FEEDING ECOLOGY AND NUTRITIONAL STATUS OF SOME FISH SPECIES FROM TUNGAN KAWO RESERVOIR, KONTAGORA, NIGER STATE, NIGERIA

BY

USMAN, Habiba

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DEPARTMENT OF ANIMAL BIOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA

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ABSTRACT

The study of the biology of three fish species; *Tilapia zillii, Clarias gariepinus and Synodontis clarias* with reference to their diet composition is an important aspect in fish biology. This research was aimed at evaluating the Feeding Ecology and nutritional status of selected fish species from Tungan Kawo Reservoir, Kontagora, from July 2018 February 2019. The Physicochemical parameters, stomach content analysis, proximate composition and amino acid profile were determined using standard methods. Four different sampling stations of human activities in the reservoir were selected for the study. Three fish species *(Synodontis clarias, Clarias gariepinus and Tilapia zillii)* were selected. The results from the physicochemical parameters showed that Water Temperature 27.00 - 32.40 ºC, alkalinity 19.25-29.50 mg/L, hardness 28.00 - 50.75 mg/l, phosphate 0.40 - 2.50 mg/L, nitrates 3.2-7.5 mg/L conductivity 81-125 µS/cm, dissolved oxygen 2.40 - 5.20 mg/L, biochemical oxygen demand 1.90 - 4.40 mg/L and total dissolved solid 117-198 ppm were within the limits specified by Nigerian Industrial Standard and World Health Organization, with the exception of pH 6.3 - 9.5 which exceeded the standards. This indicates the good health status of the reservoir for aquatic organisms. The results obtained from analysis of stomach content revealed varying food items. A total of 52 fishes were sampled for gut analysis out of which 12 had full stomach, 27 had ½ stomachs full, 8 had 3/4 stomach full, while 5 had empty stomach. The major food items of the three species were plants materials, insect's remains, algae, fish remains, detritus and sand grains. The total percentage of the food occurrence for *S. clarias* 36.0 %, *C. gariepinus* 41.4 % and *Tilapia zillii* 22.5 %. The results from *proximate* analysis showed that moisture content of *T. zilli* was 52.19±0.55 g/100 g, *C. gariepinus* 49.87±1.82 g/100 g, *S. Clarias* 45.94±2.56 g/100 g. Ash content of *T. zilli* 7.89±0.84 g/100 g, *C. gariepinus* 16.48±2.37 g/100 g, *S. clarias* 15.30±0.43 g/100 g. Protein content of *T. zillii* 19.37±0.13 g/100 g, *C. gariepinus* 18.83±0.56 g/100 g *and s. clarias* 19.54±0.56 g/100 g Fat content *of T. zilli* was 2.72±0.16 g/100 g, *C. gariepinus* 3.34±0.40 g/100 g, *S. clarias* 3.43±0.46 g/100 g. Fiber content *of T. zilli* was 3.98±0.06 g/100 g, *C. gariepinus* 3.73±0.60 g/100 g, *S. clarias* 4.79±0.36 g/100 g and carbohydrate *of T. zilli* 3.85±23.13 g/100 g, *C. gariepiunus* 7.75±1.39 g/100 g *and S. Clarias* 11.00±1.33 g/100 g. The *S. clarias, C. gariepinus* and *T. zillii* of fish analyzed for amino acid composition showed that Glutamic acid and Aspartic acid are the most concentrated amino acid present in the fish ranging between 13.0 to 14.20 g/100 g protein and 8.71 to 9.21 g/100 g protein respectively. The total essential amino acid composition was higher in *T. zillii* 47.15 % than the other species analyzed. Special attention is needed in monitoring human activities which largely contribute to the reduction of the nutritional qualities of fishes from Tungan Kawo reservoir.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The study of the biology of some fish species with preference to their diet composition is an important aspect in fish biology. Fish digestive system varies with their feeding habits which include; carnivorous, omnivorous, and herbivorous. Fish food varies from seasons to seasons because seasonal changes in temperature influence food consumption as well as the available food organisms, and from species to species. Fish diet has been found to be an important factor governing fish growth, condition factor, fecundity and migration patterns (Adeyemi *et al*., 2019). Feeding habits of fish provide essential information on bionomics of single species. The analysis of stomach contents in fish is a common method for investigating the diet of fish, and thus describing food chains and webs shared by different species. Such studies also reveal interactions among species (Kenneth *et al*., 2014). Accurate quantification of fish diets is an important aspect of fisheries management (Quinton *et al*., 2017). Extensive studies have been done on diet composition (Nutritional) and trophic ecology of the fish species from different water bodies especially reservoirs, lakes and lagoons. These include: diet and dietary habits of the fish *Schilbe mystus* (Siluriformes: Schilbeidae) in two artificial lakes in Southwestern Nigeria (Ayoade *et al*., 2018).

Lawson and Aguda (2010) worked on the diet composition of ten pounder, *E. lacerta* from Ologe lagoon. The dietary habit of fishes, based on stomach analyses, is widely used in fish ecology as an important method to investigate trophic relationships in aquatic communities. Food and feeding habit of fish are important biological factors for selecting a group of fish for culture in ponds to avoid competition for food among themselves and live in association and to utilize all the available food (Manon and

Hossain, 2011). It is virtually impossible to gather sufficient information of food and feeding habit of fish in their natural habitat without studying its gut contents. (Manon and Hossain, 2011).

Information concerning the chemical composition of freshwater fishes in general is valuable to nutritionists concerned with readily available sources of low-fat, high-protein foods such as most freshwater fishes (Mozaffarian *et al.*, 2003; Foran *et al.*, 2005) and to the food scientist who is interested in developing them into high-protein foods, while ensuring the finest quality flavor, color, odor, texture, and safety obtainable with maximum nutritive value (Elagba *et al*., 2010), in other to help consumers in choosing fish based on their nutrient values. In the present study, physico-chemical parameters, gut content analysis, proximate composition analysis and amino acids profile of some fish species namely *Clarias gariepinus, Synodontis clarias* and *Tilapia zillii* were examined. These species are commercially important and commonly available in Tungan Kawo reservoir Kontagora. Also, the selection of the fish species was based on a preliminary investigation on consumer preferences.

1.2 Statement of the Research Problem

Fish is a very important food stuff, especially in developing countries due to its high protein content and nutritional value of unsaturated fatty matter. The ecology and nutritional content is an issue of concern on capture fish species from Tungan Kawo Reservoir, Kontagora Local Government, Niger State as their feeding composition and nutritional quality are not well known. The three fish species supply from the wild is declining on a daily basis.

1.3 Justification for the Study

According to Oladipo and Bankole (2013) there is a need for comprehensive information on the level of nutrient content in fishes mostly found on the dining table of the less privileged across the third world nations of Africa and Asia. In Africa alone, over 60% of infants below the age of five die annually due to Protein- Energy Malnutrition (Bene and Heck, 2005).

All fishes require energy for growth, reproduction and migration, which must be obtained from its food source. Understanding food and feeding habits of fish is useful to all scientists who are concerned with any aspect of fisheries as well as to common people who are into fish farming. Edegbena and Agbaja (2014) investigated the effect of some environmental variables on the community structure of zooplankton in Tungan Kawo Reservoir. Abdullahi *et al.*, (2015) also studied the seasonal quality assessment of agricultural soils along the bank of Tungan Kawo Reservoir. Abdullahi *et al*. (2016) also studied the distribution pattern of metals in sediment of Tungan Kawo Reservoir. Therefore, there is no well-known information concerning the diet composition and trophic relationship among fishes in Tungan Kawo Reservoir despite the fact that the Reservoir is an excellent source of commercially important fish species. The information from this study will be useful in defining the feeding ecology and nutritional quality of fishes in Tungan Kawo Reservoir.

1.4 Aim and Objectives of the Study

The aim of the research was to investigate the feeding ecology and nutritional composition of selected fish species from Tungan Kawo Reservoir, Kontagora, Niger State Nigeria and The objectives of this study were to determine the:

i. physico-chemical parameters of the water.

ii. gut content of the three fish species.

iii. proximate composition of the three fish species.

iv. amino-acid profile of the three fish species.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Physico-chemical Parameters

Reservoirs have put enormous pressure and stress on the quality of water impounded by the reservoir. The impact of human activities in and around the reservoir is felt on the unique physical and chemical properties of water on which the sustenance of fish that inhabit the reservoir is built as well as to the functions of the reservoir. Water as a habitat for fish must have favorable quality parameters such as dissolved oxygen, biological oxygen demand, minerals, ammonia, nitrate, nitrite, phosphate etc in such amounts that are not harmful to fishes (Bankole, 2002).

United Nations Environment Programme (2006) states “Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter”. There is a range of physical, chemical and biological components that determine the water quality. These components can be examined and measured accurately to ascertain the quality of water. These parameters include temperature, pH, conductivity, river flow rate, dissolved oxygen and turbidity. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know details about different physico-chemical parameters such as color, temperature, acidity, hardness, pH, sulphate, chloride, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, alkalinity used for testing of water quality. Some physical test should be performed for testing of its physical appearance such as temperature, colour, odour, pH, turbidity, while chemical tests should be performed for its BOD, COD, dissolved oxygen, alkalinity, hardness and other characters. Being a basic need of human development, health and wellbeing, safe

drinking water is an internationally accepted human right (WHO, 2008). A survey of the freshwaters of Nigeria including the wetlands was estimated at 743, 100ha representing about 3.4 % of the total area of Nigeria. An estimate of 230 fish species inhabiting the various fresh-water ecosystems was made indicating the potential and fish diversity in the rivers, lakes and reservoirs in Nigeria (Ita, 2003). The overall contribution of the fresh water species to the total domestic fish production in Nigeria was estimated at 248,000 metric tons representing about 47.8 % of the total fish catches mainly by artisan fishermen all over the rivers, lakes and reservoirs (Ita, 2003). The availability of good quality water is an indispensable feature for preventing disease and improving quality of life. The physico-chemical properties will also help in the identification of sources of pollution, for conducting further investigations on the eco-biological impacts and also for initiating necessary steps for remedial actions in case of polluted water bodies (Ekwenye and Oji, 2008; Singh and Singh, 2008). Therefore, the nature and health of any aquatic community are an expression of quality of the water. In recent years, increase in human population, demand for food, land conversion, and use of fertilizer have led to faster degradation of many freshwater resources (Jayakumar *et al*., 2009; Mushini *et al*., 2012).

The discharge of urban, industrial, and agricultural wastes has added the quantum of various harmful chemicals to the water body considerably altering their inherent physicochemical characteristics (Kim *et al*., 2001). The monitoring of quality of such surface waters by estimating hydrobiological parameters is among the major environmental priorities as it permits direct assessment of the status of ecosystems that are exposed to deleterious anthropogenic factors (Vandysh, 2004). The alteration in physico-chemical parameters leading to eutrophication has become a widely recognized problem of water quality deterioration (Jayakumar *et al*., 2009).

Physical parameters define those characteristics of water that respond to the sense of sight, touch, taste or smell. Suspended solids, turbidity, colour, taste, odour and temperature fall under this category. Chemical parameters are related to the solvent capabilities of water. Total dissolved solids, alkalinity, hardness, fluorides, metals, organics, and nutrients are chemical parameters of concern in water-quality management (Ramachandra and Malvikaa, 2007).

2.1.1 Water temperature

Temperature exerts a major influence on the biological activities and growth. Many aquatic organisms are sensitive to changes in water temperature (Bellingham, 2012). Bellingham (2012) noted that water bodies will naturally show change in temperature seasonally and daily; however, man-made changes to stream water temperature will affect fish's ability to reproduce. To a certain point the increase in temperature leads to greater biological productivity, above and below which it falls and it also governs the kind of organisms (species composition). At elevated temperatures, metabolic activity of organism increases, requiring more oxygen but at the same time the solubility of oxygen decreases, thus accentuating the stress (Boulton, 2012). Temperature influences water chemistry such as DO, solubility, density, pH, and conductivity. Water holds lesser oxygen at higher temperatures (Akin-Oriola, 2003; Agricultural Water Quality Alliance, 2012). Some compounds are more toxic to aquatic organisms at higher temperatures. Additionally temperature of drinking water has an influence on its taste (Ramachandra and Malvikaa, 2007).

2.1.2 Total dissolved solids (TDS)

Total Dissolved Solids (TDS) are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers). TDS is a measure of the amount of material

dissolved in water (Sheila, 2007). This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for aquatic life (Sheila, 2007). If TDS concentrations are too high or too low, the growth of many aquatic lives can be limited, and death may occur. Total dissolved solid or mineral in the natural waters is a useful parameter in describing the chemical density as a fitness factor and as a general measure of edaphic relationship that contributes to productivity within the water body (Abolude, 2007).

2.1.3 Water pH

The pH of natural water can provide important information about many chemical and biological processes and provides indirect correlations to a number of different impairments (Bellingham, 2012). pH – potential of hydrogen, is the measure of the concentration of hydrogen ions. It provides the measure of the acidity or alkalinity of a solution and is measured on a scale of 0 – 14. The pH of water is 7, which is neutral, and lower than 7 is acidic, while higher than 7 is alkaline. The closer pH gets to 1, the more acidic while the closer pH gets to 14, the more basic (Kelly-Addy *et al*., 2004). The pH of water determines the solubility and biological availability of certain chemical nutrients such as phosphorus, nitrogen, carbon and heavy metals like lead, copper, cadmium (Bellingham, 2012). pH determines how much and what form of phosphorus is most abundant in water. It also determines whether aquatic life can use the form available. pH of natural waters would be around 7, but mostly basic. pH of seawater is around 8.5. pH of natural water usually lies in the range of 4.4 to 8.5 (Bellingham, 2012). pH is typically monitored for assessments of aquatic ecosystem health, recreational waters, irrigation sources and discharges, livestock, drinking water sources, industrial discharges, intakes, and storm water runoff.

2.1.4 Total hardness

Water hardness is the traditional measure of the capacity of water to react with soap. Hard water requires a considerable amount of soap to lather. Hardness is generally caused by the calcium and magnesium ions (bivalent cations) present in water (Ramachandra and Malvikaa, 2007). Polyvalent ions of some other metals like strontium, iron, aluminium, zinc and manganese are also capable of precipitating the soap thus contributing to hardness. However, the concentration of these ions is very low in natural waters therefore hardness is generally measured as concentration of only calcium and magnesium, which are far higher in quantities over other hardness producing ions (Ramachandra and Malvikaa, 2007).

