Vol. 4, No. 4, pp. 248-260, (September 2023)
DOI: 10.21608/AUJES.2023.211901.1153

Aswan University Journal of Environmental Studies (AUJES)
Online ISSN: 2735-4237, Print ISSN: 2735-4229
Journal homepage: https://aujes.journals.ekb.eg/ E-mail: AUJES@aswu.edu.eg

Original research

Water quality assessment and bacteriological evaluation of fishpond in Ilorin

Wakili Tope Aborisade*[1], Abdullahi Taiwo Ajao[1], Iyore Blessing Idemudia[2]

[1]*Department of Microbiology, Faculty of Pure and Applied Sciences, Kwara State University, Malete*
[2]*Department of Microbiology, Faculty of Life Sciences, University of Benin*

Received: 18/5/2023 Accepted: 9/8/2023

Abstract:

Good water quality is essential for a productive aquaculture system and to safeguard the health of the consumer. We assessed the quality of fishpond water in Phase 1, Mubo-Royal Valley fish farm in Ilorin, Kwara State, Nigeria. Water samples were collected in the 1st and 3rd weeks of fish breeding from three earthen and two concrete fishponds. The bacteriological and physicochemical parameters of the samples were determined in line with standard methods. Results showed that the pH, temperature, and dissolved oxygen (DO) values were within the recommended range of the National Environmental Standard and Regulations Enforcement Agency (NESREA). However, higher chemical oxygen demand (COD) values above the NESREA recommended range were recorded in the 1st and 3rd weeks of sampling in earthen Pond 1 and Pond 2, respectively. The Nitrate (NO_3^{2-}) and phosphate (PO_4^{2-}) contents of all sampling ponds were within the acceptable values of NESREA in the 1st week of sampling. While significant ($p < 0.05$) increases in NO_3^{2-} and PO_4^{2-} were observed in earthen ponds in the 3rd week. Copper and iron (mg/l) values were higher than NESREA recommended range, while lead and chromium values were within the range. Bacterial loads varied with the period of sampling with significant ($p < 0.05$) increases in the population of heterotrophic bacteria and *Salmonella-Shigella* in the 3rd week of sampling. The nine bacterial genera isolated were *Pseudomonas* sp., *Micrococcus* sp., *Staphylococcus* sp., *Salmonella* sp., *Escherichia coli*, *Enterobacter* sp., *Proteus* sp., *Streptococcus* sp. and *Bacillus* sp. All the isolates were present in earthen and concrete ponds except *Proteus* sp. and *Streptococcus* sp. were absent in concrete ponds. *Pseudomonas* sp. had the highest frequency of occurrence while *Streptococcus* sp. had the lowest. Regular monitoring of water quality parameters is recommended to prevent potential risks associated with potential pathogens in fishponds.

Keywords: Concrete, earthen, ponds, samples

Corresponding author*: E-mail address: wakkyhome@gmail.com

1- Introduction

Fish farming is one of the key agricultural and food-producing sectors that provide major sources of income for millions of people throughout the world (Oliver and Abudou-Fadel, 2021). The fish farming system is practiced for boosting food production values, increasing income, improving the nutrient acquisition of the communities, and conserving biodiversity. About 12% of the human population globally derived their livelihood from aquaculture. In Nigeria, over 10 % population were involved in the fishery sector (Elekwachi, 2018). The required basic physicochemical parameters should be within the standard range to have productive breeding in artificial fishponds.

Water quality influences not only the health of the nursery fish but the overall productivity of the fish farm (Tumwesigye *et al*., 2022). Water qualities include physical properties such as temperature, level of suspended solids and settleable solids, chemical parameters such as pH, alkalinity, hardness, and heavy metal contents, and biological properties (Honcharova *et al*., 2021).

Surface water such as streams and rivers usually serve as the major sources of water for fish farmers in Nigeria (Cheikyula *et al*., 2020). The greatest challenges to water sources are pollution. Human, commercial and industrial activities contribute large amounts of waste polluting water bodies. These wastes are sometimes xenobiotics, toxic or potentially toxic and could constitute problems for aquatic organisms. In Developing countries, industries are usually sited close to water bodies and thereby discharge their effluents directly into them (Idu, 2015). More than 90% of the effluent generated during industrial processes has been reported to end up in water bodies (Bijekar, 2022). Likewise, water pollution has become a great issue, especially in the area where waste dumping is encouraged near or into the water bodies and could have severe impacts on fisheries production.

In developing countries, local fish production involves rearing fish in artificial ponds under controlled environmental conditions (Rantlo, 2022). Earthen and concrete ponds are the two major conventional systems for commercial fish culturing in Nigeria (Njoku *et al*., 2015; Oladimeji *et al*., 2017). Although microorganisms are important members of aquatic communities, the occurrence and presence of few members could constitute problems to the stability of the aquatic ecosystem. Microorganisms are indicators of pollution and provide insight into the quality of the aquatic environment. Microorganisms are key players in the formation, breakdown, and regeneration of organic matter, as well as in the structure of aquatic ecosystems.

It is established that the interaction of the various physical, chemical, and biological components of ponds ultimately determines the water quality and consequently influences fishponds' productivity (Eghomwanre *et al*., 2019; Abd'El-Hack *et al*., 2022). The aquatic environment quality can be determined by abiotic factors such as pH, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), turbidity, total alkalinity, total hardness, and nitrate, as well as biotic composition among others (Saah *et al*., 2021).

