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Comparative Study of Water Quality Parameters of Two Fish Farm Estate in Ikorodu, Lagos State, Southwest Nigeria

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Abstract

The water quality of two fish farms were assessed through physico-chemical parameters, trace metals and bacteriological analysis of the waste water. Samples were collected from the two fish farms (Fish Farm Estate, Odongunyan and Erikorodo Fish Farm Estate) both in Ikorodu, Lagos State, Southwest Nigeria. These two farms were carefully selected for the study as fish farming has been practiced extensively within the areas for many years. Two waste water samples from the fish farms were collected and taken to Lagos State Environmental Protection Agency (LASEPA) for the laboratory analysis of the water samples using standard procedures and the result obtained was compared with the Lagos State Environmental Protection Agency (LASEPA) permissible standards to know the condition of the waste water from the farms discharged into the environment. Physical Parameters analyzed in both samples (A & B) include Turbidity, Appearance, Colour, Conductivity, Temperature, Total Dissolved Solids, Total Suspended Solids and Total Solids. Chemical Parameters analyzed include Total Acidity, Total Alkalinity, Chloride, Nitrate, Phosphate, Sulphate, Phenol, Dissolved Oxygen, Chemical Oxygen Demand and Biological Oxygen Demand. Trace metal Parameters analyzed in samples A and B include Calcium, Magnesium, Zinc, Copper, Iron, Chromium, Sodium, Cobalt, Manganese, Lead, Cadmium, Potassium, Nickel, Silver and Mercury. Bacteriological analyses carried out on the samples include Total Plate Count, Presence of Coliform (MCA) and Confirmatory Feacal Coliform Test. Results obtained showed that both samples A and B have different levels of contaminant when compared with

the Lagos State Environmental Protection Agency (LASEPA) permissible standards for aquacultural waste water quality. Sample A however contains high microbial loads and presence of coliform when compared with LASEPA standards while sample B has contaminants of suspended particles as well as coliforms although not as much as sample A Based on the analyzed results, it was however recommended that waste waters from aquacultural farms be treated properly before being discharged into the environment.

***Keywords**: Bacteriological, Water Quality, Trace Metals, Physico-Chemical*

Introduction

The increasing demand for animal protein by man, coupled with the reduction in supply from livestock and poultry, has shifted attention to fishery to meet human needs. Studies have shown that production of protein through fishery is cheaper, less laborious and the protein is of comparatively high quality. Fishes are responsible for about 55% of the protein intake sources of Nigeria citizens. (Adekoya, 2001)

Good water quality is very essential for fish growth and survival and this water quality is dependent on various physical. chemical and biological factors that directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983). All living organisms have their limits of tolerance of water quality in which they perform optimally and a sharp drop or an increase within these limits has adverse effects on their body functions (Davenport, 1993: Kieran, 2010). Physical factors that are important in domestic fish farming include, shape and size of the pond, type of substrate, temperature, turbidity and transparency etc. (Philips, 2006), Pond shape is a major factor that determines growth rate and health of fish (Imsland *et al*., 2006). Temperature on the other hand, influences the rate of metabolism such as growth rate, egg formation and maturation, food consumption and digestion etc. (Jonassen *et al*., 1999).

Water Quality Management

According to Boyd (1995), water quality management is considered to be one of the most important aspects of pond aquaculture but less attention has been given to the management of pond bottom soil quality. The condition of pond's bottoms and the exchange of substances between soil and water can strongly influence water quality.

Fish depends on water to carry out their bodily functions such as breathing, feeding and growth, excreting wastes, maintenance of salt balance in their body,

and reproduction (Bronmark and Hansson, 2005). Water quality focuses on the various aspects of the physico-chemical parameters of water by which state of a water body can easily be observed. It is the first most important limiting factor in fish culture and it is normally governed by a number of parameters including color, odor, temperature, pH, DO, BOD, TDS, transparency, acidity, alkalinity and hardness (Boyd, 1990). Each of these parameters has a standard value for fish culture (James, 2000). A guiding principle of fish culture is that water quality and hence efficient production are a direct consequence of good water chemistry (Swann, 1993). Therefore, the maintenance of good water quality is essential for healthy fish culture. The majority of fish culture throughout the world is conducted in ponds. Pond habitats can easily be manipulated by controlling the water characteristics for an optimum environment, yielding high level fish production (Swann, 1993).

Anita Bhatnagar and Pooja Devi (2013), explained some important water quality parameters as presented below

Temperature

This **is** said to be the degree of hotness or coldness in the body of a living organism either in water or on land (Lucinda and Martin, 1999). As fish is a cold blooded animal, its body temperature changes according to that of environment and this affects its metabolism, physiology and ultimately affects production. Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and so increase in oxygen demand. It further cause decreased solubility of oxygen and also increased level of ammonia in water.

Delince (1992) noted that 30-350C is tolerable to fish, Bhatnagar *et al*. (2004) also suggested the levels of temperature at 28-320C is good for tropical major carps; <120C is lethal but good for cold water species; 25-300C is ideal for *Penaeous monodon* culture; < 200C is sub lethal for growth and survival for fishes

Turbidity

This is the ability of water to transmit the light that restricts light penetration and limit photosynthesis and is the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the decomposition of organic matter.

Boyd and Lichtkoppler (1979) mentioned that the clay turbidity in water to 30 cm or less may prevent development of plankton blooms, 30 to 60 cm and as below 30 cm is generally adequate for good fish production, When values are above 60 cm, as light penetrates to greater depths encourage underwater macrophyte growth, and so there is less plankton to serve as food for fish. According to Bhatnagar *et al*. (2004) turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture

system and < 12 cm causes stress. Santhosh and Singh (2007) mentioned that transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture.

Water Colour

National Agricultural Extension and Research (1996) states pale colour, light greenish or greenish waters suitable for fish culture Bhatnagar *et al*. (2004) explained that dark brown colour is lethal for fish/shrimp culture, light green colour is good for fish culture, dark green colour is not ideal for fish/shrimp culture and clear water is unproductive for fish culture. Delince (1992) stated that the abundance of phytoplankton and zooplankton is responsible for the determination of colour of an aquatic body and green, bluish green/ brown greenish colour of water indicates good plankton population hence, good for fish health.

Dissolved Oxygen (DO)

Solis, (1988) stated that dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of aquatic organisms. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones, due to low solubility of oxygen in water and solubility decreases with factors like increase in temperature; increase in salinity; low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. Bhatnagar and Garg, (2000) said that Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly.

Banerjea (1967) mentioned that DO between 3.0-5.0 ppm in ponds is unproductive and for average or good production it should be above 5.0 ppm. According to Bhatnagar and Singh (2010) DO level >5ppm is essential to support good fish production. Bhatnagar *et al*. (2004) also suggested that 1-3 ppm has sublethal effect on growth and feed utilization; 0.3-0.8 ppm is lethal to fishes and >14 ppm is lethal to fish fry, and gas bubble disease may occur. DO less than 1 brings about the Death of Fish, Less than 5 -Fish survive but grow slowly and will be sluggish, 5 and above is Desirable. According to Santhosh and Singh (2007) Catfishes and other air breathing fishes can survive in low oxygen concentration of 4 mg L-1. Fish can die if exposed to less than 0.3 mg L-1 of DO for a long period of time, minimum concentration of 1.0 mg L-1 DO is essential to sustain fish for long period and 5.0 mg L-1 are adequate in fishponds. (Ekubo and Abowei, 2011)

Biochemical oxygen demand (BOD)

BOD is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage etc.

