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Research Article
Quality Evaluation of Commercial Fish Ponds in Uli, Anambra State and Their Health Implications

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Abstract

Background and Objective: Uli is a town that hosts a university campus and accommodates a population of people that like catfish delicacies. The study aimed to determine the physicochemical and biochemical analysis of some selected fish ponds in Uli and their health implications for man. **Materials and Methods:** Physicochemical and bacteriological studies of selected fish ponds in Uli, Anambra State, Nigeria were analyzed using standard procedures to evaluate the water quality of the ponds. The ANOVA statistics at 0.05 level of significance were used for statistical analysis. **Results:** The physicochemical properties showed that the temperature ranged from 31.00±1.0°C to 32.50±1.00°C, while pH ranged from 4.82±0.01 to 5.17±0.01, dissolved oxygen from 1.81±0.06 to 5.50±0.10 mg L^{-1}, conductivity ranged from 99.0±1.00 to 891.0±1.0 mS cm^{-1}, phosphorus values also vary from 0.5±0.01 to 6.0±1.00 mg L^{-1}. Bacteria of public health importance like *E. coli*, *Shigella* spp. and *Salmonella* spp. were also detected. The presence of these organisms shows that there is a lack of qualitative management regimens in these ponds. This is attributed to fecal contamination observed within the environment where the fish ponds are located. **Conclusion:** This study, therefore, encourages the need for good pond water quality management to forestall an epidemic outbreak in light of encouraging fish consumers' safety in fish consumption.

Key words: Health implications, physicochemical, bacteriological, concrete pond, fish, contamination

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Water is a pertinent component of life and its main sources include rain, lakes, wells, streams, springs, ponds and ocean[1]. Natural water sources are mostly polluted with wastes that are dangerous to health. Microorganisms in these sources are numerous in numbers and diversity[2].

The daily speed of microbial evolution and invasion of the foods that man consumes, including fish, has prompted diversified researchers in this area to meet up the challenging demands on professional fish researchers "Water has no enemy" and indeed fish is not an enemy to water, provided those physicochemical and biochemical conditions are monitored. They are further encompassed to promote the proper handling and processing of fish[3]. The entire globe has been woken up to the inherent benefits of man consuming fish and fish products. Statistics have shown that fish provides at least 20% of the protein consumed by man[4]. Water which is a neutral oxide of hydrogen is one the most important oxide known to be abundant in the earth's crust. Its presence or absence plays a role in human settlement[5].

Worthy of note is the cultivability potentials obtained from the zooplankton (protozoa, heterotrophic flagellates, rotifers, cladoceran and copepod). They provide natural food sources in fish hatcheries and hydrobiological assay tests[6]. However, the wet season supported more zooplankton than nematodes and cladocerans over a wet/dry season transition period[7].

There is this obvious need to balance investment costs and returns. This underscores the reasoning of the aquaculture practitioners (fish culturists, in particular) to know the preferred culture environment to adapt to at a given time. Once that is done, there will then be a higher probability of a sustained and viable fish.

Water provides fish with the physical support they need to perform life-sustaining activities like feeding, swimming, breeding, digestion and excretion. Fish is also a cheap source of protein[8]. The majority of the world's population (56%) gets at least 20% of its animal protein from fish[9,10]. This is because, whether compared to chicken, beef, hog or mutton, fish is the preferred source of highly wanted animal protein. In comparison to other production sources, it is more affordable, highly regarded and has little to no religious prejudice[11].

The type of life in a pond is typically influenced by a variety of factors, such as the water level regime (especially the depth and duration of flooding) and nutrient levels, but other factors, such as the presence or absence of trees for shade, streams, the effects of grazing animals, salinity and other factors may also be significant[10].

Fish is a rich source of protein and has been referred to, against other protein sources, cheaper and a highly acceptable delicacy of all ethnic-religious groups, quite cultivable in fish farms (earthen and concrete alike) ponds, wooden, plastic[11].

