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Research Article

Microbiological and Physicochemical Quality Measurements of Some Fish Ponds in Nigeria

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Abstract

Background and Objective: Cultivating fish in a controlled environment has been found to expose them to contamination by microorganisms (pathogenic and opportunistic organisms). This contamination is attributed to questionable water quality and high stocking densities. Inability to change the water in ponds exposes the fish to microbial agents which when encountered, cause diseases and death. The microbiological and physicochemical qualities of some fish ponds water at MOUAU, Umudike alongside a reservoir that supplies the water at NRCRI, Umudike were measured out. **Materials and Methods:** The microorganisms were identified with biochemical tests and molecular techniques using PCR and DNA sequencing. The physicochemical parameters were assessed using appropriate methodologies. The fungi isolates were identified based on colony features and microscopic examination of mounts of the isolate made in lactophenol blue. **Results:** The total heterotrophic bacteria mean count ranged from $5.6 \times 10^6 \pm 1.41$ in the reservoir to $1.56 \times 10^7 \pm 1.41$ in pond 3. Similarly, the fungal count ranged from $1.8 \times 10^6 \pm 0.14$ in the reservoir to $3.8 \times 10^5 \pm 0.14$ in pond 5. The bacteria isolated were *Alcaligenes faecalis* (16.9%), *Salmonella bongori* (13.8%), *Staphylococcus sciuri* (18.5%), *Proteus mirabilis* (15.4%), *Pseudomonas aeruginosa* (24.6%), *Escherichia coli* (10.8%), while the fungi were *Aspergillus niger* (36.4%), *Aspergillus fumigatus* (27.3%), *Penicillium glabrum* (24.2%) and *Rhizopus oryzae* (12.1%). The mean values of the physicochemical parameters ranged as follows: pH, 6.71-6.81, temperature, 26.60°C in pond 2 to 27.14°C in reservoir, dissolved oxygen, 4.47 in pond 3 to 5.03 mg L⁻¹ in pond 1, biological oxygen demand, 1.83-2.04 mg L⁻¹, turbidity, 8.06-36.12 mg L⁻¹, ammonia, 0.32-2.13 mg L⁻¹, phosphate, 0.24-1.77 mg L⁻¹, electricity conductivity, 62.4-173.60 µs cm⁻¹. **Conclusion:** Mean values obtained for temperature, dissolved oxygen and pH were within the WHO standard, while turbidity and ammonia were above the standard limits.

Key words: Microbiological, physicochemical, fish, water, pond, quality

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INTRODUCTION

The farming of aquatic organism 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 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 *et al.*¹, 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-Hafedh². Its quality is one of the most overlooked aspects of good management until it affects fish production or cause risk to human health, poor-water quality can result in low profit, low product quality and potential human risk.

Shoko *et al.*³, believed that production is reduced when the water contains contaminants that can impair development, growth, 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. For this to be effective there is a need for the fish culturist to regularly monitor the parameters⁴. When there is no balance in nature, there will be difficulty in efficient food conversion growth and marketability of the final product. The overriding concern of the fish culturist is to maintain 'balance' or 'equilibrium' conditions concerning water chemistry and its natural consequence⁴.

Water quality for aquaculturists refers to many characteristics of water that affects the survival, reproduction and growth of the desired organism being reared. Water quality for aquaculturists refers to the quality of water that enables the successful propagation of the desired organisms. According to Boyd⁵, the water quality variable generally means the components of water which must be present for the best possible growth of aquatic organisms. As noted by Bhatnagar and Devi⁶, water quality is made up of physical (temperature, density) chemical (pH, conductivity, nutrients) and biological (bacteria, plankton and parasites) which influence the use of water in fish culture purposes. According to Venkatesharaju *et al.*⁷, water quality is an important aspect of the aquaculture system. Non-optimum water physicochemical parameters (dissolved oxygen, pH, salinity, ammonia, temperature, etc.) and poor management

practices (overfeeding, inadequate nutrition, overcrowding, etc.) can cause stress to the cultured fish and thus make them more susceptible to disease outbreaks.

Fish cultivation in the restricted environment is contaminated by microorganisms (pathogenic and opportunistic organisms)⁸. Huicab-Pech *et al.*⁹, attributed this contamination to questionable water quality and stocking densities. According to Pękala-Safińska¹⁰, Ikpi and Offem¹¹, microorganisms contribute a significant fraction of importance in the aquatic ecosystem and they have been observed to be among to factors that cause the emergence of infectious diseases in the practice of aquaculture.