BOD range of 2 to 4 mg L-1 does not show pollution while levels beyond 5 mg L-1 are indicative of serious pollution (Clerk, 1986). According to Bhatnagar *et al*. (2004) the BOD level between 3.0-6.0 ppm is optimum for normal activities of fishes; 6.0-12.0 ppm is sublethal to fishes and >12.0 ppm can usually cause fish kill due to suffocation. Santhosh and Singh (2007) recommended optimum BOD level for aquaculture should be less than 10 mg L-1 but the water with BOD less than 10-15 mg L-1 can be considered for fish culture. According to Ekubo and Abowei (2011) aquatic system with BOD levels between 1.0 and 2.0 mg L-1 -considered clean; 3.0 mg L-1 fairly clean; 5.0 mg L-1 doubtful and 10.0 mg L-1 definitely bad and polluted.

Carbon-dioxide (CO2)

CO2 when dissolved in water it forms carbonic acid which decrease the pH of any system, especially insufficiently buffered systems, and this pH drop can be harmful for aquatic organisms.

According to Boyd and Lichtkoppler (1979) fish avoid free CO2 levels as low as 5 mg L-1 but most species can survive in waters containing up to 60 mg L-1 carbon dioxide, provided DO concentrations are high.

According to Ekubo and Abowei (2011) tropical fishes can tolerate CO2 levels over 100 mg L-1 but the ideal level of CO2 in fishponds is less than 10 mg L-1. Bhatnagar *et al*. (2004) suggested 5-8 ppm is essential for photosynthetic activity; 12-15 ppm is sublethal to fishes and 50-60 ppm is lethal to fishes. Santhosh and Singh, (2007) mentioned that the free carbon dioxide in water supporting good fish population should be less than 5 mg L-1

pH

The pH of waters is greatly influenced by the levels of carbon dioxide which is an acidic gas (Boyd, 1979).

The average blood pH of of fish is 7.4, a little deviation from this value, generally between 7.0 to 8.5 is more optimum and conducive to fish life. pH between 7 to 8.5 is ideal for biological productivity, stress sets in when water pH ranging from 4.0 to 6.5 and 9.0 to 11.0 and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011). According to Santhosh and Singh (2007) the suitable pH range for fish culture is between 6.7 and 9.5 and lideal pH level is between 7.5 and 8.5 and above and below this is stressful to the fishes. Ideally, an aquaculture pond should have a pH between 6.5 and 9 (Wurts and Durborow, 1992: Bhatnagar *et al*., 2004).

Alkalinity

Alkalinity is a measure of the total concentration of bases in pond water including carbonates, bicarbonates, hydroxides, phosphates and borates, dissolved calcium, magnesium, and other compounds in the water.

Moyle (1946) mentioned the range of total alkalinity as 0.0 - 20.0 ppm for low production, 20.0 - 40.0 ppm in low to medium, 40.0 - 90.0 ppm in medium to high production and above 90.0 ppm- productive. Boyd and Lichtkoppler (1979) suggested that water with total alkalinities of 20 to 150 mg L-1 contain suitable quantities of carbon dioxide to permit plankton production for fish culture. According to Wurts and Durborow (1992) alkalinity between 75 to 200 mg L-1, but not less than 20 mg L-1 is ideal in an aquaculture pond. Total alkalinity values of at least 20 ppm for catfish production and for good pond productivity. Bhatnagar *et al*. (2004) suggested that <20ppm indicates poor status of waterbody, 20-50 ppm shows low to medium, 80-200 ppm is desirable for fish/prawn and >300 ppm is undesirable due to non- availability of CO2. (Swann, 1997)

Calcium

Fish absorb calcium either from the water or from the food they eat. Wurts and Durborow (1992) gave a recommended range for free calcium in culture waters to be 25 to 100 mg L-1 (63 to 250 mg L-1 CaCO3 hardness). Channel catfish can tolerate minimum level of mineral calcium in their feed but may grow slowly under such conditions. Water with free calcium concentrations as low as 10 mg L-1 if pH is above 6.5 can be tolerated by Rainbow trout, 40 to 100 mg L-1 range (100 to 250 mg L-1 as CaCO3 hardness) are desirable for striped bass, red drum or crawfish.

Chloride

Chlorine (Cl-) is a gas which is added in water as a disinfectant to control harmful bacteria and Chloride is the same element found in the form of a salt, both have dramatically different chemical properties. Chloride is a common component of most waters and is useful to fish in maintaining their osmotic balance**.**

Stone and Thomforde (2004) mentioned that the desirable range of chlorides for commercial catfish production is above 60 mg L-1 and acceptable range is 10 times the nitrite concentration. Chloride (in the form of salt) is required at a minimum concentration of 60 mg L-1 and a ratio of chloride to nitrite of 10:1 reduces nitrite poisoning as catfish are susceptible to “brown blood” disease (caused by excess nitrite in the water). It becomes a matter of concern if chloride levels become high as above 100 mg L-1 in the waters because even in very small concentrations, it burns the edges of the gills with long term after effects

The table below shows the acceptable and desirable levels of some water quality parameters for fish production

Table 1: Suggested water-quality criteria for pond water fishery for getting high yield. (Anita Bhatnagar and Pooja Devi, 2013).

No	Parameter	Acceptable range	Desirable range	Stress
1.	Temperature (0C)	15-35	20-30	<12, >35
2.	Turbidity (cm)		30-80	<12,>80
3.	Water colour	Pale to light green	Light green to light brown	Clear water, Dark green &Brown
4.	Dissolved oxygen (mg L-1)	3-5	5	<5, >8
5.	BOD (mg L-1)	3-6	1-2	>10
6.	CO2 (mg L-1)	0-10	<5, 5-8	>12
7.	pH	7-9.5	6.5-9	<4, >11
8.	Alkalinity (mg L-1)	50-200	25-100	<20, >300
9.	Hardness (mg L-1)	>20	75-150	<20,>300
10.	Calcium (mg L-1)	4-160	25-100	<10, >250
11.	Ammonia (mg L-1)	0-0.05	0- <0.025	>0.3
12.	Nitrite (mg L-1)	0.02-2	<0.02	>0.2
13.	Nitrate (mg L-1)	0-100	0.1-4.5	>100, <0.01
14.	Phosphorus (mg L-1)	0.03-2	0.01-3	>3
15.	H2S (mg L-1)	0-0.02	0.002	Any detectable level
16.	Primary productivity (C L-1 D-1)	1-15	1.6-9.14	<1.6, >20.3
17.	Plankton (No. L-1)	2000-6000	3000-4500	<3000, >7000

Bacteriology

Bacteriological monitoring is based on the detection of coliform bacteria and the specific indicator of human faecal contamination, Escherichia coli (Idakwo, P.Y. *et al*., 2004). The term "indicator organisms" refers to micro-organisms whose presence in water shows that the water is polluted (Pelczer, M. J. *et al*., 1993). This kind of pollution means that the opportunity exists for the various pathogenic organisms, which periodically occur in intestinal tract, to enter the water, such water is described as non-potable water, and it is not safe for drinking. The use of intestinal organisms as indicators of faecal contamination is a universally acceptable process for monitoring and assessing the microbiological safety of water supply before distribution.

