PHYSICO-CHEMICAL PARAMETERS AND FISH SPECIES DIVERSITY OF DADIN-KOWA RESERVOIR, GOMBE STATE, NIGERIA

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BY

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DEDICATION

This work is dedicated to my dear mother Hajia Maryam Kumo and my little angels Maryam, Faruq and Kamal.

DECLARATION

I hereby declare this dissertation entitled ‘’Physico-chemical parameters and fish species diversity of Dadin-Kowa reservoir, Gombe State, Nigeria’’ has been performed by me in the Department of Biological Sciences, Ahmadu Bello University, Zaria. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this project thesis was previously presented for another degree at this or any other institution.

YERIMA RASHIDA …….. ……

Signature Date

CERTIFICATION

This thesis entitled **"Physico-chemical parameters and fish species diversity of Dadin-Kowa reservoir, Gombe State, Nigeria''** by YERIMA Rashida, meets the regulations governing the award of the Degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

The study was conducted to determine the monthly variation in some physico-chemical parameters, fish species composition and diversity, and condition factor of the resident fish species in Dadin-Kowa reservoir. The water electrical conductivity and total dissolved solids, and pH were measured by Hanna conductivity meter model EC 215 and pH meter model H198107. Other parameters which include: water temperature, waterdepth**,** transparency, dissolved oxygen (DO), biochemical oxygen demand (BOD), carbon dioxide and water hardness were measured using standard methods. The fish samples were identified using standard descriptions keys. The Shannon Weiner diversity index was used to determine the diversity of fish species in the reservoir. One-Way Analysis of Variance (ANOVA) was used to test for significant differences in species diversity among stations and Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist. Student's T – test was used to compare the variation in physico-chemical parameters and fish diversity in dry and wet seasons. There was high significant ($P \leq 0.05$) variation in the physico-chemical parameters with months in the reservoir except for water depth, carbon dioxide and hardness. There was high positive association between BOD and DO (r =1.00) and between carbon dioxide with EC and TDS (r = 0.80). Temperatures showed moderate significant positive relationship with carbon dioxide, BOD and DO. A positive and significant association was observed between TDS and EC. Water depth was found to significant negative association with temperature, EC, BOD, TDS, DO and carbon dioxide. Of the total 690 fish sampled, thirty (30) fish species representing eleven (11) families were identified. The family Mormyridae had the highest number of species (6) followed by the family Mochokidae (5) then the families Alestidae, Cyprinidae,Clariidae and Claroteidae while the families Malapteruridae, Polypteridae and Schilbeidae had the least number of species each. The highest percentage was in the family Mormyridae with 20.0% fish followed by

Mochokidae with 16.7%. The family Malapteruridae, Polypteridae and Schilbeidae with 3.3% had the least catch. Of the total of 690 fish sampled, the highest percentage of 18.99% fish belongs to the genus *Petrocephalus*, followed by *Heterobranchus* with 16.23%. The least catch was in the genus *Malapterurus* with 0.72% fish. Out of total fish species sampled *Mormyropsanguilloides, Clariasanguillaris*and *Schilbemystus* had 14.5%, 8.7% and 8.6% respectively of the fish composition. *Labeosenegalensis* and *Synodontisbudgetti*had 6.9% and 5.8% respectively. While the remaining fish species had percentage occurrence of less than 5%. There was significant variation ($P \leq 0.05$) in the number of fish species sampled monthly in the reservoir. The highest diversity index of 2.056 was in the family Cyprinidae. The least index value of 1.32 was obtained in the family Claroteidae. The degree of evenness of the families was lowest (0.8296) in Alestidae and highest (0.976) in Cyprinidae. The family Malapteruridae with the least individuals had the least dominance while the family Cichlidae had the highest value of 0.188. The genera *Hyperopisus, Mormyrops*and *Malapterurus*had the lowest indices while *Petrocephalus, Clarias, Barbus*and *Oreochromis*had the highest number of fish species. Highest condition factors of 1.1 and 1.09 were observed in *Brycinusmacrolepidotus*and *Malapterurusminjiriya* respectively. Lower values of 0.31 and 0.30 were obtained in *Chrysischthysnigrodigitatus*and *Momyropsanguilloides* respectively. This indicates that the fish species in this study showed good physiological state and health condition.The study revealed marked monthly variation in the physicochemical factors, rich fish composition with important economic species and variation in condition factor of highly diversified fish community structure in the reservoir. It is hereby recommended that regular monitoring of the physicochemical parameters of water and sustainable management of the fisheries resources of the reservoir be encouraged.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The rapid urbanization of many towns and cities across the world necessitate theconstruction of reservoirs to supply these towns with potable pipe borne water. Dadin-Kowareservoir is one of such water bodies located in the north east of Nigeria in Gombe State. It supplies municipal water to Dadin-Kowa,YamaltuDeba Local Government Area and other parts of Gombe State. Reservoirs apartfrom their primary function also have secondary uses for fisheries and irrigation of farmlands(Ahmed and Philip, 2012).

Water is an essential component for life on earth. It contains minerals which are extremelyimportant in human nutrition (Versari *et al.,* 2002). However, the drastic increase inpopulation results in an enormous depletion (Ho *et al*.,2003). It is observed that human activities are a major factor determining the quantity and quality of thewater through atmospheric pollution, effluent dischargesand use of agricultural chemicals,eroded soils and land use (Sillanpa *et al.,* 2004).As pointed out by Kofi(2001), freshwater is indispensable and is sensitive ashuman activities have great impact on the quantity and quality of freshwater: both thequality and quantity of our planet's freshwater are under threat.

According to Roy and Mazumdar (2005), the use of water in the world has increasedby more than 35 times over the past three centuries and recent estimate shows that 3240km^3 offreshwater is withdrawn globally on annual basis. A major portion of this (69%) is used foragriculture, 23% for industry and the remaining 8% for domestic use.Owing to inadequatemanagement of wastes, freshwater potential has been reduced due to widespreadpollution. Studies have shown deterioration of water quality and low faunal abundance anddiversity caused by stress imposed by effluents from land based sources (Chukwu andNwankwo, 2005). If left unchecked, these ecosystems will cause a

seriousthreat to aquatic life as well as to man due to continuous depletion and eventual extinction of some fishspecies.Biodiversity is the variability among living organisms from all sources includingterrestrial, marine and other aquatic ecosystem and ecological complex of which they are part(Ali, 1999). The diversity of fish mainly depends upon the biotic factors and types ofecosystem (Nanda and Tiwari, 2001). Climatic characteristics influence the waterquality and quantity and that invariably affects biodiversity.

The general desire to protect freshwater fisheries has led to an expansion of research into their quality requirements in their habitat in terms of physico-chemical parameters such as pH, temperature,dissolved oxygen, transparency, salinity and electrical conductivity etc. Thesefactors serve as base for the richness or otherwise of biological production of any aquaticenvironment (Imevbore, 1990).Several of these physico-chemical parameters have been studied on large man-madelakes in Nigeria by Adeniji and Ita (1977) and Adeniji (1981). Other works on physico-chemical parameters include that of Balarabe (1989) on Makwayelake, Oniye*et al*. (2002)on A.B.U. reservoir, Ugwumba and Ugwumba (1993) on Awbalake in Ibadan.Kolo andOladimeji (2004) studied the water quality and some nutrients level of Shiroro lake, Niger State.

Reservoirs have helped to harness water for drinking, irrigation, and industrial uses andhave also brought about lacustrine conditions which are conducive in the maintenance of thefish stock that can be exploited through capture fisheries and aquaculture.It is necessary to maintain reservoirs by addressing the consequences of presentand future threats of contamination and degradation of our water bodies. Azionu (2004)showed that the soil structure and composition, natural environmental hazards,biochemical oxygen demand, dissolved oxygen, pH, temperature, transparency , e.t.c. allinfluence the quality of the medium which in turns determine the health of the fish and theirperformance.Dadin-Kowa reservoir was created through impoundment of River Gongola in 1984 by the Federal Government of Nigeria with the goal of providing irrigation and electricity for theplanned Gongola Sugar Plantation Project.

1.2 Statement of Research Problem

The distribution of fish species is affected by biotic and abiotic factors (Kadye *et al.*,2008). Akbulut (2009) reported some physicochemical parameters to significantly restrict survival, growth and distribution of fish. The Nigerian inland water bodies are primarily utilized for fishing by fisher folks (Adaka *et al.*, 2014). Fisheries resources are on the decline in Nigeria due to over exploitation and inadequate management of her coastal waters (Lawson and Olusanya, 2010). Human activities, population growth, oil exploitation and exploration have been identified to alter the ecology of inland waters in Nigeria (Keremah *et al*., 2012).

Dadin-Kowa reservoir is a multiple used water body intended for hydro-electricitygeneration,irrigation and domestic use to serve Gombe, Bauchi and southern parts of Borno State.Multiple - use of water bodies can result in pollution with drastic effect on aquatic lives.Paucity of information on the present physical and chemical properties of Dadin-Kowa reservoir has necessitated this research.