The continuous rise in the level of heavy metals in the aquatic environment resulting from anthropogenic activities is of great concern. Due to their toxicity, bioaccumulation, biomagnification, and persistence properties, metal contamination in water causes a significant impact on aquatic organisms (Mao *et al*., 2020). It has been emphasized that the bioaccumulated heavy metals by aquatic organisms have the tendency to biomagnify along the food chain and consequently pose a risk to the health of human consumers (Ndayisenga and Dusabe, 2022). A recent report established a strong correlation between the concentration of heavy metal levels in the fishpond and various tissues of the fish body (Leonard *et al*., 2022).

Understanding the ponds' physicochemical and biological characteristics is one of the requirements for effective fish management. Therefore, we aimed for assessing the water physicochemical and bacteriological parameters of fishponds.

2- Materials and Methods

2.1. Study Area

The study area was Phase 1, Mubo-Royal Valley fish farm in Ilorin, Kwara State, Nigeria. The farm holds more than thirty contour of parallel earthen fishponds and six concrete ponds. The source of water for the earthen ponds was the flowing freshwater Asa River along the Mubo-Royal Valley area, while the concrete ponds was from the shallow wells.

The study area is found at latitude 8° 30' and longitude 4° 34' (Figure 1). The area was selected as the study location because it is one of the largest artificial commercial fish farms in Ilorin and the ponds' water source is exposed to domestic-related point sources and agricultural-related non-point sources form of pollution.

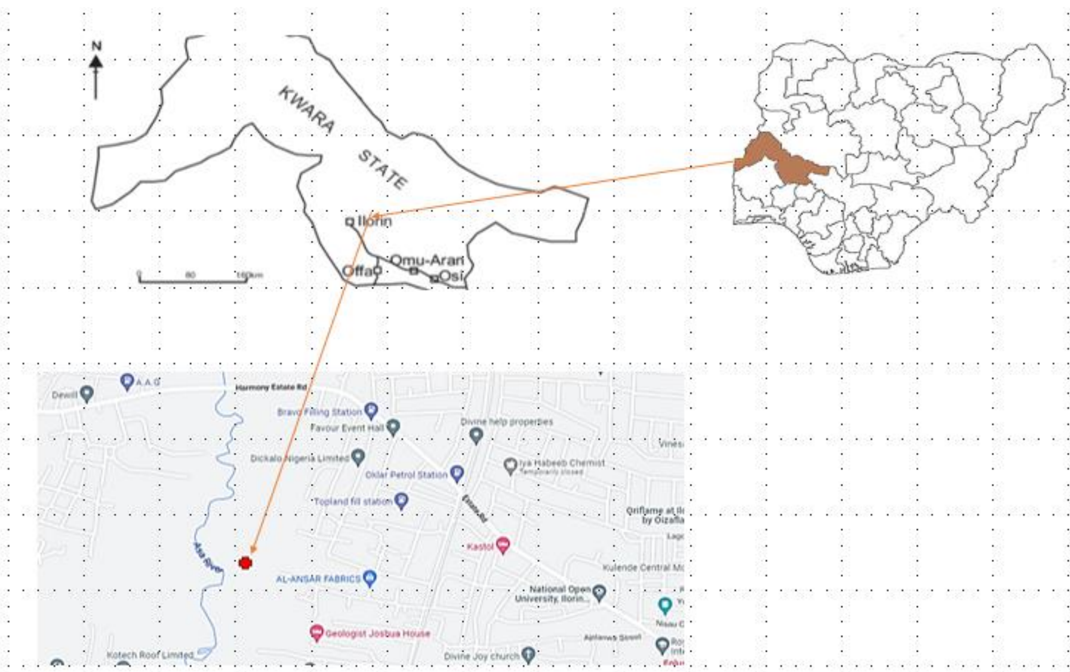

Figure 1: Map showing the study area. Source: Field survey 2023

2.2. Water samples collection and analysis

The water samples were collected from three (3) earthen and two (2) concrete fishponds following the method described by Saah *et al*. (2021) with slight modifications using the discrete sampling techniques. Into the 1000 ml sterile sampling bottle, with the aid of a sample grabber, water samples were randomly collected from a mid-depth at about 25 cm beneath the surface of the pond. The samples were collected during the 1st week and the 3rd week period of stocking in triplicate making a total number of thirty samples for the analysis. The samples were immediately transported to the laboratory in ice-parked containers for analysis.

The pH, temperature, and dissolved oxygen (DO) values of the pond's water were determined *in situ* with the aid of an onsite multiparameter analysis instrument (YSI-Pro1020 Model). The biological oxygen demand (BOD) was determined through the differential values of initial dissolve oxygen (DO) and the 5 days DO value after incubation of water samples at 20 ℃. The chemical oxygen demand (COD) was determined by oxidizing the organic matter contents of the water samples with potassium dichromate ($K_2Cr_2O_7$) in the presence of Ag_2SO_4 as catalyst.

The nitrate, and phosphate contents of the water samples were determine using the spectrophotometer (Shimadzu model 752, Japan) at absorbance values of λmax 410 nm and λ max 690 nm respectively in line with the standard methods of APHA (1998)..