Coliform bacteria are a group of intestinal bacteria used as indicators to determine if treated water is acceptable for human consumption. Coliforms will not likely cause illnesses. However, the presence of coliforms in drinking indicates the presence of disease-causing organisms (Nwachukwu, C. I. *et al*., 2006). The Coliform includes the

members of the family Enterobacteriaceae, e.g. Escherichia coli, Enterobacter aerogenes, Salmonella and Klebsiella.

MATERIALS AND METHODS

Description of the study area

This study was carried out in Ikorodu, Lagos State. Pond water samples were collected from two fish farms namely, Fish Farm Estate Odongunyan and Erikorodo Fish Farm Estate. This study area was chosen for this study as aquaculture has been developed extensively in this area for the last few years.

Table 2: Study Area Location

Study site	Longitude	Latitude
Fish Farm Estate Odongunyan Sample A	3.519928^0E	6.659904^0N
Erikorodo Fish Farm Estate Sample B	3.5439615^0E	6.6381419^0N

Samples Collection

Pond water sample from Fish Farm Estate Odongunyan was labelled sample A, while Pond water from Erikorodo Fish Farm was labeled sample B and collected into a 5-litre white keg.

Samples A and B were collected from the fish pond into 5-litre white kegs, The 5-litre white keg was closed with its cover before it was deepened into the pond so as to prevent air from entering into it. The cover was then opened so as to be filled with water to the brim. The kegs were then covered inside the pond water before it was taken out.

The water samples collected was then taken to Lagos State Environmental Protection Agency LASEPA, located in Alausa, Ikeja for analysis.

Analysis of physical and chemical parameters

Physico-chemical parameters of the pond were measured according to APHA, 1999

Colour

The colour of the samples were determined visually and recorded.

Temperature (^oC)

water temperatures were taken by dipping the mercury-in-glass thermometer into the water sample. The thermometer was allowed to remain in the water for about 3-6mins

before taking the readings. The values were recorded accordingly for each station sampled throughout the period of sampling.

pH (Hydrogen Ion Concentration)

The principal chemical system controlling pH in natural waters is the carbonate system. The Hanna's instrument was used to determine the pH by dipping the probe into 1 litre of water sample and reading off the values from the meter.

Total suspended solids

Total suspended solids was also determined using the spectrophotometer but on a wavelength of 810nm. BOD (mgl-1) was determined by first measuring the Dissolved Oxygen of the water samples on the first day and then aerating the sample in a BOD bottle. The aeration was carried out for 5 days at 20°C in an incubator. Distilled water (used as water for dilution and as a blank) was aerated for five days too using a clean supply of compressed air, then the Dissolved oxygen,

Turbidity

Turbidity was analysed using a spectrophotometer (HACH model DR/2010), using distilled water as a blank and read at a wavelength 860 nm.

Conductivity ($mScm^{-1}$)

The conductivity of the water was determined by using the refractometer. The left side of the refractometer measures the conductivity. Drops of water were placed on the refractometer and the corresponding values on the instrument were recorded.

Acidity

Acidity was determined titrimetrically by adding two drops of Phenol naphthalene to 50 ml of sample which is then titrated against 0.02 M sodium hydroxide (NaOH), pink colour appears because of the indicator in the sample. Sulphate, SO4 2- (mgl-1) was analysed using the colorimetric method where equal volumes (25 ml) of sample and Barium chloride were measured into a Nessler tube. The turbidity of the resulting solution, was measured at a wavelength of 420 nm in a spectrophotometer after allowing it to stand for 15 min. Nitrate, NO3 - (mgl-1)

Alkalinity

Alkalinity was measured by titrating 50 ml of water sample to which two drops of methyl orange indicator has been added, against 0.02N HCl

Total Dissolved Solids (TDS) (mg/l)

The total dissolved solid (TDS) was determined by using the Cole Parmer TDS meter (wide range). The meter was calibrated using calibration standards which were

obtained from commercially prepared solution. The probe was immersed into the water sample and the reading noted. Whatman GF/C grade glass fibre disc was used in the determination of the total dissolved solids. The disc was washed with 20ml of distilled water. A clean evaporating dish was heated at 105^0C in an oven for hour. The heated evaporating dish was reweighed and the difference in weight represented the TDS.

Turbidity (NTU)

Turbidity was measured with the use of the turbidimeter, or nephelometer, which determines turbidity by the light scattered at an angle of 90^0 from the incident beam a 90E detection angle is considered to be the least sensitive to variabtions in particle size. Bephelometry has been adopted by Standard Methods as the preferred means for measuring turbidity because of the method's sensitivity, precision, and applicability over wide range of particle size and concentration. The nephelometric method is calibrated using suspensions of formalin polymer. The preferred expression of turbidity is NTU.

Chemical dissolved oxygen

Chemical dissolved oxygen (COD) was analyzed by open condensation and digestion by titration (Dinesh *et al.,* 2017).

Nitrates (mg/l)

The determination of nitrate content was carried out using the method outline in APHA (1995). 1ml of freshly prepared 0.5% sodium salicylate was mixed with 20ml of the samples. The solution was then evaporated on a water bath and allowed to cool. 2ml of sulphuric acid was added. 25ml of water was used to wash the solution into a calorimeter cylinder or cuvette and 7ml of alkali reagent was added. After 10 minutes reaction time, the solution was made up to the 50ml mark with distilled water. Finally a yellow colour emerged and was matched with prepared standards while the absorbance was read from a spectrophotometer at the wavelength of 500nm.

Phosphates (mg/l)

The analysis of the phosphate content in the samples collected was carried out using the Vanadomolybdate phosphoric acid colorimetric method. 10ml of Vandatemolybdate reagent was added to 35ml of samples and diluted to 50ml with distilled water. Ten minutes reaction time was allowed after which another sample containing 35ml of distilled water was prepared, Vandatemolybdate reagents, the absorbance of the water sample and the blank was measured at a wavelength of 470nm.

The absorbance value of the sample was converted into equivalent phosphate as parts per million (ppm) from the standard calibration curve.

Dissolved Oxygen (mg/l)

Dissolved oxygen was determined chemically by using the Winkler's method. Water sample to be analyzed was collected using 25ml glass stopper bottles. 2ml of Manganese sulphate solution ($MnSO_4$) was added using pipette. The stopper was replaced and the components mixed. 2ml of tetraoxosulphate (VI) acid was added to dissolve the precipitate formed and the bottle was shaken gently. Then 100ml of the resulting solution was transferred into a conical flask and titrated against 0.025N Sodium Thiosulphate Solution using 2ml starch solution as an indicator. A strong blue disappearance marked the end point of the reaction. The total amount of sodium thiosulphate (in ml) used then substituted into the function below to obtain the dissolved oxygen.

