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RESEARCH ARTICLE

MICROBIOLOGICAL AND PHYSICOCHEMICAL CHARACTERISTICS OF FISH POND WATER IN UGHELLI, DELTA STATE, NIGERIA

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ABSTRACT

Microbiological and physicochemical characteristics of fish pond water obtained from various locations in Ughelli-South Local Government Area of Delta State were carried out. The mean total aerobic plate count ranged from 5.09 $\pm$ 0.03 to 5.16 $\pm$0.01Log$_{10}$cfu/ml. The mean fungal ranged from 4.65 ± 0.02 to 4.72 ± 0.02 Log10cfu/mL. The mean coliform count ranged from 3.63 $\pm$ 0.01 to 3.71 $\pm$0.01Log10cfu/mL. There was no count for *Escherichia coli, Salmonella-Shigella* and *Vibrio cholera*. Bacteria genera isolated included *Micrococcus* species (29.8%); *Bacillus* species (20.8%); *Proteus* species (16.4%); *Pseudomonas* species (17.1%) and *Klebsiella* species (15.6%). Fungal genera were *Penicillum* species (55.8%) and *Aspergillus* species (44.1%). The mean values ranges of the physicochemical parameters were pH, 5.85 to 6.26; temperature, 30.02 to 30.10^{0}C; conductivity, 30.35 to 51.70µS/cm; total dissolved solid, 16.08.to 27.41mg/L; turbidity, 6.80 to 5.71mg/L; biological oxygen demand, 4.85 to 5.30mg/L; chemical oxygen demand, 7.04 to 7.63mgL; salinity, 4.99 to 7.80ppt; alkalinity, 2.22 to 3.78mg/L; phosphate, 1.88 to 1.02mg/L; sulphate, 1.50 to 3.02mg/L; nitrite, <0.01 mg/L; nitrate, 0.17 to 0.55mg/L and ammonia, 0.54 to 1.00mg/L. This shows that the ponds contain microorganisms and chemicals that can cause disease to the fish and eventually to man when consumed.

INTRODUCTION

A fish pond is an artificial lake (reservoir, pond) intended for fish breeding. In the medieval times in Europe, it was typical for many monasteries and castles (small, partly self sufficient communities) to have its fish pond. Fish ponds are still common in Canada, Europe, especially in the Czech Republic, where common carp may be kept and in East Asia where koi may be kept. Such ponds are also being promoted in developing countries. They not only provide a source of income for small farmers from the sale of fish but can also meet irrigation needs and water for livestock (FAO, 2009).

A pond is a quiet body of water that is too small for wave action and too shallow for major temperature differences from top to bottom. Fish ponds are unnatural aquatic ecosystems that farmers must manage in order to produce fish crops. Physical characteristics of a fish pond directly impact pond water quality and indirectly the whole ecosystem and therefore, production management potential for the farmers. The influences are common to all pond technology systems and are not unique to 80:20 pond cultures. Once a pond is constructed, the physical characteristics are essentially permanent. Farmers are left without practical means of correcting site, design and construction flaws and must rely on excess management technique to compensate for them. However, it is often difficult to classify the differences between a pond and a lake, since the two terms are artificial and the ecosystems really exist on a continuum. Generally, in a pond, the temperature changes with the air temperature and is relatively uniform. Lakes are similar to ponds, but because they are larger, temperature laying and stratification takes place in summer and winter and theses layers turnover in spring and fall. Ponds gain their energy from the sun (dela Cruz, 1983; Bullock and Sneiszko, 1999).

This region abounds in many artificial pond and temporary water bodies of large and small size. Fish pond typically fall into two types namely excavated pond built on a relatively flat land with water basin formed by surrounding dikes and contour pond built in a shallow valley with a basin formed with a single dike(dam) across the valley. Contour ponds are difficult to manage and often impractical for raising fish, principally because of excessive depth, irregular shoreline, uneven bottom and lack of water supply control. They cannot be standardized relative to design and engineering features because they

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must take the shapes, areas, depths and bottom configurations dictated by characteristics of the valley. In contrast, excavated ponds may be standardized with duplicated design and engineering features, including identical shapes, areas, depths and bottom configurations. Consequently, excavated ponds are much more easily and predictably controlled and allow for development and application of more scientific and standardized farm management systems (dela Cruz, 1983).