The prevalence of the infectious disease has been observed to depend on the interactions between fish pathogens and the aquatic environment¹⁰. Moreso, the stocking of fish in fish ponds may expose them to new pathogens. The bacteria flora of the fish depicts the level of bacteria in the water environment. Soon *et al.*¹² opined that the fish bacterial flora is shown by the bacteriological quality of the water which 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 pathogenesis¹³, the condition that fishes are cultured may be potentially stressful.

Biological respiration, including that related to decomposition processes, reduces DO concentration. The measurement of DO can be used to indicate the degree of pollution by organic matter, its determination is also used in the measurement of Biochemical Oxygen Demand (BOD)^{14,15}.

Previous studies have been on the comparative assessment of *Oreochromis niloticus* (tilapia) from the pond with those from the pond in Uzere, Delta State as regards bioaccumulation of heavy metals and the effect of nutritional state of the fishes¹⁶. The bacterial and fungal flora of sediments, pond water and fish from the fish culture ponds of MOUAU has previously been reported by Ekwenye and Ugwoje¹⁷. The purpose of this study was to determine the microbiological and physicochemical qualities of some fish ponds in the Michael Okpara University of Agriculture, Umudike.

MATERIALS AND METHODS

Study area: Microbiological and physicochemical quality of some fish ponds was carried out from January to May, 2016.

The fish ponds were located in the Michael Okpara University of Agriculture, Umudike while the source of water to the ponds is a reservoir at National Root Crops Research Institute, Umudike, Abia State, Nigeria. Umudike lies between latitude 5°29'N and 7°39'E. The average temperature of the area is 26°C, the maximum being 32°C and the minimum is 22°C. Umudike is 122 m (400 ft) above sea level. It has an average rainfall of 2169.8 mm. The main activity around the pond and reservoir is purely agricultural.

Sample collection: The collection of water samples was from a depth of about 25 cm beneath the surface of the earthen ponds and from the source of water to the pond (reservoir) in sterile bottles. Before collection, the sampling bottles were thoroughly washed and rinsed with the same water to be collected from the ponds. One time sampling in triplicate was carried out in each pond. Until analysis, the water collected was appropriately labelled and kept in a cool container with ice packs.

Enumeration of microorganisms: Isolation of total heterotrophic bacteria and fungi was done using the spread plate method. Nutrient agar and Sabouraud dextrose agar was used, respectively. The total bacterial and coliform counts were enumerated from these sources and gram stained. Isolates of morphologically different colony types were selected from plate count agar and subcultured.

Identification and characterization of microorganisms isolated: The microorganisms were identified using biochemical tests which included catalase test, oxidase, indole test, citrate utilization test and hydrogen sulphide production test.

Identification of bacteria by DNA extraction and sequencing: The genomic DNA was extracted from cultures by the method adopted from Ye *et al.*¹⁸. Using the Zymo Research Quick DNA fungal/bacterial miniprep kit.

DNA sequencing was performed as opined by Fei *et al.*¹⁹. The result was obtained as nucleotides. Sequence analysis from resultant nucleotides base pairs was performed by blast analysis by direct blasting on American database (<http://blast.ncbi.nlm.nih.gov>). For every set of isolate, a read was BLASTED and the resultant top hits with minimum t-score for every BLAST result showing species name was used to name the specific organism.

Identification of fungi: The characterization of the isolates was based on the colony features and microscopic examination with mounts of the isolates made in lactophenol blue (dye), the features recorded were the presence of hyphae (septate or non-septate), nature of sporangiophore and conidiophores. Their identification was performed according to Tafinta *et al.*²⁰.

Determination of physicochemical parameters: The water samples from the different ponds and the reservoir were examined for physicochemical factors. This includes temperature, pH, dissolved oxygen, biochemical oxygen demand, turbidity, hardness, electrical conductivity, alkalinity, phosphate, nitrate, iron, zinc and ammonia.

Statistical analysis: Data from laboratory analysis are expressed using illustrative table. Results are expressed as Mean $\pm$ Standard Deviation of triplicate.