DO = K.200 Volume of thiosuphate used / Volume of sample titrated

Where K = constant to correct for added reagents: 2ml $MnSO_4$, 2ml alkaline iodide and 2ml tetraoxosulphate VI acid.

$$K = \frac{\text{Volume of bottle used}}{\text{Volume of bottle – volume of reagents added}}$$

Oil and grease

- The conical flask was labeled.
- It was washed thoroughly with liquid soap and water.
- It was rinsed with deionised water.
- A dry conical flask was placed on the industrial oven
- The dried conical flask was placed in the Desiccator to cool in order to avoid atmospheric moisture settling into the flask.
- The cooled empty conical flask was weighed on the weighing balance (Initial weight).
- Measuring cylinder was used to measure 100ml of the sample into the flask.
- The conical flask was into the Fume cupboard.
- 2 – 3 drops of HNO_3 was added into the sample in the conical flask and stirred.
- 100ml of Diethyl Ethe was poured into the sample in the conical flask and stirred
- The mixture was poured into the Separating Funnel mounted on the Retort stand
- The separating funnel was unmount and shake/swirl then remount on the retort stand.
- 2 - 3 layers are observed in the separating funnel;

- ✓ The top layer - Diethyl Ether
- ✓ The middle layer - Oil
- ✓ The last/bottom layer - Water sample

- The water sample, which is at the bottom layer was decant into a beaker, leaving very little to avoid decanting the oil and grease content.
- The remaining content/mixture was decant into the conical flask and place in the water bath for evaporation to occur, allowing total drying to take place.
- After drying, the flask was brought out and place in the desiccator to cool.
- The flask was weighed on the weighing balance to get the final weight.

Calculation = (Final Weight - Initial Weight) x 1000

Heavy/Trace Metals Analysis

The heavy metals investigated in this work were determined using AA 689 pie unican 2003 atomic absorption spectrophotometer (AAS). The analysis of heavy metals was carried out in sediments samples and water samples. The samples were analyzed for Silver (Ag), Copper (Cu), Cadmium (Cd), Chromium (Cr), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn). The samples were first made to undergo acid digestion. An aliquot of the filtrate was taken and the absorbance was determined at their characteristics wavelength using the AAS. More than one replicates into flame, furnace and vapour were determined for each sample and the result reported as mean values. The mean concentration in parts per million (ppm) for the metals in the samples were then determined.

Concentration of samples (ppm) = absorbance concentration/Absorbance of standard

Note: the calibration standard of each metal was used to standardize the solution.

RESULTS AND DISCUSSION

RESULTS

Table 3: The comparative study of physical parameters of samples A and B with Lagos State Environmental Protection Agency (LASEPA) standard

Physical Parameters	**Sample A**	**Sample B**	**LASEPA STANDARD**
Colour	357pt.co.APHA	83pt.co.APHA	250pt.co.APHA
Appearance	Cloudy with suspended particles	Clear with suspended particles	Clear
Temperature ^{0}c	29.4^{0}c	29.1^{0}c	35 - 40^{0}c
PH	6.26	6.76	5.5 – 9.0
Turbidity	5.5NTU	45.4NTU	NTU

Conductivity	287uS/cm	124uS/cm	uS/cm
Total suspended solids	134mg/l	8mg/l	100mg/l
Total dissolved solids	134mg/l	6mg/l	2100mg/l
Total solids	268mg/l	14mg/l	2200mg/l

Table 4: The comparative study of chemical parameters of samples A and B with Lagos State Protection Agency (LASEPA) standard

Chemical Parameters	**Sample A**	**Sample B**	**LASEPA STANDARD**
Total acidity	40mg/l	4mg/l	NS
Total alkalinity	300mg/l	150mg/l	200 mg/l
Chloride	35mg/l	35mg/l	250mg/l
Nitrate	35.3mg/l	7.4mg/l	10mg/l
Phosphate	4.74mg/l	1.10mg/l	5.0mg/l
Sulphate	22mg/l	5mg/l	30mg/l
Phenol	NA	NA	1.0mg/l
Chemical Parameters	**Sample A**	**Sample B**	**LASEPA STANDARD**
Oil and Grease	NA	NA	10.0mg/l
Dissolved Oxygen **(DO)**	0.24mg/l	5.56mg/l	Not less than 2mg/l
Chemical Oxygen Demand **(COD)**	857mg/l	119mg/l	200mg/l
Biological Oxygen Demand **(BOD)**	214.25mg/l	29.75mg/l	10mg/l

Table 3: The comparative study of trace metal parameters of samples A and B with Lagos State Protection Agency (LASEPA) standard

Trace Metal Parameter	**Sample A**	**Sample B**	**LASEPA STANDARD**
Calcium	0.2630mg/l	0.8874mg/l	200mg/l
Magnesium	NA	NA	5.0mg/l
Zinc	NA	NA	1.0mg/l
Copper	0.0000mg/l	0.0000mg/l	3.0mg/l
Iron	0.0338mg/l	0.017 mg/l	10.0mg/l
Chromium	0.0281mg/l	0.0000mg/l	0.01mg/l

Sodium	0.2588mg/l	0.4974mg/l	
Cobalt	NA	NA	
Manganese	0.0000mg/l	0.0000mg/l	5.0mg/l
Lead	0.0000mg/l	0.0066mg/l	0.001mg/l
Cadmium	0.0000mg/l	0.0000mg/l	2.0mg/l
Potassium	0.1950mg/l	0.0796mg/l	<20.00mg/l
Nickel	0.0070mg/l	0.0144mg/l	3.0mg/l
Silver	0.0000mg/l	0.0000mg/l	<0.10mg/l
Mercury	NA	NA	0.001mg/l

Where; NA= Not Analysed

Table 4: The comparative study of microbiology parameters of samples A and B with Lagos State Protection Agency (LASEPA) standard

Microbiology Parameter	**Sample A**	**Sample B**	**LASEPA STANDARD**
Total Plate Count	TNTC	50cfu/ml	350cfu/ml
Presence of Coliform **(MCA)**	+ve	+ve	Negative/Nil
Confirmatory Feacal Coliform Test	+ve	+ve	Negative/Nil

Where; TNTC = Too Numerous to Count

DISCUSSION

PHYSICAL PARAMETERS

The physical parameters of Sample A and Sample B was discussed and compared with the standard set by LASEPA.:

Results for colour of Sample A and sample B are 357pt.co.APHA and 83pt.co.APHA respectively, LASEPA standards for this parameter indicates 250pt.co.APHA. this shows that sample A is higher than the standard of LASEPA while Sample B is in line with the LASEPA standard.

The Appearance of Sample A showed that it is cloudy with suspended particles while Sample B indicates clear water with suspended particles. LASEPA standards indicate that water must be clear. This shows that Sample A does not conform to standards set by LASEPA, while Sample B is in line with the LASEPA standard but only differs with the suspended particles.

Temperature reading showed that Sample A and Sample B results (29.4^0C and 29.1^0C respectively), were below the LASEPA standards (40^0C.)

The PH in Sample A and Sample B were 6.25 and 6.76 respectively and this is in line with the standard of LASEPA with the PH ranging from 5.5 – 9.0. Boyd (1979) stated

that water is greatly influenced by cardon dioxide which is an acid gas. Ekubo and abowei (2011) also mention that the acceptable pH for fish culture should be 6.5-9.0. pH higher could reduce productivity.