2.1.5 Electrical conductivity

Electrical conductivity (EC) in natural waters is the normalized measure of the water's ability to conduct electric current. This is mostly influenced by dissolved salts such as sodium chloride and potassium chloride. Most dissolved inorganic substances in water are in the ionized form and hence contribute to conductance. Thus, measurement of conductivity also gives a rapid and practical estimate of the dissolved mineral contents of water. Conductivity is reported in mmho or μ mhos/cm, though the recent unit of conductivity has been named Siemens/cm (S) instead of mho. Most freshwater sources will range between 0.001 and 0.100 S/cm (Bellingham, 2012). EC is also the measure of the water quality parameter "Total Dissolved Solids" (TDS) or salinity. At about 0.3 S/m is the point at which the health of some crops and fresh water aquatic organisms will be affected by the salinity.

2.1.6 Phosphate-phosphorus (PO_4-P)

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates and organically bound phosphates. They occur in solution, in particles or detritus or in the bodies of aquatic organisms. Orthophosphate is the phosphorus form that is directly taken up by algae, and the concentration of this fraction constitutes an index of the amount of phosphorus immediately available for algal growth (Ramachandra and Malvikaa, 2007). Unlike total ammonia, phosphates are less soluble and less volatile, therefore, phosphates will form salts with sodium and calcium and fall out of solution to accumulate in the sediment. Phosphates ions in natural waters will exist in solution in its ionized form, as salts, in organic form or as a particulate species. Higher concentrations rarely occur, because after it enters a water system, it will be rapidly taken up by plants (Bellingham, 2012). In general, phosphorous is an essential nutrient to living organisms. In unpolluted waters, phosphorous can enter a water system from the weathering of phosphorous-bearing rocks and minerals. In areas of high volcanic activity, phosphorous may be naturally abundant in the soils. Man-made sources of phosphate in the environment include domestic and industrial discharges, agricultural runoff where fertilizers are used, and changes in land use in areas where phosphorous is naturally abundant in the soil. In general, phosphates are not very toxic to people or other living organisms. Like nitrogen containing compounds, the main environmental impact associated with phosphate pollution is eutrophication. High levels of phosphorus will be quickly consumed by plant and microorganisms, impairing the water by depleting the dissolved oxygen and increasing the turbidities. These impairments will kill or harm fish and other aquatic organisms (Bellingham, 2012).

2.1.7 Water alkalinity

The alkalinity of water is a measure of its capacity to neutralize acids. The alkalinity of natural waters is due to the salts of carbonates, bicarbonates, borates, silicates and phosphates along with the hydroxyl ions in free states. However, the major portion of the alkalinity in natural waters is caused by hydroxide, carbonate and bicarbonate, which may be ranked in order of their association with high pH values. Alkalinity values provide guidance in applying proper doses of chemicals in wastewater treatment processes, particularly in coagulation, softening and operational control of anaerobic digestion. Alkalinity is expressed as mg/L (Ramachandra and Malvikaa, 2007).

2.1.8 Dissolved oxygen (DO)

Sources of oxygen in water are by diffusion of oxygen from the air into the water, photosynthetic activity of aquatic autotrophs and inflowing streams. DO is a very important parameter for the survival of fishes and other aquatic organisms. Diffusion of oxygen or transfer of oxygen in these organisms is efficient only above certain concentrations. Too low concentrations of oxygen may not be enough to sustain life. Oxygen is also needed for many chemical reactions that are important to lake functioning (oxidation of metals, decomposition of dead and decaying matter). Measurement of DO can be used to indicate the degree of pollution by organic matter. DO is expressed as mg/L. DO concentrations of below 5 mg/L may adversely affect the functioning and survival of biological communities. Below 2 mg/L may lead to fish mortality (Ramachandra and Malvikaa, 2007).

2.2 Gut content

Fish stomach or fish gut content analysis refers to methods of analyzing fish diet through assessment of materials found in dissected fish stomachs (Jordán *et al.*, 2006).

Fish stomach contents are typically assessed in terms of mass and / or volume, and then prey items are identified by taxonomists, enumerated, assessed for their state of digestion and measured or weighed, as necessary (Jordán *et al.,* 2006). The study of the gut content is not only a way to know the diet but also superior source of information on many aspects of fish biology and ecology. Food habits of different species have been investigated for a variety of specific reasons important in a broader sense. Knowledge of natural diet in an animal species is generally essential for studies of animal nutritional requirements and the recruitment dynamics within a species and across various habitats to understand trophic, material and energy dynamics and to model outcomes for all ecosystems (Cutwa and Turingana, 2000; Jordán *et al.,* 2006).

Food and feeding habits have been known to vary for individual fish with respect to size, age, sex, life history stage, kinds of food available, season, time of the day, as well as locality in which they are found (Lagler, *et al*., 2003). Data on feeding ecology can be used to construct food webs and predict possible changes in food chains and material and energy transfers between and within ecosystems (Nakano and Murakami, 2001; Baxter *et al*., 2004, 2005; Rezende *et al*., 2008). Ndome and Victor (2002) emphasized that information on the feeding ecology of fish species is a prerequisite to the use of the fish for culture, exploitation and rationale management

Many authors have reported that African catfish feed on a variety of food items including phytoplankton, zooplankton, insects, detritus, macrophytes, fish parts, gastropods and nematodes (Dadebo, 2000; Dadebo, 2009; Dadebo *et al*., 2014; Admasu *et al*., 2015). However, in terms of prey importance, the foods of animal origins were the most consumed food items by the fish in all of the water bodies. For instance, studies carried out in some water bodies of Ethiopia in Lake Babogaya and Lake Hayq indicated that insects, fish prey, zooplankton, detritus and macrophytes were the most

consumed food items by African catfish in Lake Chamo, Lake Hawassa and Lake Koka (Dadebo, 2000; Dadebo, 2009; (Dadebo *et al*., 2014 and Admasu *et al*., 2015). Insects were the most important food items followed by macrophytes and zooplankton occurred in (82 %), (60 %) and (60 %) respectively in Lake Babogaya (Admasu *et al*., 2015). However, zooplankton were the most preferred food items followed by detritus and insects occurred in (75.4 %), (33.7 %) and (27.2 %) respectively in Lake Chamo (Dadebo, 2009). Similarly, zooplankton were the most important food items followed by insects, fish preys and macrophytes occurred in (60 %), (46 %), (26 %) and (24 %) respectively in Lake Hayq.

Nwani *et al*. (2006) worked on the food and feeding habits of 417 samples of *Campylomormyrus* tamandua (*Osteichthyes Mormyridae*) in Anambra River, Nigeria from October 2002 to March 2004. Out of the eight (8) categories of food consumed, the most dominant group was benthic invertebrates (44.92 %) followed by a lochthonous invertebrates (33.40 %) while the least was mud/sand (10.02 %). Variation in the stomach fullness condition showed that 82 (19.66 %) of the stomachs studied were empty 40 (9.59 %) were full while 295 (70.74%) were partially filled with Food. Richness and diet breadth showed no significant difference between the seasons and sex respectively ($P > 0.05$).

Nwani *et al*. (2006) indicated that insects, fish prey, zooplankton, detritus and macrophytes were the most consumed food items by African catfish. According to Admasu *et al*. (2015) insects were the most abundant food items found in the gut (82 %), followed by macrophytes and zooplankton at (60 %) respectively, in Lake Babogaya. According to Dadebo, (2009) *C. gariepinus* possess long, numerous and compact gill rakers to filter large amount of zooplankton such morphological adaptation important to shift from one kind of feeding habit to the other depends on the availability

of food items in the lake as well as zooplankton production depends on water productivity and temperature. However, in Lake Hawassa, fish prey were far the most important food items in the diet of *C. gariepinus* occurred in (81.7%) followed by macrophytes (24.7%) and insects (24.7%) in the lake (Dadebo, 2010).

The fish has morphological adaptation for piscivorous feeding habit like big mouth, marginal and pharyngeal teeth, tough and muscular stomach with high acidity and short intestine as well as high availability of *Oreochromis niltocus*as fish prey and the absence of top predator (piscivory) (Dadebo, 2009). In Lake Koka, detritus, insects, zooplankton, macrophytes and fish prey were the most consumed in the diet of the fish occurred in (79.6%), (63.6%), (56.2%), (63%) and (>20%) respectively reported by (Dadebo *et al*., 2014). However, studies showed that the ingestion of detritus, macrophytes, algae, sand particles and benthic food items indicated the ability of the species to possess benthic habitats and accidentally ingested while the fish was searching other prey organisms that are attached with the macrophyte vegetation and the bottom of the sediment (Admasu *et al*., 2015). However, detritus are considered as under low nutritional value. Moreover, studies noted that lotic and lentic water system was considered that an increased consumption of detritus is a prime response to a decline of higher value primary food resources (King *et al*., 2013). The contributions of other food items were low throughout the water bodies. This indicates the changing of food items composition in the diet of African catfish based on the diet composition in the lakes, which may varies depending on environmental condition, season (water level) and habitat differences of the lakes.

2.3 Proximate and Amino Acid Composition of Fishes

Components of proximate analysis from fish carcass include ash, lipids, protein, crude fibre and Nitrogen Free Extract. This analysis is performed on fishes to ensure they

meet specific and nutrient requirements (Watermann, 2000; Anon, 2000). Fish, like most animals, contain reasonable quantity of amino acids, especially lysine which is known to be in low quantity in cereals. Thus, protein from fish could serve well in augmenting total protein profile in most combinations of food of carbohydrate origin (FAO, 2005).

Fishes are sources of animal protein found in many low-income homes even in metropolitan areas (Bene and Heck, 2005). In Nigeria, agricultural sector engages up to 70 % of employees and fish plays a vital role as it accounts for 50 % of total animal protein consumed by larger percentage of the populace. Components of proximate analysis from fish carcass include ash, lipids, protein, crude fibre and Nitrogen Free Extract. This analysis is performed on fishes to ensure they meet specific and nutrient requirements (Watermann, 2000; Anon, 2000). Fish has been recognized as a very significant supply of animal protein and most of the necessary nutrients in human food (Fawole *et al*., 2007). According to Oladipo and Bankole (2013) there is a need for comprehensive information on the level of nutrient content in fishes mostly found on the dining table of the less privileged across the third world nations of Africa and Asia. In Africa alone, over 60 % of infants below the age of five die annually due to Protein-Energy Malnutrition (Bene and Heck, 2005).

The human body needs nutrients to enable it function effectively and to maintain health; such nutrients are sourced from foods. Food nutrients include water, carbohydrates, proteins, fats, vitamins and minerals amongst others. Fishes are known to provide protein, fat and vitamins which are of great benefit to human health as it has been proven by scientists (Elagba *et al.,* 2010). Fish protein is of high quality since it has an almost ideal proportion of essential amino acids. The protein in fish is easily digestible, as it contains less collagen fibre than the protein found in meat; this helps the body to

maximally utilize its protein. The fats found in fish contain unsaturated fatty acids which do not pose a threat to the heart as they help reduce blood triglycerides (Alasalvar *et al*., 2012).

According to Abolude and Abdullahi (2015) fish is one of the most important animal protein and other vital nutrients sources that are widely consumed by all races and classes of people. Fish meat contains significantly low lipids and high water compared to that of beef or chicken and is favored over other white or red meats (Nestel, 2011). Poly-unsaturated fatty acids from fish have been reported to have preventive and/or curative effects for several diseases including arterial hypertension cancers and inflammatory diseases. It may also aid in lowering the risk of Dementia, Alzheimer's diseases and cardiovascular diseases (Cahu *et al.,* 2014).

Proximate composition is a good indicator of physiology which is needed for routine analysis of fisheries investigation (Elagba *et al.,* 2010). However, fish of various species do not provide the same nutrient profile to their consumers (Job *et al.,* 2015). These differences in the nutritional compositions of different species may be attributed to food composition, food and feeding habit, feeding rate, habitats, sex, age, size, genetic traits and season/migration (Ajah, 2009). Besides being used as food, fish is also increasingly demanded for use as feed. Information concerning the chemical composition of freshwater fishes in general is valuable to nutritionists concerned with readily available sources of low-fat, high-protein foods such as most freshwater fishes (Aberoumad and Pourshafi 2010) and to the food scientist who is interested in developing them into high-protein foods, while ensuring the finest quality flavor, color, odor, texture, and safety obtainable with maximum nutritive value studied (Elagba *et al.,* 2010). Biochemical composition of flesh is a good indicator for the fish quality (Hernandez *et al.*, 2001), physiological condition of fish and habitat of fish (Aberoumad and Pourshafi, 2010;

Shamsan and Ansari, 2010; Ravichandran *et al.*, 2011). Fish of various species do not provide the same nutrient profile to their consumer and the nutritive value of a fish varies with season (Varljen *et al*., 2013).

Moisture, dry matter, protein, lipids, vitamins and minerals are the most important components that act as sources of nutritive value of fish meat. Quantifying proximate composition is important in ensuring the requirements of food regulations and commercial specifications (Waterman, 2000). Moisture content of flesh is a good indicator of its relative content of energy, protein and lipid (Aberoumad and Pourshafi, 2010). Fish meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meals (Nestel, 2000). The total lipid and ash content of fish vary with the increasing weight or length of the fish; it may also vary with the season and varied habitats. Among the proximate composition, protein in fish is the excellent source, because of the amino acid composition and degree of digestibility (Louka *et al*., 2004).

Amino acids, the building blocks of protein, act as a precursor of many enzymes, hormones, neurotransmitters, nucleic acids and other molecules essential for life (Moses, *et al.*, 2018). They are classically divided into three categories: essential, nonessential and conditional essential amino acids.