1.3 Justification

The study of the physico-chemical parameters of an aquatic ecosystem is basic for understanding its biological productivity. Although each factor plays its individual role but it is the synergistic effect of various parameters which determines the composition and productivity of the flora and fauna. Conducive range of these factors is essential for obtaining optimum fish production (Bisht *et al*., 2013). For sustainability of fisheries resources in Nigeria, an adequate knowledge of species

composition, diversity and relative abundance ofish resources must be understood and vigorously pursued (Lawson and Olusanya, 2010).

Information on the physico-chemical parameters and current fish species diversityof the reservoir is necessary for proper documentation and vital for sustainable management of the reservoir. Also, this study will provide information on the degree of pollution through determination of the physico-chemical factors of the reservoir, serving as pointers to the magnitude of deleterious anthropogenic activities.

1.4Aim and Objectives

The aim of the study was to evaluate the variation in the physico-chemical parameters and fish species diversity of Dadin-Kowa reservoir.

The specific objectives were:

i. To determinethe physico-chemical parameters of Dadin-Kowa reservoir.

ii. To determine the fish species composition and diversity in the reservoir.

iii. To determine the length-weight relationship and the condition factor of some selected species of theresident fish species in the reservoir.

1.5 Research Hypotheses

i. The physico-chemical parameters of Dadin-Kowareservoir are within acceptable limits.

ii. Dadin-Kowa reservoir is not rich in fish species composition.

iii. There is no significant difference in the length-weight relationship and the condition of factor of fish species in the reservoir.

CHAPTER TWO

LITERATURE REVIEW

2.1 Water as a Natural Resource

Water is absolutely essential for life; it is undoubtedly the precious natural resource that exists on the planet.The quality of water available and accessible to a community has tremendous impact on their living standard and well-being, thus global and local efforts are widespread at ensuring adequate provision of clean and safe water to the worlds' growing population (DWAF, 2003).

Water is a fundamental component of life; it is integral to thesurvival of organisms in terms of food, domestic and industrial production. Water is a majornatural resource and environment for the aquatic organisms (Blackmore, 2000).It is an elixir of life. Water governs the evolution and function of the earth. The aquatic ecosystems cover 70 % of the surface of the Earth. USGS (2006) reported marine water to constitute 97 % of the water available on earth. Freshwater represents 2.2 – 2.75 %, of the total water on earth of which less than 0.01 % of that occur as surface water in lakes, swamps and rivers. Freshwater has become a scarcecommodity due to over exploitation and pollution(Gupta *et al*. 2011).

Reservoirs are man-made water bodies constructed for domestic use such as irrigation, navigation and hydro-electricity generation. Freshwater ecosystems have been used in the investigation of factors controlling the abundance and the distribution of aquatic organisms. (Atobatele and Ugwumba, 2008; Esenowo and Ugwumba, 2010).The creation of large reservoir in a river environment could affect the socio-economicstatus both at the upstream and the downstream sectors of the entire catchment-basin(Blackmore, 2000).A healthy reservoir is dependent upon the

physico-chemical and biological characteristics(Venkatesharaju*et al.*, 2010). Water quality has been known to play an important role in public health, recreational useand aquacultural capability of reservoirs (Ibrahim *et al*., 2009).Oniye *et al*., (2002) reported thateutrophication brings changes in water quality leadingtoalteration or even total destruction of the food web. Campbell and WildBerger (2001)observed that abundance,diversity and distribution of aquatic organisms have been influenced bywater quality.

2.2 Physico-Chemical Parameters of Water

2.2.1 Water Temperature

Water temperature is the degree of hotness or coldness of water. Temperature is dependent on the changes in other environmental conditions. Temperature influences fish by controlling theirreproductive cycles, feeding, metabolic rate, growth rate and distribution (Constant, 1975).Jackson and Ye (2000) reported that temperature could affect fish stock structure throughfood production.

Wetzel (1983) reported that the main abiotic factors whichdetermine the suitability of an environment are temperature and dissolved oxygen. Thereexists a direct relationship between temperature and dissolved oxygen. More dissolved oxygen is present in water with a lower temperature compared to water with a higher temperature.

Jackson and Ye (2000) described the influence of temperature on thermal stratification. McConnell (1975) reported that respiration, photosynthesis and nutrient uptake are dependenton temperature.

2.2.2 Water Depth

Dugan (2004) reported that one of the most important morphometric considerations is the mean depth which is believed to determine the productivity of a reservoir. Thisis based on the fact that shallower reservoirs are more productive than deep reservoirs whose depth

serve as sink where organic matter accumulate and thus the nutrients are unavailable at the photosynthesis zone. Bako *et al.*,(2005) pointed out that siltation is a major problem to lentic habitat as it seriously reduces the depth of the reservoirs. Wetzel(1983) stated that water level fluctuation is inversely related to the temperature, that is to say, the lower the depth, the more exposed the water is to direct sunlight and the higher the temperature and vice-versa.

2.2.3 Transparency

Transparency is the degree of accessibility to viewor the amount of lightthat can penetrate a given water body. Light penetration is important in reservoirsbecause of photosynthesis. The turbidity of water reduces the amount of light penetration,which will in turn lower the rateof photosynthesis. Bilotta and Brazier (2008) reported that suspended solids can influence macrophytes and algae, primarilythrough affecting the amount of light penetrating through thewater column. The reduction in light penetration could restrict the rate at which periphyton andemergent and submersed macrophytes can assimilate energythrough photosynthesis, which will impact directly onprimary consumers.Ibrahim *et al*., (2009) showed that flood water during the rainy season that fill up man-made reservoirs after the draw down are usually turbid and accompanied with high level ofsuspended particles which reduce the transparency of reservoir's water. Turbid conditionsare also attributed to both autochthonous and allochthonous materials from the catchments.High turbidity could also be due to planktonic organisms or clay particles (Kolo and Oladimeji,2004).

2.2.4 Water pH

The pH is the measure of the acidity or alkalinity of water. Water contains H^+ (hydrogen) ions and OH^-(hydroxyl) ions. If a water sample being measured contain more H^+ ions than OH^-

ions, it is considered acidic. If on the other hand it contains more OH^- ions that H^+ it is considered basic. Low pH causes a decrease in metabolism. The pH of water is related to large number of dissolved substances and therefore a good indicator of water quality (Kalff, 2003).Kendirim (2000) reported that maximum pH values coincided with period of high phytoplankton activity as a result of depletion of carbon dioxide by photosynthetic activity of the phytoplankton. Boyd (2008) showed that the desirable pH range for fish production is between the ranges of 6.5 to 9.0.

2.2.5 Electrical Conductivity (EC)

Conductivity is a general indicator of water quality (Thomas *et al.,* 1996). It is also themeasure of the amount of ions present in a water body and it can be used to measureproductivity and fisheries potential. Conductivity and mean depth of areservoir can be used to calculate the potential fish yield. Chapman andKimstach (1996) reported that conductivity is sensitive to variation in dissolved solids, mostlysalt, and that the conductivity of fresh water ranges from 10-100 μscm^{-1} but exceeds1000 μscm^{-1}in polluted water or those receiving large quantity of land run-off. Electricalconductivity relates to the total amount of dissolved ions in water and has positive correlationwith tropic gradient and phytoplankton abundance (Dinar *et al*.,2007).

2.2.6 Water Hardness

Hardness generally indicates water type, productivity and buffering ability. The hardness of water depends on the presence of dissolved calcium and magnesium salts.Saki (1982) reported that soft water has low buffering action while hard water has high buffering action.Bartman and Balance (1996) also noted that seasonal variation in water hardness often occursleading to highest levels during flow conditions and lowest values during flood. Hardnessisimportant in fish culture because it allows fishes to grow well. Some fish species like catfishdo not grow well in water deficient of hardness.

2.2.7 Dissolved Oxygen (DO)

The presence of optimum level of oxygen in water is a positive sign for the health and the stability of the aquatic ecosystem while its absence is a signal of severe pollution. Sudden and gradual depletion in dissolved oxygen can cause major shift in the kind of aquatic organisms from pollution intolerant species to pollution tolerant species (Kalff, 2002).

Nanda and Tiwari (2001) reported that with a decrease in dissolved oxygen level, many different kinds of aquatic insects, sensitive to low dissolved oxygen such as themayflynymph, stonefly nymphs, caddis fly larvae and beetle larvae may be reduced. Decrease in oxygenconcentration can be attributed mostly to respiration by plant, animals and abiotic bacterialdecay (Cole, 199s9). Concentration below 5mg/l may adversely affect the functions andsurvival of biological communities and below 2mg/l can lead to the death of most fishes (Chapman and Kimstash, 1996).

2.2.8 Biochemical Oxygen Demand(BOD)

Biochemical oxygen demand refers to the amount of dissolved oxygen needed by microbes to break down organic materials present in a given water sample at a certain temperature over a specific period. Biological oxygen demand (BOD) determination is an indication of thelevel of organic pollution. It is nearly an exact measure of the biochemically degradable organicmatter present in a sample (Deas and Orlob, 1999).Biochemical Oxygen Demand test measures the amount of oxygen that is needed for carbon breakdown in five days; however the process can be completed in 3days in tropical areas (Hu*et al*., 2006).Micro-organisms use oxygen dissolved in water, which is their source of carbon forbiochemical oxidation of organic matter. Where the level of pollution is much, more of thedissolved oxygen is used which results in its depletion with the resultant adverse effects on the livingbiota.