The Turbidity for Sample A and Sample B were stated to be 5.5NTU and 45.4NTU respectively, LASEPA standard doesn't have a specific value for this parameter. However, Bhatnagar and Pooja Devi, (2013). mentioned that the desired turbidity for fish is 30-80cm and that less than 12cm is not good for production. This means that based on the result for turbidity, sample A indicates a contaminated water not fit for fish culture while sample B is still within range

The Conductivity for Sample A and Sample B were 287uS/cm and 124uS/cm respectively,

The Total Suspended Solid (TSS) content in Sample A and Sample B were 134mg/l and 8mg/l respectively, this analysis showed that Sample A is not in line with the standard of LASEPA due to high value of the TSS, while Sample B is.

The Total Dissolved Solid (TDS) content in Sample A and Sample B were 134mg/l and 6mg/l respectively, these results showed that Sample A and Sample B are in line with the standard of LASEPA although sample A is still the highest of the two

The Total Solid (TS) is said to be the addition of TDS and TSS the result from Sample A and Sample B were 284mg/l and 14mg/l respectively, The LASEPA standard for TS is said to be 2200mg/l so it can be said that Samples A and B are in line with the standard of LASEPA.

These water quality parameters are some of the major limiting factors in pond fish production (boyd,1990) and if well controlled can bring about optimum yield of fish during production (swann,1993)

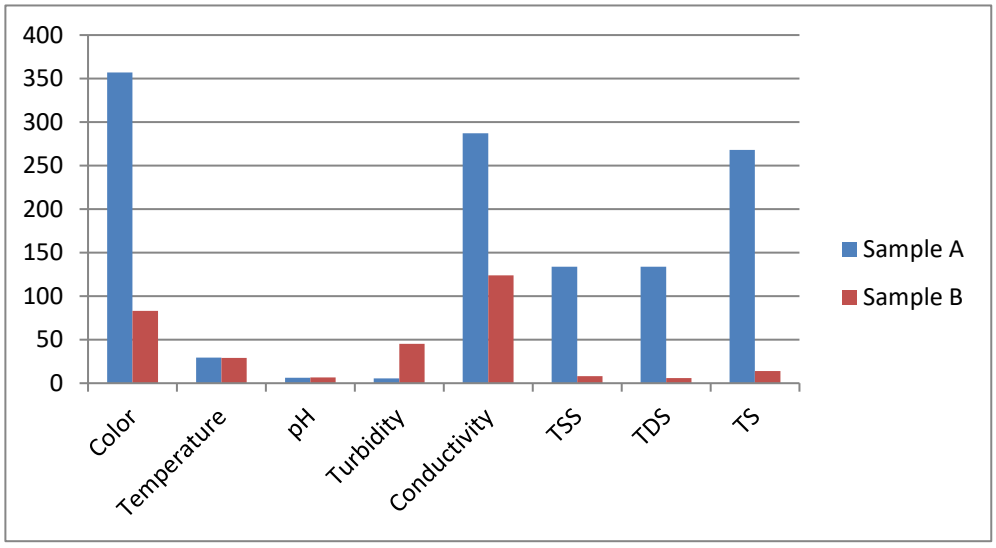

Fig 1: variation in physical water quality parameters in the samples collected

The figure above showed the variation in values of water parameter between sample A and B. sample A has high values of the physical water parameters when compared with sample B.

CHEMICAL PARAMETERS

James (2000) stated that physico-chemical parameters have standard values for fish culture. The Lagos State Protection Agency (LASEPA) standards (in table 2) serves as a standard for measuring all the chemical parameters in station A and B as presented below

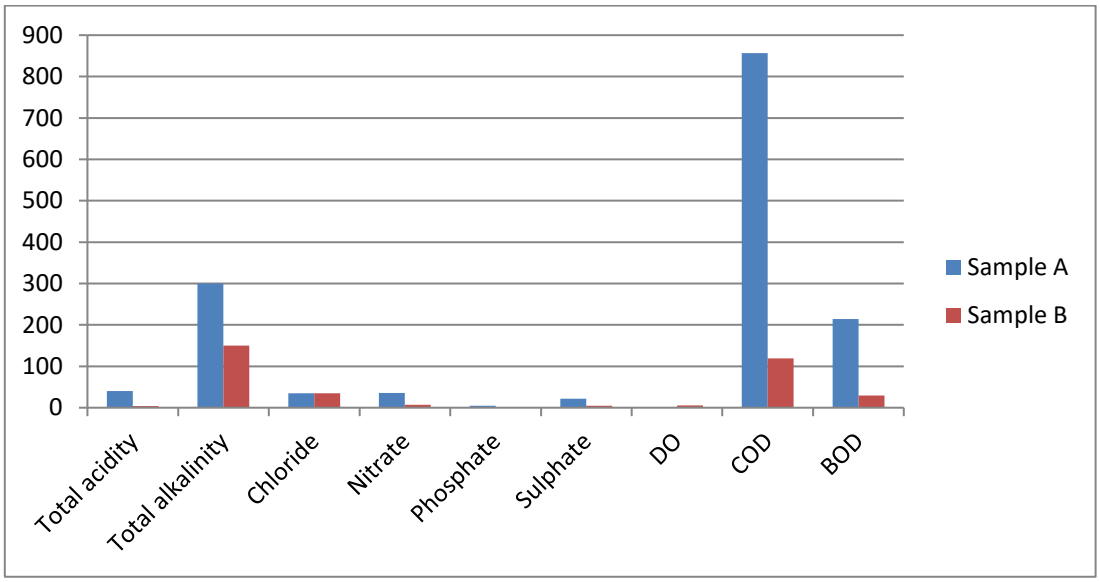

Fig 2. Graph of the variation in chemical water quality parameters in samples A and B

The chemical parameters of Sample A and Sample B was discussed and compared in line with the standard set by LASEPA.

The Total Acidity of Sample A and Sample B were 40mg/l and 4mg/l respectively and the Total Alkalinity of Sample A and Sample B were 300mg/l and 150mg/l respectively. Although, no standard was given by LASEPA but Anita Bhatnagar and Pooja Devi, (2013) mentioned that alkalinity of good aquacultural water should be within the range of 25- 100mg/l. this showed that values for alkalinity in both samples are high.

The Chloride content present in Sample A and Sample B were of the same value which is 35mg/l, and is in line with the LASEPA standard which is above 35mg/l (250mg/l). The Nitrate, Phosphate and Sulphate for Sample A were 35.3mg/l, 4.74mg/l and 22mg/l respectively, while for Sample B were 7.4mg/l, 1.10mg/l and 5mg/l

respectively. According to Anita Bhatnagar and Pooja Devi, (2013), levels of nitrate should be less than 0.02mg/l and phosphate levels should be within 0.01-3 mg/l. this means that levels of nitrates in both sample A and B is high and unacceptable in aquaculture. Phosphate levels in sample A is higher than recommended while in sample B, it is still within range.

The Phenol and Oil and Grease was not analyzed in both Sample A and Sample B. The LASEPA standard were 1.0mg/l and 10.0mg/l respectively.

Bhatnagar and Garg (2000) mentioned that oxygen depiction in water can lead to poor feeding of fish, starvation, reduced growth and mortality either directly or indirectly. The Dissolved Oxygen (DO) content in Sample A and Sample B were 0.24mg/l and 5.56mg/l respectively, LASEPA standard had it that it must not be less than 2mg/l therefore, Sample A is not in line with the LASEPA standard, while Sample B is.