The rapid expansion of agriculture during the past years may be attributed to a number of factors primarily related to the provision of food for human consumption. If aquaculture is viewed as a substitution for fishing, the fish can be reared to marketable size on farms to offset any lack of supply from the sea. At present, however, it seems unlikely that fish farming will replace deficiencies in annual catch rates from the sea because of the enormous differences in volume of production (Purdom, 1996).

Presently pond fishery is being practiced in the country in large scale for better augmentation of fish product. The relationship between the fish, their biotic and abiotic environments is not an isolated phenomenon; changes of one may reflect and affect the other (Bullock and Sneiszko, 1999). Pond water or water used in intensive fish rearing contains many microorganisms which include different bacteria (some known to be pathogenic to fish or human), plankton population (Alexander, 1997). The majority of the bacteria are heterotrophic, although autolithotrophic and phototrophic are also widely distributed (Fletcher, 2000). Fishes are also dependent on water and atmosphere temperature, pH, dissolved oxygen, alkalinity, salinity, BOD (biological oxygen and demand) and some salts for growth and development (Bullock and Sneiszko, 1999). Studies have been conducted on physiochemical and bacterial qualities of aquatic ecosystem ranging from fresh water-lakes, ponds, rivers and ground water, to brackish and estuarine conditions and the pelagic water and benthic-zones of the oceans. The aim of this research is to determine the microbiological and physiochemical characteristics of the fish pond water.

MATERIALS AND METHODS

Study Area

Ughelli is the headquarters of Ughelli Local Government Area of Delta State. It is situated in the South – South geopolitical zone of Nigeria. All the fish ponds water sampled were located in the area. They are also constructed to standard.

Collection of Fish Pond Water Samples

The samples were collected randomly from the pond for the microbial counts, the samples were collected in white plastic containers, which were previously sterilized with 70% alcohol and rinsed with distilled water. At the ponds, the containers were rinsed twice with the pond water before being used to collect the samples. Samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD) were collected with clean brown bottles. The samples for the other physiochemical parameters were collected with 500ml sterile plastic containers.

Chemical Reagents

Chemical reagents used in the study were of analytical grade and were products of Hach Company, Colorado, USA; BDH Chemicals, Pooles, England and Sigma Chemical Company, St. Louis Missouri, USA. The microbiological media used were products of Oxoid and Difco Laboratories England. They were nutrient agar used for the estimation of total heterotrophic aerobic bacteria, purification and for stock culture; Sabouraud dextrose agar used for the isolation of fungi, *Salmonella-Shigella* agar for the isolation of *Salmonella* and *Shigella*, thiosulphate bile salt agar for the isolation of *Vibrio cholerae,* eosin methylene blue agar for the isolation of *Escherichia coli* and MacConkey agar for coliform counts.

Physicochemical Parameters

A number of physicochemical parameters of the pond water samples were determined. They included temperature, dissolved oxygen (DO), pH, conductivity, total dissolved solids (TDS), salinity, total suspended solids (TSS), turbidity, alkalinity and others were nitrite, nitrate, ammonia, phosphate, sulphate, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The pH was measured in-situ using Hach pH meter (Model EC1O); temperature, conductivity, salinity and total dissolved solids were measured in-situ using Hach conductivity meter (Model CO150). The dissolved oxygen was also measured in-situ using Hach DO meter (Model DO175). Sulphate was determined using Barium chloride (Turbidimetric) method. Nitrate, nitrite were determined using Cadmium reduction and diazotization, NED rapid liquid methods respectively. Alkalinity, ammonia and phosphate were measured following potentiometric titration, Nessler reaction and Ascorbic acid methods respectively. Chemical oxygen demand and biochemical oxygen demand were determined using Walkley and Black dichromate reflux and Azide modification methods respectively. All analyses were in accordance with the *Standard Methods for the Examination of Water and Wastewater* (2005).

Enumeration of Total Aerobic Bacteria and Fungi

Samples of the pond water were serially diluted in ten folds. Total viable heterotrophic aerobic plate counts were determined by plating in duplicate, using pour plate technique. Molten nutrient agar, Sabouraud, dextrose agar, *Salmonella- Shigella* agar, thiosulphate bile citrate salt agar, MacConkey agar and eosin methylene blue agar at 45^0C were poured into the Petri dishes containing 1mL of the appropriate dilution for the isolation of the total heterotrophic bacteria, fungi, *Salmonella Shigella*, *Vibrio cholerae*, coliforms and *Escherichia coli* respectively. They were swirled to mix and colony counts were taken after incubating the plates at room temperatures for 48 hours.