Water quality refers to the state of the water, including its chemical, physical and biological qualities, usually about whether it is suitable for a certain activity, such as drinking or swimming or whether it is possible to use the water in certain ponds to grow fake fish[12]. There are acceptable water quality ranges where all living things function at their best. Within these limitations, a dramatic decrease or increase hurts their bodily processes[13].

The increase in demand for fish and its products has led to an increase in the artificial production of fish in controlled environments. Ponds (concrete or earthen) and vats (wooden or fiberglass) are a few examples of these various culture mediums or controlled environments[14]. Omojowo and Omojosola[15] assert that the presence of germs in fish meant for human consumption may pose a risk since they may serve as reservoirs for bacteria that are resistant to antibiotics. When fish is cooked incorrectly, it might result in treatment failure and expensive treatment costs. The microbiological quality and physicochemical characteristics of a few particular concrete fish ponds in Uli town, Anambra State, should thus be assessed and compared.

However, some militating factors that predispose these fishes to microbial contamination are poor water quality, unregulated stocking densities, feeding frequency etc. Hence, there is a higher use of concrete ponds than earthen ponds in recent fish cultivation[16,17].

Other sources of microbial introduction into the fish culture media is the use of animal protein as supplements or entirely as feed in fish feeding, a practice common in the tropics and Asian countries. The resultant effect is that the fish in the culture gets in direct contact with microorganisms and when a man consumes an improperly cooked fish, he becomes infected by the parasites hosted in the fish[15]. The use of constructed ponds in various aquaculture for domestic purposes makes it a common innovation ranging from natural to a ground-filled depression that retains water. Sometimes, semi-streams or spring water is usually channeled into these pond formations[18].

Generally, microbes (bacteria, fungi, algae, protozoa, nematodes and viruses) get to the fishes through the culture water, in which all the biological, chemical and physical conditions must be under good watch.

The microbial loads of the fish have a connection with the water levels[19]. Fishes have adaptational measures such as scale, fins, mucous body secretions and antibiotics potential in self-combating these invading microorganisms[20,21]. The indicator organism, *Escherichia coli* in the bacteriological evaluation of water conditions cannot be overemphasized. The present study examines the findings (physicochemical, bacteriological parameters) in the use of concrete fish ponds in semi-rural communities and also establishes the level of awareness and attitude of people to concrete fish ponds management techniques that are available to them.

MATERIALS AND METHODS

Study area/pond description: This Uli community is an ancient town and is under the Ihiala Local Government Area of Anambra State. Uli hosts one of the campuses of the Anambra State University now known as Chukwuemeka Odumegwu Ojukwu University, Uli Campus. It is fairly commercial and populous. Four concrete fish ponds were selected from Uli town in Ihiala Local Government Area, Anambra State, Nigeria. Pond 1 has a dimension of 2.65, 1.8, and 1.37 m deep, is surrounded by a banana plantation and is stocked with adult *Heteroclarias* which are fed once a day with 6 mm aqualis fish feed. Ponds 2, 3 and 4 were stocked with *Clarias gariepinus*, respectively. The study was carried out from February, 2022 to April, 2022 and the analysis was carried out in the Biological Science Laboratory of the Chukwuemeka Odumegwu Ojukwu University, Uli campus.

A sampling of water/collection of sample: The experimental water samples were collected from the four selected ponds between February, 2022 and April, 2022 and analyzed in the Department of Biochemistry Laboratory of the Anambra State University. Water sample plastic containers sterilized with alcohol and properly labeled were variously lowered, 20-30 cm below the surface of the four concrete ponds. The containers were carefully operated to allow water while disallowing the introduction of air bubbles. Thereafter, the containers were recapped and the sample was quickly transported to the analytical laboratory under care to avoid exposure of the sample water to extraneous contamination.

A basic (nutrient agar) medium, MacConkey agar, Salmonella-Shigella agar and eosin-methylene blue agar were used. These media were also differential and selective in their best ways of differentiating and interpreting bacteria.

Duplicate samples were simultaneously provided for each of the ponds studied to allow for a comparison with the control physicochemical plate.

The samples for the bacteriological and physicochemical analyses were collected on the same day to avoid factorial disparities.