2.2.9 Carbondioxide (Carbon IV Oxide)

Carbon dioxide is produced within water bodies by the respiration of aquatic (birds)during aerobic and anaerobic heterotrophic decomposition of suspended and sedimentedorganicmatter. Carbon-dioxide (CO_2) is easily soluble in water and atmospheric carbon-dioxide isabsorbed at the air -water interface (Bartman and Balance, 1996).High levels of carbon dioxide buildup in the aquatic ecosystem can become extremely harmful to fish or other aquatic animals. Levels of 30 ppm (parts per million) are harmful to most organisms while levels greater than 35 ppm are considered limiting to all aquatic organisms.

2.2.10 Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is the total amount of solids dissolved in the water, including soluble hydrogen carbonate ions, chloride salts, sulphates, calcium, magnesium, sodium, potassium, volatile solids and non-volatile solids.The concentration and composition of TDS in natural waters is determined by the geology of the drainage, atmospheric precipitation and the water balance (Wetzel, 2001). The concentrations of TDS in natural waters often result from industrial effluent, changes to the water balance (by limiting inflow, by increased water use or increased precipitation), or by salt-water intrusion.Total dissolved solids cause toxicity through increases in salinity, changes in the ionic composition of the water and toxicity of individual ions (Weber-Scannell and Duffy, 2007).Total dissolved solid was reported to decrease fish survival and larger fish are more tolerant of high concentrations of TDS (Dickerson and Vinyard, 2011).

2.3 Fish Composition of Water Bodies

Fish communities generally include species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores) and their diet often include food from both the terrestrial and aquatic environments. Fish species are primarily affected by macro - environmental influences and careful examination of recruitment

and growth data over years can help to pinpoint periods of unusual stress (Carr and Nearly, 2006).

Maintenance of species richness has become a central issue in conservation biology as habitat degradation continues on a global scale. This is particularly the case with the fish fauna of inland waters. Habitat alteration and destruction is generally the major cause of extinction of freshwater fishes (Thomas *et al*.,1994; Lévêque 2005). Many fish species have become highly endangered, particularly in rivers where heavy demand is placed on freshwater. However, the impact of the anthropogenic activities, habitat degradation, exotic species introduction, water diversions, pollution and global climate change are the main causative agents for the aquatic species rapid decline **(**Basavaraja *et al.*, 2014). Fish communities differ per water body, hence site-specific management is important in fishery biology and fish community conservation. Fish assemblages in lakes and reservoirs are greatly influenced by water quality parameters (Mondal and Kaviraj, 2009). Freshwater ecosystems support large numbers of species of plants and animals. One important descriptor of a community is the number of species present and their relative abundances (species richness and diversity). The diversity of biological species in a river correlates strongly with the diversity of its habitat parameters (Kadye and Marshal, 2006). Fish inhabiting freshwaters comprise 25% of living vertebrates (about 55,000 described species) and represent 13-15% of the 100,000 freshwater animal species currently known (Leveque, 2005). In Africa, a large proportion of the inland fisheries are located along the shores of lakes, but the continent's vast river systems are also rich in fisheries and may produce up to one-half the total catch from inland waters (Welcome, 1997).

2.4 Fish Diversity

Reports of fish assemblages and diversity in Nigerian freshwater ecosystem abound. The fish fauna of Tagwai Lake Minna, Nigeria (Ayanwale *et al*., 2013) comprised of 8 species in 7 genera and 6 families, with two *Cichlids* species, *Tilapia zilli* and *Sarotherodon galilaeus* (Cichlidae)being the most abundant representing 33.01 and 26.06% of the total catch

respectively. Onuoha *etal*., (2010) reported that the ichthyofauna of Ntak Inyang stream of Ikpa river, Nigeria belonged to 4 orders, 7 families, 14 genera and 26 species. The Characidae was the dominant family (442 specimens) (80.06%) while *B. longipinnis* was the dominant species by number and preponderance 46 (28.45%) and 48.70% respectively. Mustapha (2008) identified 18 species belonging to 14 genera and 9 families in Oyun Reservoir in Offa, Kwara State. Komolafe and Arawomo (2008) identified 4 families comprising of 7 species in Osinmo Reservoir, Osun State. David *et al.*,(2015) reported that 57 species in 16 fish families were observed at Kiri Lake and 40 species in 16 fish families were observed at Gyawana Lake in Adamawa State Nigeria. The fish family Cichlidae was the most diversified in Kangimi Lake with 5-species representation but dominated by *Hemichromis fasciatus* (Balogun, 2005). Also Dankishiya (2012) reported the family Cichlidae was the most dominant family by number (72.79%) and weight (34.72%). This was followed by the family Cyprinidae with 22.75% while, Clariidae, Bagridae, Mormyridae and Mochokidae had 1.85%, 1.20%, 0.80% and 0.60% respectively. Members of the family Cichlidae (4 species) had the highest weight (87.77 g) representing 75.3 % of the total catch and 63.41 % abundance in a tropical lotic freshwater ecosystem. Other families represented include Bagridae, (4.53 %), Mochokidae (2.37 %) and even lower percentage occurrence and diversity for Notopteridae, Osteoglossidae, the Schilbeidae and Cyprinidae (Okoh *et al.*,2007). Thirty eight (38) species of fish, belonging to seventeen (17) families were recorded during the survey. The fishes of the Hadejia-Nguru wetlands were dominated by members of the families Cichlidae and Mormyridae that have nine species of fishes each. The family Characidae has three species, the families Distichodontidae, Bagridae, Clariidae and Malapteruridae had two species each (Abubakar *et al*., 2015).

Anwana and Nwosu (2014) observed four dominant fish families in three lakes (Adigbe, Efi and Obaa) in southwestern Nigeria. These were Mochokidae, Citharinidae, Cichlidae and Channidae. The Mochokidae was the most diverse, having six (6) represented by species. Lawson and Olusanya (2010) also reported theFamily Mochokidae(*Synodontis membranaceous*) to have the highest number from Lake Esiribi from the same geographical region.

2.5 Length-weight Relationship and Condition Factor of Fish

The concepts of length- weight relationships for estimating the condition of fish have been used in fisheries research since the beginning of the 20th Century (Froese, 2006). The weight corresponding to a given length and condition factors are used for comparing the condition, fatness, or well-being (Tesch, 1968) of fish, based on the assumption that heavier fish of a given length are in better condition. Fisheries researchers have used the length-weight relationship study in fisheries management to provide information on stock condition (Bangenal and Tesch, 1978). This is applied in order to predict the weight from the given length of a fish and to compare the average associated parameters between fish groups spatially or temporally. Pauly (1993) reported that length-weight relationships can be used to predict weight from length measurements made in the yield assessment. The exact relationship between length and weight differs among species of fish according to their inherited body shape, and within a species according to the condition (robustness) of individual fish (Scheneider *et al.*, 2000). Furthermore, the length-weight relationship can be extended for the estimation of fish condition assuming that a heavier fish of a given length is in a better condition,in yield assessments (Garcia *et al.,* 1998) and in the calculation of biomass (Martin-Smith, 1996). Different growth patterns in fish have been attributed to length-weight factors as highlighted by Riedel *et al.*, (2007), where isometric growth is associated with no change of body shape as an organism grows. Negative allometric growth implies the fish becomes more slender as it increase in weight while positive allometric growth implies the fish becomes relatively stouter or deeper-bodied

as it increases in length.Hamid *et al.*, (2015) provided baseline data on length-weight relationship and condition factor for seven major species sampled from Temengor Lake. The sampled fishes in the lake were in good condition except for two of the species(*Oxygaster anomalura* and *Labiobarbus leptocheilus*)that showed negative allometric growth. Studies on the length-weight relationship and condition factor have been well documented in many Nigerian freshwater fishes. Ighwela *et al.*,(2011)reported significant correlation between length and weight, while the condition factor computed for *Oreochromis niloticus* were 1.64, 1.77, 1.74, 1.72 and 1.79, which indicated good health condition during the experiment and it indicated an isometric growth. According to Dankishiya (2012) the length-weight regression analysis for five fish species gave coefficients that varied between 2.2 and 2.3 for *Tilapia zilli*, 1.4 and 1.6 for *Tilapia mariae. Oreochromis niloticus* had values that range between 2.1 to 2.3 while *Barbus occidentalis and Barilius loati* had values that ranging between 1.9 to 2.2 and 2.3 to 2.4, respectively with the condition factor for the five species ranged between 1.06 and 2.02. Analysis of both the males and females separately and combined showed that all the species exhibited negative allometric growth pattern.