Amino acids play important roles in cell signaling and act as regulators of gene expression and protein phosphorylation cascade, nutrient transport and metabolism in animal cells, and innate and cell-mediated immune responses (Mohanty *et al*., 2014). The amino acid histadine for example, plays multiple roles in protein interaction (liao *et al*., 2013) and it is also a precursor of histamine (Mohanty *et al*., 2014) whereas leucine increases the synthesis of muscle proteins (Etzel, 2004) and has important therapeutic

role in stress conditions like burn, trauma, and sepsis (De Bandt and Cynober, 2006) methionine is used as a treatment for liver disorders, wounds, depression, alcoholism, allergies and Parkinson's disease (Mischoulon and Fava, 2002) and lysine is required for optimal growth and its deficiency leads to immunodeficiency (Chen *et al*., 2003). Threonine is important in treating various nervous system disorders (Hyland, 2007). Phenylalanine serves as a precursor for synthesis of tyrosine (Fernstrom and Fernstrom, 2007). The nonessential amino acid alanine is highly beneficial for supporting gluconeogensis and leucocyte metabolism (Kudsk, 2006). Glutamic and aspartic acid are vital in the synthesis of glutathione and precursor for essential amino acids (Mohanty *et al*., 2014). Serine is the precursor of glycine, cysteine, and tryptophan and plays many important roles in cell signaling. Arginine plays an important role in cell division, wound healing, immune function blood clotting, and maintenance of blood pressure (Mohanty *et al*., 2014). Glycine plays an important role in metabolic regulation, enhancing anti-antioxidant activity, promoting protein synthesis and wound healing. Tyrosine is a precursor for several biologically active substances including catecholamine, neurotransmitters, hormones and melanin skin pigments.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

The Tungan Kawo Reservoir is located between latitude 10˚21"58.51˚N - 10˚23"28.50˚N of the equator and between longitude 5˚19"29.23˚E - 5˚20"59.23˚E in Tungan Kawo village, Northwest of Kontagora. It is 7 km along Kontagora -Yauri road and in Kontagora Local Government Area of Niger State (figure 3.1). The Lake has a catchments area of 143 km2 with a total storage capacity of 17.7 m Cubic meters, 20m high and Lake Crest length of 1000 m. The Lake was commissioned in May, 1991. It is the largest source of water supply in Kontagora Township. The people of Tungan Kawo and its environs are predominantly farmers and have remained so for years (Abdullahi, 2009).

3.2 Description of Sampling Stations

3.2.1 Station 1

Kwatan Mustafa: It is located upstream of the lake between latitude 10^0 24’42.36” N and longitude 5^0 20’30.36” E. Farming of vegetables, banana and okro are done around the shore area of the lake. The area is surrounded with excavated hip of mud stand.

3.2.2 Station 2

Babban Kwatan: There is a market depot for fishes in this station. A lot of domestic wastes and agricultural wastes are discharge into the reservoir. The common crops plants in this station are mostly grains. The station is located at the upstream on the latitude 10^0 24’.36.19” N and longitude 5^0 21’7.51” E.

3.2.3 Station 3

Kwatan Abdullahi: It's located at the midstream of the lake. This station is located in latitude 10^0 25'25.67" N and longitude 5^0 20'12.26" E. The vegetation is mainly shrubs and few tall trees. Dead fishes, leaves, shrimps are observed at the shore area of the lake.

3.2.4 Station 4

Gonan Hagiya: It's located in the downstream of the reservoir. It was observed that the fishermen keep their boats here. Other activities include washing of clothes and bathing. It is located in between latitude 10^0 26'1.70" N and longitude 5^0 20'27.83" E.

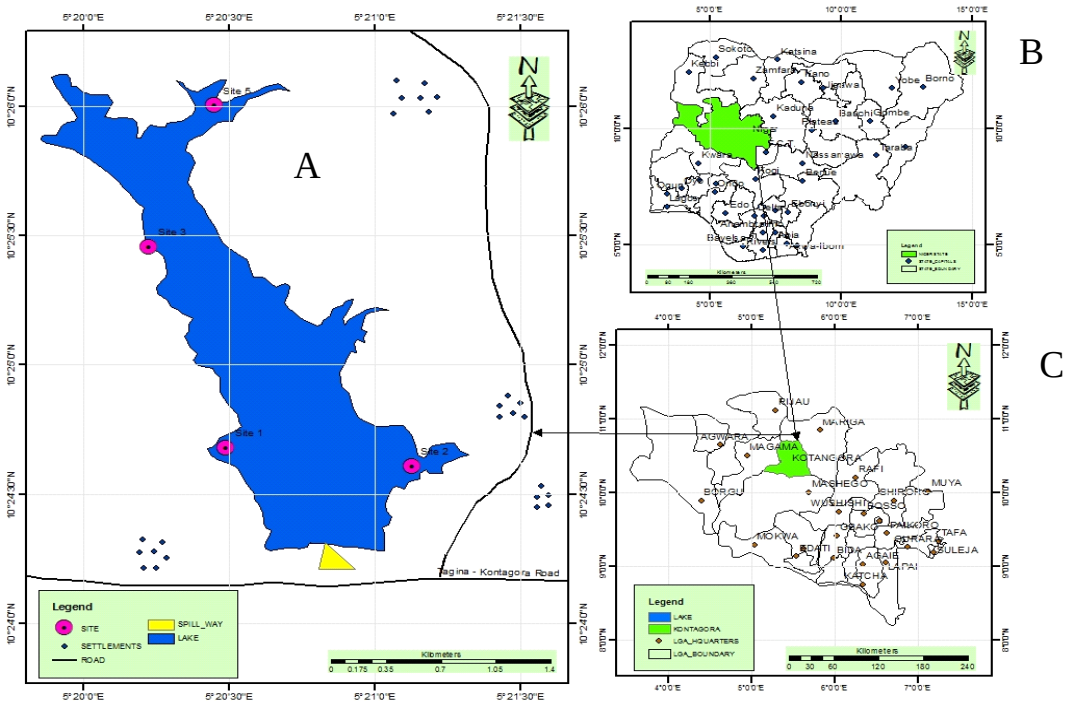
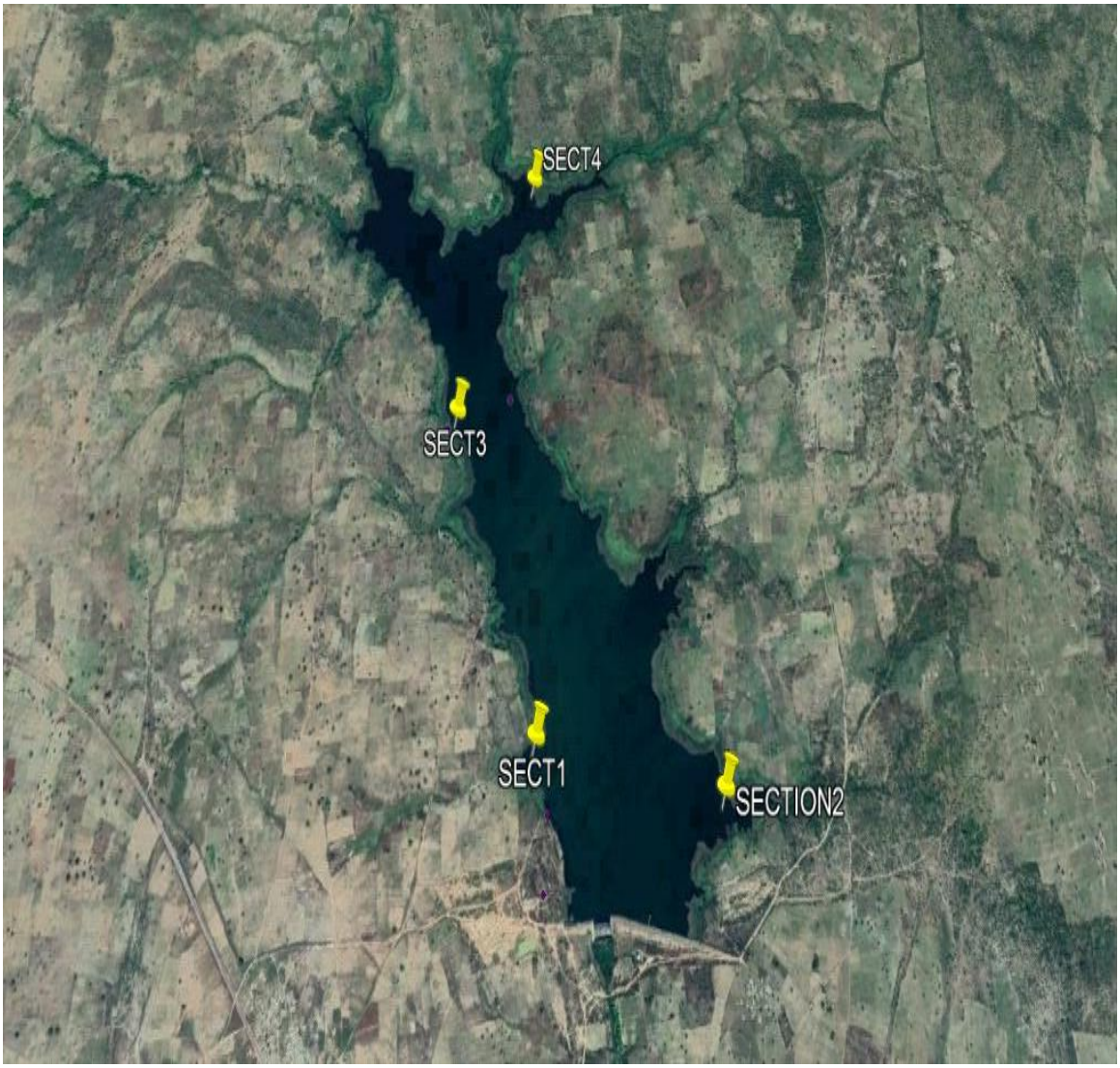


Figure 3.1: Map of the study area:
Source: Remote sensing Laboratory, F.U.T. MINNA (2019)

A: Map of Nigeria showing Niger State.

B: Map of Niger State showing sample site Location.

C: Hydrological Map of sample Stations.



Google earth Map of study area, (2019)

3.3 Determination of Water Physicochemical Parameters

In other to determine the physiochemical parameters of the water, samples were collected from three different points in three replica periods along the water course that is upstream, downstream and midstream that represent the location of the reservoir. Water sample collected was processed according to the method prescribed by the American Public health Association (APHA, 2014). The pH, total dissolved solids (TDS) and electrical conductivity (EC) of the water samples was tested using pre-calibrated pH, TDS and Conductivity meter in-situ with (Hanna microprocessor

pH/EC/TDS meter), while the determination of dissolved Oxygen (DO), was done in situ using a portable dissolved Oxygen analyzer (Model JPB-607). The water temperature of the lake was measured with a mercury-in-glass thermometer in-situ and the reading was expressed in degrees Celsius (^{o}C) while air temperature was determined using a phone galaxy sensors reader. Collected and preserved water samples were used to test the potassium (k), sodium (Na), hardness, Alkalinity, Biochemical Oxygen Demand (BOD) and phosphate (Po_4) following the method of the (APHA, 2013) in WAFT Laboratory, School of Agriculture Technology, Federal University of Minna (FUTMINNA) for each sample sites.

3.3.1 Determination of water temperature

Air and water temperatures were measured at each station in degree centigrade using mercury- in-glass bulb thermometer (0 – 110 ^{o}C). Readings were taken at level of the eye meniscus. Air temperature was determined by holding the thermometer above water for about 5 minutes until it becomes constant before reading was taken to (Environmental Protection Agency (EPA, 2010). The water temperature was determined by lowering the thermometer into the water and reading was taken when constant following the method of (EPA, 2010).

3.3.2 Determination of electrical conductivity, total dissolved solids and pH

This was determined according to APHA (2013) method. At the field, pre-calibrated pH, TDS and Conductivity meter in-situ with (Hanna microprocessor pH/EC/TDS meter) and readings was taken when established. Firstly, pre-calibrated pH, TDS and Conductivity meter electrode was washed out by distilled water. And then the cell constant of the conductivity meter was checked. The electrode meter was drop inside

and waited for at least 10 seconds. Then Electrical Conductivity (EC), Total Dissolved Solid (TDS) and pH readings were collected from this meter and recorded.

3.3.3 Determination of water dissolved oxygen (DO)

Dissolved Oxygen was determined using Azide modification of Winkler's method (APHA 2014); First DO meter was calibrated with distilled water and buffer solution. The probe was dipped inside the water and allows to stabilize for five minutes. The DO reading was taken and recorded. In the same way, all other stations DO was measured but before every measurement DO meter was sterilized in distilled water.

3.3.4 Determination of water biochemical oxygen demand (BOD)

This was determined according to APHA (2014) method. At the field, the reagent bottles set aside for BOD was filled with water samples and wrapped with black polythene bags to avoid any form of light penetration. They were taken to the laboratory and kept in a dark cupboard. After five (5) days, they were untied and fixed using Winkler solutions A and B. The procedure for carrying out dissolved oxygen was repeated to check the amount of oxygen that has been used up by microorganisms.

Calculation:

BOD=DO1-DO5 (mg/l)

DO_1= Initial dissolved oxygen at the first day

DO_5= Dissolved oxygen reading after 5-days

Result expressed in milligram per liter (mg/L)

3.3.5 Determination of sodium and potassium

A flame photometer 128 with a gas supply was used to determine the sodium and potassium concentration. Preparation of stock potassium solution: The reading starts from zero point 0.1907 g pre-dried potassium chloride was dissolved with 1 liter of distilled water. 1 mL=0.1 mg/k. Working potassium solution: a series of standards of concentration 10, 20, 40 and 60 mg/L of potassium was prepared by pipetting 5, 10, 20 30 mL 0f stock and diluted to 50 mL with distilled water. The compressor of the flame photometer was switched on and the pressure of air was adjusted to 0.45 kg/cm^2. The gas supply was switched on to maintain the air gas mixture to get a blue flame. The blue flame was adjusted into cone shaped and aspirated with distilled water. The sodium and potassium standards were mixed in equal proportion. The instrument was calibrated by curve-fit method by aspirating with series of standards of know n concentration. The samples were introduced and the readings were noted.

Calculation: sodium (mg/L) = Observed values * calibration factor

3.3.6 Determination of water phosphates

This was determined by colorimetric method. A total of 2 mL aliquot of the water sample in a 25 mL volumetric flask was added one drop of phenolphthalein indicator followed by 2 mL of ammonium molybdate and then 1 mL of freshly diluted stannous chloride solution. These was made up to 25 mL volume with distilled water and mixed thoroughly. After 5 - 6 minutes and before 20 minutes, the color intensity (absorbance) was measured at a wavelength of 660 nm in a Spectrophotometer (OPTIMA SP 300, U.K.) following the method of APHA, (2013).

