteria from feed added to the ponds are the principle source of bacteria of health importance and Dabbor (2008) who reported similar organisms in the microbiological study of El-quanter fish pond. *E. coli* was the most dominant organism occurring in both concrete and earthen ponds. The presence of *E. coli* in water or food indicates the possible presence of causative agents of many gastro-intestinal diseases (Ampofo and Clerk, 2010). *Pseudomonas*, *Proteus*, *Staphylococcus* species have been implicated in food poisoning (Oni et al., 2013).

Aeromonas species were also predominantly present in both ponds. This organism is one of the most opportunistic pathogen for fresh water fish and the main etiological agents in disease outbreak were several mortalities were recorded in India (Das and Mukheyce, 1999).

Fungal infection is an important economic and limiting factor in intensive fish production. The fungi genera isolated from the ponds were *Aspergillus* sp., *Penicillum* sp., *Cladosporium* sp., *Mucor* sp., and *Fusarium* sp. *Aspergillus* and *Penicillum* species formed the dominant group of fungi in this study. The observation is consistent with the work of Obire and Anyanwu (2009) who noted that *Aspergillus* and *Penicillum* species are believed to penetrate into the environment through dead plants materials and remains for long period of time. Similarly, Eze and Ogbaran (2010) cited *Penicillum* sp. as the most abundant fungi during his study on the micro-biological and physiochemical of fish pond water in Ughelli, Delta State Nigeria. In contrast to the present

Table 2. Distribution of isolates from the different ponds.

Isolates	Concrete pond1	Concretepond2	Earthen pond1	Earthen pond2	Frequency	Frequency (%)
E. coli	+	+	+	+	43	20.7
Staphylococcus	+	+	+	+	28	13.5
Salmonella	+	+	+	+	10	4.8
Aeromonas	+	+	+	+	33	15.7
Shigella	+	+	+	+	21	10.1
Pseudomonas	+	+	+	+	5	2.4
Proteus	+		+	_	8	3.8
Enterobacter	+	+	_	_	4	1.9
Vibrio	+		+	+	25	12
Serattia	-		+	_	2	0.96
Streptococcus	+	+	+	_	12	5.7
Klebsiella	+	+	+	+	17	8.2

Table 3. Occurrence of fungal isolates within the ponds.

Ponds	*Aspergillus*	*Penicillum*	*Cladosporium*	*Fusarium*	*Mucor*
Concrete pond 1	+	+	+	_	_
Concrete pond 2	+	+	+	_	_
Earthen pond 1	+	+	+	+	+
Earthen pond 2	+	+	+	+	+
Frequency	28	21	10	2	2
Frequency (%)	44.4	33.3	15.9	3.2	3.2

result, Fafioye (2011) reported *Cladosporium* sp. as the dominant fungi species. The occurrence of *Fusarium* sp. and *Mucor* sp. in earthen ponds could be attributed to the fact that the earthen ponds was a more conducive environment for their growth and proliferation due to the presence of soil and plants in the earthen ponds.

Total aerobic heterotrophic bacteria count, fungal counts, *Salmonella/Shigella* count, *Vibrio* count and *Coliform* count (Table 1) were high and varied within the ponds. The values were due to water temperature, which was within optimum for bacterial growth and also due to the organic matter load found within pond water resulting from the diet used in feeding the fish. Thus, the pond water becomes an ideal culture medium for the proliferation of bacterial pathogens causing bacterial infection in fish and an important cause of food poisoning (Eze and Ogbaran, 2010).

Among water and food borne pathogens in coastal ecosystems, *Vibrios* contribute the major part. *Vibrio* sp. has been found to play a vital role in fish and shrimp culture system (Amand et al., 2010). They affect water quality causing disease and mortality to the fish as secondary and primary pathogens. The presence of specific pathogenic human species of *Vibrio* can serve as an indicator of public health risk of water and food

destined for human consumption (Ganesh et al., 2009).

The pH recorded in all the ponds were within range required for aquaculture (6.5-9.5), thus suitable for fish production. The measurement of pH helps to determine if the water is a proper environment for fish, although most fish can tolerate pH as low as 5.0. The pH obtained in this study was similar to that of Ehiagbonare and Ogunrinde (2010) who studied the physiochemical analysis of fish pond water in Okada in Edo State. Ntengwe and Edema (2008) observed that the appro-priate pH for increased fish production is 6-9. While Mohammed (2005) reported that rapid changes can cause extreme stress in the fish similar to shock in humans.

Temperature is a factor of great importance for aquatic ecosystem, as it affects the organisms as well as the chemical and physiochemical parameters of water. The optimum condition for increased fish productivity was found to be at 20-30°C (Ntegwu and Mojisola, 2008). The temperature obtained from this study ranged from 26-29°C and was within the limit that supports fish productivity. Thus, this corroborates with the report of Fafioye (2011), who observed a temperature of 27-28°C in the preliminary studies and water characteristic and bacterial population in Kojalo fish pond.

The dissolved oxygen, obtained in this study was below

the 5 mg/L required for fish production. Generally, concentration below 5 mg/L may adversely affect the functions and survival of biological organisms while below 3 mg/L leads to death of most fish (Swan, 2006). The low dissolved oxygen recorded in ponds could be attributed to elevated temperature, increased microbial and organic load and resultant increase in metabolic activity may also account to low dissolved oxygen concentration (FAO, 2005), coupled with high phosphate that lead to eutrophication, hence reduces the amount of circulating oxygen in the water, especially in the concrete pond where the concentration of phosphate was above the recommended value. Similar results were also reported by Okpokwasili and Ubah (1991), who worked on water quality and bacteria disease in fish ponds but different from the reports of Onome and Ebinimi (2010) who recorded higher DO of 4.34 – 6.33 mg/l as a result industrial input from the surrounding industries near the fish farm.