Bhatnagar and Singh (2010) stated that dissolved oxygen levels of above 5mg/l is essential to support growth and feed utilization. Since dissolve oxygen is one of the most important chemical parameters in aquaculture, low dissolved oxygen as seen in sample A could cause adverse effect on productivity

The Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) content in Sample A are 857mg/l and 214.25mg/l respectively, while Sample B are 119mg/l and 29.75mg/l respectively, in which LASEPA standard had it to be 200mg/l and 50mg/l. So, Sample A is said to be high than the standard but Sample B is in line with the standard of LASEPA.

According to Bhatnagar et al (2004), high BOD levels can cause fish kill due to suffocation. BOD OF 2-4mg/l does not show polluted waters. Bhatnagar et al (2004) mention that 3-6mg/l is optimum for normal activity of fish.

TRACE METAL PARAMETERS

The Trace metal parameters of Sample A and Sample B was discussed and compared in line with the standard set by LASEPA.

Copper, Manganese, Lead, Cadmium, Silver were analyzed in Sample A and the content was stated to be 0.0000mg/l for all the metals, while in Sample B the content was stated to be 0.0000mg/l for all the stated metal except for Lead that is 0.0066mg/l. LASEPA standard had them to be 3.0mg/l, 5.0mg/l, 0.1mg/l, 2.0mg/l, <0.10mg/l respectively. So, Sample A and B are said to be in line with the LASEPA standard for trace metals.

Sodium content in Sample A and Sample B were 0.2588mg/l, 0.4974mg/l respectively. Calcium, Iron, Chromium, Potassium, Nickel content in Sample A were 0.2630mg/l, 0.0338mg/l, 0.0281mg/l, 0.1950mg/l, 0.0070mg/l respectively, the above metals content in Sample B were 0.8874mg/l, 0.0172mg/l, 0.0000mg/l, 0.0796mg/l, 0.0144mg/l respectively. LASEPA standard had them to be 200mg/l, 10.0mg/l,

0.1mg/l, 200.00mg/l, 3.0mg/l respectively. This showed that Samples A and B values are in line with the LASEPA standard.

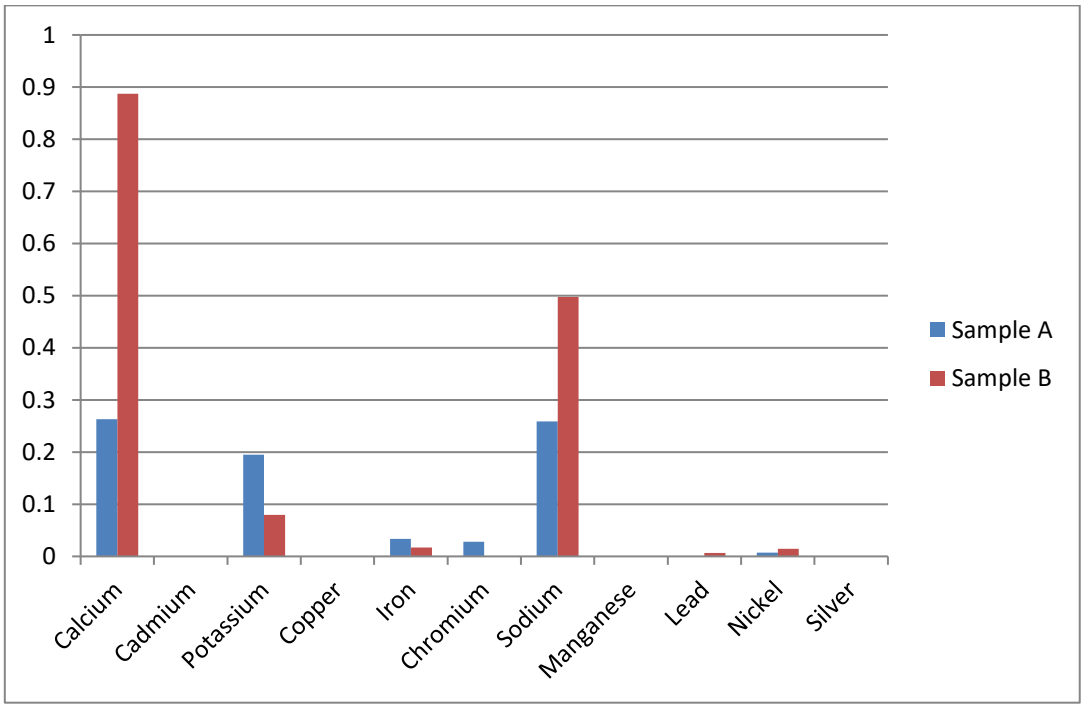

Fig 3. Variation in vales of trace metals in collected samples

MICROBIAL PARAMETERS

Table 4: The comparative study of microbiology parameters of samples A and B with Lagos State Protection Agency (LASEPA) standard

Microbiology Parameter	**Sample A**	**Sample B**	**LASEPA STANDARD**
Total Plate Count	TNTC	50cfu/ml	350cfu/ml
Presence of Coliform **(MCA)**	+ve	+ve	Negative/Nil
Confirmatory Feacal Coliform Test	+ve	+ve	Negative/Nil

Where; TNTC = Too Numerous to Count

The Microbiology parameters of Sample A and Sample B was discussed and compared in line with the standard set by LASEPA.

The Total Plate Count present in Sample A was Too Numerous To Count (TNTC) , which was not in line with the LASEPA standard, while for Sample B it was counted to be 50cfu/ml which was in line with the 350cfu/ml set by LASEPA as standard.

The Coliform present (MCA) is said to be present and positive in both Sample A and Sample B, which LASEPA standard stated that it is should be Nil/Negative. Both Samples A and B are not in line with the LASEPA standard.
According to Idakwo (2004) bacteriological monitoring is based on the knowledge of the sanitary condition of water supply which is based on the detection of coliform bacteria. This only means that the presence of coliform bacteria in sample A and B signifies contaminated waters
The Confirmatory Faecal Coliform Test is as well discovered to be present and positive in both Sample A and Sample B, which LASEPA standard states that it is meant to be Nil/Negative. Both Samples A and B are not in line with the LASEPA standard.

CONCLUSION

The condition of aquacultural waters speaks volume about the productivity and expected yield of any farm business. Considering all the presented results for physico-chemical parameters, trace metals and bacteriological analysis of the water samples collected, it is important to note that the two water samples (A and B) from odogunyan fish farm estate and Ikorodu farm estate are contaminated.
Sample A (from odogunyan fish farm estate) is highly polluted/contaminated since the various values of parameters measure are way above the recommended standards while sample B (from erikorodo farm estate) is fairly polluted considering some of the parameters (such as most of the trace metals and some physico-chemical parameters) are still within the prescribed standards.

RECOMMENDATIONS

Based on the above finding, it is recommended that waste water from the form should be treated properly before being discharged into the environment
Similarly, water supply to the fish pond should be clean and free of contamination. Sample of the fish pond water should be taken and examined in the laboratory for its Microbiological, Physiochemical and Trace metals Parameters before stocking. This will also give an insight to the possible presence of certain types of Microorganisms, Trace metal and unfavorably Physiochemical parameters, hence provide enabling environment for aquaculture purposes.