Characterization and Identification of Bacterial and Fungal Isolates

The bacterial isolates were characterized and identified after studying their Gram reaction as well as their cell micro morphology. Other tests performed were spore formation, motility, oxidase and catalase production, citrate utilization, oxidative/fermentative (OF) utilization of glucose, indole production, methyl red-Voges Proskaur reaction, urease and coagulase production, starch hydrolysis, production of H_2S from triple sugar iron (TSI) agar and sugar fermentation. The tests were performed according to the methods described by Cruickshank *et al*. (1980); Gerhardt *et al*. (1981) and Cheesborough, 2005. Microbial identification was performed using the keys provided in the *Bergey's Manual of Determinative Bacteriology* (1994). Fungal isolates were examined microscopically using the needle mouth technique. Their identification was performed according to the scheme of Barnett and Hunter (1972), and Larone (1986).

RESULTS

The result of the microbiological and physiochemical characteristics of the pond water samples are shown in Tables 1-3.

Table 1 shows the mean count of microorganisms isolated from the fish pond water samples. The total aerobic plate mean count ranged from 5.09 $\pm$ 0.23 to 5.16 $\pm$ 0.02Log$_{10}$cfu/mL. The F.O. Adugbo farm has the highest count of 5.16 $\pm$ 0.02 Log$_{10}$cfu/mL while the Oginigbo farm had the least count 5.09 $\pm$ 0.23Log$_{10}$cfu/L. The ANOVA, P >.0.05 showed that there was no significant difference in the mean count among the locations. The Coliform count ranged from 3.61 $\pm$ 0.02 to 3.71 $\pm$ 0.01 Log$_{10}$cfu/mL.The Oginigbo farm had the highest of count 3.71 $\pm$ 0.01Log$_{10}$cfu/mL and the Eyara farm had the least of 3.61 $\pm$ 0.02Log10cfu/L. The ANOVA, P > 0.05 showed that there was no significant difference in the mean counts among the locations. There were no *Escherichia coli*, *Vibrio cholera* as well as *Salmonella-Shigella* counts. The fungal count ranged from 4.65 $\pm$ 0.02 to 4.72 $\pm$ 0.01cfu/mL. The Emadaja farm had the highest count of 4.72 $\pm$ 0.01cfu/mL while F.O. Adigbo and Otu Jeremi farms had the lowest counts of 4.65 $\pm$ 0.02 Log10cfu/L.The ANOVA, P > 0.05 showed that there was significant difference in their coliform mean count from the locations.

Table 2 shows the microorganisms isolated and their percentage occurrence. The isolated microorganisms were *Micrococcus* species (29.8%); *Bacillus* species (20.8%); *Proteus* species (16.4%); *Pseudomonas* species (17.1%); *Klebsiella* species (15.6%); *Penicillum* species (55.8%) and *Aspergillus* species (44.1%).

The mean values of the physiochemical parameters are shown in Table 3. The pH mean value ranged from 5.83 to 6.26. The Emadaja fish pond had the highest value of 6.26 while the Oginigbo had the least value of 5.83. The ANOVA, P > 0.05 showed that there was no significant difference in their mean values. The mean values for conductivity, temperature and total dissolved solids were 30.35 to 51.70 µS/cm; 30.02 to 30.10^{0}C and 16.08 to 27.41mg/L respectively. The ANOVA, P < 0.05 showed that there was significant difference in the mean values for conductivity and total dissolved solids among the locations while the ANOVA, P > 0.05 showed that there was no significant difference in the mean values for temperature in all the locations. The mean values for turbidity and total suspended solids ranged from 6.80 to 15.68 mg/L and 8.12 to 19.00 mg/L respectively. The ANOVA, P > 0.05 showed that there was no significant difference in the mean values for the two parameters among the locations. The mean values for DO, BOD, COD, salinity and alkalinity ranged from 4.08 to 5.17 mg/L, 4.85 to 5.30 mg/L; 7.04 to 7.63 mg/L; 4.99 to 7.49 mg/L and 2,22 to 3.78 mg/L respectively. The ANOVA, P > 0.05 showed that there was no significant difference in the mean values for these parameters among the locations. The mean values for phosphate, sulphate, nitrite, nitrate and ammonia ranged from 1.02 to 1.88 mg/L, 1.50 to 3.02 mg/L, <0.01mg/l; 0.17 to 0.55 mg/L and 0.57 to 1.00 mg/L respectively. The ANOVA, P > 0.05 showed there was no significant difference in the mean values for the parameters among the locations.