Alkalinity of water is the amount of dissolved calcium, magnesium and other compounds in water. The optimum alkalinity for increased fish production is 20-300 mg/l. The alkalinity in this study was higher in the concrete ponds than the earthen ponds. This could be attributed to the leaching outs of these substances (lime) from the walls of the concrete ponds into the water (UNESCO/WHO/UNED, 1996). The values obtained in the earthen ponds were below 20 mg/l and therefore should be adjusted for maximum productivity by liming.

Ammonia occurs in fish ponds as a result of accumulation of left over rich protein feed, fish waste, and microbial decomposition of organic matter (Durbrow et al., 1997). The ammonia concentrations in all the ponds were above the permissible level of 0.2 mg/l recommended for aquaculture (Table 1), although no adverse effect was observed on the fish during the period of study because at higher pH and temperature, the more toxic the ammonia, thus the pH and temperature were within the recommend range. Normally, the concentration of ammonia in pond water should be zero. Studies have shown that ammonia tends to block oxygen transfer from the gills to the blood and can cause both immediate and longtime gill damage (Durborow et al., 2000). Similarly, higher ammonia concentration was also obtained by Onome and Ebinimi (2010) who attributed the high ammonia concentration in new Calabar River to industrial nitrogenous waste.

Nitrite is termed the invisible fish killer as it is deadly to the smallest fish at a concentration as low as 0.25 ppm. Nitrite concentration obtained in this study was above the permissible limit of 0.1 mg/l (Figure 2). This could be as a result of decomposition of excess feed which polluted the pond environment or by the action of algae through nitrogen fixation and water plants. Nitrite is a skin irritant and will cause the fish to display symptoms of irritability such as rubbing themselves, jumping and skimming across the surface of the pond (Eze and Ogbaran, 2010).

Nitrite prevents the blood cells from absorbing oxygen from water. This process turns their blood to a dull brown color and hence the popular name of nitrite poisoning "brown blood disease" (Durbrow et al., 1997).

Phosphate level in concrete ponds was above the 3 mg/l. This limit should be controlled to avoid eutrophication of the ponds as it fostered the growth of algae which also accounted to the low dissolved oxygen in the ponds (Eze and Okpokwasili, 2010). Phosphate may be introduced into the pond through fish feed or through surface run off, and could also be from the building materials used in the construction of the ponds. These fishes can also store phosphate in their organs and when they die, they release the previously absorbed into the water which triggers the growth of new algae (Durbrow et al., 1997).

Sulphate concentration in the ponds varied from 0.25-4.0 (mg/l) with the concrete ponds significantly higher than the earthen ponds. These values are similar to that of Ehiagbonare and Oguunrinde (2010) (0.66-1.09 m/l) and different from Utang and Akpan (2012) who reported 42.46-57.36 mg/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 in New Calaber River.

The electrical conductivities of the water samples generally varied significantly ($P < 0.05$) and ranged from 9 to 400 µs/cm for both ponds throughout the period of study. Higher conductivities were observed in concrete ponds than in earthen ponds. Electrical conductivity is a useful indicator of mineralization and salinity or total salt in a water sample. The FAO acceptable limit for conductivity in aquaculture is 20-1500 µs/cm (DWAF, 1996). This limit was not exceeded in these ponds. Thus, the parameter is suitable for fish production.

Turbidity is the result of several factors including suspended soil particles, planktonic organisms and humic substances produced through decomposition of organic matter (FAO, 2002). It hinders the penetration of sunlight into the pond making it difficult for aquatic habitat to receive the positive effect of light (Ali et al., 2004). Turbidity values obtained from the concrete ponds and earthen ponds were within the range which allows light penetration and photosynthesis of plant and algae that supports aquatic life. Thus, at average turbidity of less than 25 NTU as recorded in these ponds coupled with phosphate concentration, favored the growth of planktons.

The BOD and COD were low and within the permissible range of <10l and <20 mg/l, respectively. The result is different from that obtained by Odewumi and Zakari, (2010) who recorded a higher value of COD and BOD in the study of cat fish ponds in Jos suggesting that the fish ponds were grossly polluted. Similarly, Ehiagbonare and Ogurinde (2010) reported BOD of 2.2, 2.36mg/l in concrete ponds in Oluko and Igusa and 1.6 mg/l in earthen pond at Afugle during the study of physio-chemical analysis of pond water in Okada and its environs.

In conclusion, the microbial qualities of the two ponds were not significantly different. However, there were differences in the concentration of nutrients with the concrete pond showing concentrations above the recommended limit of the FAO in most of its parameter, while the earthen ponds were within the recommended limit. The high concentrations in the concrete ponds could be attributed to leaching of these substances from the walls of the concrete pond into the water. Thus, the earthen pond could be said to be a better pond for fish production in terms of physiochemical parameters. The study also revealed that both ponds were grossly contaminated with pathogenic bacteria that could affect fish cultivated, since the microbial quality of any fish pond water is a reflection of the microbial flora of the fish itself. These organisms could lower fish yield, causes diseases and economic loss and equally endanger the ultimate consumers (humans) particularly if the fish harvested from the ponds are under processed.

Conflict of interest

Authors did not declare any conflict of interest.

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