The weighing (according to Manufacturer's instruction) pH stabilization, sterilization, aseptic dispensing precautions and placing the culture plates in an inverted position, were all discreetly carried out by APHA[22]. As 0.1 mL of the sample from each of the test tubes (post serial dilution): Dilution factors 10^5, 10^6 and 10^7, respectively were inoculated into the different agar media (NA, SSA, MacConkey). Similarly, the control (duplicate) plates were simultaneously and separately cultured with the diluted samples of the various pond water. The entire plates were monitored and observed post 24 hrs (Generation time) of bacteria incubation, at 37°C. A visual-viable estimation of the bacteria was done. The colonies of grown bacteria on the cultured plates (total count) were further determined using Colony Counter Model AVI 659 by Labtech, Beijing, China.

To further ascertain the efficiency of the autoclave used in the study, a simple Bowie-Dick Adhesive Tape Autoclave test was fastened on the autoclave and no colored change was detected. To obtain a pure culture, colonies were picked randomly from the test and control plates. The colonies were streak-plated on the nutrient agar (NA) and eosin-methylene blue agar, culture plates were subsequently incubated at 37°C for 24 hrs. The culture plates were separately observed in good light, using a low-power magnifying lens. The morphological details presented the bacterial colonies' appearances when the culture plates were viewed from above (colonies may appear round, irregular, cremated or branching, transparent, opaque, capsulated-mucoid) and flat/raised, beveled, central elevated or depressed colonies, when viewed from the side some colonies are soft or hard to touch with a wire loop, while the color changes are noted when using differential media containing indicator[23].

Further identification methods such as gram staining, biochemical testy (catalase, oxidase) were done using standard procedures[23].

- **Test for dissolved oxygen:** This was determined by Titration Method[24]
- **Test for phosphate:** Phosphate was determined by Molybdenum Method
- **Test for nitrate:** Nitrate was determined by Brucine Colorimetric Method
- **Test for sulphate:** Sulphate was determined using Mohr's Argentometric Method
- **Test for chloride:** Chloride was determined by Mohr's Argentometric Method
- **Test for total hardness:** Total hardness was determined by Titration Methods

Bacterial determination in water samples: Culture media (MacConkey agar, Nutrient Agar, Salmonella-Shigella Agar (SSA) and Eosin Methylene Blue (EMB) were used for the bacterial analysis of the pond samples.

Identification of isolates: Bacterial isolates were identified using Gram staining and other biochemical tests.

Ethical consideration: The Ethical Approval officer of the University gave his approval. We don't have an Animal Rights commission in Nigeria.

Statistical analysis: The ANOVA statistics at 0.05 level of significance were used.

RESULTS

Bacteriological analysis: The result of colony counting of water samples done using MacConkey Agar, Nutrient Agar and *Salmonella-Shigella* Agar with serial dilutions 10^5, 10^6 and 10^7 was presented in Table 1. The morphology of the bacterial species isolated from the different ponds was presented in Table 2. In this case, the colonial appearance in Ponds, 1, 2, 3 and 4, respectively showed the presence of rods and additional cocci in Pond 1. The colonies observed were characteristically raised, transparent and smooth in all the ponds.

Biochemical analysis and identification of bacteria species: This study has shown the presence of *Salmonella* species, *Shigella* species, *Proteus* species and *Escherichia* species. These were identified from the morphology of the colonies, the media they grew in and the biochemical tests that were carried out. The species of these microorganisms cannot be determined until the molecular characterizations of those microorganisms are done.

Selective media such as Salmonella Shigella Agar (SSA), MacConkey Agar (MCA) and Eosin Methylene Blue (EMB) were used. In identifying the microorganisms, morphologically in Salmonella-Shigella Agar after 24 hrs of incubation at 37°C, colonies that were colorless usually with black spots were observed. *Proteus* species and *Salmonella* species were suspected because they are the microorganisms that have such morphologies when grown in SSA. *Shigella* species were also observed. The colonies of the *Shigella* species were colorless and they had no black spots, unlike the *Salmonella* species. In identifying the microorganisms morphologically in MacConkey Agar after 24 hrs of incubation at 37°C, colonies that were pinkish in color were observed. *Escherichia* species were suspected because they ferment the lactose in the medium, making the colonies turn pinkish/reddish due to the acidic pH of the medium.