DISCUSSION

The result of the microbiological characteristics showed that the total aerobic plate count and fungal counts were high and varied with location. This result may be due to the water temperature which was within optimum for bacterial growth and could also be attributed to the organic matter load in pond water resulting from the diet used in feeding the fish (Axelrod and Schultz, 1996). Gram negative bacteria were dominant in the genera of the bacteria isolated from the pond water. The microorganisms isolated were *Pseudomonas* species, *Klebsiella* species, *Proteus* species, *Bacillus* species, *Micrococcus* species, *Aspergillus* species and *Penicillum* species. This was in line with the work of Daboor (2008) who reported similar organisms in a related study carried out. The coliforms isolated were an indication of the contamination of the pond water with faecal materials, which may result in the presence of pathogenic organisms. Coliforms pose a threat to the health of the fishes and the consumers and are the potential problem in the pond effluents management. The faecal materials may be excreted into the ponds by the fish or through runoff (Kay *et al*., 2008). The presence of pathogenic microorganisms can lead to the transmission of water borne diseases. However, the non isolation of *Esherichia coli*, *Salmonella, Shigella* and *Vibrio cholera* was an indication that the pond water as well as the fish was free from such pathogens. But the isolation of *Bacillus* and *Aspergillus* spp is a concern. The pond water should be properly handled and treated to avoid the spread of diseases such as aspergillosis, anthrax, food poisoning and gastroenteritis (Frazier and Westhoff, 2004; Eze *et al*., 2006; Piet, 2009).

Temperature is a factor of great importance for aquatic ecosystem, as it affects the organisms as well the chemical and physical characteristics of water (Declince, 1993).The optimum conditions for increased fish productivity were found to be at temperature of 20 - 30^{o}C (Ntengwe and Mojisola, 2008).The temperature obtained from the study was within the limit that will support fish productivity. The temperature of the pond normally follows that of its surrounding depending on the size of the pond. Temperature changes in the pond can be attributed to direct sunlight during the day which can cause it to rise and heat loss in the night that leads to its drop. Biologic activities have been observed to double for each 10^0 rise in

Table 1. Mean Counts of Microorganisms isolated from the Fish Pond Water Samples.

		Log_{10}cfu/ml				
Location	TAPC	CC	ECC	FC	SSC	VCC
F.OAdugbo Farm	5.16+0.01	3.63+0.01	0	4.65+0.02	0	0
Emadaja	5.12+0.01	3.65+0.01	0	4.72+0.01	0	0
Eyare	5.14+0.03	3.61+0.02	0	4.71+0.02	0	0
Ogunigbo	5.09+0.03	3.67+0.01	0	4.69+0.02	0	0
Out-jeremi	5.14+0.02	3.63+0.01	0	4.65+0.02	0	0

KEY: TAPC= Total aerobic plate count; CC= Coliform count; ECC= *Escherichia coli* count; FC= Fungal count; SSC= *Salmonella-Shigella* count; VCC = *Vibrio cholera* count

Table 2. Microorganisms isolated from the Fish Pond Water Samples and their Percentage Occurrence.

Isolates	FCF	EJF	EYF	OGF	OJF	TNI	% occurrence
Bacreria							
Micrococcus species	11(27.5%)	14(35%)	15(37.5%)	0(0%)	0(0%)	40	30.5
Bacillus species	5(20.0%)	3(12.0%)	0(0%)	6(24.0%)	11(44.0%)	25	10.1
Proteus species	4(18.2%)	3(13.6%)	0(0%)	6(27.3%)	9(40.9%)	22	16.8
Klebsiella species	6(28.6%)	4(19.0%)	2(9.5%)	5(23.8%)	4(19.0%)	21	16.0
Pseudomonas species	5(21.7%)	3(12.0%)	0(0%)	6(26.1%)	9(39.1%)	23	17.6
Total	31	27	19	23	33	131	100
Fungi							
Penicillium species	4(21.1%)	0(0%)	7(36.8%)	5(26.3%)	3(15.8%)	19	55.9
Aspergillus species	3(20%)	4(26.7%)	0(0%)	7(46.7%)	1(6.7%)	15	44.1
Total	7	4	7	12	4	34	100

Legend: FCF=F.C. Adugbo farm; EYF= Eyara farm, OGF= Oginibo farm; OJF= Otu Jeremi Farms; TNI= Total number of Isolates.