The condition factor in fish serves as an indicator of physiological state of the fish in relation to its welfare (Le Cren, 1951). It also provides information when comparing two populations living in certain feeding density, climate and other conditions (Weatherly and Gills, 1987). Thus, condition factor is important in understanding the life cycle of fish species and it contributes to adequate management of these species, hence, maintaining the equilibrium in the ecosystem (Imam *et al*., 2010). The condition factor which show the degree of well-being of the fish in their habitat is expressed by 'coefficient of condition' also known as length – weight factor. This factor is a measure of various ecological and biological factors such as degree of fitness, gonad development and the suitability of the environment with regard to the feeding condition (Mac Gregoer, 1959). When condition factor value is higher it means that the fish has attained a better condition. The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds,

and other water quality parameters (Khallaf *et al*., 2003). Bhatnagar and Devi (2013) proposed that if the condition factor Kvalue is 1.00, the condition of the fish is poor, long and thin. The K value of 1.20 indicates that the fish is of moderate condition and acceptable to many anglers. A good and well-proportioned fish would have a K value that is approximately 1.40. Gupta *et al*., (2011) reported that availability of food organisms at a particular time as well as the difference of gonad development could be responsible for the difference in condition factor in fish. Kouamelan*et al*., (2000) emphasized that measurements of condition factor are generally intended to act as indicators of tissue energy reserves. This is with the expectation that a fish in relatively good condition should demonstrate higher growth rates, greater reproductive potential and higher survival than a lower conditioned counterpart, given comparable environmental conditions (Cone, 1989).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

Dadin-Kowa Reservoir is located 5km North of Dadin-Kowa village about 37km from Gombe Town, along Gombe - Biu Road in Yamaltu Deba Local Government Area of Gombe State in the North East of Nigeria. The area lies within Longitude 11^0E and 11^0E and Latitude 10^0 and 10^0N coordinates of the equator (UBRDA, 1980) (Figure 3.1). The reservoir was completed by the Federal Government in 1984 with damming of River Gongola. The reservoir had a capacity of 800 million cubic meters of water and a surface area of 30, 000 hectares (William,2001).

The surrounding settlements of Dadin-Kowa majorly depend on agriculture as major source of livelihood. Theflood plains known as Fadama lands, as a result of the Dadin-Kowa River, a tributary to river Benue makes both ground water and surface water available and accessible. It is basically an agrarian society that produces agricultural products such as sorghum, millet, cotton, vegetables, rice,

maize, groundnut, banbara-nut, as well as fruits and engaged in activities which includes weaving, fishing, hunting among others (Ahmed and Philip, 2012).

3.2 Sampling Stations

Three sampling stations were selected in the reservoir as follows:

Station A was located around the entrance of water into the reservoir. The water movement was relatively obvious due to ingress of large amount of water at this Station compared to other parts of the reservoir. Station B was located around the central portion of the reservoir with no obvious sign of water movement. The third Station, C was the part of the reservoir where the water is shallower and with a lot of human activities.

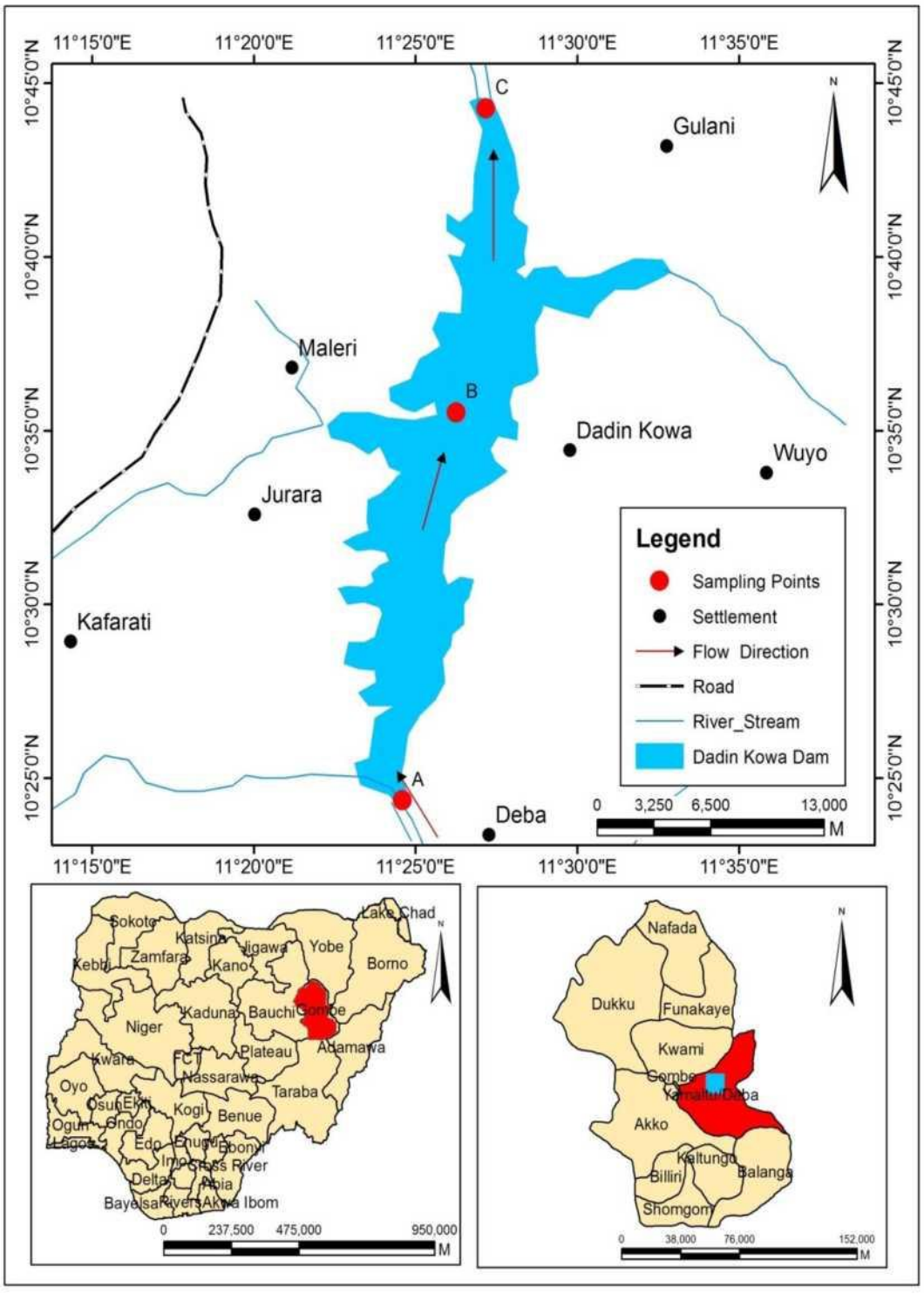


Fig 3.1 Map showing Dadin-Kowa reservoir and the sampling Stations (A, B andC). (UBRDA,1980)

3.3 Determination of Physico-Chemical Parameters

3.3.1 Water Surface Temperature

Thetemperatures were determined using mercury in glass thermometer between 8.00 – 9.00 hours of the day. Thethermometer was submerged into the water at each station for about 3-4 minutes, then thereadings were recorded (^{o}C) (APHA, 1999).

3.3.2 Water Depth

Calibrated rope of known length weighted at one end was used to measure the water depth at eachstation. The rope was dipped down gradually until the weight settled down on the bottom of the reservoir then the water level was marked and recorded in meters.

3.3.3 Transparency

Transparency was determined by the use of a 25cm diameter Secchi disc.The procedure involved lowering the Secchi disc into the water at each station until it ceased to be visible. The depth at disappearance and reappearance were measured to the nearest cm and the average was taken.

3.3.4 Hydrogen ion concentration(pH)

The hydrogen ion concentration was measured by the use of Hanna pH meter model H198107.The pH meter was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for about 3-4 minutes and the final reading showing on the meter were recorded (APHA, 1999).

3.3.5 Electrical Conductivity(EC) and Total Dissolved Solids (TDS)

These parameters were measured using Hanna conductivity meter model EC 215. Water samples from all the sampling stations were placed into clean beakers, conductance cell of the meter was immersed into sample solution. The resistance was measured in µS/cm the readings of conductivity and total dissolved solids were recorded with the conductivity meter by changing the measurement to TDS. The cell was rinsed in a beaker with ionized water after each reading.

3.3.6 Water Hardness

Hardness was determined by diluting 25mls of water sample and 25mls of distilled water making 50mls. Two 2mls of buffer solution and 0.1g of Eriochrome black T-dye were then added followed by EDTA -titrant drop until a blue colour end point was observed. The calculation was based on the equation by Lind (1979) and APHA (1999).

EDTA hardness (Mg/l- CaCO3)2 M/titrant x 40

3.3.7 Dissolved Oxygen (DO) and Bio-chemical Oxygen Demand(BOD)

Hanna Dissolved Oxygen meter model H12400 was used to determine dissolvedoxygen. The DO meter was calibrated according to the instruction manual provided by themanufacturer. Water samples was collected in 100ml beaker, the electrode of DissolvedOxygen meter was dipped into the beaker that contained the water sample for about 3-4minutes, then the readings were recorded in mgl^{-1}.For biological oxygen demand; 100ml ofthe water sample was incubated for five days in a dark cupboard at room temperature and DissolvedOxygen was determined. The difference between the initial value (at day one) of dissolved oxygen and thefinal value (after day five) that is the value after incubation was used as value of biochemical oxygen demandof the water sample (APHA, 1999).