Faecal coliforms of colonies were observed when colonies from MacConkey Agar were subculture and grown in eosin methylene blue (EMB) medium. The medium is selective and it is only faecal coliforms that grow in this medium. Colonies were observed after 24 hrs of incubation at 37°C. These faecal coliforms are pathogenic thus, the water may not be safe for drinking and fish rearing.

Table 1: Morphology of sample micro-organism colonies

Sample	Color of microorganisms	Shape of microorganisms	Elevation of microorganism	Optic	Surface
Pond 1	Creamy, pink	Rods, cocci	Raised, flat	Transparent	Smooth
Pond 2	Pink, blackish	Rods	Raised	Transparent, opaque	Smooth
Pond 3	Pink, creamy	Rods	Raised, convex	Transparent	Smooth
Pond 4	Pink	Rods	Flat	Transparent	Smooth

Table 2: Biochemical test and identification of isolates from pond samples

Sample	Catalase	Oxidase	Grams staining	Glu	Lac	Suc	Cit	HS	Identified bacteria
Pond 1 NA	+	-	+	+	+	+	+	-	*Staphylococcus aureus*
Pond 1 MCA	+	-	+	+	+	+	+	-	*Staphylococcus aureus*
Pond 1SSA	+	-	-	+	-	-	-	-	*Shigella* spp.
Pond 2 NA	+	-	-	-	-	+	-	+	*Escherichia coli*
Pond 2 MCA	+	-	-	-	-	+	-	+	*Escherichia coli*
Pond 2 SSA	+	-	-	+	-	-	+	+	*Salmonella* spp.
Pond 3 NA	+	-	-	+	+	+	+	-	*Klebsiella pneumonia*
Pond 3 SSA	+	-	-	+	-	-	+	+	*Salmonella* spp.
Pond 3 MCA	+	-	-	-	-	+	-	+	*Escherichia coli*
Pond 4 NA	+	-	-	-	-	+	-	+	*Escherichia coli*
Pond 4 MCA	+	-	-	-	-	+	-	+	*Escherichia coli*
Pond 4 SSA	+	-	-	+	-	-	-	+	*Salmonella* spp.

Table 3: Values of the physico-chemical parameters of concrete fish pond in Uli

Physicochemical parameters	Pond 1	Pond 2	Pond 3	Pond 4	Nigerian Industrial Standard
Temperature (°C)	32.50±0.10[a]	31.00±1.00[a]	32.00±1.00[a]	32.00±1.00[a]	40
pH	5.00±0.01[b]	4.82±0.01[d]	5.06±0.01[a]	5.17±0.01[c]	6.5-8.5
Conductivity (μs cm^{-1})	641.67±1.53[b]	891.00±2.65[a]	99.00±1.00[d]	570.18±1.53[c]	1000 max
TS (mg L^{-1})	640.00±1.00[c]	1200.00±0.58[a]	800.00±1.00[b]	586.07±23.17[d]	
TDS (mg L^{-1})	420.00±1.00[b]	570.00±1.00[a]	110.00±1.00[d]	230.00±1.00[c]	500
TSS (mg L^{-1})	220.00±1.00[d]	630.00±1.00[a]	690.00±1.00[a]	270.00±1.00[c]	25
Total acidity (mg $CaCO_3$/L)	102.00±1.00[b]	206.00±1.00[a]	76.00±1.00[c]	50.05±1.00[d]	
Total alkalinity (mg $CaCO_3$/L)	140.00±1.00[c]	640.00±1.00[a]	450.00±1.00[b]	16.00±1.00[d]	150
DO (mg L^{-1})	5.50±0.10[a]	1.87±0.06[d]	3.60±0.10[c]	4.33±0.06[b]	≥2.0
Salinity (mg L^{-1})	8.13±0.01[c]	1.08.40±0.10[a]	3.60±0.01[d]	11.74±0.01[b]	250
Total hardness (mg $CaCO_3$/L)	238.67±0.58[b]	222.00±1.00[c]	44.00±1.00[d]	284.00±1.00[a]	100
NO_3^- (mg L^{-1})	BDL	BDL	BDL	BDL	
CL^- (mg L^{-1})	112.72±0.01	112.93±0.01	13.50±0.01	111.30±0.01	
SO_4^- (mg L^{-1})	BDL	BDL	BDL	BDL	
PO_4^- (mg L^{-1})	4.50±0.01	60.00±1.00	BDL	0.50±0.0.01	