2.3. Heavy metal analysis

Fifty milliliters of water samples from each sampling pond were acidified to pH < 2 with nitric acid. The acidified solutions were digested on a hot plate at 90 ℃ for 2 hours. The cooled cleared pre-treated solutions were used to quantitatively analyze for the presence of copper (Cu), lead (Pb), chromium (Cr), iron (Fe), and cadmium (Cd) with atomic absorption spectrophotometer (AAS) (Agilent model 200AA). All the analyses were run in triplicate.

2.4. Bacteriological analysis

The bacteriological analysis of fishpond water samples was evaluated using standard spread plate techniques as described by Fawole and Oso (2007).

The total heterotrophic bacteria (THB), total coliform (TC), faecal coliform (FC), and *Salmonella-Shigella* (SS) counts were carried out onto nutrient agar (Oxoid), MacConkey agar (Sigma-Aldrich), eosin methylene blue agar (Sigma-Aldrich) and *Salmonella-Shigella* agar (Sigma-Aldrich) plates respectively.

Ten-fold serial dilution of the pond water samples was prepared aseptically with sterile distilled water up to a 10^{-9} dilution factor. With the aid of a digital pipette, 100 µL of the 10^{-5} and 10^{-6} aliquots of each diluted sample were inoculated onto nutrient agar plates for THB in triplicates. For TC, FC and SS count 100 µL of 10^{-2} and 10^{-3} were used to inoculate the respective media plates in triplicates. The inoculated plates were spread with a sterile glass spreader and incubated at 37 ℃ for 24 h.

Distinct colonies were subcultured by streaking technique onto a nutrient agar plate to obtain a pure culture. The isolates were identified via cultural, morphological, and biochemical characteristics with reference to the standard manual for the identification of bacteria (Cowan and Steel, 1993).

2.5. Statistical analysis

The data obtained were subjected to statistical analysis using IBM Statistical Package for Social Sciences (SPSS) version 23. The data on bacterial counts were analyzed using analysis of variance (ANOVA) and further subjected to Duncan multiple range test (DMRT) to compare the mean values for significant differences. Differences were considered statistically significant at $P \leq 0.05$.

The average values of all the data obtained for physicochemical parameters and heavy metals were compared with the National Environmental Standards and Regulation Enforcement Agency permissible limit values for Nigeria's fisheries and recreation surface water quality (**NESREA, 2011**).

3- Results and Discussion

3.1.Physiochemical parameters of pond water samples

The results for the physicochemical parameters of the pond water samples are presented in Table 1. The average values for pH of the pond water samples range from 7.1 - 7.9 and 7.2 - 7.8 for the 1st and 3rd weeks respectively. The temperature (℃) values range from 23.7 – 25.2 and 24.5 – 25.6 for the 1st and 3rd weeks respectively. The values for DO (mg/l) range from 14.7 – 19.1 and 10.6 – 18.6 for the 1st and 3rd weeks respectively. The pH, temperature (℃) and DO (mg/l) values were within the specified value range of the National Environmental Standard and Regulations Enforcement Agency (NESREA) for fisheries and recreation surface water standards (Table 1).

The BOD (mg/l) values range were 2.1 – 5.2 and 3.1 – 5.9 for the 1st and 3rd weeks respectively. The BOD values for ponds 1, 2, and 3 water samples in the 1st and 3rd week of sampling, respectively, and ponds 4 and 5 in the 3rd week of sampling were higher than the specified limit values of NESREA (Table 1).

The COD (mg/l) values range from 10.3 – 32.1 and 13.8 – 35.6 for the 1st and 3rd weeks respectively. All the COD values were within the specified limit values of NESREA except for COD values of pond 1 at week 3 and pond 2 at week 1 and 2 respectively which were above the regulatory standard limit (Table 1).

The nitrate content (mg/l) value range from 2.4 – 8.7 and 4.3 – 18.7 for the 1st and 3rd week respectively. The phosphate content ranges from 1.8 – 2.6 and 3.1 – 5.9 for the 1st and 3rd weeks respectively. The average values for the nitrate and phosphate contents (mg/l) of the pond water samples were within the specified limit values of NESREA except for the values recorded in the 3rd week in ponds 1, 2, and 3 respectively (Table 1).

The Cu (mg/l) contents of the pond water samples range from the values 0.000 - 0.093 and 0.000 - 0.058 for the 1st and 3rd week respectively. The Cu contents (mg/l) of the pond 1, 2, and 3 water samples were above the standard regulatory limit of NESREA.

The Pb (mg/l) contents values range from 0.000 - 0.009 and 0.000 - 0.007 for the 1st and 3rd weeks respectively. The Pb contents (mg/l) values of the pond water samples are within the regulatory safe range of NESREA for fisheries and recreational surface water.

The Cr (mg/l) contents values range from 0.000 - 0.016 and 0.000 - 0.019 for the 1st and 3rd weeks respectively. The values for the Cr contents (mg/l) of the pond water samples are within the regulatory safe range of NESREA for fisheries and recreational surface water.

The Fe contents (mg/l) values range from 0.036 – 0.224 and 0.025 – 0.231 for the 1st and 3rd weeks respectively. The Fe contents (mg/l) of the pond 1, 2, and 3 water samples were above the standard regulatory limit of NESREA. The Cd (mg/l) was not detected in any of the pond water samples.