3.3.8 Free Carbon dioxide

The titration method described by Needham and Needham (1975)was used. The procedure involved 10 drops of phenolphthalein indicator being added to 100mls water sample and titrated against Sodium carbonate until a weak pink colour end point was obtained.

$MgCO_2$ per liter =ml of titration x 10

3.4 Fish Sampling

The commercial catches of the fishermen operating in the reservoir (upstream and downstream) were assessed monthly for the period of eight months. The types of fishing gear employed by the fishermen in Dadin-Kowa reservoir were also documented.

3.4.1 Identification of Fish Samples

The fish samples obtained from the fishermen were identified using two methods;firstly, fishermen identification in the local language was done and secondly the fishes were transported to the Hatchery Unit/Laboratory, Department of Biology, A.B.U. Zaria in an ice- box where they were identified up to family and generic levelsusing description keys such asHolden and Reed (1992) and Babatunde andRaji (1998). Fish identification was then to species level using description keys of Balogun (2006) and Suleiman (2016), and in line with FishBase (2016).

3.4.2 Morphometrics of Fish Samples

The fish sampled were mopped using filter paper before weighing to remove excess water from their body in order to ensure accuracy (Anderson and Gutreuter, 1985). The weight of individual fish was measured using a sensitive digital Sartorius™ weighing balance to the nearest gram. The length was measured to the nearest centimeter using meter rule calibrated in centimeters, as distance from the snout to the tip of the caudal fin.

3.5 Determination of Length - Weight Relationship (LWR)

The relationship between the length (L) and Weight (W) were calculated using:

Log W= a+b logL (Begeneal and Tesch,1978).

Where:

W= Weight of fish (g)
L=length of fish (cm)
a=constant
b= exponent.

3.5.1 Condition Factor

The relative condition factor K ((Gomiero and Braga, 2005).) was calculated usingequation:

$K=100W/L^3$

Where:
W=Weight of the fish(g)

L=Length of the fish (cm)

3.6 Determination of Fish Diversity

Diversity of the fish fauna was determined using the Shannon -Wiener (Shannon-Wiener, 1963)

index given by the formula:

$$H = -\sum_{i=1}^{k} p_i \log p_i$$

Where:

H = Shannon - Wiener diversity index.

i = Count denoting the ith species ranging from 1 n.

pi = Proportion that the ith species represents in terms of number of Individuals with respect to the total number of individuals.

The Simpson's index(Simpson, 1949) was used to calculate both species richness, and an evenness of abundance among the fish species sampled from the reservoir. The formula is given by:

$$D = \frac{\sum n_i (n_i - 1)}{N(N-1)}$$

Where:

D = Simpson's index

n_i = the total number of organisms of each individual species

N = the total number of organisms of all species.

3.7Data Analysis

One-Way Analysis of Variance (ANOVA) was used to test for significant differences in mean physico-chemical parameters among stations and Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist. Correlation analysis was used to test the level of association among the physico-chemical parameters and fish species composition. Statistical significant difference was set at $P \leq 0.05$.

CHAPTER FOUR

RESULTS

4.1Physico-Chemical Parameters

The results of the physico-chemical parameters were presented in table 4.1. The mean Temperature (30.04±0.74ºC), Transperancy (62.33±2.37cm),pH(7.03±0.10), Electrical conductivity (44.92±2.73µS/cm), BOD (3.63±0.17mg/l), Dissolved oxygen (6.77±0.44mg/l), Carbon dioxide (3.58±0.24mg/l) and Hardness (39.13±4.85mg/l) were all within the acceptable range. On the other handTDS (22.50±1.38mg/l) was above the acceptable range.

There was high significant (P≤0.05) variation inthe physico-chemical parameters with months in the reservoir except forwater depth, carbon dioxide and hardness (Table 4.1). The highest temperature of 34.40°C was recorded in the month of April, while January had the lowest temperature of 24.17°C.There was little temperature variation among the months of March, April and May as well as between the months of October and February. While the

months of November, December and January significantly differed from the other months. Transparency showed variation among closely followed months. October and November were significantly different from months of December, January and February as well as April and May. Transparency was highest in February with 76.00, followed by January (74.33µscm-^{1}) andDecember (73.33µscm-^{1}), with the least transparency was observed in the month of November(46.00µscm-^{1}) which was not significantly different from October (49.00µscm-^{1}).

Though there wasvariation in pH among the months, some similarities were observed in November, Decemberand February and also October and January. October had the highest pH of 7.67, followed byJanuary and March with 7.60 and 7.33, respectively. April had the least pH of 6.30. Althoughthe depth of the water body did not vary significantly, the highest (18.50 m) was observed inthe month of December while May had the least depth with 11.20 cm. The electricalconductivity and total dissolved solids showed similar pattern of variation among themonths. The dissolved oxygen showed similarities in months while the biochemical oxygendemand distinctly varied throughout the months.

4.2 Variation in Physico-chemical parameters among stations

All of the physico-chemical parameters buthardness did not vary significantly ($P > 0.05$) in the sampling stations in the reservoir (Table4.2). The mean water hardness value of 14.75±7.48 mg/l in station C was significantlylower ($P \leq 0.05$) than those of stations A and B.

The monthly temperature variation among the stations is represented in Figure 4.1. Watertemperature varied from the lowest value of 23.0 ^{o}C in January in Station A to the maximumof34.5^{o}CinApril.The water depth was observed to gradually decrease with months across the Stations (Figure4.2). The water in the reservoir was deepest (20m) in October and shallowest (11m) in May atall the Stations.Figure 4.3 shows the monthly variation in the transparency of the water in the reservoir in thethree stations. The lowest value of 42 m was observed in station C in October with the highestvalue of 78m in February in Station B. In all the months, transparency

values were higher in Station B.The variation in electrical conductivity in Dadin-Kowa reservoir is presented in Figure 4.5.The lowest value of 20.0µs/cm was observed in Station A in November and thehighest(68µS/cm) was in May in Station B. There was significant increase in EC between themonths of January and February.There was similarity in the variation of the pH values of the water in the three Stations acrossthe months (Figure 4.4). The highest pH of 7.9 was observed in January and the lowest (5.8)was in April.The variation in BOD in all the stations showed gradual increase from the lowest value of 2-6mg/l in October to the highest value of 5.4 mg/l in April before s slight drop in May. TheStations showed similarity in the pattern of variation in BOD in the reservoir (Figure 4.6). The TDS varied significantly across the months but consistently similar in the three Stations.

Table 4.1:Summary of Mean monthly variation of the physicochemical parameters of water in Dadin-Kowa Reservoir

Months	Temperature (°C)	Depth (m)	Transparency(cm)	pH	Electrical Conductivity (µS/cm)	BOD (mg/l)	TDS (mg/l)	Dissolved Oxygen (mg/l)	Carbon dioxide (mg/l)	Hardness (mg/l)
October	30.65±0.24^{b}	13.40±6.70^{a}	49.00±4.04^{d}	7.67±0.09^{a}	47.67±1.45^{c}	2.70±0.06^{g}	23.83±0.73^{c}	4.33±0.09^{c}	3.57±0.23^{ab}	32.33±1.45^{a}
November	28.53±0.15^{c}	18.10±0.38^{a}	46.00±1.73^{d}	6.83±0.03^{c}	24.00±2.08^{e}	2.90±0.06^{f}	12.00±1.04^{e}	4.57±0.58^{c}	2.47±1.25^{ab}	36.00±1.00^{a}
December	25.63±0.39^{d}	18.50±0.40^{a}	73.33±1.45^{a}	6.63±0.09^{c}	28.33±1.67^{e}	3.10±0.06^{e}	14.17±0.83^{e}	7.27±0.09^{b}	2.33±1.20^{b}	51.33±0.88^{a}
January	24.17±1.09^{e}	17.67±0.44^{a}	74.33±1.45^{a}	7.60±0.12^{a}	58.67±0.88^{a}	3.27±0.03^{d}	29.33±0.44^{a}	4.07±0.12^{c}	3.77±0.15^{ab}	34.33±17.17^{a}
February	30.23±0.15^{b}	15.93±0.47^{a}	76.00±2.00^{a}	6.70±0.17^{c}	53.33±1.76^{b}	3.27±0.03^{d}	26.67±0.88^{b}	7.33±0.12^{b}	3.73±0.15^{ab}	35.00±17.50^{a}
March	33.50±0.36^{a}	14.90±0.21^{a}	65.67±1.20^{b}	7.33±0.12^{ab}	39.00±2.08^{d}	4.20±0.06^{c}	19.50±1.04^{d}	7.67±0.03^{b}	4.27±0.15^{ab}	35.00±17.52^{a}
April	34.40±0.17^{a}	11.80±0.42^{a}	57.67±2.19^{c}	6.30±0.12^{d}	45.67±0.67^{c}	5.20±0.06^{a}	22.83±0.33^{c}	9.33±0.09^{a}	4.00±0.29^{ab}	36.67±18.41^{a}
May	33.23±0.15^{a}	11.20±0.17^{a}	56.67±1.76^{c}	7.17±0.09^{b}	62.67±1.45^{a}	4.40±0.06^{b}	31.67±0.83^{a}	9.60±0.06^{a}	4.53±0.32^{a}	52.33±26.24^{a}
Mean	**30.04±0.74**	**15.19±0.90**	**62.33±2.37**	**7.03±0.10**	**44.92±2.73**	**3.63±0.17**	**22.50±1.38**	**6.77±0.44**	**3.58±0.24**	**39.13±4.85**
Acceptable Range	**26 – 32 (FAO, 2006)**		**10 –100 (Boyd, 1990)**	**6.5 – 9.0 (Davies,1993)**	**20 – 1,500 (Boyd, 1990)**	**3 – 20 (Boyd, 2003)**	**0.13 –13.6 (Davies, 1993)**	**3 – 5 (Boyd, 1990)**	**0.0 -10 (Boyd, 1990)**	**20-150 (WHO, 2003)**
P value	**0.000***	**0.266ns**	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.000***	**0.228ns**	**0.961ns**