Values of Mean±SD of triplicate determinations values in the same row bearing different superscript letters are statistically significant $p<0.05$, BDL: Below detectable limit, TS: Total solid, TDS: Total dissolved solid, TSS: Total suspended solid and DO: Dissolved oxygen

Table 4: Values of anions of four concrete fish ponds in Uli

Anions	Pond 1	Pond 2	Pond 3	Pond 4	Nigerian Industrial standard
NO_3^- (mg L^{-1})	BDL	BDL	BDL	BDL	10
CL^- (mg L^{-1})	112.72±0.01	112.93±0.01	13.50±0.01	111.3±0.01	250
SO_4^- (mg L^{-1})	BDL	BDL	BDL	BDL	250
PO_4^- (mg L^{-1})	4.50±0.01	60.00±1.00	BDL	0.50±0.01	2.0

Values of Mean±SD of triplicate determinations values in the same row bearing different superscript letters are statistically significant $p<0.05$ and BDL: Below detectable limit

Physico-chemical analysis: The pH obtained from the four different ponds in this study varies within the range of 4.82±0.01 to 5.17±0.01 with Pond 2 having the lowest value and Pond 4 having the highest value which also is acidic and in contrast to the acceptable pH value for pond aquaculture. The temperature value of the four different ponds studied ranged from 31.00±1.00 to 32.50±1.00°C which showed no significant variation in contrast to its electrical conductivity which varied significantly among the pond studied. The conductivity value of the ponds was within the range of 99.00±1.00 to 891.00±1.00 mS cm^{-1}, with Pond 2 having the highest conductivity value followed by Pond 1, 4 and 3, respectively as shown in Table 3.

The total solid (TS), total dissolved solid (TDS) and total suspended solid (TSS) varied significantly in each pond. Pond 2 had the highest value of TS, Pond 3, 1 and 4 followed, respectively in values of TS which ranged from 586.0±23.17 to 1200±0.58 mg L^{-1}. Pond 2 had 570.00±1.00 mg L^{-1} which was the highest value of TDS, followed by Pond 1 with a value of 420.00±1.00 mg L^{-1}, then Pond 4 with a value of 230.00±1.00 mg L^{-1} and finally Pond 3 with a values 110.00±1.00 mg L^{-1}. The TSS of the studied sample varied significantly from pond to pond with ranges from 220.00±1.00 mg L^{-1} observed in Pond 1, 690.00±1.00, 630.00±1.00 and 270.00±1.00 mg L^{-1} were observed on Pond 2, 3 and 4, respectively.

The total acidity of the studied samples varied significantly within the ranges of 50.05±1.00 to 206.00±1.00 mg $CaCO_3$/L with Pond 2 having the highest value, pond 1, 3 and 4 following, respectively. The total alkalinity of the four ponds studied had a very wide, significant variation in values within ponds having the highest value of 640.00±1.00 mg $CaCO_3$/L and pond 4 having the lowest value of 16.00±1.00 mg $CaCO_3$/L. The value of the dissolved oxygen varied in the four different ponds which ranges from 1.87±0.06 to 5.50±0.10 mg L^{-1}. The salinity was higher in Pond 2 with a value of 108.40±0.10 mg L^{-1}, followed by pond 4, 1 and 3, respectively as observed in Table 3. The total hardness of the four ponds varied significantly with the highest value in pond 4 followed by Pond 1, 2 and 3, respectively.