The pH values of the studied earthen and concrete fishpond water tend comparatively towards alkaline. The alkalinity of the water samples could be attributed to the dissolution of carbonate-containing compounds from the environment. Similar pH values were reported by Njoku *et al*. (2015), Sule *et al*. (2016), and Orji *et al*. (2022). The pH values obtained were within the specified value range of NESREA for fisheries and recreation surface water standards (NESREA, 2011). Studies have shown the influence of pH fluctuations on fish productivity ranging from poor metabolism, weight loss, and exposure to toxic bye products to the increase in mortality in stocked fish (Swain *et al.,* 2020; Abdulazeez *et al.*, 2021; Dnyanraj and Khandagale, 2021).

The temperature measured was within the optimum temperature range recommended by NESREA (20.0 – 32.2 °C) for productive fisheries. Temperature plays an important role in fisheries' metabolic activities as it affects the feed intake, digestion rate, and assimilation of essential nutrients by fish in the aquatic environment (Handeland *et al*., 2008).

Dissolved oxygen (DO) is essential for the survival of oxygen-dependent aquatic organisms (Eze and Ajmal, 2020; Bulbul and Abha, 2022). The values of DO obtained were greater than the recommended minimum requirement (≥ 6.0) and therefore better for the survival of fish. Reports have shown that DO values below the recommended limit can induce stress responses in fish, reduce immunity, and increase susceptibility to pathogens (Bulbul and Abha, 2022). Furthermore, low DO values can impair fish growth and increase the death rate (Schafer *et al*., 2021).

The biological oxygen demand (BOD) values (mg/l) of the earthen ponds' water samples were above the NESREA recommended value in the 1st and 3rd weeks as compared to the concrete ponds' samples where the higher BOD values were only recorded in the 3rd week of sampling. The higher BOD values were an indication that the source water was polluted with organic materials. These could cause hypoxia and death in aquatic animals (Adong *et al*., 2011).

The COD values (mg/l) recorded from concrete fishponds samples were within the NESREA recommended limit (≤ 30.0 mg/l). However, higher COD values above the recommended range were recorded in the 1st week in Pond 1 and the 1st and 3rd weeks in Pond 2. The higher the COD values the higher the amount of non-biodegradable oxygen-demanding pollutants in water samples (Orobator *et al*., 2020). The report has shown that high COD could harm the survival of aquatic life (Njoku *et al*., 2015).

The NO_3^{2-} and PO_4^{2-} contents (mg/l) of all the sampled ponds were within the specified limits of NESREA in the 1st week. However, significant ($P<0.05$) increases in the NO_3^{2-} and PO_4^{2-} contents above the NESREA recommended values were observed in ponds 1, 2, and 3 in the 3rd week. Reports have pointed out that NO_3^{2-} and PO_4^{2-} of the pond water tend to increase due to exogenous contamination from the feeds, fertilizers, or food-based supplements added to boost the growth of fish (Islam *et al*., 2018). Massive accumulation of NO_3^{2-} and PO_4^{2-} is one of the serious problems for the development of aquaculture and might contribute to eutrophication (Orji *et al*., 2022; Bai *et al*., 2023).

Assessment of heavy metals in fishponds is important due to their ability to bioaccumulate into fish tissue and their adverse effect on human health (Orobator *et al*., 2020). In this study, two out of the metals analyzed (Cu and Fe) from the earthen ponds water samples were found to be higher than NESREA recommended range, while Pb and Cr were within the recommended range. The presence of high heavy metal levels in fishponds has been linked to air deposition, industrial runoff, and sewage outfall contamination (Mao *et al*., 2020). Several reports have shown that higher concentrations of heavy metals in the aquatic environment may lead to histopathological dysfunction in the major organ of fish and disrupt the proper fish growth and reproduction (Garai *et al*., 2021; Agbugui and Abe, 2022; Leonard *et al*., 2022).