3.3.7 Determination of water alkalinity

This was determined by titration methods (APHA, 2013). To 50 mL of the water samples in clean 150 mL conical flask and 3 drops of phenolphthalein indicator. The samples were titrated with 0.05 M H_2SO_4, until the color disappeared. 3 drops of methyl orange indicator was added to the colorless solution and titrated further until the color change from yellow to permanent reddish color and the titre values were recorded and used to compute the alkalinity.

3.3.8 Determination of water total hardness

The water sample was thoroughly shaken and 25 mL was taken and diluted to 50 mL with distilled water. A total of 2 mL of Phosphate buffer solution was added to bring the pH of the water sample to 10. Three drops of ferrochrome black indicator were also added. This was titrated with 0.01 Mol/L EDTA to a blue color end point. Hardness was then calculated according to APHA, (2013).

3.4 Sample Collection

A total of 52 fishes were randomly collected from commercial fishermen at the four stations. Fish identification was carried out following the field guide of Nigerian freshwater fishes. Stomach contents were collected from the freshly collected fishes; and preserved in 5 % formalin at the site and were transported to the laboratory for further analysis and examination under microscope.

3.5 Analysis of Stomach Content

Frequency of occurrence of each food object was obtained by expressing the number of stomach each food item occurred as percentage of total number of stomach. Numerical method in which the number of individual of each food type in each stomach was counted and expressed as a percentage of the total number of food items in the sample

studied, occurrence method were food items are sorted and identified and expressed as percentage and fullness/eye estimation method by directly estimating the food items.

3.6 Proximate Composition Analysis

The proximate analysis of the samples for moisture, total ash, crude fibre, and fat were carried out in triplicates using methods (Onwuka, 2015). The nitrogen was determined by micro Kjeldal method and the nitrogen content was converted to protein by multiplying by a factor of 6.25. Total carbohydrate content was estimated by difference. All the proximate values were reported in percentage (%).

3.6.1 Determination of moisture

Moisture was determined by oven drying method. Two (2) grams of samples was accurately weighed in clean, dried crucible (W_1). The crucibles were allowed in an oven at 100-105 C for 6-12 h until a constant weight was obtained. Then the crucible was placed in the desiccator for 30 min to cool, after cooling it was weighed again (W_2). The percentage moisture was calculated by following Formula: % Moisture $=W_1-W_2 \times 100$

Where

W_1 = Initial weight of crucible + Sample 1

W_2 = Final weight of crucible + Sample 2.

3.6.2 Determination of ash

For the determination of ash, clean empty crucible was placed in a muffle furnace at 550 ^{0}C for an hour, cooled in desiccator and then weight of empty crucible was noted (W_1). Two (2) grams of each of sample was taken in crucible (W_2) and was placed over a burner, until it was charred. Then the crucible was placed in muffle furnace for ashing at 550 ^{0}C for 2-4 h. The appearance of gray white ash indicates complete oxidation of all

organic matter in the sample. After ashing the crucible was cooled and weighed (W_3). Percentage ash was calculated by the following formula.

% Ash = W x 100

Difference in weight of ash W = $W_3 – W_1$

3.6.3 Determination of crude protein

Protein in the sample was determined by Kjeldahl method. Zero point two five (0.25 g) grams of dried samples was taken in digestion flask, with 6 mL of concentrated H_2SO_4 and a speck of kjeldah1 catalyst (mixture of 10 g Na_2SO_4+5g $CuSO_4$+ 0.05g selenium). The flask was swirled in order to mix the contents thoroughly then digested on the digestion block till the mixtures become clear (colorless or greenish in color). The digest was cooled and transferred to 100 mL volumetric flask and volume was made up to mark by the addition of distilled water. Distillation of the digest was performed in Markham Distillation Apparatus. Ten (10) milliliters of digest was introduced in the distillation tube then 10 mL of 40 % NaOH was gradually added through the same way. Distillation was continued for at least 10 min and NH_3 produced was collected as NH_4OH in conical flask containing 5 mL of 4 % boric acid solution with few drops of methyl red indicator. During distillation yellowish color appears due to NH_4OH. The distillate was then titrated against standard 0.1 N HCI solutions till the appearance of pink color. A blank was also run through all steps as above. Percentage crude protein content of the sample was calculated by using the following formula;

% Crude Protein = 6.25* x %N (*. Correction factor)

%N = x 100

Where:

S = Sample titration reading B = Blank titration reading

N = Normality of HCI D = Dilution of sample after digestion

V = Volume taken for distillation. 0.014 – mill equivalent weight of Nitrogen

3.6.4 Determination of crude fat

Crude fat was determined by ether extract method using Soxhlet apparatus. Approximately 2 g of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. A weighed, cleaned and dried receiving flask was filled with petroleum ether and fitted into the apparatus. The soxhlet apparatus was assembled and allow refluxing for 6 hrs; extract was transferred into clean glass dish with either washing which was evaporated on water bath. Then the dish placed in an oven at 105 ^{0}C-110 ^{0}C for 1hr and cooled it in a desicator. The percentage crude fat was determined by using the following formula:

% Crude Fat = x 100

3.6.5 Determination of crude fibre

Two grams (2 g) of sample was defatted with per ether; boiled under reflux for 30 min with 200 mL solution containing 1.25 g of H_2SO_4 per 100 mL. The solution was filtered through linen or several layers of cheese cloth on fluted funnel, washed with boiling water until the washings are no longer acidic then the residue was transferred into a beaker and boiled for 30 min with 200 mL of solution containing 1.25 g of carbonate free NaOH per 100 mL. The final residue was filtered through a thin but close pad of washed and ignited asbestos in a Gooch crucible, then dried in an electric oven and weighed after which it was incinerated, cooled and reweighed. The loss in weight after incineration 2 x 100 is the percentage crude fibre.

3.6.6 Carbohydrate content determination

The nitrogen free method described by A.O.A.C (2013) was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameter as Nitrogen free Extract (NFE) percentage carbohydrate (NFE) = 100-(m+p+F+A+F_2).

Where M= moisture; P=protein; F_1=Fat; A=ash; F_2=crude fibre.

3.6.7 Determination of amino acid profile

The Amino Acid profile in the known sample was determined using methods (Benitez, 1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Defatting Sample:

The sample was defatted using chloroform/methanol mixture of ratio 2:1. About 500mg of the sample was put in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 2006).

Nitrogen Determination:

A small amount (115 mg) of ground sample was weighed, wrapped in whatman filter paper (No.1) and put in the Kjelcihal digestion flask. Concentrated sulphuric acid (10 mL) was added. Catalyst mixture (0.5 g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ratio of 10:5:1 was added into the flask to facilitate digestion. Six pieces of anti-bumping granules were added.

The flask was then put in Kjeldhal digestion apparatus for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100 mL

in standard volumetric flask. Aliquot (10 mL) of the diluted solution with 10 mL of 45 % sodium hydroxide was put into the Markham distillation apparatus and distilled into 10ml of 2 % boric acid containing 4 drops of bromocresol green/methyl red indicator until about 70ml of distillate was collected.

3.6.8 Hydrolysis of the sample

A known weight (mentioned in the calculation sheet) of the defatted sample was weighed into glass ampoule. Seven mililitre of 6NHCL was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of some amino acids during hydrolysis e.g. methionine and cystine). The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105 ^{0}C ± 5 ^{0}C for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. It should be noted that tryptophan is destroyed by 6 HCL during hydrolysis.

The filtrate was then evaporated to dryness using rotary evaporator. The residue was dissolved with 5 mL to acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

3.6.9 Loading of the hydrolysate into analyzer

The amount loaded was 60 microlitre. This was dispensed into the cartridge of the analyzer. The analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate.

3.6.10 Method of calculating amino acid values

An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids.

3.7 Data Analysis

Mean and Standard deviation of physicochemical variables, and SPSS correlation version 17.0 were used. Data collected was subjected to cluster analysis to test the similarity in the feeding habit of the fish species. Descriptive statistics (such as mean and standard deviation) were performed on all the data using Microsoft Excel 2010 version. A two -way ANOVA was used to compare means of the different parameters measured for two seasons (wet and dry) for eight months (July 2018-Febraury 2019). Duncan multiple range (DMR) tests was used to separate means where significant. Means were considered significantly different at $P< 0.05$.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

4.1.1 Spatio-Temporal variation of physicochemical parameters of Tungan Kawo Reservoir.

The mean and standard error of physicochemical parameters measured during the study period in Tungan Kawo Reservoir, Kontagora are summarized in Table 4.1. The results obtained for water temperature showed a generally high-water temperature in all the months sampled. There was significant difference ($p<0.05$) between the months with December having the highest mean value of 31.65±0.31 ^{0}C and the lowest value of 27.53±0.25 ^{0}C recorded in August. The Water temperature ranged between 27.00-31.00 ^{0}C. The mean pH value ranged from 6.50 to 9.55. The highest mean value (9.55±0.10) was recorded in the month of October and the lowest mean value (6.50±0.09) was recorded in January 2019. Repeated measurement of Electrical Conductivity did not show any significant difference ($P > 0.05$) among the stations sampled. It fluctuated in all the months, with October having the highest mean value of 119.00±2.27 µS/cm. Thus, the mean value ranged from (85.50 to 119.00 µS/cm). (Figure 4.1).

For Dissolved Oxygen, the highest mean value was recorded in February and lowest in July, although there was no significance difference in the value recorded in the months of January, 2019 to February, 2019. The lowest mean value of Biochemical Oxygen Demand was (2.05±0.06 mg/L) was observed in July 2018, whereas the highest mean value (3.93±0.15 mg/L) was recorded in February 2019. The result obtained for Total Dissolved Solids (TDS) of the Tungan Kawo Reservoir, increased gradually from September, 2018 to August, 2019. The lowest mean value (119.5±2.40 mg/L) was observed in September, while the highest mean value was recorded in August

(167.5±10.3 mg/L). Alkalinity had mean values ranges of 19.25 to 29.5 mg/L. In general, mean values for alkalinity were insignificant in all the study months. However, the lowest value was 19.25±1.11 mg/L in August, while the highest value was 29.50±1.85 mg/L in November. Similarly, the result of total hardness recorded showed slight variations in some month except in September where the mean value was higher throughout the study month. The highest mean value recorded in September was 50.75±1.70 mg/L while 28.5±1.26 mg/L was recorded as the lowest mean value in August. Phosphates mean values ranged from 0.48±0.06 mg/L to 1.23±0.23 mg/L. There was decrease in December and followed by a rapid increase in February. Mean Nitrate ranged from 3.64 to 6.75 mg/L. The lowest mean value of 3.64±0.20 mg/L was observed in July, while the highest value of 6.75±0.48 mg/L was recorded in of February.

Table 4.1 Mean Standard Deviation, Minimum and Maximum Range, of Physicochemical Parameters of Tungan Kawo Reservoir. Niger State. Nigeria.

Parameters	station 1 mean±SD min-max	station 2 mean±D min-max	station mean±SD min-max 3	station 4 mean±SD min-max	*NIS	**WHO
Temperature (^{0}C)	29.70±0.51a (27.2-32.1)	30.39±0.46a (28-31.8)	30.4±0.48[a] (27.9-32.1)	30.65±0.63a (27-32.4)	–	30-32
Conductivity (µS/cm)	104±5.09a (87 – 122)	96.4±3.92a (84 – 115)	104.3±5.40a (81 – 124)	105±5.28a (88 – 125)	1000	1000
Total Dissolved Solids (ppm)	151.48±8.42a (117 – 198)	144.73±5.61a (120 – 165)	143.88±5.59a (118 – 168)	147.64±4.13a (126 – 163)	500	600
pH	8.4±0.46a (6.6 – 9.8)	8.11±0.50a (6.3 – 9.5)	8.3±0.48a (6.5 – 9.6)	8.5±0.44a (6.4 – 9.7)	6.5-8.5	6.5-8.5
Dissolved Oxygen (mg/L)	4±0.33a (2.6 – 5.2)	3.89±0.28a (2.5 – 5.1)	3.6±0.29b (2.4 – 4.8)	3.78±0.29b (2.6 – 4.9)	–	7.5
BOD (mg/L)	3.25±0.30a (2.0 – 4.4)	2.83±0.26b (2.0 – 3.8)	2.63±0.26b (1.9 – 3.8)	2.83±0.26b (2.0 – 3.8)	–	6

Phosphate (mg/L)	0.89±0.14a	1.15±0.24a	1.36±1.1a	0.96±0.11a	–	5
	(0.6-1.5)	(0.4-2.5)	(0.4-2.0)	(0.5-1.5)		
Alkalinity (mg/L)	24±0.73a	23±1.11a	25±1.24a	23.4±2.09a	100	100
	(22 – 28)	(20 – 29)	(18 – 30)	(16 – 34)		
Nitrate (NO_3) (mg/L)	4.48±0.57a	4.90±0.58b	4.55±0.40a	5.24±0.44b	50	11
	(3.2 – 7.5)	(3.5 – 7.5)	(3.4 – 6.5)	(3.6 – 7.5)		
Hardness (mg/L)	33.5±2.25a	35.75±3.06a	34.75±3.02a	33.38±3.49a	150	150
	(25 – 46)	(26 – 52)	(28 – 54)	(20 – 51)		

Values are mean±standard deviation, values followed by the same subscript(s), in the same row are not significantaly different at (p> 0.05) tested by DMRT

4.1.2 Water temperature

The monthly variations in water temperature are represented in Figure 4.1. The highest values of water temperature were recorded in December and February. The water temperature value was relatively stable in the months of July, September, October and November but declined in August.