Anions analysis: The concentration of nitrate (NO_3^-) and sulphate in the four concrete ponds studied were below detectable limits and so were recorded as shown in Table 4. Pond 2 had the highest value of chloride ion which was 112.93±0.01 mg L^{-1} which did not vary significantly with Pond 1 which had the value of 112.72±0.01 mg L^{-1}. The potassium levels in Pond 2 were the highest with the value 60.00±1.00 mg L^{-1}, followed by pond 1 and 4 with the values 4.50±0.01 and 0.50±0.01 mg L^{-1}, respectively. In Pond 3, potassium concentration was below the detectable limit.

Heavy metals analysis: The concentration of some heavy metals analyzed in some of the different ponds was below detectable limits when analyzed with an atomic absorbance spectrophotometer. Iron (Fe) although below the recommendation: The value ranges from 0.01±0.00 to 0.02±0.00 as observed in Pond 4 and Pond 1, respectively. Furthermore, Pond 3 was below the detectable limit. Pond 1 showed the highest value for Zinc (Zn) with the value 0.45±0.01 and Pond 2 seconded with the value 0.10±0.00 while Pond 3 and 4 were below detectable limits.

The levels of Copper (Cu) were below detectable limits in the studied pond except pond 1 with a value of 0.20±0.00. The values of lead did not vary significantly in Pond 2 and 3 with a value of 0.01±0.00 in each pond, while Pond 1 and 4 were below detectable limits. Cadmium (Cd) was low in pond 1 with a value of 0.01±0.00 and below detectable limits in other ponds. Mercury (Hg) was below detectable limits in all ponds.

DISCUSSION

The pH plays a significant role in regulating the development of microorganisms. The pH measurement aids in figuring out whether the water is suitable for fish, plants and algae. According to Njoku *et al.*[25] and Kamal *et al.*[26], the pH measured in this study from four distinct ponds varied between 4.82±0.01 and 5.17±0.01, falling beyond the range of pH 7.0 to 10.0 needed for aquaculture and therefore, acidic. The temperature ranged between 31.00 and 32.50°C in the four distinct ponds that were under study, which was within the range that promotes fish productivity. According to Ntegwu and Edema[27], fish productivity is boosted at a temperature between 20 and 30°C. This report follows the best practices and was by the optimum temperature range as stated by Nigeria Industrial Standard.

The conductivity measurements from this investigation ranged from 99.0 to 891.0 S cm^{-1}. This was significantly greater than Olukunle and Oyewumi[28] findings, which ranged from 1.03±0.57 to 7.72±1.16 S cm^{-1} [29]. This limit was not breached in the ponds under study, nor was it a shortfall. The parameter is therefore appropriate for fish production. The outcome, however, conflicts with that of Ehiagbonare and Ogunrinde[24], who stated that the conductivity of fish pond water in Okada and its surroundings ranged from 0.012 to 0.017 S cm^{-1}.

The study's measurements of dissolved oxygen (DO) ranged from 1.81±0.06 to 5.50±0.10 mg L^{-1}. The results of this study were lower than those reported by Olukunle and Oyewumi[28], who recorded high values ranging from 41.67 to 62.77 mg L^{-1}. However, they were within the range of those reported by Davies and Ansa[17], who reported DO of 4.34 and 6.33 mg L^{-1} from the nearby industries to fish farms. For tropical fish, Saloom and Duncan[30] recommended a minimum DO of 5 mg L^{-1}. Except Pond 2, 1, 3 and 4 all displayed significant levels of dissolved oxygen, which could be attributed to the ponds' higher temperatures, higher microbial and organic loads and higher levels of metabolic activity[31].

The fish will exhibit signs of irritability, such as rubbing themselves, leaping and skimming across the surface of the pond, as nitrate is a skin irritant. An algal bloom is caused by high nitrate values, while nitrate deficiency increases the lipid content of algae, which in turn influences the aquatic ecology[32]. The nitrate concentration found in this research's findings was below detectable levels. The lack of eutrophication may be the cause of the low nitrate concentration. These results, however, contrasted with those of Ehiagbonare and Ogunrinde[24], who showed nitrate values ranging from 2.21 to 4.91 mg L^{-1}. According to Matsui *et al.*[33], a high nitrate concentration hinders blood cells from collecting oxygen from water, causing their blood to turn a dull brown color. For this reason, nitrate poisoning is also known as "brown blood disease".