Table 1: Physicochemical parameters of pond water samples

Parameters /	week	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Permissible range**
pH	**1**	7.9 ± 0.33	7.8 ± 0.10	7.7 ± 0.88	7.1 ± 0.22	7.1 ± 0.88	6.5 – 8.5
	3	7.5 ± 0.88	7.8 ± 0.88	7.6 ± 0.15	7.3 ± 0.58	7.2 ± 0.12	
Temp.	**1**	25.1 ± 0.12	25.2 ± 0.58	23.7 ± 0.12	24.3 ± 0.18	24.3 ± 0.20	20.0 – 32.2
°C	**3**	25.6 ± 0.23	25.3 ± 0.18	25.0 ± 0.00	25.0 ± 0.12	24.5 ± 0.03	
DO	**1**	19.1 ± 0.66	17.7 ± 0.06	15.7 ± 0.53	14.7 ± 0.80	17.8 ± 0.58	≥ 6.0
(mg/l)	**3**	17.3 ± 1.49	14.8 ± 0.12	12.2 ± 0.69	10.2 ± 0.09	16.1 ± 0.12	
BOD	**1**	5.2* ± 0.15	5.2* ± 0.10	4.1* ± 0.18	2.1 ± 0.06	2.5 ± 0.32	≤ 3.0
(mg/l)	**3**	5.9* ± 0.23	5.9* ± 0.32	5.6* ± 0.38	3.1* ± 0.06	3.6* ± 0.35	
COD	**1**	28.9 ± 0.52	32.1* ± 0.58	25.2 ± 0.35	11.1 ± 1.10	10.3 ± 0.61	≤ 30.0
(mg/l)	**3**	32.9* ± 0.55	35.6* ± 1.04	28.1 ± 0.38	13.8 ± 0.06	16.2 ± 1.19	
Nitrate	**1**	8.7 ± 0.43	7.9 ± 0.93	8.2 ± 1.04	2.4 ± 0.33	2.9 ± 0.61	≤ 9.1
(mg/l)	**3**	16.6* ± 1.45	18.7* ± 0.66	18.2* ± 0.88	4.3 ± 0.20	5.5 ± 1.19	
PO_4^{2-}	**1**	2.6 ± 0.23	2.3 ± 0.45	2.1 ± 0.54	1.8 ± 0.06	2.3 ± 0.58	≤ 3.5
(mg/l)	**3**	5.4* ± 0.72	5.9* ± 0.58	4.6* ± 0.12	3.3 ± 0.40	3.1 ± 0.37	
Cu	**1**	0.093*± 0.40	0.087*±0.20	0.090*±0.10	ND	ND	0.001
(mg/l)	**3**	0.058*± 1.25	0.075*±1.00	0.077*±0.20	ND	ND	
Pb	**1**	0.009 ± 0.40	0.003 ± 0.12	ND	ND	ND	0.01
(mg/l)	**3**	0.007 ± 1.25	0.007 ± 0.00	ND	ND	ND	
Cr	**1**	0.016 ± 0.26	0.010 ± 0.31	0.003±0.01	ND	ND	0.5
(mg/l)	**3**	0.019 ± 0.69	0.012 ± 0.20	ND	ND	ND	
Fe (mg/l)	**1**	0.224*±0.58	0.206*±0.15	0.194*±0.81	0.042±0.25	0.036±1.05	0.05
	3	0.231*±0.33	0.209*±0.95	0.211*±0.93	0.029±0.59	0.025±0.03	
Cd	**1**	ND	ND	ND	ND	ND	0.005
(mg/l)	**3**	ND	ND	ND	ND	ND	

Key: All the values were presented in mean plus / minus standard error of the mean; Mean value with an asterisk (*) are not within the NESREA acceptable limit for fisheries and recreation surface water's standard; PSO_4^{2-} = phosphate; ND is not detected

** National Environmental Standard and Regulations Enforcement Agency (NESREA) for fisheries and recreation surface water standards

3.2.Average bacterial counts of the pond water samples.

The values for average bacterial counts of the pond water samples are presented in Table 2.

The average values for heterotrophic bacterial counts (cfu/ml) of water samples range from 3.2 x 10^5 - 6.3 x 10^5 and 9.7 x 10^5 – 12.1 x 10^5 for the 1st and 3rd weeks of sampling respectively. The values for the heterotrophic bacterial counts in the 3rd week were significantly higher ($p < 0.05$) than the average value obtained in the 1st week of sampling.

The mean values for total coliform counts (cfu/ml) of water samples range from 2.0 x 10^3 - 4.2 x 10^3 and 0.9 x 10^3 – 4.7 x 10^3 for the 1st and 3rd weeks of sampling respectively. There were significant ($p < 0.05$) decreases in the total coliform counts in the 3rd week as compared to the average values obtained in the 1st week.

Faecal coliforms count values (cfu/ml) of water samples range from 0.7 x 10^3 – 2.6 x 10^3 and 0.2 x 10^3 – 1.6 x 10^3 for the 1st and 3rd weeks of sampling respectively. There were significant (p < 0.05 decreases) in the faecal coliform counts in the 3rd week as compared to the average values obtained in the 1st week.

The values for *Salmonella-Shigella* counts range from 1.1 x 10^3 – 2.3 x 10^3 and 0.9 x 10^3 – 3.1 x 10^3 for the 1st and 3rd weeks of sampling respectively. Significant ($p < 0.05$) increases in *Salmonella-Shigella* counts were observed in the 3rd week as compared to the average values obtained in the 1st week.

The results of the bacteriological analysis showed that bacterial loads from each pond varied significantly with the period of sampling. Significant ($p < 0.05$) increases in the heterotrophic bacteria and *Salmonella-Shigella* counts were observed in the 3rd week. While the total coliform and faecal coliform counts significantly reduced in the 3rd week. The variation in bacteriological properties of the sampling ponds may be related to the bacteria exploitation of the nutrient-riched conditions provided by fish management strategies that introduce a high level of organic-based feed from the fish diet. Reports had confirmed that apart from contamination from the environment, the nature of feeds could have a greater influence on the microbial load of the pond system (Banu *et al*., 2001; Chukwuma, *et al*., 2020).

Table 2: Average bacterial counts of the pond water samples.