RESULTS

The results of the analysis of the fish pond water samples are shown in Table 1-3. Table 1 shows the mean counts of microorganisms isolated from the different ponds and reservoir. The total heterotrophic count ranged from $1.56 \pm 1.4 \times 10^7$ in pond 3 to $5.6 \pm 1.4 \times 10^6$ in the reservoir while the fungal count ranged from $3.8 \pm 0.1 \times 10^5$ to $5.6 \pm 1.4 \times 10^6$. The coliform count ranged from 34 MPN/100 mL in pond 3 to 7 MPN 100 mL⁻¹ in pond 2. Statistically, dilution factor sample means with the same superscripts, across rows show that there was no significant difference ($p > 0.05$), while means with different superscript across each row shows that there was a significant difference ($p < 0.05$). Table 2 showed the microorganism isolated from the ponds and the percentage occurrence. *Pseudomonas aeruginosa* had the highest occurrence with 24.6% while *Escherichia coli* had the least occurrence of 10.8% for the bacterial isolates, while for the fungi, *Aspergillus niger* had the highest occurrence and *Rhizopus oryzae* had the least occurrence of 12.1%. The mean values of the physicochemical parameters of the pond water samples are shown in Table 3. The mean values ranged as follows, temperature 26.60 ± 0.0 - $27.14 \pm 0.7^\circ\text{C}$, pH 6.71 ± 0.0 - 6.81 ± 0.0 , dissolved oxygen 4.47 ± 0.0 - 5.03 ± 0.0 mg L⁻¹, biological oxygen demand 1.83 ± 0.0 - 2.04 ± 0.0 mg L⁻¹, turbidity 8.05 ± 0.0 - 36.12 ± 0.0 NTU, hardness 11.19 ± 0.0 - 42.65 ± 0.0 mg L⁻¹, electricity conductivity 62.50 ± 0.0 ms cm⁻¹, alkalinity 99.12 ± 0.0 - 183.43 ± 0.0 mg L⁻¹, phosphate 0.24 ± 0.0 - 1.77 ± 0.0 mg L⁻¹, nitrate 16.35 ± 0.0 - 19.78 ± 0.0 mg L⁻¹, iron 0.002 ± 0.0 - 0.008 ± 0.0 mg L⁻¹, zinc 0.003 ± 0.0 - 0.004 ± 0.0 mg L⁻¹ and ammonia 0.32 ± 0.0 - 2.13 ± 0.0 mg L⁻¹.

Table 1: Mean total heterotrophic bacterial, fungal and coliform count

Ponds	THC (CFU mL ⁻¹)	FC (CFU mL ⁻¹)	Coliform MPN (100 mL ⁻¹)
1	1.43 ± 1.41 ^b	2.60 ± 0.14 ^c	26
2	9.70 ± 1.41 ^d	2.20 ± 0.14 ^c	11
3	1.56 ± 1.41 ^a	3.60 ± 0.14 ^b	34
4	7.20 ± 1.41 ^e	3.40 ± 0.14 ^b	17
5	1.24 ± 1.41 ^c	3.80 ± 0.14 ^b	33
Reservoir	5.60 ± 1.41 ^f	1.80 ± 0.14 ^a	14

THC: Total heterotrophic count, FC: Fungal count and CFU mL⁻¹: Colony-forming unit per millilitre

Table 2: Microorganisms isolated from the ponds and their percentage occurrence

Microorganisms	Number of isolates	Occurrence (%)
Bacteria		
<i>Escherichia coli</i>	7	10.8
<i>Alcaligenes faecalis</i>	11	16.9
<i>Proteus mirabilis</i>	10	15.4
<i>Staphylococcus sciuri</i>	12	18.5
<i>Salmonella bongori</i>	9	13.8
<i>Pseudomonas aeruginosa</i>	16	24.6
Fungi		
<i>Penicillium glabrum</i>	8	24.2
<i>Aspergillus niger</i>	12	36.4
<i>Aspergillus fumigatus</i>	9	27.3
<i>Rhizopus oryzae</i>	4	12.1