Table 3. Mean Values of the Physiochemical Parameters of the Fish Pond Water samples

Parameters	FCF	EJF	EYF	OGF	OJF
pH	6.16	6.26	6.03	5.85	5.94
Conductivity(µS/cm)	30.35	41.98	51.70	39.23	37.30
Temperature(^{0}C)	30.05	30.1	30/07	30.02	30.07
Total dissolved solids(mg/L)	16.08	22.24.	27.41	20.79	22.31
Turbidity(mg/L)	14.17	6.80	6.86	15.68	12.61
Total suspended solids(mg/L)	16.87	8.73	8.12	19.00	15.50
Dissolved oxygen (mg/L)	5.26	5.71	5.64	4.08	5.32
BOD(mg/L)	5.30	4.85	5.17	5.23	5.24
COD(mg/L)	7.63	7.04	7..12	7.55	7.63
Salinity (mg/L)	4.99	7.08	7.49	7.44	6.13
Alkalinity (mg/L)	2.28	3.78	3.12	2.46	2.22
Phosphate(mg/L)	1.02	1.10	1.88	1.60	1.09
Sulphate(mg/L)	1.64	3.02	2.29	2.34	1.50
Nitrite(mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate(mg/L)	0.32	0.21	0.48	0.55	0/17
Ammonia(mg/L)	0.60	0.54	0.94	1.00	0.57

KEY: FEF: F.O. Adugbo farm, EJF-Emadaja farm, EYF-Eyara farm, OGF-Oginigbo farm, OJF: Otu-jeremi farm

temperature while the toxicity of ammonia increases and dissolved oxygen decreases with a rise in temperature (Norm, 1996).

A pH measurement will help to determine if the water is a proper place to put a fish although most fish can tolerate a pH as low as 5.0. The pH values obtained from the various pond water samples were within the optimum for the survival of the fish. Ntengwe and Mojisola (2008) observed that the pH appropriate for increased fish productivity is 6 – 9. Norm (1996) reported that rapid changes can cause extreme stress to the fish similar to shock in humans. Increase in pH might be caused by lime leaching out of concrete on the walls of the pond and to a lesser degree by concentration due to bacterial action that release acidic compounds. It has also been observed that established ponds will normally maintain the values if sludge and decaying organic materials are routinely removed from the pond by mechanical filters and biological converter. Monitoring the pH by recording weekly readings can provide an excellent indication of any developing problem. The pH values do change every 24 hours depending on the temperature, quality of plants (algae) and the size of the pond. If the pH gets out of control, high or low, aeration in the pond should be increased and daily water change be conducted to bring it back into range. Only under emergency should chemical means be used to adjust the pH in a pond because attempting to lower the pH chemically can be particularly hazardous to the operator, the biological converter and the fish (Norm, 1996; Richard, 1992).

Alkalinity of water is related to the actual number of base components and can be thought of as the intensity of the pH. If the alkalinity is low, it indicates that even a small amount of acid can cause a large change in the pH. Ntengwe and Mojisola (2008) reported that the alkalinity optimum for increased fish productivity is 80 – 200mg/L. The value obtained from the study fell short of this report and should therefore be adjusted for maximum productivity. Alkalinity is also related to the amount of dissolved calcium magnesium and other compounds in the water and as such tends to be higher in harder water. Lime leaching out of concrete on the walls of the ponds is a primary source of alkaline but it is also slowly increased by evaporation which concentrates the surface compounds. Alkalinity is naturally decreased over time through bacterial action, which produces acidic compounds that combine and reduce it. It is normally prevented by routine water change (Norm, 1996).

The normal concentration of ammonia in pond water should be zero. The result obtained from the study is in contrast because the values showed the presence of ammonia in the pond water. Studies have shown that when ammonia is dissolved in water, it is partially ionized depending upon the pH and temperature. The ionized form is ammonium, which is not toxic to fish. It was also reported that as the pH drops and temperature increases, the ionization of ammonia increases thus decreasing the toxicity (Durborow *et al*., 1997). It has been shown that ammonia tends to block oxygen transfer from the gills to the blood and can cause both immediate and long term gill damage. The bacteria of the genus *Nitrosomonas* has been shown to be capable of removing ammonia in the pond by producing nitrite as an end product. It is treated chemically with formaldehyde but if the bioconverter is healthy, there is no need for the chemical agent (Durborow *et al*., 1997; Richard, 1992).