Parameters/week		HB (CFU/ml) x 10^5	TC (CFU /ml) x 10^3	FC (CFU /ml) x 10^3	SS (CFU /ml) x 10^3
Pond 1	**1**	$5.8^b \pm 1.79$	$4.2^a \pm 0.91$	$2.4^a \pm 0.15$	$2.3^b \pm 0.91$
	3	$11.4^a \pm 2.99$	$2.1^b \pm 0.03$	$1.2^b \pm 0.76$	$3.1^a \pm 0.51$
Pond 2	**1**	$6.3^b \pm 0.18$	$4.7^a \pm 0.33$	$2.1^a \pm 0.31$	$1.1^c \pm 0.71$
	3	$10.2^a \pm 0.56$	$2.9^b \pm 0.74$	$1.6^b \pm 0.57$	$1.7^{bc} \pm 0.80$
Pond 3	**1**	$5.9^b \pm 0.67$	$3.8^{ab} \pm 0.16$	$2.6^a \pm 0.23$	$1.5^{bc} \pm 0.07$
	3	$11.3^a \pm 0.96$	$2.6^b \pm 0.31$	$0.3^c \pm 0.11$	$2.3^b \pm 0.93$
Pond 4	**1**	$4.6^b \pm 1.57$	$4.4^a \pm 1.52$	$0.7^c \pm 0.04$	$2.1^b \pm 0.20$
	3	$12.1^a \pm 0.91$	$2.9^b \pm 0.19$	$0.2^c \pm 0.15$	$2.9^b \pm 0.16$
Pond 5	**1**	$3.2^c \pm 0.67$	$2.0^b \pm 0.81$	$0.9^{bc} \pm 0.37$	$1.3^{bc} \pm 0.61$
	3	$9.7^a \pm 0.03$	$0.9^c \pm 0.13$	$0.6^c \pm 0.43$	$0.9^c \pm 0.39$

Key: THB is total heterotrophic bacterial; TC; is total coliforms; FC is fecal coliforms; SS is *Salmonella-Shigella*; No significant difference between the mean value in the column with the same superscript (a, b) at p = 0.05.

3.3.The frequency of occurrence of bacterial isolates from the pond water samples.

The frequency of occurrence of bacterial isolates from the pond water samples is presented in Table 3. The nine bacterial genera isolated from the fishpond water samples were *Pseudomonas* sp. (24.2 %), *Micrococcus* sp. (13.5%), *Staphylococcus* sp. (16.3 %), *Salmonella* sp. (6.7 %), *Escherichia coli* (10.7 %), *Enterobacter* sp. (11.8 %), *Proteus* sp. (5.8 %), *Streptococcus* sp. (3.4

%) and *Bacillus* sp. (8.4 %) (Table 3). *Pseudomonas* sp. (24.2 %) had the highest frequency while *Streptococcus* sp. had the lowest.

The present result on various groups of bacteria isolated from fishponds is consistent with previous research showing that diverse bacteria in fishponds are the allochthonous bacteria that are introduced to the pond from environmental contamination and feed added to the ponds for fish feeding (Njoku *et al*., 2015; Chukwuma *et al*., 2020; Orji *et al*., 2022).

The significance of the bacterial genera in fishponds water has been reported in previous research. The detection of coliform in the fishponds is an indication of the presence of disease-causing microbes in the water samples (Some *et al*., 2021).

The presence of pathogenic microorganisms in fishponds can constitute dire health challenges to fish, especially in intensive aquaculture operations, where fish are kept at high densities and can be more susceptible to disease. *Pseudomonas* sp. are commonly found in aquatic environments, while some strains are harmless, some have been implicated in several diseases of fish including fin rot, tail rot, and ulcers on the skin or gills of fish (Saikia *et al*., 2018).

Salmonella sp. can enter a fishpond through a variety of sources such as contaminated feed, water, or equipment. Once present in the pond, it can spread through faecal matter from infected fish or other animals, as well as through contaminated water. In fish, *Salmonella* infections can cause a range of symptoms, including lethargy, loss of appetite, and abnormal swimming behaviour (Bibi *et al*., 2015). Salmonella can also contaminate the flesh of infected fish, potentially posing a risk to human consumers.

Table 3: Frequency of occurrence of bacterial isolates from the fishpond

Isolates	Occurrence and frequencies						
	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Total	Frequency of occurrence (%)
Staphylococcus sp.	+	+	+	+	+	43	24.2
Micrococcus sp.	+	+	+	+	+	24	13.5
Pseudomonas sp.	+	+	+	+	+	29	16.3
Salmonella sp.	+	+	+	+	+	12	6.7
Escherichia coli	+	+	+	+	+	19	10.7
Enterobacter sp.	+	+	+	-	+	21	11.8
Proteus sp.	+	+	+	-	-	9	5.0
Streptococcus sp.	+	+	+	-	-	6	3.4
Bacillus sp.	+	+	+	+	+	15	8.4

Key: (+) = present; (-) = absent; % = percent

4- Conclusion.

There were variations in physicochemical parameters of earthen and concrete fishponds with significant increases in Nitrate (NO_3^{2-}) and phosphate (PO_4^{2-}) above the recommended range of the (NESREA) at the 3rd week of sampling. The presence of Coliforms in the pond water samples was an indication of potential fecal contamination of the studied fishponds' water samples. Therefore, regular monitoring, and maintaining good water quality in fishponds can help in fish productivity and safeguard the heath of the consumers.

References

Abd'El-Hack M. E., El-Saadony M. T., Nader M. M, Salem H. M., El-Tahan A. M., Soliman S. M., Khafaga A. F. (2022). Effect of environmental factors on growth performance of Nile tilapia (*Oreochromis niloticus*). *International Journal of Biometeorology,* **66**(11):2183-2194. https://doi.org/10.1007/s00484-022-02347-6.

Abdulazeez M., Bitrus M. G., Mubarak U. J., Godfrey A. A., Hamzat A. W., Shamsudeen M. (2021). Preliminary study of some physicochemical parameters of Kitoro reservoir in NIFFR Estate, New Bussa, Niger state. *International Journal of Fisheries and Aquatic Studies* 9(3): 98-101 https://doi.org/10.22271/fish.2021.v9.i3b.2478.