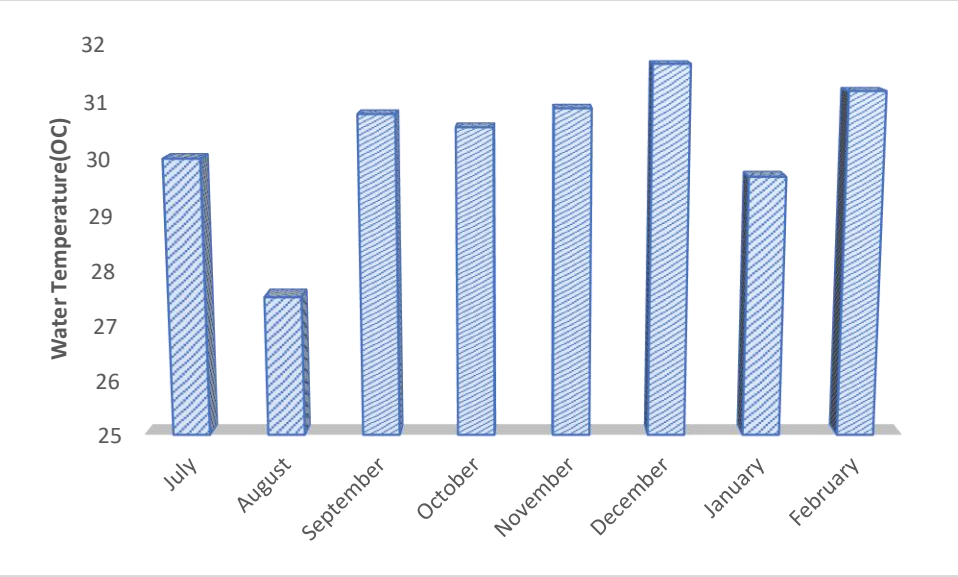


Figure 4.1 Monthly Variations in Water Temperature from July 2018 to February 2019

4.1.3 Electrical conductivity

The monthly variations in the value of electrical conductivity across the four stations are represented in Figure 4.2. The value of Electrical conductivity fluctuates from July to September. A sharp increase was recorded between the month of October, December, July and February. The highest value was in October and the lowest was in August.

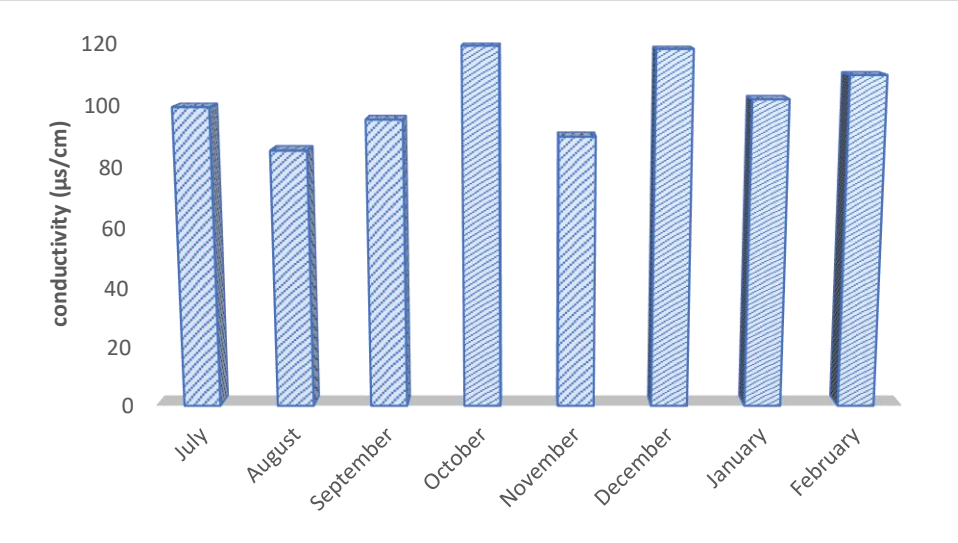


Figure 4.2: Monthly Variations in Electrical Conductivity from July 2018 to February 2019

4.1.4 Total dissolved solids (TDS)

The monthly variations in total dissolved solids within four stations are represented in Figure 4.3. There was a steady decline in the value of TDS in August to September. The highest was recorded in August and the lowest was in September.

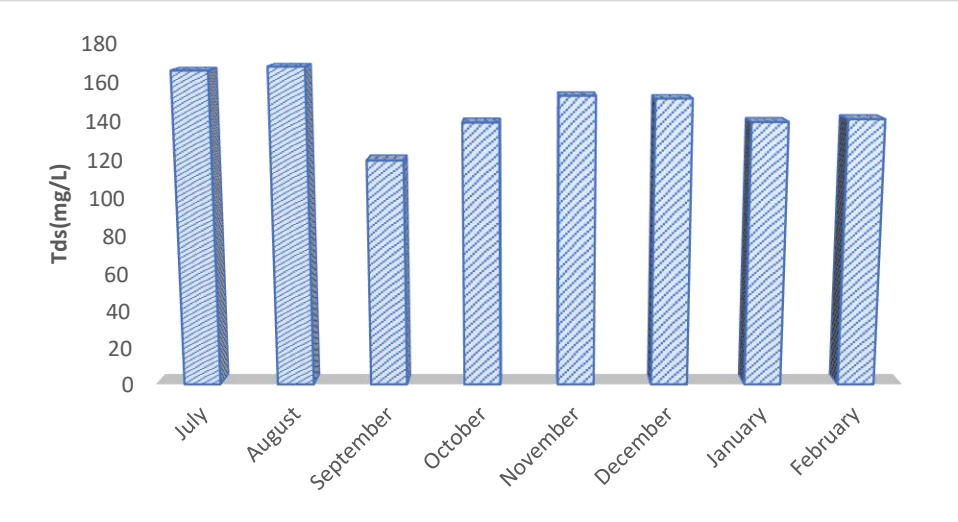


Figure 4.3: Monthly Variations in Total Dissolved Solid from July 2018 to February 2019

4.1.5 Water pH

The monthly variations in the value of pH across the four stations are represented in Figure 4.4. The lowest value of pH was recorded December and January. There was a sharp increase recorded in the month of November, August and July with a slight decline in September. The highest pH value recorded was in October 2018.

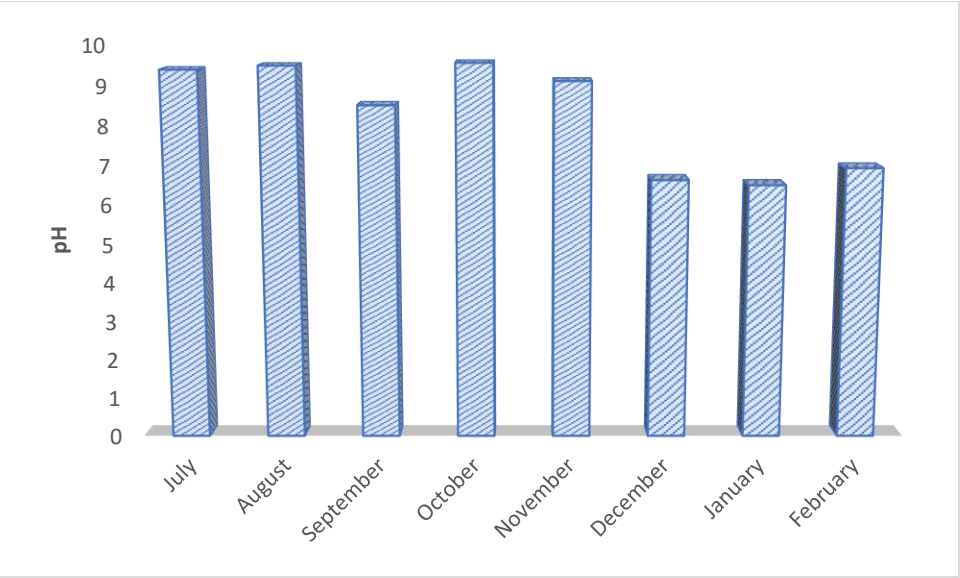


Figure 4.4: Monthly Variations in Water pH from July 2018 to February 2019

4.1.6 Dissolved oxygen

The monthly variations of the Dissolved Oxygen values for the four stations are represented in Figure 4.5. The lowest value was recorded in September and there was an increase in November, and a gradual increase from November to February. The highest value was recorded in February.

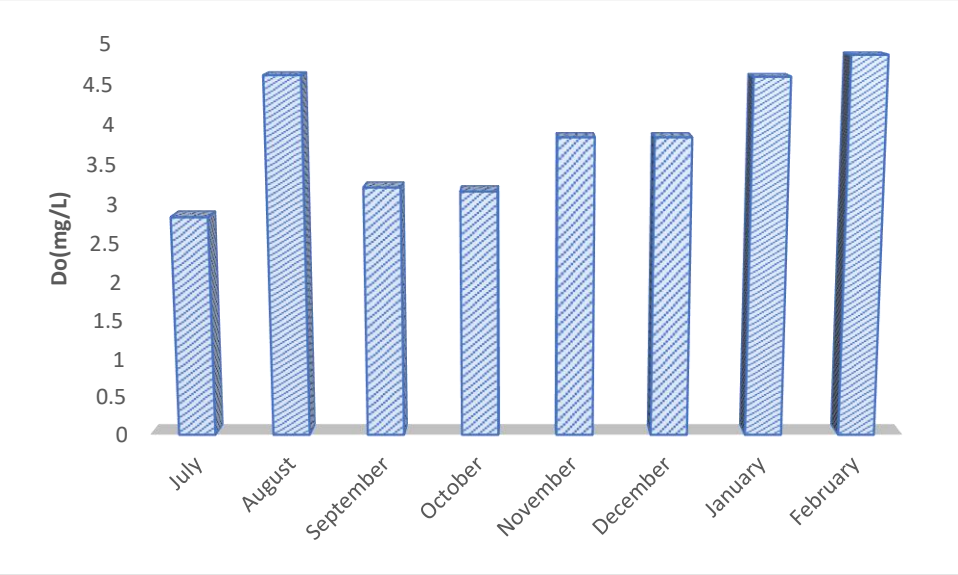


Figure 4.5 Monthly Variations in Dissolved Oxygen from July 2018 to February 2019

4.1.7 Biochemical oxygen demand (BOD)

The monthly variations in the value of biochemical oxygen demand (BOD) across the four stations are represented in Figure 4.6. The lowest value of Biochemical Oxygen Demand (BOD) was recorded in July, and the highest in August. A gradual decline from September to December. There was a gradual increase from January to February and the highest value was recorded in August.

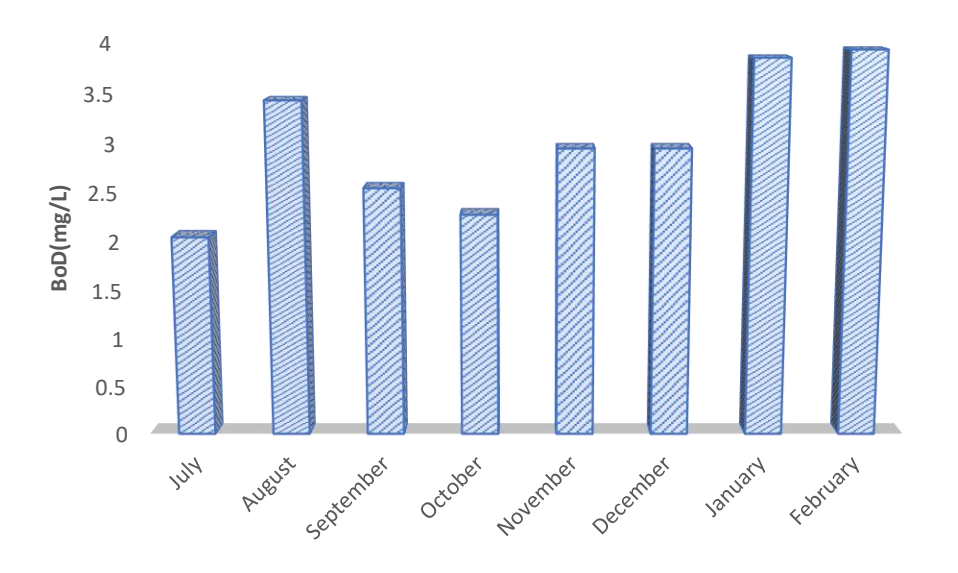


Figure 4.6 Monthly Variations in Biochemical Oxygen Demand from July 2018 to February 2019

4.1.8 Phosphate content

The monthly variations in the Phosphate across the four stations are represented in Figure 4.7. The lowest value of phosphate was recorded in December in Station 2. There was a relative increase in the value from August to December and a decline from November to December.

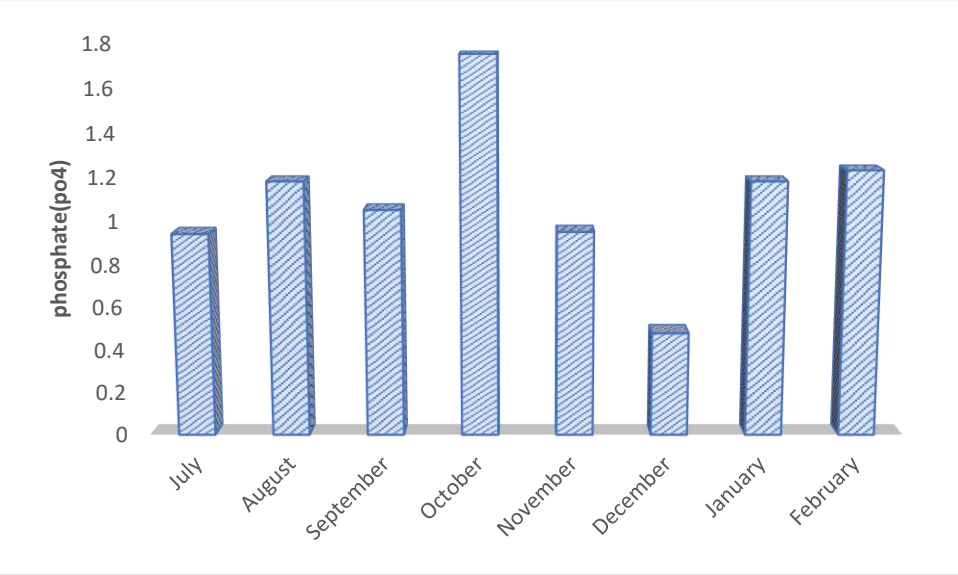


Figure 4.7 Monthly Variations in Phosphate content (PO_4) from July 2018 to February 2019

4.1.9 Alkalinity content

The monthly variations in the value of alkalinity across the four stations are represented in Figure 4.8. The alkalinity value of Station 2 gradually increased from July to November, a slight decline from July to August and later increased from August to November. The highest value was recorded in November, the values gradually decline from November to January. A slight increase was recorded between January to February; however, the lowest value was recorded in December.