Table 3: Mean values of the physicochemical parameters of the pond water samples

Parameters	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Reservoir	Mean ± SD	WHO limit
Temperature (°C)	26.66 ± 0.00 ^d	26.60 ± 0.00 ^e	26.63 ± 0.07 ^e	26.89 ± 0.07 ^c	26.94 ± 0.07 ^b	27.14 ± 0.00 ^a	26.75 ± 0.1705	<35
pH	6.81 ± 0.00 ^a	6.71 ± 0.07 ^c	6.79 ± 0.07 ^a	6.81 ± 0.03 ^a	6.73 ± 0.07 ^{bc}	6.77 ± 0.07 ^{ab}	6.78 ± 0.042	6.5-8.5
DO (mg L ⁻¹)	5.03 ± 0.07 ^a	4.53 ± 0.07 ^d	4.47 ± 0.00 ^e	4.59 ± 0.00 ^c	4.69 ± 0.00 ^b	4.72 ± 0.07 ^b	4.66 ± 0.19	4-6
BOD (mg L ⁻¹)	2.04 ± 0.00 ^a	2.03 ± 0.03 ^a	1.94 ± 0.07 ^{ab}	1.98 ± 0.00 ^b	1.95 ± 0.00 ^c	1.83 ± 0.07 ^d	1.89 ± 0.165	6
Turb (NTU)	31.65 ± 0.07 ^d	36.12 ± 0.07 ^e	35.45 ± 0.07 ^a	33.71 ± 0.07 ^c	35.1 ± 0.70 ^b	8.05 ± 0.00 ^f	30.5 ± 10.86	-
Hardness (mg L ⁻¹)	42.65 ± 0.07 ^a	39.87 ± 0.00 ^c	42.46 ± 0.07 ^b	39.66 ± 0.07 ^d	38.83 ± 0.07 ^e	11.19 ± 0.07 ^f	35.05 ± 12.04	600
EC (µs cm ⁻¹)	173.60 ± 0.00 ^a	62.50 ± 0.70 ^f	85.10 ± 0.70 ^d	111.30 ± 0.70 ^b	77.70 ± 0.70 ^e	106.70 ± 0.70 ^c	103.1 ± 39.29	300
Alkalinity (mg L ⁻¹)	130.49 ± 0.00 ^e	183.43 ± 0.07 ^a	153.56 ± 0.07 ^c	151.29 ± 0.07 ^d	160.59 ± 0.00 ^b	99.12 ± 0.00 ^e	146.4 ± 28.76	600
Phosphate (mg L ⁻¹)	1.76 ± 0.00 ^b	0.24 ± 0.00 ^d	0.31 ± 0.00 ^f	1.77 ± 0.00 ^a	1.42 ± 0.00 ^c	0.74 ± 0.00 ^e	1.0356 ± 0.69	-
Nitrate (mg L ⁻¹)	1.76 ± 0.00 ^b	16.35 ± 0.07 ^f	19.78 ± 0.00 ^a	17.87 ± 0.07 ^c	17.38 ± 0.03 ^e	17.45 ± 0.07 ^d	17.91 ± 1.186	50
Iron (mg L ⁻¹)	0.004 ± 0.10 ^a	0.002 ± 0.00 ^a	0.004 ± 0.00 ^a	0.006 ± 0.00 ^a	0.004 ± 0.00 ^a	0.008 ± 0.00 ^a	0.0045 ± 0.0002	-
Zinc (mg L ⁻¹)	0.003 ± 0.00 ^d	0.004 ± 0.00 ^a	0.003 ± 0.00 ^{bc}	0.003 ± 0.00 ^c	0.004 ± 0.00 ^{ab}	0.003 ± 0.00 ^c	0.003 ± 0.0008	-
NH ₄ (mg L ⁻¹)	1.87 ± 0.00 ^c	1.93 ± 0.07 ^b	2.13 ± 0.00 ^a	1.68 ± 0.00 ^d	0.99 ± 0.00 ^e	0.32 ± 0.00 ^f	1.485 ± 0.6919	-

In each column means followed by different superscript letters (a, b, c, d, e, etc.) are significantly different at p < 0.05, Turb: Turbidity, DO: Dissolved oxygen, EC: Electrical conductivity, BOD: Biochemical oxygen demand and WHO: World Health Organization (2009)

DISCUSSION

The result of the microbiological examination of the ponds showed that the total heterotrophic bacterial and fungal counts were high and varied with location. This goes to show a high level of contamination. This may be due to the water temperature which is within optimum for bacterial growth and could also be attributed to the organic matter load in the ponds where BOD values obtained showed that the ponds are moderately polluted. Gram-negative bacteria were dominant in the bacteria isolated from the ponds.

The bacteria isolated and identified were *Pseudomonas aeruginosa*, *Staphylococcus scuri*, *Escherichia coli*, *Proteus mirabilis*, *Salmonella bongori*, *Alcaligenes faecalis* while the fungi were *Aspergillus niger*, *Aspergillus fumigatus*,

Penicillium glabrum and *Rhizopus oryzae*. This could be linked to neglecting good fish pond management practices. It could be a result of the increase in the rate of microbial infiltration possibly due to faecal contamination either through runoff or due to the bushes shrubs or plants where smaller mammals may have been coming around to drink water, thereby passing out faeces into the pond²¹. Since there are farmlands within the location, also birds can be a significant source of faecal coliform bacteria. This is in line with the work of Ekwenye and Ugwoje¹⁷, Eze and Ogbaran²² and Njoku *et al.*²³. Ampofo and Clerk²⁴ noted that the presence of *Escherichia coli* in water and food indicates the possible presence of causative disease, *Pseudomonas*, *Proteus*, *Staphylococcus* species have been implicated in food poisoning²⁵.