Adong X. Y., Qin J. G., Zhang X. M. (2011). Fish adaptation to oxygen variations in aquaculture from hypoxia to hyperoxia. Journal of Fisheries and Aquaculture 2(2): 23-28.

Agbugui M. O., Abe G. O. (2022). Heavy Metals in Fish: Bioaccumulation and Health. *British Journal of Earth Sciences Research* **10**(1): 47-66. https://doi.org/10.37745/bjesr.2013.

APHA (American Public Health Association) (1998). Standard methods for the examination of water and wastewater, 20th ed., American Public Health Association, Washington DC, USA. 541pp.

Banu, A. N. H., Islam, M. A. and Chowdhury, M. B. R. (2001). Bacterial load in pond water and different organs of an Indian major carp *Cirrhinus mrigala* Ham. *Bangadesh Journal of Fisheries Research* 5(1): 53-58.

Bai, D., Li, X., Liu, Z., Wan, L., Song, C., Zhou, Y., Cao, X. (2023). Nitrogen and phosphorus turnover and coupling in ponds with different aquaculture species. *Aquaculture*, 563(30): 738997. https://doi.org/10.1016/j.aquaculture.2022.738997.

Bibi, F., Qaisrani, S. N., Ahmad, A. N., Akhtar, M., Khan B. N., Ali, Z. (2015). Occurrence of *Salmonella* in freshwater fishes: a review. *The Journal of Animal & Plant Sciences*, **25(**3): 303-310.

Bijekar, S., Padariya, H.D., Yadav, V.K., Gacem, A., Hasan, M.A., Awwad, N.S., Yadav, K.K., Islam, S., Park, S., Jeon, B. H. (2022). The state of the art and emerging trends in the wastewater treatment in developing nations. *MDPI Water*, 14: 2537-2556 https://doi.org/10.3390/w14162537.

Bulbul A. A., Abha M. (2022). Effects of dissolved oxygen concentration on freshwater fish: a review. *International Journal of Fisheries and Aquatic Studies* 10(4): 113-127. https://doi.org/10.22271/fish.2022.v10.i4b.2693.

Cheikyula, J. O., Garba, A. A., Ocheinu, J. (2020). Comparitive experimental fish culture on the river Benue and in a concrete pond at MAKURDI, NIGERIA. *Journal of Research in Forestry, Wildlife and Environment*, 12(2): 100-104. http://www.ajol.info/index.php/jrfwe.

Chukwuma, O. U., Echezonachukwu, E. P., Maxwell, O. (2020). Microbial assessment of some selected fishponds in Awka, Anambra State: comparative study and modelling. *Agricultural and Biological Sciences Journal*, 6(2): 91-99.

Cowan, S. T., Steel, K. J. (1993). *Manual for the identification of medical bacteria*. Barrow, G. I. and Feltham, R. K. A. (editors) 3th edition, Cambridge University Press, London. 331pp.

Dnyanraj, K., Khandagale, V. P. (2021). Importance of water pH and hardness on fish biological processes. *International Journal of Scientific Development and Research* 6(11): 8 – 11.

Eghomwanre, A. F., Obayagbona, O. N., Imarhiagbe, E. E. (2019). Bacteriological and physicochemical assessment of fishpond waters collected from Idogbo Community, Edo State, Nigeria. *FUW Trends in Science and Technology Journal*, 4 (2): 582-585.

Elekwachi, L. O. (2018). Investigating the level of awareness of fish farming in Delta State, Nigeria. *International Journal of Scientific and Engineering Research*, **9**(8):1432-1445.

Eze, E., Ajmal, T. (2020). Dissolved Oxygen Forecasting in Aquaculture: A Hybrid Model Approach. *Applied Sciences*, 10(20): 7079-7083 http://dx.doi.org/10.3390/app10207079.

Fawole, M. O., Oso, B. A. (2007). *Laboratory Manual of Microbiology*. Spectrum Books Limited, Ibadan, 123 pp.

Garai, P., Banerjee, P., Mondal, P., Saha, N. C. (2021). Effect of heavy metals on fishes: toxicity and bioaccumulation. *Journal of Clinical Toxicology* **11**(18): 1-10.

Handeland, S. O., Imsland, A. K., Stefansson, S. O. (2008). The effect of temperature and fish size on growth, feed intake, food conversion efficiency and stomach evacuation rate of Atlantic Salmon post-smolts. *Journal of Aquaculture*, 283(1): 36–42. http://dx.doi.org/10.1016/j.aquaculture.2008.06.042.

Honcharova, O. V., Paraniak, R. P., Kutishchev, P. S., Paraniak, N. M., Hradovych, N. I., Matsuska, O. V., Rudenko, O. P., Lytvyn, N. A., Gutyj, B.V., Maksishko, L. M. (2021). The influence of environmental factors on fish productivity in small reservoirs and transformed waters. *Ukrainian Journal of Ecology*, **11**(1): 176-180. https://doi.org/10.15421/2021_27.

Idu, A. J. (2015). Threats to water resources development in Nigeria. *Journal of Geology and Geophysics*, **4(**3): 1-10. https://doi.org/10.4172/2329-6755.1000205.