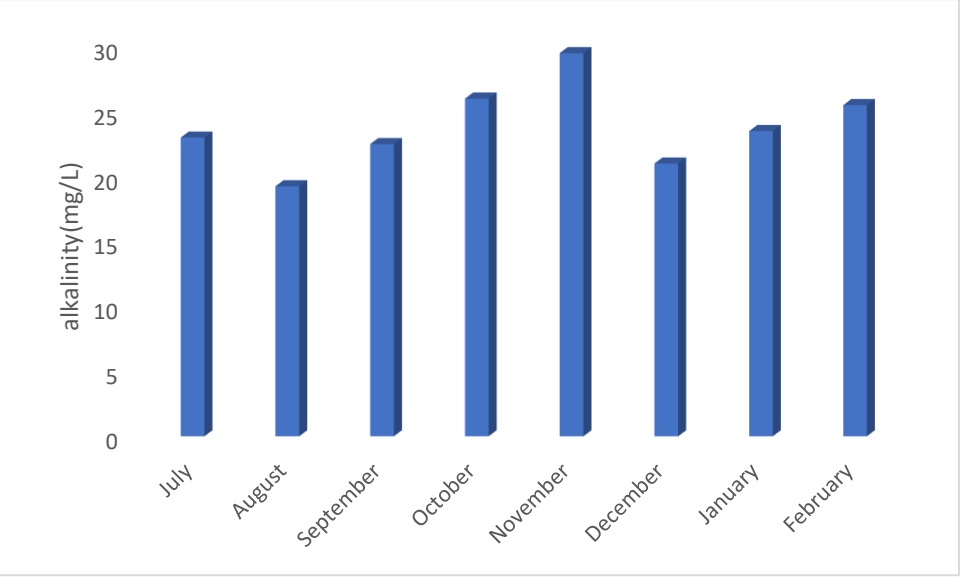


Figure 4.8 Monthly Variations in Alkalinity content from July 2018 to February 2019

4.1.10 Nitrate content

The monthly variations in the value of nitrate across the four stations are represented in Figure 4.9. The lowest value recorded was in September. The values were relatively stable from July to September and there was a sharp increase in October. A gradual decline from November to December and a sharp increase in February was recorded.

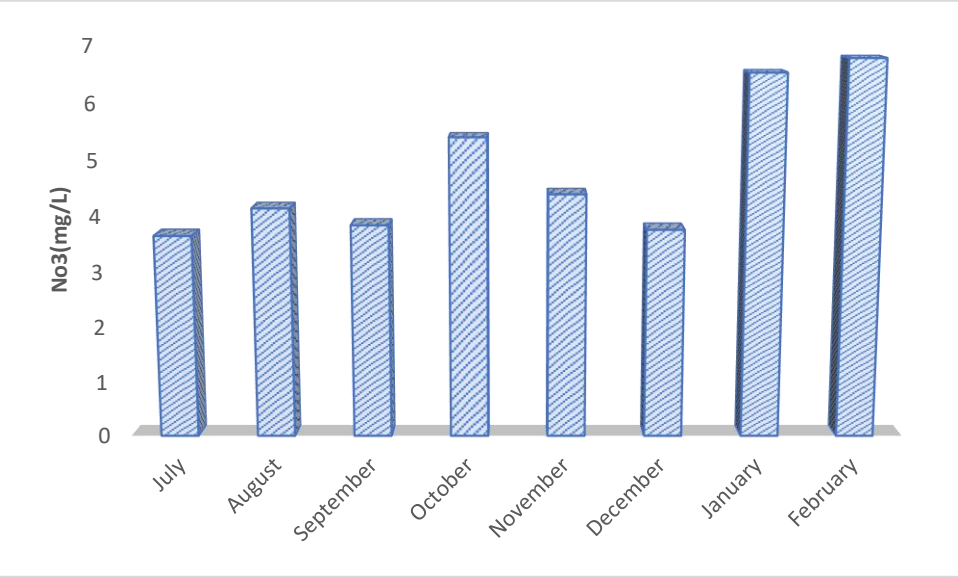


Figure 4.9 Monthly Variations in Nitrate content from July 2018 to February 2019

4.1.11 Total hardness

The monthly variations in the value of hardness across the four stations are represented in Figure 4.10. The highest value of total hardness was recorded in September especially in station 3. There is a gradual decline from September to January and a rise in February.

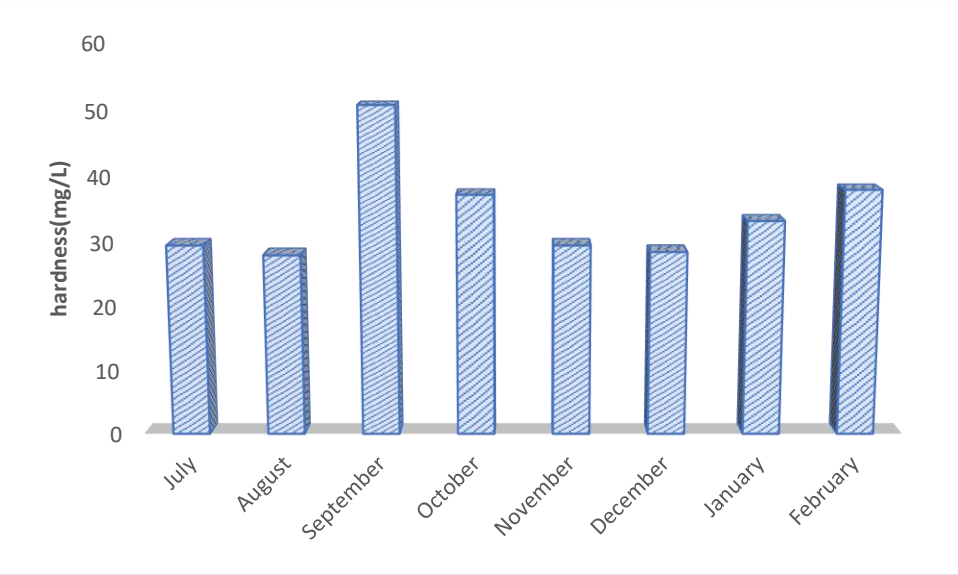


Figure 4.10: Monthly Variations in total hardness from July 2018 to February 2019

4.1.12 Analysis of stomach content.

The table 4.2 revealed stomach fullness analysis from the collected samples, 27 samples had ½ stomachs at (51.9 %) as indicated on the table, followed by fishes with content full stomach 12 at 23.1 %, followed by ¾ stomachs 8 at 15.4 % and the least are those with empty stomachs contents at 9.6 %.

Table 4.2 Analysis of Stomach Fullness of Fish Samples in Tungan Kawo Reservoir from July, 2018 to Feb, 2019

Fish species	Number sampled	Full stomach	½ stomach	¾ stomach	Empty stomach	Occurrence (%)
T. zillii	19	2	7	1	2	23.07
C. gariepinus	19	4	12	4	2	42.31
S. clarias	14	6	8	3	1	34.62

4.1.13 Gut Content of *Tilapia zillii*

Table 4.3 indicated that *T.zillii* feeds more on plant material and Algae at 35 % and 27.5 % respectively. It also shows the percentage at which they fed on fish remains and insect remains which are the lowest at 2.5% and 5.0 % respectively.

Table 4.3 Gut Content of *Tilapia zillii* from July, 2018 to Feb, 2019

Food Items	Food Occurrence	Frequency of Occurrence (%)
Plant materials	14.00	35.00
Detritus	9.00	22.50
Algae	11.00	27.50
Fish remains	1.00	2.50
Insects remains	2.00	5.00
Sand grains	3.00	7.50
Total	40.00	100

4.1.14 Gut Content of *Clarias gariepinus*

The feeding in these fishes showed that *Clarias gariepinus* fed more on insect's remains and plant materials as indicated on the Table 4.4 at 26.1 % and 23.9 % respectively. The *Clarias gariepinus* fed less on sand grains at 4.3 %, they also fed averagely on fish remains with a percentage of 19.6 %.

Table 4.4: Gut Content of *Clarias gariepinus* from July, 2018 to Feb, 2019

Food Items	Food Occurrence	Frequency of Occurrence (%)
Plant materials	11.00	23.90
Detritus	5 .00	10.90
Algae	7.00	15.20
Fish remains	9.00	19.60
Insects remains	12.00	26.10
Sand grains	2.00	4.30
Total	46.00	100

4.1.15 Gut Content of *Synodontis clarias*

Table 4.5 indicates the consumption of plant materials and detritus amongst *Synodontis clarias* collected from Tungan Kawo reservoir which have the highest percentages at 28 and 20 % respectively, followed by insect's remains at 16 %.

Table 4.5: Gut Content of *Synodontis clarias* from July, 2018 to Feb, 2019

Food Items	Food Occurrence	Frequency of Occurrence (%)
Plant materials	7.00	28.00
Detritus	5.00	20.00
Algae	3.00	12.00
Fish remains	3.00	12.00
Insects remains	4.00	16.00
Sand grains	3.00	12.00
Total	25.00	100

4.1.16 Proximate Analysis (%) of the three Fish Species from Tungan Kawo Reservoir Kontagora.

Table 4.6 showed the proximate composition of the three fish species from Tungan Kawo Reservoir, Kotangora. On the general note, the proximate analysis revealed that there was significant difference ($P<0.05$) in the proximate content among the three fish species examined. The Moisture content was significantly higher in *Tilapia zilli* (52.19±0.07 %) compared to the moisture content recorded for *S. clarias* (49.87±1.81 %) and *Clarias gariepinus* (45.94±2.56 %). There was no significant difference in the ash contents recorded for *S. clarias* (17.89±0.84 %) and *Clarias gariepinus* (16.48±2.37 %). There was no significant difference in the protein contents recorded for *Tilapia zillii* (19.76±0.13 %) and *S. clarias* (19.54±0.56 %). Similarly, fat content was found to be significantly lowest in *Tilapia zillii* (2.72±0.06 %). While, the highest fibre content was found in *Tilapia zilli* (4.79±0.36 %), there was no significant difference in the fibre contents recorded for *S. clarias* (3.98±0.06 %) and *Clarias gariepinus* (3.73±0.60 %). The carbohydrate contents was significantly highest in *S. clarias* (29.86±23.13 %) compared to the carbohydrate contents recorded for other fish species *Tilapia zillii* (16.97±1.39 %) and *Clarias gariepinus* (4.44±1.33 %).

Table 4.6: Proximate Composition of the Three Fish Species from Tungan Kawo Reservoir.

Samples	Moisture	Ash	Protein	Fat	Fibre	Carbohydrate
T. zillii	52.19±0.55[b]	17.89±0.84[b]	19.37±0.13[b]	2.72±0.16[b]	3.98±0.06[a]	3.85±23.13[b]
C. gariepinus	49.87±1.81[b]	16.48±2.37[b]	18.83±0.15[b]	3.34±0.40[a]	3.73±0.60[a]	7.75±1.39[b]
S. clarias	45.94±2.56[a]	15.30±0.43[a]	19.54±0.56[a]	3.43±0.46[a]	4.79±0.36[b]	11.00±1.33[a]

Values are mean $\pm$ Standard deviation, values followed by the same superscript(s), in the same column, are not significantly different at ($P \geq 0.05$) tested by DMRT

4.1.17 Essential, non-essential, acidic, basic, neutral, amino acid (g/100 g) protein of the three fish species.

Table 4.7 gave an illustration on the analysis of the essential, non-essential, acidic, basic, neutral, amino acid (g/100 g) protein of the three fish species. Amino acids content in the three fish species analyzed, Glutamic, Aspartic and Leucine had the highest concentration in all three fish species.

Table 4.7 Essential, Non-Essential, Acidic, Basic, Neutral, Amino Acid (G/100 g) Protein of the Three Fish Species.

AMINO ACID	*T. zillii*	*C. gariepinus*	*S. clarias*
Leucine (Leu)[e]	8.00	6.71	7.20
Lysine (Lys)[be]	6.60	5.35	7.66
Isoleucine (Ile)[e]	3.50	3.34	3.80
Phenylanine (Phy)[e]	3.55	4.00	4.10
Norleucine	-	-	-
Tryptophan(Try)[e]	1.05	0.90	0.94
Valine(Val)[e]	3.40	4.00	4.30
Methionine(Met)[e]	2.24	2.20	2.30
Proline (Pro)	3.86	3.45	4.46
Arginine (Arg)[be]	5.50	5.00	6.01
Tyrosine (Tyr)	3.10	3.10	3.10
Histidine (His)[be]	2.40	2.55	2.81
Cystine (Cys)	0.80	0,85	0.81
Alanine (Ala)	4.81	4.40	5.91
Glutamic (Glu)[a]	13.02	13.50	14.20
Glycine(Gly)	4.61	4.06	6.86
Threonine (Thro)[e]	4.11	3.66	3.94
Serine(Ser)	3.80	3.70	4.00
Aspartic (Asp)[a]	9.00	8.71	9.21

Key: a= acidic, b= basic and e= essential

4.1.18 Total amino acids, non-essential, neutral, acidic, basic, and essential of the three fish species (g/100 g).

The table 4.8 shows the total concentrations of all the amino acids in the three fish species with their percentages. It indicates that the highest concentration of Total Amino Acids (TAA) and Total Essential Amino Acids (TEAA) was in *Synodontis clarias* followed by *Clarias gariepinus* and *Tilapia zillii*.

Table 4.8 Total Amino Acids, Non-Essential, Neutral, Acidic, Basic, and Essential of the Three Fish Species (g/100 g).