The presence of the potentially pathogenic bacteria in different water samples varied with ponds. Microbiological analysis of the water samples showed different genera of bacteria, *Salmonella*, *Pseudomonas*, *Escherichia coli*, *Proteus*, *Staphylococcus* and *Alcaligenes*. The isolated microorganisms were *Pseudomonas* (24.6%), *Staphylococcus* (18.5%), *Alcaligenes* (16.9%), *Proteus* (15.4%), *Salmonella* (13.8%) and *Escherichia coli* (10.8%).

Pseudomonas aeruginosa is the highest percentage occurrence are opportunistic pathogens and can in rare circumstances becomes community-acquired pneumonia as well as ventilator-associated pneumonia, being one of the most common agents isolated in several studies²⁶. Karafistan and Arik²⁷ entered *Pseudomonas* bacteria as an indicator of microbiological water quality during their study in Manyas Lake.

Staphylococcus aureus regarded as an important indicator of the whole aquatic ecosystem health, including fish and birds through the food web and mostly released by humans. Most of these bacteria species from pond water have been isolated in different water bodies in other studies. From the water analyzed, in the fish ponds, pathogenic bacteria, *Pseudomonas*, *Salmonella*, *Escherichia coli*, *Staphylococcus* were detected. These findings were consistent with previous studies conducted in Nigeria²⁸. These bacterial isolates are common intestinal bacteria of both animals and human gut contamination on the ponds could have been as a result of human and livestock activities²⁹. The bacteria from fish only become pathogenic when fish are physiologically unbalanced, nutritionally deficient or there are stressors namely, poor water quality, over-stocking, which allow opportunistic bacterial infections to prevail³⁰. In addition, physicochemical characteristic influence the growth and diversity of the microbial population. The study has indicated that the fish ponds were significantly contaminated with pathogenic bacteria.

The fungal isolates were identified to belong to the genera of *Aspergillus*, *Penicillium* and *Rhizopus*.

Fungal infection is an important economic and limiting factor in fish production. *Aspergillus* and *Penicillium* species were the dominant group of fungi in this study. The study is consistent with the work of Njoku *et al.*²³. Obire and Anyanwu³¹ also noted that *Aspergillus* and *Penicillium* species are believed to get into the environment through dead plant materials and remain for long period. Eze and Ogbarán²² observed *Penicillium* species as the most abundant fungi during their study in fish pond water in Ughelli, Delta State, Nigeria.

The isolation of *Aspergillus* species calls for proper treatment and handling to avoid the spread of diseases such as aspergillosis, anthrax, food poisoning and gastroenteritis³².

The pond water temperature was significantly different at all ponds measured ($p < 0.05$) the highest temperature of 27.17°C was recorded in the reservoir, while the pH level in the ponds varied showing a significant difference ($p < 0.05$) and ranged from 6.71-6.81, the dissolved oxygen value ranged from 4.47 mg L⁻¹ in pond 3 to 5.03 mg L⁻¹ in pond 1. There were variations in the physicochemical parameters.

The temperature range of 26.60-27.14°C obtained in the ponds was within a recommended temperature range of optimum fish production and for microbial growth.

Afzal *et al.*³³ recommended a temperature range of between 25 and 32°C for good performance of fish. The highest recorded temperature 27.14°C in the reservoir is due to its highest exposure to sunlight with less shade from the trees around the location.

The World Health Organization has set the limit to be 35°C. Biological activities have been observed to double each 10°C rise in temperature while the toxicity of ammonia increases and dissolved oxygen decreases with the temperature rise.

The pH range 6.71 ± 0.07-6.8 ± 0.00 recorded falls within the recommended pH range of 6.5-8.5 for good fish performance. The desirable range for good pH (6.5-8.5) according to WHO and an acceptable range of 7.0-9.5⁶. Thus good pond productivity and fish health can be maintained. Furthermore, a similar range was obtained by Umeh *et al.*³⁴, who reported a range of 6.21-8.15.

Dissolved oxygen values from this study were significantly different across ponds the mean values range from 4.47 ± 0.00 in pond 3 to 5.03 ± 0.07 in pond 1.