Islam, M. A., Nusrat, N., Khan, M. Z., Billah, S. M., Amin, S., Kabir, K. A. (2018). Nutrients load in ponds both water and soil due to application of different levels of carbon and nitrogen with feeding. *Asian Journal of Soil Science and Plant Nutrition* **3**(4): 1-16. https://doi.org/10.9734/AJSSPN/2018/44848.

Leonard, L. S., Mahenge, A., Mudara, N. C. (2022). Assessment of heavy metals contamination in fish cultured in selected private fishponds and associated public health risk concerns, Dar es Salaam, Tanzania. *Marine Science and Technology Bulletin*: 11(2): 246- 258. https://doi.org/10.33714/masteb.1108314.

Mao, B. J., Huang, Z. W., Zeng, F. T., Du, H. W., Fang, H. Y., Lin, S., Zhang, Y. Y., Shi, L. (2020). Assessment of heavy metal pollution in the water, sediment and fish during a complete breeding cycle in the pond of the Pearl River Delta, China. *Journal of Environmental Protection*, 11: 509-530. https://doi.org/10.4236/jep.2020.116030.

Ndayisenga, J. D., Dusabe, S. (2022). Ponds' water quality analysis and impact of heavy metals on fishes' body. *Journal of Sustainability and Environmental Management*, 1(2): 62-72.

NESREA (National Environmental Standard and Regulations Enforcement Agency) (2011). National Environmental (surface and groundwater quality control) regulation. The Federal Republic of Nigeria Official Gazette. 693-727 pp.

Njoku, O. E., Agwa, O. K., Ibiene, A. A. (2015). An investigation of the microbiological and physicochemical profile of some fishpond water within the Niger Delta region of Nigeria. *African Journal of Food Science*, 9(3): 155-162. https://doi.org/10.5897/AJFS2014.1208.

Oladimeji, Y. U., Abdulsalam, Z., Mani, J. R., Ajao, A. M., Galadima, S. A. (2017). Profit Efficiency of Concrete and Earthen Pond Systems in Kwara State, Nigeria: A path towards Protein Self-Sufficiency in Fish farming. *Nigerian Journal of Fisheries and Aquaculture*, 5(2):104 – 113.

Oliver, K., Abudou-Fadel, B. S. S. (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. *Aquaculture and Fisheries*, **6**: 535-547.

Orji, C. V., Ekwenye, U. N., Eze, V. C., Anuforo, P. C. (2022). Microbiological and physicochemical quality measurements of some fishponds in Nigeria. *Journal of Applied Sciences*, 22: 68-75. http://dx.doi.org/10.3923/jas.2022.68.75.

Orobator, P. O., Akiri-Obaroakpo, T. M., Orowa, R. (2020). Water quality evaluation from selected aquaculture ponds in BENIN CITY, NIGERIA. *Journal of Research in Forestry, Wildlife and Environment* 12(1): 24-33.

Rantlo, A. M. (2022). Factors influencing farmers' participation in fish production in Lesotho. *Journal of Agricultural Extension*, 26 (2): 34 – 43. https://dx.doi.org/10.4314/jae.v26i2.4.

Saah, S. A., Adu-Poku, D., Boadi, N. O. (2021). Heavy metal contamination and water quality of selected fishponds at Sunyani, Ghana: A comparison with WHO standards. *Chemistry International*, **7**(3): 181-187. https://doi.org/10.5281/zenodo.4899629.

Saikia, D. J., Chattopadhyay, P., Banerjee, G., Talukdar, B., Sarma, D. (2018). Identification and pathogenicity of *Pseudomonas aeruginosa* DJ1990 on tail and fin rot disease in spotted snakehead. *Journal of the World Aquaculture Society*, **49**(4): 703-714. https://doi.org/10.1111/jwas.12476.

Schafer, N., Matousek, J., Rebl, A., Stejskal, V., Brunner, R. M., Goldammer, T., Verleih, M., Korytar, T. (2021). Effects of chronic hypoxia on the immune status of Pikeperch (*Sander lucioperca* Linnaeus, 1758). *Biology* 10(7): 649-658 https://doi.org/10.3390/biology10070649.

Some, S., Mondal, R., Mitra, D., Jain, D., Verma, D., Das, S. (2021). Microbial pollution of water with special reference to coliform bacteria and their nexus with the environment. *Energy Nexus Journal*, 1: 1-8. https://doi.org/10.1016/j.nexus.2021.100008.

Sule, I. O., Agbabiaka, T. O., Ahmed, R. N., Saliu, B. K., Olayinka, K. J. (2016). Bacteriological and physicochemical analysis of wastewater from fishponds. *Ethiopian Journal of Environmental Studies and Management* 9 (2): 167-178. http://dx.doi.org/10.4314/ejesm.v9i2.5.

Swain, S., Sawant, P. B., Chadha, N. K., Chhandaprajnadarsini, E. M., Katare, M. (2020). Significance of water pH and hardness on fish biological processes: A review. *International Journal of Chemical Studies* 8(4): 830-837 https://doi.org/10.22271/chemi.2020.v8.i4e.9710.

Tumwesigye, Z., Tumwesigye, W., Opio, F., Kemigabo, C., Mujuni, B. (2022). The effect of water quality on aquaculture productivity in Ibanda District, Uganda. *Aquaculture Journal*, 2(1):23-36. https://doi.org/10.3390/aquacj2010003.