Amino acids (%)	*Tilapia zillii*	*Clarias gariepinus*	*Synodontis clarias*
Total Amino Acids(TAA)	83.35	79.48	91.61
Total non-essential amino acid(TNEAA)	43.00	41.77	48.55
Total Neutral Amino Acids(TNAA)	47.28	44.37	51.72
Total Acidic Amino Acid (TAAA)	22.02	22.21	23.41
% TAAA	32.6	32.8	34.6
Total Basic Amino Acids (TBAA)	14.50	12.90	16.50
% TBAA	33.0	29.4	37.6
Total Essential Amino Acids (TEAA)	40.35	37.71	43.06
% TEAA	33.30	31.10	35.60

4.2 Discussion

All water parameters were within acceptable ranges for sustenance of aquatic life except phosphates according to (WHO, 2014). Generally, the reservoir showed higher concentrations of nitrate than phosphate with overall mean concentration of nitrate and phosphate ranging from 3.64 to 6.75 mg/L and 0.48 mg/L to 1.75 mg/L respectively. With the exception of nitrate which was found to be within the acceptable range for lentic ecosystems (0.003 to 7.00 mg/L), phosphate was above the recommended level ($P<0.05$ mg/L) (Wetzel, 2001). Through personal observations and interviews with some farmers, the higher levels of phosphate compounds could be attributed to the use of a high phosphate containing fertilizer (Root developer) with Nitrogen, Phosphorous and Potassium (N P K) ratio of 10: 50: 10 in vegetable farms along the banks of the reservoir. This result corroborates the observation of Abdullahi *et al.*, (2016), who observed the existence of nearby agricultural farms as responsible for the increase in nutrients in reservoirs.

The well-being of fish could be determined partly by the quality and quantity of food it eats. According to Bagenal and Braum, (2011) maximum size that a fish can reach may possibly be affected by the various food resources and their availability in its environment. Insect parts and benthic invertebrate species such as coleopterans, and caddis fly larvae were contents found in the stomach of specimens collected from Tungan Kawo Reservoir. Such a relatively wide variation in food exploited by the three populations, suggests the availability of these food items in the reservoir. This could be due to high nutrient levels in the water triggering the abundant growth of algae and other primary producers required for the sustenance of the aquatic food chain.

Analysis of stomach fullness showed that *Tilapia zillii* feeds more on plant material and Algae at 30 and 22.5% respectively. It is evident that *Tilapia zillii* are herbivores. This agrees with (Moshe, 2015) who suggested that adult Tilapia zillii preferentially select

small zooplankters. Nevertheless, this preferential selection is a result, not of visual collection of food particle, but of swimming and the escapability trait of the species preyed on. These small and poorer escaper organisms are consumed through pumping activity of the fish. The feeding also in these fishes showed that *Clarias gariepinus* feeds on insects remains and plant materials. The food of *Synodontis clarias* in Tungan Kawo was found to be made up of plant materials especially leaves and also detritus. Supplements of green algae and insects were recorded. It may be suggested that *Synodontis clarias* had an omnivorous feeding habit and are non-selective in feeding habits. A critical look at the food consumed by these fishes makes it possible to present the trophic interrelationship. Since *Clarias gariapinus* and *Synodontis clarias* feeds on aquatic insects and crustaceans which feed mainly on microphytes, plant remains and algal filaments, they are primary consumers making up the second tropic level (Fawole *et al.*, 2007). A critical look at the food consumed by these Fishes makes it possible to present the trophic interrelationship (Bob-Manuel, 2011).

The proximate composition shows the moisture content values were within range in this study with *Tilapia zilli* (52.19±0.07) % and *Clarias gariepinus* (45.94±2.56) %. The proximate composition moisture content of all the fish species sampled was within the range earlier reported (Osibona *et al.*, 2006; Effiong and Mohammed, 2008).

But when moisture content in fish is too high, it can speed up the microbial activities that cause spoilage, leading to the breakdown of unsaturated fats and reduced fish time of storage (Omolara and Omotayo, 2018). The disparity in the ash content value of 15.30 to 17. 98 g/100 g was observed due to differences in the species, the quantity and value of food consumed and the level of demand for energy needs (Murray and Burt, 2019).

The crude protein value of *Synodontis clarias* (19.54 g/100 g), *Tilapia zillii* (19.37 g/100 g) and *Clarias gariepinus* (18.83 g/100 g). The fish species examined belonged to high-protein (15-20 %) and low fat (<5 %), the high protein and moisture content values obtained from the proximate analysis agreed with other analysis carried out (Effiong and Mohammed, 2008). On the basis of macro-nutrient in fish, values of the protein and fat are used to determine the nutritional base of each species (Aberoumad and Pourshafi, 2010).

Also, the fat content value of 2.72 to 3.43.59 g/100 g signified they were all low-fat fishes. *Synodontis clarias* (3.43 g/100 g) had the highest fat content and was the first to be accepted in terms of the fat content value, followed by *Clarias gariepinus* (3.34 g/100 g) then *Tilapia zillii* (2.72 g/100 g) had the lowest fat content value which would be considered as lean fish.

The crude fibre value of 3.73 to 4.79 g/100 g was low in comparison with the value of 3.42 to 14.38 g/100 g of crude fibre reported for *O. niloticus* (Fawole *et al.*, 2007). Nevertheless, in this study *S. clarias* (4.79 g/100 g), *C. gariepinus* (3.73 g/100 g) and *T. zillii* (3.98 g/100 g) had roughages as seen in their individual crude fibre values.

The chemical composition of amino protein varied from individual to another depending on age, sex, environment and season. Of the three species samples analyzed for amino acid profile, Glutamic acid and the Aspartic acid constitute the dominant amino acid concentration, both of which are acidic amino acids. The other amino acid which is the most concentrated in the samples is Glutamic acid which is known to protect the liver by aiding the removal of ammonia. Cystine (Cys) is the least amino acid in all the three species analyzed with a range of 0.80-0.85 g/100 g protein. For interactive, cysteine and cystine can be interconvert. Two molecules of cysteine make

cystine. It acts as antioxidant. It protects against radical production, pollution, radiation and ultraviolet light. Essential in growth, maintenance, and repairing skin. Chemical sensitivity and food allergy are implicated as a result of deficiency (Ali *et al.*, 2015).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study determined feeding and nutritional status of *Tilapia zillii, Clarias gariepinus and Synodontis clarias in tungan kawo reservoir*. The mean and standard error of

physicochemical parameters measured for the three fish samples revealed a significant difference ($p<0.05$) between the months as the mean values fluctuated in all the months recorded. Stomach fulness analysis from the collected samples revealed majority had ½ stomachs at (51.9 %) comprising of various materials ranging from plant materials to fish and insect remains, detritus, algae and sand grains. *Analysis of gut contents of Tilapia zillii had more of plant materials indicating to be herbivores while Clarias gariepinus and Synodontis clarias* had more of insect remains and detritus showed that the two fish species had an omnivorous feeding habit.

The proximate analysis revealed that there was significant difference ($P<0.05$) in the proximate content among the three fish species examined. *The* moisture, ash, protein, fat fibre and carbohydrate content in the three (3) fish species *Tilapia zillii, Clarias gariepinus and Synodontis clarias* varied among the different fish species. The Moisture content was significantly higher in *Tilapia zilli* (52.19±0.07 %) compared to the moisture content recorded for *S. clarias* (49.87±1.81 %) and *Clarias gariepinus* (45.94±2.56 %). However, the moisture content was within the minimum range of 65-80 %.

Higher protein and lipid contents were observed from the samples. This was however not significant at ($P > 0.05$) with *Synodontis clarias* having the highest crude protein content (19.54±0.56) while *Synodontis clarias and Clarias gariepinus* have low fat content which can be said to be a low-fat fish while *Tilapia zillii* (2.72 g/100 g) had the lowest fat content value which would be considered as lean fish.

The concentrations of the Essentials, Non-essentials, Acidic, Basic and Neutral Amino acids content in the three fish species analyzed, Glutamic, Aspartic and Leucine had the highest concentration in all three fish species. The total concentrations of all the amino

acids in the three fish species indicates that the highest concentration of Total Amino Acids (TAA) and Total Essential Amino Acids (TEAA) was in *Synodontis clarias* (35.6) followed by *Tilapia zillii* (33.3) *and Clarias gariepinus* (31.1).

5.2 Recommendations

1. This study recommends studies on feeding pattern to be carried out to investigate temporal variability and diet feeding measure.
2. Awareness creation among local fishermen is necessary to avoid destructive fishing thus, helping juvenile fishes to grow and mature.
3. Special attention is needed in monitoring human activities which largely contribute to the reduction and pollution of the nutritional qualities of the fishes from Tungan kawo reservoir.

REFERENCES

Abdullahi, M. S., Uzairu, A., Okunola, O. J., & Balarabe, M. L. (2016). Seasonal quality assessment of agricultural soils along the bank of Tungan Kawo Dam, Kontagora, Nigeria. *Journal of Agricultural Chemistry & Environmental*, 5, 132-151.

Abdullahi, M. S., Uzairu, A., Okunola, O. J., & Balarabe, M. L. (2015). Distribution pattern of metals in sediment of Tungan Kawo Dam, Kontagora, Nigeria. *American Journal of Chemistry*, 5(4), 96-114.

Aberoumad, A. & K. Pourshafi, (2010). Chemical & proximate composition properties of different fish species obtained from Iran. *World Journal of Fish Marine Science*., 2: 237-239.

Abolude, D. S. (2007). Water quality & metal concentrations in sediments & fish from Ahmadu Bello University Reservoir, Zaria using Neutron Activation Analysis & Atomic Absorption Spectrophotometry. *An unpublished Ph. D. thesis submitted to Postgraduate School, Ahmadu Bello University, Zaria*, 136.

Abolude, D. S., & Abdullahi, S. A. (2015). Proximate & mineral contents in component parts of *Clarias gariepinus* & *Synodontis schall* from Zaria, Nigeria. *Nigerian Food Journal,* 23, 1-8.

Adeyemi, S. O., Akombo, P. M., & Toluhi, O. O. (2019). Food & feeding habits of *Oreochromis niloticus* in Lake Gbedikere, Bassa, Kogi State. *Continental Journal of Animal & Veterinary Research,* 1, 25-30.

Admassu, D., Abera, L., & Tadesse, Z. (2015). The food & feeding habits of the African catfish, *Clarias gariepinus* (Burchell), in Lake Babogaya, Ethiopia. *Global Journal of Fisheries & Aquaculture,* 3(4), 211-220.

Ajah, P. O. (2009). Fish breeding & hatchery management. *Jerry commercial productions, Calabar*, 183.

Akin-Oriola, G. A. (2003). On the phytoplankton of Awba reservoir, Ibadan, Nigeria. *Revista de Biologia Tropical,* 51:1.

Alasalvar, C., Taylor, K. D., Zubcov, E., Shahidi, F., & Alexis, M. (2012). Differentiation of cultured & wild sea bass (*Dicentrarchus labrax*): total lipid content, fatty acid & trace mineral composition. *Food Chemistry*; 79, 145-150.

Alberta Water Quality Awareness (AWQA) (2012). Dissolved Oxygen & Albe & Rivers, AlbertaSurfaceWaterQuality.scholar.google.com/scholar?q=Alberta+water+Quality+assesment&hl=en&as_sdt

Ali, M., Iqbal, F., Salam, A., Iram, S., & Athar, M. (2015). Comparative study of body composition of different fish species from brackish water pond. *International Journal of Environmental Science & Technology,* 2(3), 229-232.

American Public Health Association (APHA) (2013). *Standard Methods for the Examination of Water and Wastewater*, 25th edn (APHA, USA).

American Public Health Association (APHA) (2014). *Standard Methods for the Examination of Water and Wastewater*, 26th edn (APHA, USA).

Anon, A. D. (2000). Chemical & proximate composition properties of different fish species obtained from Iran. *World Journal of Fish Marine Sciences,* 2 (1) 237-239.

AOAC (Association of Official Analytical Chemicals) (2006). Official Method of Analysis of the AOAC (W. Horwitz Editor Eighteen Edition, Washington; D. C., AOAC.

Association of Official Analytical Chemicals (AOAC) (2013). Official Method of Analysis of the AOAC (W. Horwitz Editor Eighteen Edition, Washington; D. C., AOAC.

Ayoade, A., Fagade, S., & Adebisi, A. (2018). Diet & dietary habits of the fish *Schilbemystus* (Siluriformes: Schilbeidae) in two artificial lakes in Southwestern Nigeria. *Revista de Biologia Tropical (International Journal of Tropical Biology)*, 56(4), 1847-1855.

Bagenal, T. B., & Braum, E. (2011). Eggs & early life- history. In: Methods for assessment of fish production in freshwaters, (T. B. Bagenal, Eds.). *Black Well Scientific Publications, London*, 165-201.

Bankole, N.O. (2002). Physicochemical Characteristics of Water Samples Collected from River Sokoto, Northwestern Nigeria. *Atmospheric and Climate Sciences*, 5, 194-199.

Baxter, C. V., Fausch, K. D., & Carl Saunders, W. (2005). Tangled webs: reciprocal flows of invertebrate prey link streams & riparian zones. *Freshwater biology*, *50*(2), 201-220.

Baxter, C. V., Fausch, K. D., Murakami, M., & Chapman, P. L. (2004). Fish invasion restructures stream & forest food webs by interrupting reciprocal prey subsidies. *Ecology*, *85*(10), 2656-2663.

Bellingham, K. (2012). Physicochemical Parameters of Natural Waters: Stevens water monitoring systems. http://www.stevenswater.com/index.aspx

Bene, C., & Heck, S. (2005*).* Fish & food security in Africa. *NAGA World Fish Centre Quarterly*, 28, 8-13.

Benitez, L. V. (1989). Amino Acid & fatty acid profiles in aquaculture nutrition studies, p. 23- 35. in S.S. De Silva (ed.) Fish Nutrition Research in Asia. Proceedings of the Third Asian Fish Nutrition Network Meeting. *Asian fish. Society Special Publication*, 4, 166.

Bob-Manuel, F. G. (2011). Food & feeding ecology of the Mudskipper (*Periopthalmus koelreuteri*). (PALLAS) Gobiidae at Rumuolumeni Creek, Niger Delta, Nigeria. *Agriculture & biology Journal of North America*, 2(6), 897-901.

Boulton A. J. (2012). Temperature impacts on stream ecology, Water Encyclopedia http://www.waterencyclopedia.com/Re-St/Stream-Ecology-Temperature-Impacts-on.html

Cahu, C., Salen E, & Lorgeril, M. D. (2014). Farmed & wild fish in the prevention of cardiovascular diseases: Assessing possible differences in lipid nutritional values. *Nutrition Metabolism & Cardiovascular Diseases*, 14, 34-41.

Chen, C., Sander, J. E. & Dale, N. M. (2003). The effect of dietary lysine deficiency on the immune response to Newcastle disease vaccination in chickens. *Avian Diseases*, 47(4), 1346–1351.