^{A,b,c,d,e}– means with the samesuperscripts along the columns were not significantly different (P > 0.05).

* - significant at P ≤0.05

ns – not significant (P >0.05)

Table 4.2: Mean monthly variation of the physicochemical parameters among stations at Dadin-Kowa Reservoir

Stations	Temperature (°C)	Depth (m)	Transparency(cm)	pH	Electrical Conductivity (µS/cm)	BOD (mg/l)	TDS (mg/l)	Dissolved Oxygen (mg/l)	Carbon dioxide (mg/l)	Hardness (mg/l)
A	29.83±1.47[a]	13.53±2.15[a]	60.75±4.28[a]	6.96±0.18[a]	43.75±5.07[a]	3.61±0.31[a]	21.88±2.53[a]	6.75±0.76[a]	3.58±0.17[a]	50.75±4.60[a]
B	30.07±1.21[a]	16.55±1.15[a]	66.13±3.88[a]	7.09±0.19[a]	45.63±4.94[a]	3.63±0.31[a]	22.81±2.47[a]	6.85±0.76[a]	4.14±0.17[a]	51.88±5.21[a]
C	30.24±1.34[a]	15.49±1.16[a]	60.13±4.36[a]	7.04±0.17[a]	45.38±4.81[a]	3.65±0.31[a]	22.81±2.47[a]	6.71±0.85[a]	3.04±0.67[a]	14.75±7.48[b]
Mean	**30.04±0.74**	**15.19±0.90**	**62.33±2.37**	**7.03±0.10**	**44.92±2.73**	**3.63±0.17**	**22.50±1.38**	**6.77±0.44**	**3.58±0.24**	**39.13±4.85**
P value	**0.976ns**	**0.395ns**	**0.546ns**	**0.888ns**	**0.958ns**	**0.996ns**	**0.954ns**	**0.992ns**	**0.189ns**	**0.000***

a,b,c,d,e_ means with the same superscripts along the columns were not significantly different (P > 0.05).

* - significant at $P \leq 0.05$
ns - not significant (P >0.05)

The pattern of variation is similar to that of the EC (Figure 4.7). The highest value of 35mg/lwas recorded in May with the lowest (10 mg/l) in November in all the stations.Figure 4.8 represents the fluctuation in the concentration of dissolved oxygen (DO). Thehighest concentration of 9.5 mg/l was observed in May in the three Stations. The lowestconcentration (3.3 mg/l) was in Station A in November. The concentration of DO increased instations A and B from October to December and dropped in January. There was gradualincrease in DO in all the Stations from February to May.The carbon dioxide concentration of the three Stations of Dadin-Kowa reservoir isrepresented in Figure 4. 9. The pattern of variation is similar in all the Stations. The highest(5.1 mg/l) CO2 concentration was observed in Station B and the lowest (3.0 mg/l) in Station A in the month of December.There was gradual increase in water hardness (Figure 4. 10) from the month of October with29 mg/l (lowest) in Station C to May with 82 mg/l (highest) in Station B. A very significantincrease in hardness was observed between November and December as well as April andMay. The pattern of variation was similar in all the three stations.

4.3 Correlation of Physico-Chemical Parameters

The relationships among the physicochemical parameters are represented in Table 4.3. There washigh positive correlation between BOD and DO and between carbon dioxide with EC and TDS.Temperatures showed moderate significant positive relationship with carbon dioxide, BOD andDO. A perfect positive and significant association was observed between TDS and EC. Waterdepth was found to have significant negative association with temperature, EC, BOD, TDS, DO andcarbon dioxide. A significant moderate negative correlation was observed between pH anddissolved oxygen.

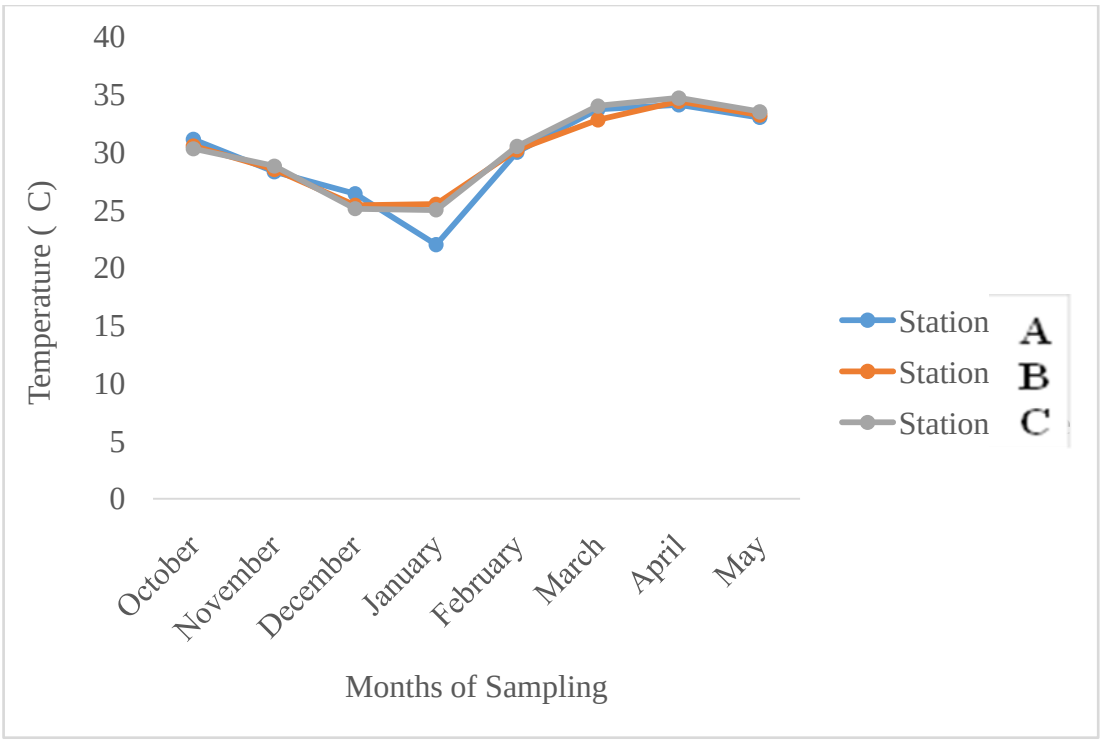


Fig. 4.1: Mean monthly variation in water temperature of the stations in Dadin-KowaReservoir

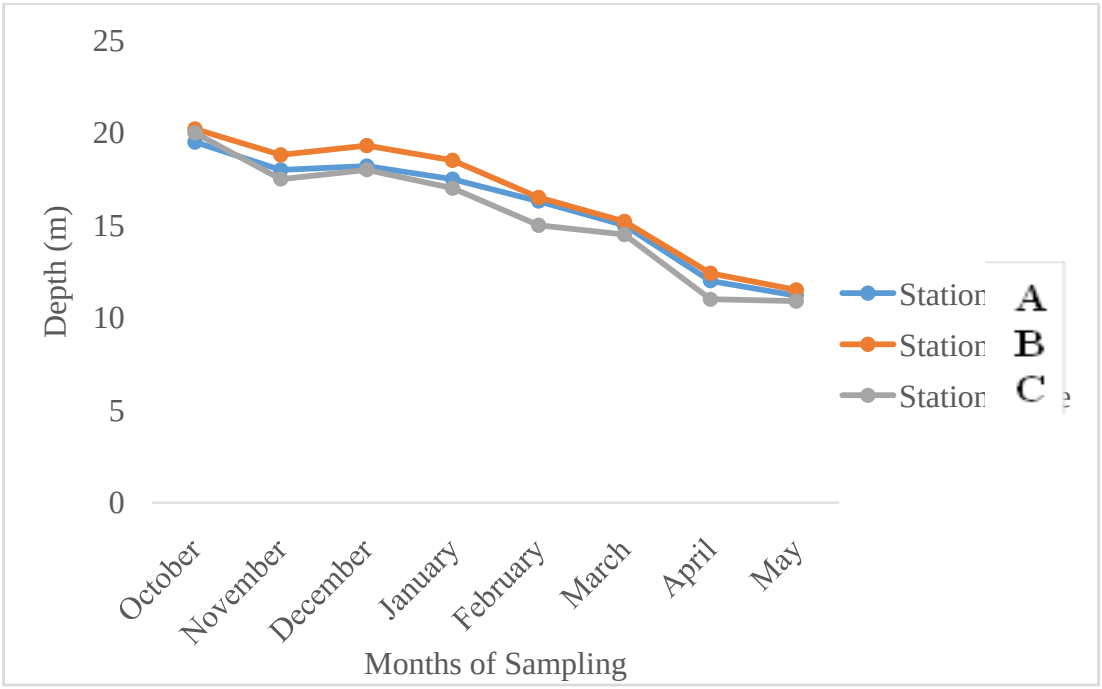


Fig. 4.2: Mean monthly variation in water depth of the stations in Dadin-Kowa Reservoir