REFRENCES

Abowei J.F.N. (2010). Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro river, Niger delta, Nigeria, *advance journal of food science and technology*. **2(1)**: 16-21.

Adekoya B.B. (2001). *Strategic fish feed development for sustainable and cost effective farm fish production.* (NIOMR), Lagos 26-29 act 1999.

Ahmed, H. (2004). Soil Quality Analysis and Considerations in the selection of sites for sustainable Aquaculture in the South East Coast of Chittagong Specially Halishahar Area. M.Sc. Thesis (unpublished), Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong, Bangladesh, 80 pp.

American Public Health Association (A.P.H.A.) (1998). *Standard methods for the examination of water and wastewater*. Twentieth ed. A.P.H.A.,1015 Fifteenth Street, NW, Washington, DC. 20005-2605.

Anita Bhatnagar and Pooja Devi (2013). Water quality guidelines for the management of pond fish culture. *International Journal of Environmental Sciences* **Volume 3** No.6. ISSN 0976 – 4402

Avnimelech, Y. (1984). *Reactions in fish pond sediments as inferred from sediment cores data.* Publication No. 341, Technion Israel Institute of Technology, Soils and Fertilizers Research Center, Haifa, Israel, pp: 1-46.

Banerjea, S. M., (1967), Water quality and soil condition of fishponds in some states of India in relation to fish production, *Indian journal of fisheries*, **14**, pp 115-144.

Barman, U. K., Jana, S.N., Garg, S. K., Bhatnagar, A. and Arasu, A.R.T., (2005), Effect of inland water salinity on growth feed conversion efficiency and intestinal enzyme activity in growing grey mullet, *Mugil cephalus* (Lin.*): Field and laboratory studies, Aquaculture international*, **13(3),** pp 241-256.

Bhatnagar A and Singh G (2004). Culture fisheries in village ponds: a Multi-location study in Haryana, India. *Agriculture and Biology Journal of North America*, **1(5)**: 961-968.

Bhatnagar, A. and Garg, S.K., (2000), Causative factors of fish mortality in still water fish ponds under sub-tropical conditions, *Aquaculture,* **1(2)**, pp 91-96.

Bhatnagar, A. and Singh, G., (2010), Culture fisheries in village ponds: a multi-location study in Haryana, India. *Agriculture and Biology Journal of North America*, **1(5),** pp 961-968.

Bhatnagar, A., (2008), Productivity and fish biodiversity of selected ponds of Haryana, Project Report submitted to Department of fisheries Government of Haryana.

Bhatnagar, A., Jana, S.N., Garg, S.K. Patra, B.C., Singh, G. and Barman, U.K., (2004), *Water quality management in aquaculture, In: Course Manual of summerschool on development of sustainable aquaculture technology in fresh and saline waters,* CCS Haryana Agricultural, Hisar (India), pp 203- 210.

Bonde, G. J. (1977). *Bacterial indication of water pollution***.** In Droop, M. R. and Jannasch, H. W. (eds). Advances in Aquatic Microbiology. Academic Press, London, **Vol.1**. pp. 273-364.

Boyd C E (1998). *Water quality for pond aquaculture*. Research and Development eries,**43**:1-11.

Boyd, C. E. and Lichtkoppler, F. R. (1999), *Water Quality Management in Fish Ponds*. Research and Development Series No. 22, International Centre for Aquaculture (J.C.A.A) Experimental Station Auburn University, Alabama, pp 45-47.

Boyd, C. E., (1979), *Water Quality in Warmwater Fish Ponds*, Agriculture Experiment Station, Auburn, Alabama, pp 359.

Boyd, C.E and Lichtkoppler, F., (1979), *Water Quality Management in Fish Ponds*. Research and Development Series No. 22, International Centre for Aquaculture (J.C.A.A) Experimental Station Auburn University, Alabama, pp 45-47.

Boyd, C.E. (1995). *Bottom Soils, Sediment, and Pond Aquaculture.* Chapman and Hall, New York, New York.

Bronmark, C. and Hansson, L. A. (2005). *The biology of lakes and ponds*. Oxford University Press, Oxford. 285p.

Bronmark, C. and Hansson, L. A., (2005), *The biology of lakes and ponds*, Oxford University Press, Oxford, pp 285.

Clerk, R.B., (1986), *Marine Pollution*. Clarandon Press, Oxford, pp 256.

Cook, R.B., Kelly, C.A., Schindler, D. W. and Turner, M. A., (1986), *Mechanisma of hydrogen ion neutralization in an experimentally acidified lake*, Limnology and Oceanography, 31, pp 134-148.

Davenport, Y., (1993), *Responses of the Blennius pholis to fluctuating salinities,* Marine Ecology Progress Series, 1, pp 101 – 107.

Delince, G., (1992), *The ecology of the fish pond ecosystem*, Kluwer Acadmic Publisers London, pp 230.

Ekubo AA and Abowei JFN (2011). Review of some water quality management principles in culture fisheries. *Research Journal of Applied sciences, Engineering and Technology*,**3(2**), pp1342-1357.

European Inland Fisheries Advisory Commission (EIFAC) (1973*), Water Quality Criteria for European Freshwater Fish,* Report on Ammonia and Inland Fisheries, Water Resources., 7, pp1011-1022.

Foster, R. and Smith, M. (2013). Fish Anatomy and Physiology. LiveAquaria.com. Veterinary and Aquatic Services Department, pp. 1- 2. http://www.peteducation.com/article.cfm?c=16+2160&aid=583. Accessed on 8th March, 2013.

Fredrickson, J. K., Zachara, J. M., Balkwill, D. L., Kennedy, D., Li, S. W., Kostandarithes, H. M., Daly, M. J., Romine, M. F. and Brockman, F. J. (2004). Geomicrobiology of high level nuclear waste contaminated vadose sediments at the Hanford Site, Washington state. *Appl. Environ. Microbiol.* **70**:4230-4241.

Garg, S. K. and Bhatnagar, A., (1996). Effect of varying doses of organic and inorganic fertilizers on plankton production and fish biomass in brackish water ponds, *Aquaculture Research (The Netherlands)*, 27, pp 157-166.

Garg, S. K. and Bhatnagar, A., (1999), Effect of different doses of organic fertilizer (cowdung) on pond productivity and fish biomass in still water ponds. *Journal of Applied Ichthyology*, 15, pp 10-18.

Garg, S.K., Jana, S.N. and Bhatnagar, A., (2003), Effect of inland groundwater salinity on digestibility and other aspects of nutrition physiology in *Mugil cephalus* and *Chanos chanos* (Forsskal), In: Fish production using brackish water in arid ecosystem (eds. Garg, S.K. and Arasu, A.R.T.), Ankush Printers, Hisar, pp 53-59.

Gogoi, P and Sharma, D. (2013). Microbial Contamination of Community Pond water in Dibrugah District of Assaam. Curr. *World Environ*, 8(1)

Harwood, V. J., Butler, J, Parrish, D. And Wagner, V. (1999). Isolation of Feacal Coliform Bacteria from the Diamondback Terrapin (Malaclemys terrapin centrata). *Applied and Environmental Microbiology.* **65(2):** 865 – 867.