Cutwa, M. M., & Turingan, R. G. (2000). Intralocality variation in feeding biomechanics & prey use in *Archosargus probatocephalus* (Teleostei, Sparidae), with implications for the ecomorphology of fishes. *Environmental biology of fishes*, *59*(2), 191-198.

Dadebo, E. (2009). Filter-feeding habit of the African catfish *Clarias gariepinus* Burchell, 1822 (Pisces: Clariidae) in Lake Chamo, Ethiopia, *Ethiopian Journal of Biological Sciences*, 8(1), 15-30.

Dadebo, E. (2010). Reproductive biology & feeding habits of catfish, *Clarias gariepinus* Burchell (Pisces: Clariidae) in Lake Hawassa, Ethiopia. *Ethiopian Journal of Science.* 23, 231-246.

Dadebo, E., Aemro, D., & Tekle-Giorgis, Y. (2014). Food & feeding habits of the African catfish *Clarias gariepinus* (Burchell, 1822) (Pisces: Clariidae) in Lake Koka, Ethiopia. *African Journal of Ecology*, 52, 471-478.

De Bandt, J. P. & Cynober L. (2006). Therapeutic use of branched-chain amino acids in burn, trauma, & sepsis. *Journal of Nutrition*, 185(1) 308–313.

Edegbena, A. O., & Agbaja, J. E (2014). Effect of some environmental variables on the community structure of zooplankton in Tungan Kawo (Wushishi Dam), Niger State, North Central, Nigeria. *Journal of Aquatic Sciences*, 29(2), 14-16.

Effiong, B. N., & Fakunle, J. O. (2011). Proximate & mineral composition of some commercially important fishes in Lake Kainji, Nigeria. *Journal of Basic Applied Science Research*, 1(12), 2497-2500.

Effiong, B.N & Mohammed, I (2008) effect of seasonal variation on the nutrient composition in selected fish species in Lake Kainji, Nigeria. *Nature & Science*, 6 (2) 1-5.

Ekwenye U. K & Oji C. A., (2008). Quality of water from boreholes in Umuahia, Nigeria," *Environment & Ecology*, 26, 543– 545.

Elagba, H. A. M., Rabie, A. & Mansour, H. M. (2010). Proximate composition, amino acid & mineral contents of five commercial Nile fishes in Sudan. *African Journal of Food Science*, 4(10), 650-654.

EPA (2010) National Drinking-Water Regulations. *Code of Federal Regulation*

Etzel, F. M. R. (2004). Manufacture & use of dairy protein fractions. *Journal of Nutrition*, 134(4), 996–1002.

FAO (2005): United Nations Food & Agriculture Organization, Nutritional elements of fish. FAO, Rome.

Fawole, O. O., Ogundiran, M. A., Ayandiran, T. A. & Olagunju, O. F. (2007). Proximate & mineral composition in some selected fresh water fishes in Nigeria. *International Journal of Food Safety*, 9, 52-55.

Fernstrom, J. D. & Fernstrom, M. H. (2007). Tyrosine, Phenylalanine, & Catecholamine Synthesis & Function in the Brain1–3. *American Society for Nutrition*, 1539-1547.

Food and Drinks Federation (FDF) (2009). Nigeria National Aquaculture Strategy. Assisted by FAO. Formally approved by Government. 18.

Foran, J. A, Carpenter, D. O, Hamilton, M. C, Knuth, B. A. & Schwager, S. J. (2005). Risk-based consumption advice for farmed Atlantic & wild pacific salmon contaminated with dioxins & dioxin- like compounds. *Environmental Health. Perspective*. 33, 552-556.

Heok-Hee, G. (2013). *Clarias insolitus*, a new species of clariid catfish (Teleostei; Siluriformes) from southern Borneo. *Journal of Zootaxa,* 284, 1-8.

Hernandez, M. D., F. J. Martinez & Garcia, B. (2001). Sensory evaluation of farmed sharpsnout seabream (*Diplodus puntazzo*). *Aquaculture International Journal*, 9, 519-529.

Hyland, K. (2007). Inherited disorders affecting dopamine & serotonin: critical neurotransmitters derived from aromatic amino acids. *Journal of Nutrition*, 137(6), 1568–1572.

Ita, O. A. (2003). Physico-chemical parameters for testing of water – A review *International Journal of Environmental Sciences,* 3 (3).

Jayakumar. P., Jothivel, N., Thimmappaand, A. & Paul, V. I. (2009). "Physico-chemical characterization of a lentic water body from Tamil Nadu with special reference to its pollution status," *The Ecoscan*, 3,(1-2), 59–64.

Job, B. E., Anta, I. E. E., Iniang-Etoh, A. P., Otogo, G. A. & Ezekiel, H. S. (2015). Feeding & condition factor of the brackish River Prawn *Macrobrachium macrobradion* (Herklots, 1851), *Pakistan Journal of Nutrition*, 14(4), 195.

Jordán, F., Liu, W. C. & Davis, A. J. (2006). Topological keystone species: measures of positional importance in food webs. *Oikos, 112*(3), 535-546.

Kelly-Addy, M. S., Linda Green M. S. & Elizabeth, H. M. A. (2004). pH & Alkalinity, URI Watershed Watch program; Department of Natural Resources Science, College of the Environment & Life Sciences, University of Rhode Isl&; http://www.uri.edu/ce/wq/ww/Publications/pH%26alkalinity.pdf

Kenneth, M. M., Judith, A. N. & Enock, O. W. (2014). Trophic ecology of some common juvenile fish species in Mtwapa Creek, Kenya. *Western Indian Ocean Journal of Marine Science,* 3(2), 179-187.

Kim B, J. H. Park, G., Hwang, M. S. Jun, & K. Choi, (2001). "Eutrophication of reservoirs in South Korea," *Limnology,* 2(3), 223–229.

King, A. J., Humphries, P. S. & Lake, P. (2013). Fish recruitment on floodplains: the roles of patterns of flooding & life history characteristics. *Canadian Journal of Fishery & Aquatic Science,* 60, 773-786.

Kudsk, K. A. (2006). Immunonutrition in surgery & critical care. *Annual Review of Nutrition,* 26, 463–479.

Lagler, K. F., Bardch, J. E., Miller, R. R. & Passino, D. R. M. (2003). *Ichthyology.* 2nd Ed, John Wiley & Sons. New York. 506.

Lawson, E. O. & Aguda, A. F. (2010). Growth patterns, diet composition & reproductive biology in ten pounder, *Elopslacerta* from Ologe lagoon, Lagos, Nigeria. *Agricultural Biology Journal of North America*, 1, 974–984.

Liao, S. M., Du, Q. S., Meng, J. Z., Pang, Z. W. & Huang, R. B. (2013). The multiple roles of histidine in protein interactions. *Chemistry Central Journal*, 7, 12-17.

Louka, N., Juhel, F., Fazilleau, V. & Loonis, P. (2004). A novel colorimetry analysis used to compare different drying fish processes. *Food Control*, 15, 327-334.

Manon, M. R. & Hossain, M. D. (2011). Food & feeding habit of *Cyprinus carpio* var. specularis. *Journal of Science Foundation,* 9(2), 163-181.

Mischoulon, D. & Fava, M. (2002). Role of S-adenosyl-L-methionine in the treatment of depression: a review of the evidence. American Journal of Clinical Nutrition, 76(5), 12-19.

Mohammed, A. Z., Agbaja, J. E., & Arimoro, F. O. (2016). Zooplankton community response to deteriorating water quality in Tungan Kawo (Wushishi Dam), North Central, Nigeria. *International Journal of Innovative Research & Advanced Studies*, 3(4), 51-56.

Mohanty, B., Mahanty, A., Ganguly, S., Sankar, T. V., Chakraborty, K. I., Rangasamy, A., Paul, A. B., Sarma, D., Mathew, S., Asha, K. K., Behera, B., Aftabuddin, M, & Debnath, D., (2014). Amino Acid Compositions of 27 Food Fishes & Their Importance in Clinical Nutrition. *Journal of amino acids.* 4, 7-13.

Moses S., Agbaji E. B., Ajibola, V. O. & Gimba, C. E. (2018). Amino Acid composition and proximate analysis in tilapia (*Oreochromis Mossambicuss*) fish from Dams and rivers in Zamfara State, Nigeria. *Journal of applied science environmental management,* 22 (6), 8899-8905

Moshe, G. (2015). Fish-Zooplankton-A predator-Prey relationships as a Key Factor for the Design of Zooplankton Distribution Sampling Program in Lake kinneret, Isreal. *Open Journal of Modern Hydrobiology*, **7**, 209-222.

Mozaffarian, M., D, Rozenn, N. L., Lewis, H. K., Gregory, L.B., Russell, P.T., & Davis, S. S. (2003). Cardiac benefits of fish consumption may depend on type of fish meal consumed. *Circulation*. 107, 1372-1382.

Murray, J., & Burt, J. R. (2019). The composition of fish, Torry Advisory Note No.3, www.fao.org/wairdocs/tan/x5916e/x5916e00.htm.

Mushini, V. S., Vaddi, R. D. & Bethapudi, S. A. A. (2012), "Assessment of quality of drinking water at Srikurmam in Srikakulam district, &hra Pradesh, India. *International Research Journal of Environment Sciences*, 1(2), 13–20.

Nakano, S. & Murakami, M. (2001). Reciprocal subsidies: dynamic interdependence between terrestrial & aquatic food webs. *Proceedings of the National Academy of Sciences*, *98*(1), 166-170

Ndome, C. B. & Victor, R. (2002). Food & feeding habits of Epiplatys senegalensis (Pisces: Cyprinodontiformes; Cyprinodontidae) in a black water pond in Benin City, Southern Nigeria. West Africa. *Journal of Applied Ecology*, 3, 105-117.

Nestel, P. J. (2000). Fish oil & cardiovascular disease: Lipids & arterial function. *American Journal of Clinical Nutrition*, 71: 228-231.

Nestel, P. J. N. (2011). Fish oil & cardiovascular disease: lipids & arterial function. *American Journal of Clinical Nutrition*, 71, 228-231.

Nwani, C. D., Eyo, J. E., & Udeh, E. F. (2006). Food & feeding habits of *Campylomormyrus Tam&ua* in Anambra River, Nigeria. *Animal Research International*, 3(1), 410-414.

Oladipo, I. C., & Bankole, S. O. (2013). Nutritional & microbial quality of fresh & dried *Clarias gariepinus* and *Oreochromis niloticus*. *International Journal of Applied Microbiology and Biotechnology*, 1, 1-6.

Omolara, O. O., & Omotayo, O. D. (2018). Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. *Biochemistry Journal*, 21, 1-7.

Onwuka, G. I. (2015) Food analysis & instrumentation, proximate composition of food minerals. 1st ed. Naplithali Print, A Divisuion of H.G. Support Nigerian Ltd, Nigeria, 64, 81-114.

Osibona, A. O., Kusemiju, K. & Akande, G. R. (2006). Fatty acid composition & amino acid profile of two freshwater species African catfish (*Clarias gariepinus*) & Tilapia (*Tilapia zillii*). *African Journal Food Agricultural Nutritional Development*, 9, 608-621.

Quinton, E. P., Kipp, A. P., Steven, R. C., & David, W. W. (2017). A method for determining stomach fullness for planktivorous fishes. *North American Journal of Fisheries Management*, 27, 932-935.

Ramachandra, T. V. & Malvikaa, S. (2007). Ecological Assessment of Lentic Water Bodies of Bangalore. *ENVIS Tecnnical Report*: 25. http://ces.iisc.ernet.in/biodiversity

Ravichandran, S., K. Kumaravel L. O., & Florence, E. P. (2011). Nutritive composition of some edible fin fishes. *International Journal of Zoological Research*, 7, 241-251.

Rezende, C. F., Caramaschi, E. P., & Mazzoni, R. (2008). Fluxo de energia em comunidades aquáticas, com ênfase em sistemas lóticos. *Oecologia Brasiliensis*, 12(4), 626-639.

Shamsan, E. F. & Ansari, Z. A. (2010). Biochemical composition & caloric content in sand whiting *Sillago sihama* (Forsskal), from Zuari Estuary, Goa. *Indian Journal of fish*, 57, 61-64.

Sheila, M. (2007). General Information on Solids. *BASINS*. City of Boulder/USGS Water Quality Monitoring. http://bcn.boulder.cous/basin/index.html.

Singh, D. K., & Singh, I. (2008). Interrelationship of certain physico-chemical parameters with plankton community of Motipur Ox-bow lakes (Muzaffarpur, Bihar), *Environment & Ecology*, 26(2), 800–803.

United Nations Environment Programme (UNEP) (2006). National Primary Drinking Water Regulations: Stage 2 Disinfectants & Disinfection Byproducts Rule. U.S. Environmental Protection Agency. *Federal Register*, 7(2), 388-493.

Vandysh, O. I. (2004). Zooplankton as an indicator of the state of lake ecosystems polluted with mining wastewater in the Kola Peninsula. *Russian Journal of Ecology*, 35(2), 110–116.

Varljen, J., Sulic, S., Brmalj, J., Baticic, L., Obersnel, V. & Kapovic, M. (2013). Lipid classes & fatty acid composition of *Diplodus vulgaris* & *Conger conger* originating from the Adriatic Sea. *Food Technology Biotechnology*, 41, 149-156.

Vignesh, R. & Srinivasan, M. (2012). Nutritional Quality of Processed Head & Bone Flours of Tilapia (*Oreochromis mossambicus)*, Peters (1852) From Parangipettai Estuary, South East Coast of India. *Asian Pacific Journal of Tropical Biomedicine*, 2(1), 368-372.

Waterman, J. J. (2000). Composition & quality of fish. Torry Research Statation, Edinburgh.

Wetzel, R. G. (2001). Limnology Lake & Reservoir Ecosystem, Academic Press, San Diego.

WHO Geneva, (2011), Guidelines for drinking-water quality (electronic resource), 3rd edition incorporating 1st & 2nd addenda, Volume 1, Recommendations.

WHO. (2008) Guidelines for Drinking-water Quality (electronic resource): incorporating 1st & 2nd addenda, 3rd ed.

WHO. (2014) WHO/UNICEF Joint Monitoring Programme for Water Supply Sanitation & Hygiene (JMP)