Nitrite should not be detected in a pond with a properly functioning bioconverter. The presence of nitrite is caused by the autotrophic bacteria, which combines oxygen and ammonia in the bioconverter and on the walls of the pond. Nitrite is termed invisible killer as it is deadly to even the smallest fish at a concentration as low as 0.25ppm. The values of nitrite from the study were far less than the above concentration and therefore should not constitute any problem in the ponds. It has been observed that nitrite damages the nervous system, liver, spleen and healthy bioconverter. The presence of nitrite in the medium can be controlled by the action of *Nitrobacter* which combines it with oxygen and converts it to relatively benign nitrate (Norm, 1996).

Nitrate is produced by autotrophic *Nitrobacter* combining oxygen with nitrite in the bioconverter and to the walls of the pond. Whereas ammonia and nitrite are toxic to fish, nitrate is essentially harmless. The level of nitrate in the pond water should be controlled to avoid causing eutrophication (Manahan, 2001). The presence of nitrate could be from the fish feed and surface water runoff. Nitrate is the end result of nitrification and is very important to plant. Nitrate is naturally controlled through routine water change and consumption by plant algae (Norm, 1996).

Phosphates are the main nutrient for algae. The phosphate level must not exceed 0.03mg/L. Even the smallest increase can trigger off an excessive growth of algae leading to eutrophication. However the phosphate levels from the study exceeded this limit and should be controlled to avoid eutrophication of the ponds (Richard, 1992; Eze and Okpokwasili, 2010). This high level of phosphate obtained may be introduced into the pond through fish feed or when the pond is filled with water that contains phosphate or through surface water runoff. This could also be from the building materials used in the construction of the pond that can also release minerals containing phosphate into the pond water. Algae have been observed to store phosphate in their organs and when they die, they release the previously absorbed phosphate into the water which can trigger off the growth of new algae It is virtually impossible to remove phosphate naturally from pond water. Phosphate and therefore algae are the main problems in artificial ponds (Durborow *et al*., 1997).

Naturally, natural waters are saturated with dissolved oxygen in equilibrium with air. The concentration at these saturation values decreases as the temperature of the water rises. Therefore as the metabolic rate of fish also increases with temperature, water has to be pumped through the gills at a faster rate to supply the fish with the oxygen which it requires. Ntengwe and Mojisola (2008) reported that the optimum dissolved oxygen for fish productivity was found to be at adequate DO level of greater than 4mg/L. The result obtained from the work was within this optimum. However the DO content of the water can be reduced by other natural factors especially the respiration of aquatic plants. It has been reported that reducing the dissolved oxygen (DO) in the water raises the respiratory rate of fish and thus increases the rate at which toxic chemicals can be taken up by the gills. But as the DO levels fall the body metabolism will become affected by increasing suffocation and very low levels will cause death. However minor fluctuations in the DO content in the water are a natural occurrence and so it is not surprising that fish have developed adaptive mechanisms to cope with these changes. When the DO of the water begins to fall, the fish increase the rate at which water is passed over the gill by increasing the rate and the depth of breathing (Richard, 1992).

Salinity is among the most important factors and exerts various effects on the vitality of microorganisms. The differences in the salinity are attributed to the increase in the evaporation rate (Mohammed, 2005). The total dissolved solids and total suspended solids are very useful parameters describing the chemical constituents of the water and can be considered as a general of edaphic relations that contribute to productivity within the water body (Goher, 2002). The presence of these parameters may be as result of the fish feed and runoff. The electrical conductivity increased with the increase in total dissolved solids and water temperature. An increase in any of these parameters may be as a result of an increase in the temperature leading to increased evaporation (Abdel-Satar, 2001).

The biological oxygen demand (BOD) and chemical oxygen demand (COD) are also important parameters in water habitat and also in fish pond. High values of BOD imply high demand for oxygen to support life processes. The BOD fluctuation observed may be attributed to additional organic matter introduced into the pond as a result of runoff and soil erosion caused by rainfall and from fish feed (Odokuma and Okpokwasili, 1996). The study had revealed that fish ponds should be properly managed so that consumers of fish will not be exposed to infectious diseases and chemicals that may affect the body systems.

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