This implies that fishes reared in pond 3 may not be having as much dissolved oxygen supply compared to other ponds. Though still with the minimum constant value of 4.0 mg L⁻¹ according to Ayanwale *et al.*³⁵. The dissolved oxygen demand values obtained from this study had ranged between 4.47-5.03 mg L⁻¹, these values are within the WHO limit of 4-6 mg L⁻¹.

The BOD in pond 1 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 ponds. The values ranged from 1.89-2.04, the BOD values are therefore below the values for optimum fish activities according to WHO and FEPA limits but are within the desirable range of 0.27 mg L⁻¹ according to Agbaire *et al.*³⁶. The result is similar to that recorded by Boyd⁵.

Turbidity obtained from this work ranges from 8.06-36.12 with a source measuring 8.06 NTU. Only the source is within the WHO limit of 10 NTU. The other ponds are above the acceptable range.

The mean values obtained for the water hardness in the ponds showed significant differences ($p < 0.05$). The mean values range from 11.19-42.65. The reservoir that has the least mean of 11.19 might not adequately support fish production, it might be necessary to add some calcium and magnesium supplements whereas pond 1 which is harder water will be more productive. Rajkumar *et al.*³⁷, opined that a total hardness value of $>20 \text{ mg L}^{-1}$ would cause stress and an optimum value of 75-150 mg L^{-1} with a lethal value of $>300 \text{ mg L}^{-1}$.

Mean electrical conductivity values for the fish ponds were between $62.50 \mu\text{S cm}^{-1}$ on pond 2 to $173.60 \mu\text{S cm}^{-1}$ in pond 1. This high surface water conductivity ($173.60 \mu\text{S cm}^{-1}$) in pond 1 is a pointer to the pollution status of the pond caused by fallen leaves, debris, excessive nutrient from feels, run-off into ponds (a consequence of improper siting of ponds) and waste products of fishes and other insects population within the pond.

The obtained alkalinity ranged from 99.12-183.43 mg L^{-1} . According to Bhatnagar and Devi⁶, optimum alkalinity for fish productivity values for the fish ponds was between 25-100 mg L^{-1} .

Phosphate is the main nutrient for algae. The values obtained from this work range from 0.24-1.77 mg L^{-1} with a mean value of 1.035 ± 0.69 . The value is within the acceptable range of 0.03-2.00 mg L^{-1} as recommended by Bhatnagar and Devi⁶. Higher values could lead to eutrophication. Nitrate concentration in this work ranged from 17.19 ± 1.18 . The values obtained are within WHO limits.

The amount of iron and zinc detected did not show any significant difference among the ponds. This could be ascribed to the fact that certain metals uptake has been associated with the geochemical (sediments, etc.) and dietary composition. Heavy metals can be mobilized from sediment if there is a change in physicochemical properties and consequently result in trophic transfer to detritivores³⁸. The degree of contamination of the aquatic environment with metals cannot always be precisely evaluated based on their water content as part of them are distributed with suspended matter and accumulated in bottom sediments³⁹.

Bhatnagar and Sing⁴⁰ recommended the level of ammonia (0.2 mg L^{-1}) for pond fishery. In this study, the ammonia concentration ranged from 0.32-2.13 mg L^{-1} . This is high which would lead to high mortality. The presence of ammonia is a result of the accumulation of leftover rut protein feed, fish

waste and microbial decomposition. It can be attributed to the addition of manure to fertilize the pond or through the process of nitrogen fixation by algae and water plants⁴¹. Studies have shown that ammonia tends to block oxygen transfer from the gills to the blood and can cause both immediate and long-time damage⁴².

CONCLUSION

Different bacterial and fungal isolates from the ponds show the presence of contamination which is a threat to health. These could have been caused by the passive process through wind, run-off, etc. All the physicochemical parameters varied from ponds, temperature, dissolved oxygen pH, phosphates, nitrate and electrical conductivity were within acceptable limit while biological oxygen demand was below the values desirable for optimum fish activities. Ammonia and turbidity were above the recommended limits. This was witnessed during sample collection as a result some fishes were seen dead. The management practices in these ponds have been found to affect the physicochemical water characteristics in the ponds and are aquatic potential health risk factors.

SIGNIFICANCE STATEMENT

The study discovered that a better understanding of the hygienic and healthiness of the ponds can be beneficial for the production of healthier fishes for human consumption. This study will also help researchers to know the key water quality parameters such as dissolved oxygen, temperature and ammonia which are more likely to cause fish losses, to be regulated.

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