The phosphate content in the ponds was found to be between 0.5±0.01 to 5.0±1.00 mg L^{-1}. The results of Ehiagbonare and Ogunrinde[24], who reported phosphate concentrations ranging from 1.40 to 4.51 mg L^{-1}, are in agreement with this conclusion. Matsui *et al.*[33] stated that a high concentration of phosphate may result in an algal bloom that kills fish in a pond.

The ponds' sulphate concentrations ranged from 0.5±0.01 to 6.0±1.00 as a consequence of this investigation. The findings of Ehiagbonare and Ogunrinde[24], who found a sulphate concentration of between 0.66 and 1.09 m/Ll, were consistent with the results of this investigation. Nevertheless, sulphate concentrations of 42.46 and 57.36 mg L^{-1} were found by Utang and Akpan[34]. The high value of sulphate may be caused by sulphate that leaches from soil fertilized with animal dung that got into the water body[24].

The pHs in these ponds were acidic indicating stress for the fish. The TSS is very high showing that there is a lot of contamination in the water. This indicated that the water is regularly changed, thereby causing the accumulation of suspended particles. The DO in Pond 2 is low and shows that a lot of biological activities that deplete oxygen are ongoing in the pond. These conditions indicate no steady source of good water for the culture of fish.

This study has shown the presence of *Salmonella* species, *Shigella* species and *Escherichia* species. These were identified from the morphology of the colonies, the media they grew in and the biochemical tests that were carried out. The species of these microorganisms cannot be determined until the molecular characterization of those microorganisms is done.

Selective media such as Salmonella Shigella Agar (SSA), MacConkey Agar (MCA) and Eosin Methylene Blue (EMB) were used. In identifying the microorganisms, morphologically in Salmonella Shigella agar after 24 hrs of incubation at 37°C, colonies that were colourless usually with black spots were observed. *Proteus* species and *Salmonella* species were suspected because they are microorganisms that have such morphologies when grown in SSA. *Shigella* species were also observed, the colonies of *Shigella* species were colourless and they had no black spots, unlike the *Salmonella* species. In identifying the microorganisms morphologically in MacConkey Agar after 24 hrs of incubation at 37°C, colonies that were pinkish in colour were observed. *Escherichia* species were suspected because they ferment the lactose in the medium, making the colonies turn pinkish/reddish due to the acidic pH of the medium. Faecal coliforms colonies were observed when colonies from MacConkey Agar were subcultured and grown in eosin methylene blue (EMB) medium. This medium is selective and it is only faecal coliforms that grew in this medium. Colonies were observed after 24 hrs of incubation at 37°C. This faecal coliforms are pathogenic thus, the water may not be safe for drinking and consequently fish.

The presence of these bacteria which are normally found in faecal deposits shows that it is not safe for people to consume fish from these ponds. Well-cooked fish may be low in these bacteria species but to be on the safe side no one should consume the fish from these ponds.

A good source of water is crucial to avoid disease outbreaks in this community. Drilling a good borehole can be of help to provide a good and steady source of water for the fish farmers in this town. This will go a long way to eliminate these bacteria and provide water with good quality parameters for fish culture. The water quality parameters must always be monitored to make sure they are okay for fish culture.

CONCLUSION

The results above have shown that the pH of the water is acidic indicating that there are contaminants in the water thereby reducing the pH and with high conductivity. The low pH also encourages the presence and multiplication of bacteria. This condition is not ideal for fish farming and it shows that the source of water for fish culture in this area is contaminated. A source of clean water not loaded with contaminants is needed and to consume fish from these ponds, the fish must be properly washed and cooked.

SIGNIFICANCE STATEMENT

This study has been able to establish that most of the fish ponds in Uli are not well managed in terms of water quality and there are a lot of contaminants present in the pond which indicates that eating the fish from this pond will lead to disease outbreaks or ill health. The study also indicates that necessary effort must be made to provide a good water source for the local fish farmers in Uli.

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