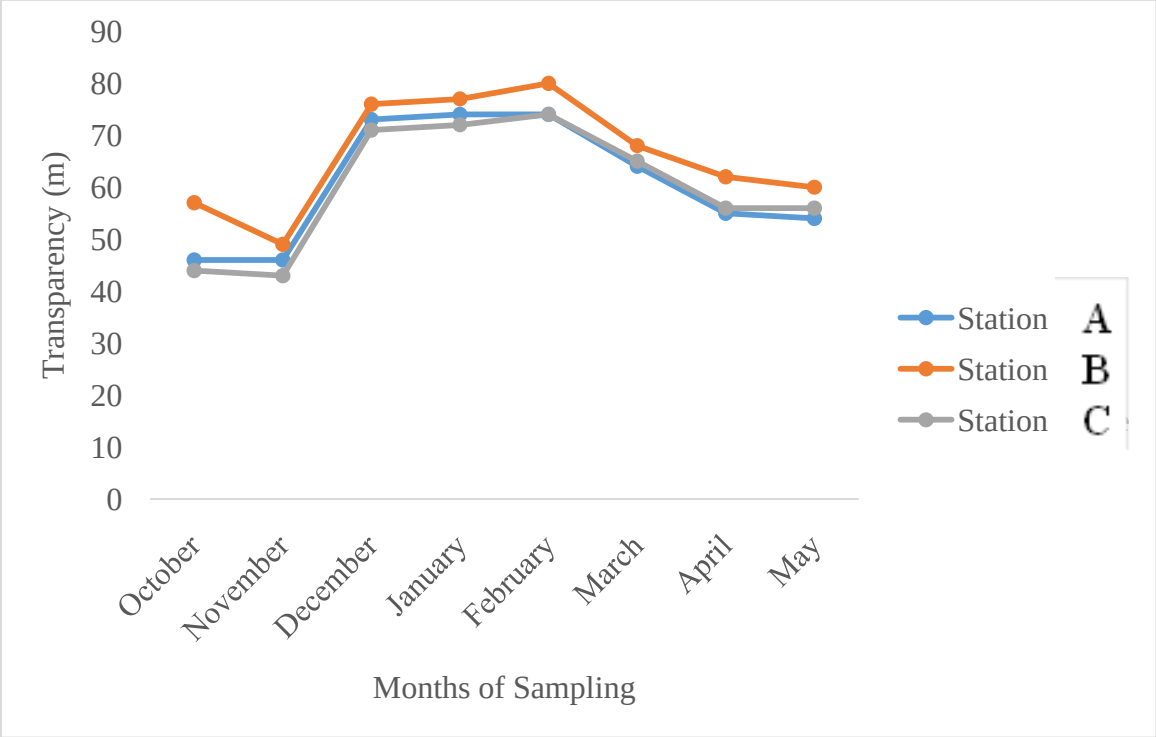


Fig. 4.3: Mean monthly variation in water transparency of the stations in Dadin-KowaReservoir

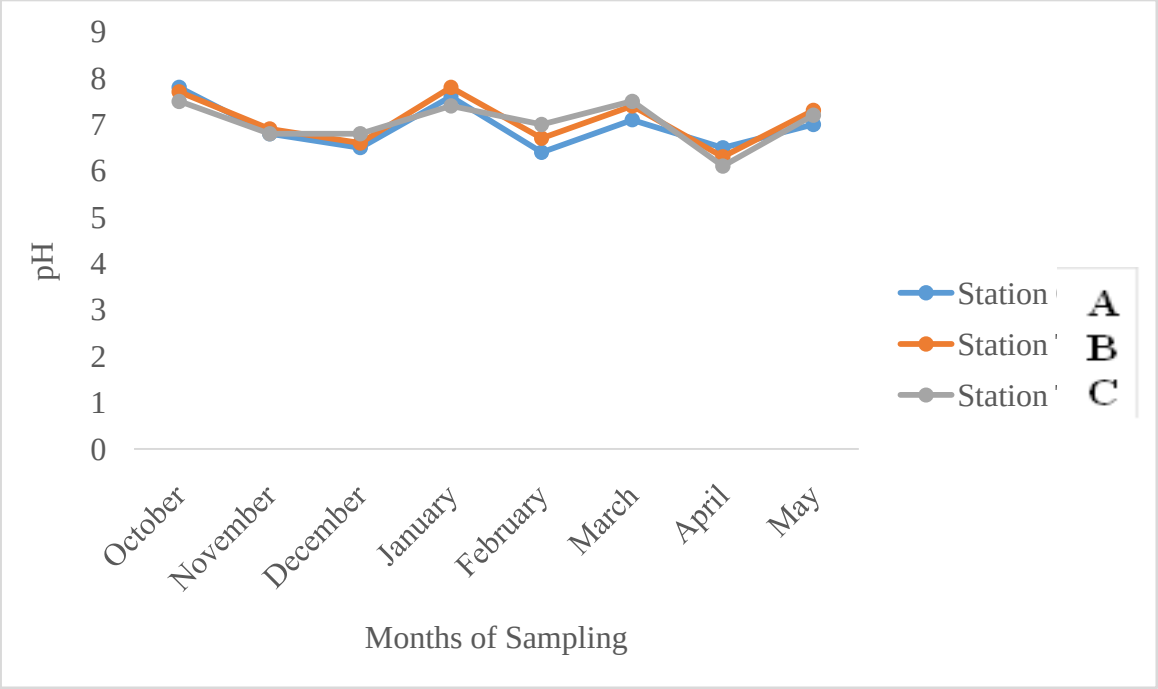


Fig. 4.4: Mean monthly variation in water pH of the stations in Dadin-Kowa Reservoir



Fig. 4.5: Mean monthly variation in electrical conductivity of the stations in Dadin-KowaReservoir

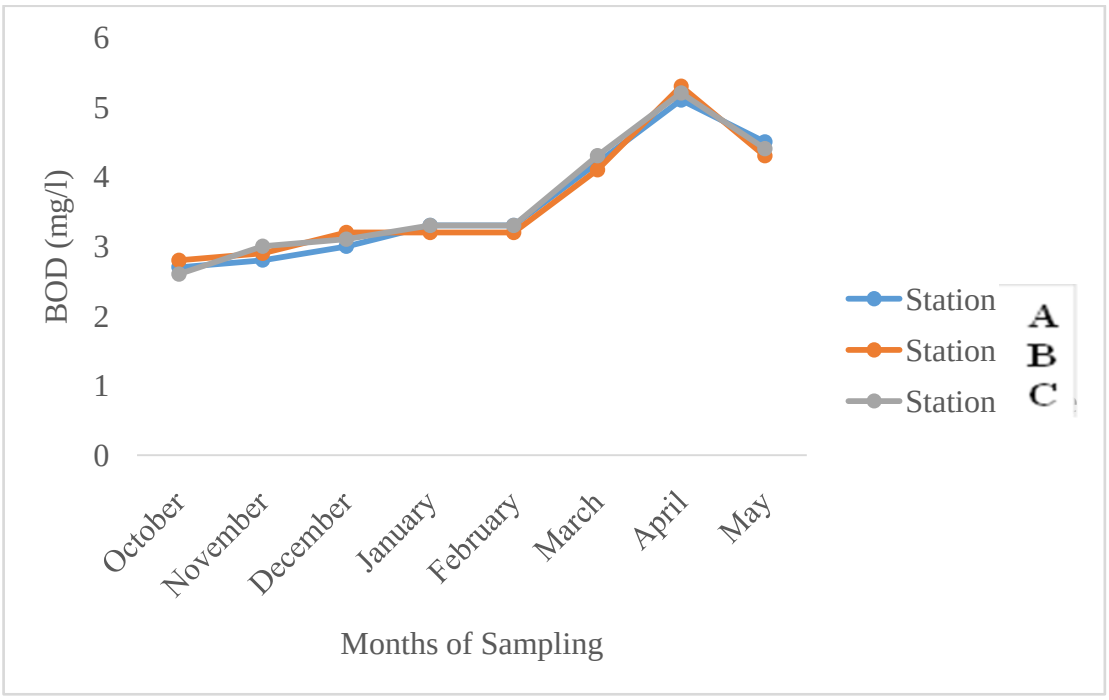


Fig. 4.6: Mean monthly variation in biochemical oxygen demand of the stations inDadin-Kowa Reservoir