Holt, J. G,. Krieg, N. R, Senath, P. H. A, Stanley, J. T. and Williams, S. T. (1994). *Bergey's Manual of Determinative Bacteriology.* 9th Edition. Baltimore Md.,Willaims and Wilkins.

Idakwo, P.Y and Abu, G. O.(2004).Distribution and Statistical Analysis of Bacteria in Lake Alau in the Arid Northern Nigeria. *Journal Appli. Sci. Mgt*. **8(1):**5 – 9.

James, M. E. (2000). *Water Quality and Recalculating Aquaculture Systems*. Aquaculture Systems Technologies, LLC. New Orleans, LA. 16-17p, 28p.

Jonassen TM, Sland AK and Stefansson SO (1999) The interaction of temperature and size on growth of juvenile Atlantic Halibut. *Journal of fish Biology* **54**:556-572.

Kimdirim RC and Adeniji S (1993) Periodicity and succession of phytoplankton in upland and lowland impoundement in plateau state, Nigeria in relation to nutrient level and physical characteristics. *Journal of Aquatic science*, **5**:43-52.

Kiran BR (2010). Physico-chemical Characteristics of fish pond of Bhadra Project at Karnataka, *RASAYAN Journal*, **3(2),** pp 1342-1357.

Kiran, B. R., (2010), Physico-chemical characteristics of fish ponds of Bhadra project at Karnataka, RASĀYAN *Journal of Chemistry*, **3(4),** pp 671-676.

Larry ER (1995). Automated water quality monitoring and control in aquaculture. *World Aquaculture Journal*, **26(2):** 35-37.

Lewis WMRCH and Tetzlaff BL (1981). *Tank culture of striped bass.* Fisheries research laboratory, southern Illinois University Carbondale 115pp

Lucinda, C. and Martin, N., (1999), Oxford English Mini- Dictionary Oxford University Press Inc, New York, pp 200-535.

Mathias, J. A., Charles, A. T. and Baotong, H.(1994). *Integrated Fish Farming*. CRC Press, Boca Raton, pp. 140-143.

Moses BS (1983). *Introduction to Tropical Fisheries*, Ibadan University press, UNESCO/ICSU, pp: 102-105.

Moses, B.S., (1983), *Introduction to Tropical Fisheries,* Ibadan University Press, UNESCO/ICSU, Part, pp: 102-105.

Moyle, J.B., (1946), *Some indices of lake productivity*, Transactions of the American Fisheries Society, **76**, pp 322-334.

Mumtazuddin, M., Rahman, M. S. and Mostafa, G., (1982), Limnological studies of four selected rearing ponds at the aquaculture experiment station, Mymenshingh. *Bangladesh Journal of Fisheries Research*, 2-5 (1-2), pp 83-90.

Munsiri, P., Boyd, C.E. and Hajek, B.F. (1995). Physical and chemical characteristics of bottom soil profiles in ponds at Auburn, Alabama, and a proposed method for describing pond soil horizons. *Journal of the World Aquaculture Society*, **26:** 346-377.

Munsiri, P., Boyd, C.E., Teichert-Coddington, D. and Hajek, B.F. (1996). Texture and chemical composition of soils from shrimp ponds near Choluteca, Honduras. *Aquaculture International*, **4**: 157-168.

National Agricultural Extension and Research, (1996), *Water Quality Management in Fish Culture*, Extension Bulletin No. 98 Fisheries Series No 3 Published by Liaison Services Ahmadu Bello University, Zaria.

Nwachukwu, C. I. and Otokunefor, T. V. (2006). Bacteriolgical quality of drinking water supplies in the University of Port Harcourt, Nigeria. *Nig. J. Microbiol*. **20**: 1383-1388.

Ogbeibu, A. E. and Victor, R., (1995), Hydrological studies of water bodies in the okomu forest reserves (sanctuary) in Southern Nigeria, physico-chemical hydrology, *Tropical Freshwater Biology*, 4, pp 83-100.

Paul, A. K. (2010). *Wetland ecology*; Principles and Conservation Cambridge University Press, Cambridge. UK p.497

Pelczer, M. J., Chan, E. C. S. And Krieg, N. R.(1993*). Microbiology. 5th Edition*. New Delhi Tata McGraw Hill Inc. New York. Pp 663 – 664.

Rajiv, P., Hasna, A. S., Kamaraj, M. Rajeshwam, S and Balgi, R.(2012) Comparative Physicochemical and Microbial Analysis of Various Pond Waters in Coimbatore District, Tamil Nadu, India. *Annals of Biological Research*, **3 (7):**3533-3540.

Robinette, H. R., (1976), Effect of Selected Sublethal Levels of Ammonia on the Growth of Channel Catfish (*Ictalurus punctatus*), Progressive Fish Culturist, 38, pp 26-29.

Salle, A. J. (2002). *Fundamental Principles of Bacteriology*. 7th edn. Tata McGraw-Hill Publishing Company limited, New Delhi, India, 688 p.

Santhosh B and Singh NP (2007). *Guideline for water quality management for fish culture in Tripura*, Research Complex for NEH Region, Tripura Centre, PublicationNo.29

Sikoki, F.D. and J.V. Veen, (2004), *Aspects of Water Quality and the Potential for Fish Production of Shiroro Reservoir Nigeria*, Living System Sustainable development, 2, pp 7.

Solis, N.B., (1988), The Biology and Culture of *Penaeus Monodon*, Department Papers. SEAFDEC Aquaculture Department, Tigbouan, Boilo Philippines, pp 3-36.

Stone, N. M. and Thomforde H. K., (2004), *Understanding Your Fish Pond Water Analysis Report*. Cooperative Extension Program, University of Arkansas at Pine Bluff Aquaculture / Fisheries.

Stumn, W. and Morgan, J.J., (1981), An introduction imphasizing chemical equlibria in natural waters, *Aquatic chemistry*. 2ND Ed., John Wiley and Sons, New York, pp 780.

Swann LaDon. (1993). *Water Sources Used in Aquaculture*. Illinois-Indiana Sea Grant Program. AS-486. Purdue University, West Lafayette, IN. 4p.

Swann, L.D., (1997), *A Fish Farmer's Guide to Understanding Water Quality,* Aquaculture Extension Illinois, Purdue University, Indiana Sea Grant Program Fact Sheet AS-503.

Townsend, W.N. (1982). *An Introduction to the Scientific Study of the Soil*. Edward Amold (Publishers) Ltd. U.K, 209pp.

Uzoigwe, C. I. and Agwa, O. K.(2012). Microbiological quality of water collected from boreholes sited near refuse dumpsites in Port Harcourt, Nigeria. *African Journal Biotechnol*., **11(13):** 3135- 3139.

WHO (2003). *Guidelines for Drinking Water Quality* 3rd Edn. WHO, Geneva.

World Health Organization (1993). Guidelines for Drinking Water Quality, Volume I, II and III, World Health Organizations, Geneva.

Wrobel, (1983). *Instrumental Methods for Analysis of Soil and Plant Tissues*. (Ed. By L.M. Walsh). American Soil Institute, 120pp.

Wurts, W.A. and Durborow, R. M., (1992), *Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds* Southern Regional Aquaculture Center, SRAC Publication No. 464.

Zhang, Z. Y. and Tang, Y. J. (1989). *Pond Fish Culture in China*. Science Publishing House, China, pp. 45-47