Fig. 4.7: The mean monthly variation in total dissolved solids of the stations in Dadin-Kowa Reservoir

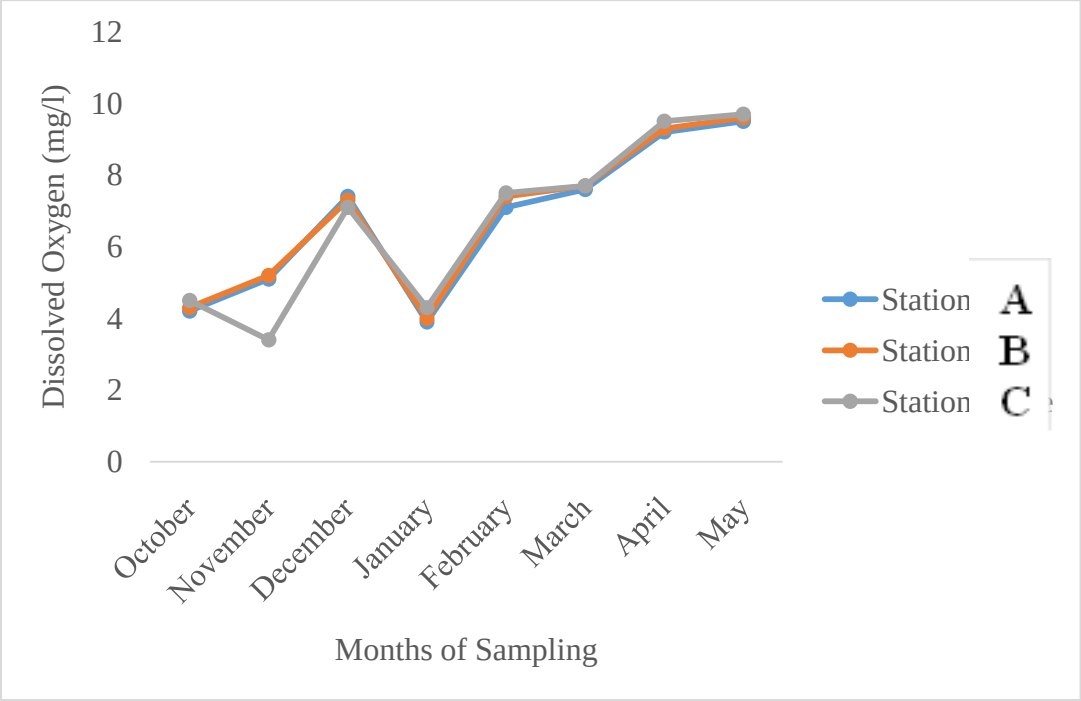


Fig. 4.8: The mean monthly variation in dissolved oxygen of the stations in Dadin-Kowa Reservoir

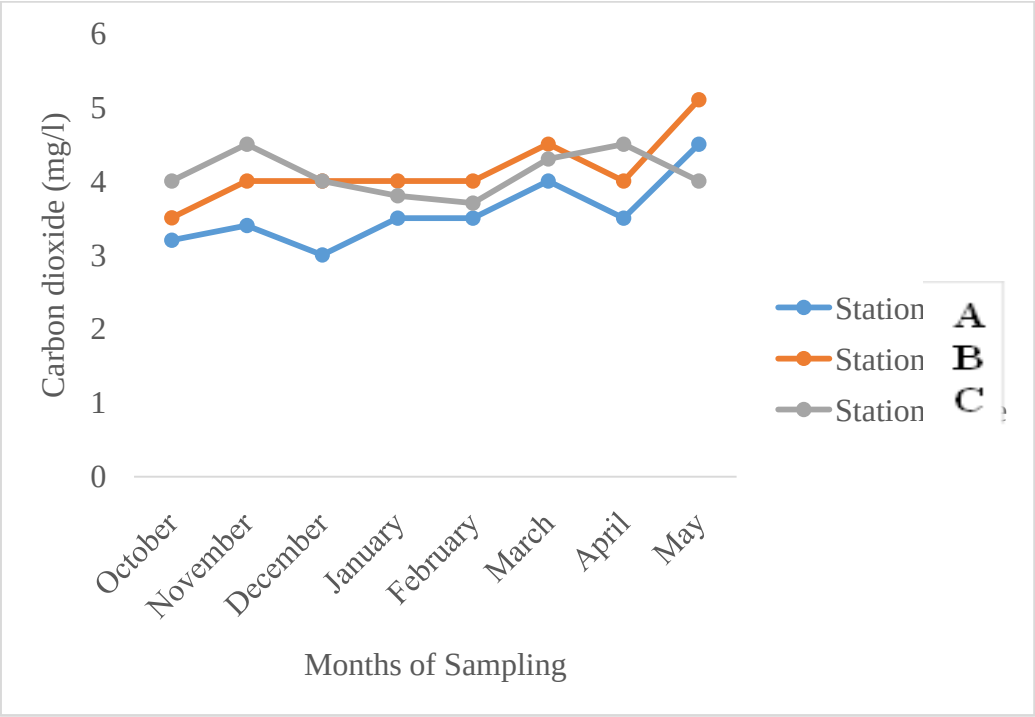


Fig. 4.9: The mean monthly variation in carbon dioxide of the stations in Dadin-Kowa Reservoir

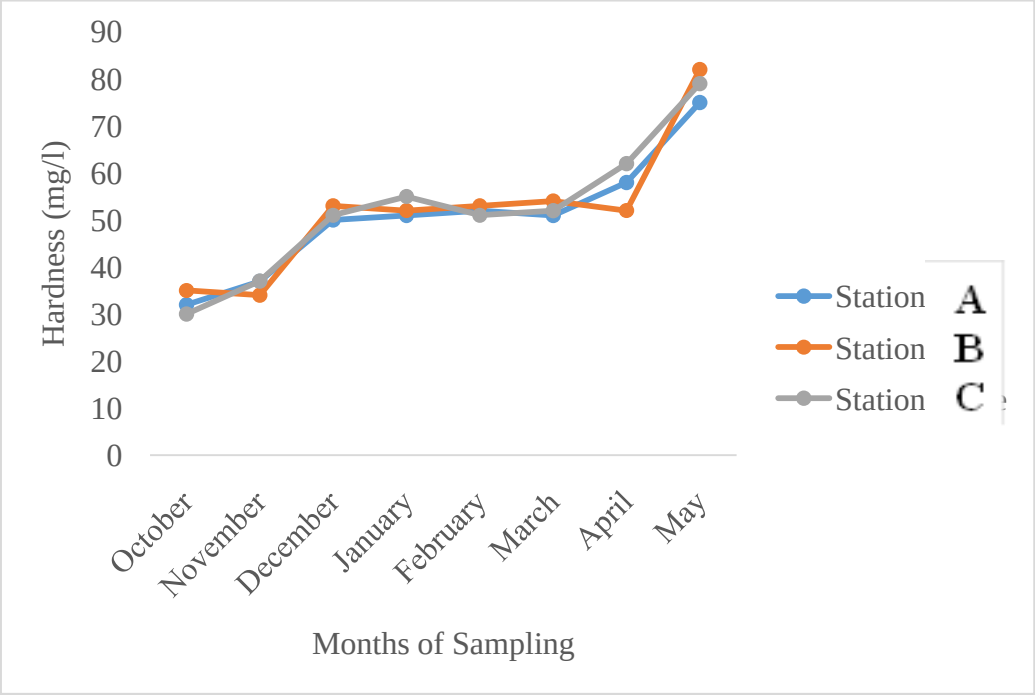


Fig. 4.10: The mean monthly variation in water hardness of the stations in Dadin-Kowa Reservoir

Table 4.3: Correlation of physicochemical parameters in Dadin-Kowa Reservoir

	Temp.	**Depth**	**Transp**	**pH**	**EC**	**BOD**	**TDS**	**DO**	**CO2**	**Hardn**
Temp.	1.00									
Depth	-0.85*	1.00								
Transp	-0.41	0.39	1.00							
pH	-0.21	-0.01	-0.09	1.00						
EC	0.18	-0.55*	0.25	0.38	1.00					
BOD	0.71*	-0.69*	-0.01	-0.40	0.30	1.00				

TDS	0.19	-0.56*	0.24	0.37	1.00*	0.30	1.00			
DO	0.67*	-0.61*	0.13	-0.56*	0.21	0.82*	0.22	1.00		
CO2	0.64*	-0.77*	0.06	0.30	0.80*	0.65*	0.80*	0.47	1.00	
Hardn	-0.04	-0.09	0.13	-0.28	0.00	0.19	0.01	0.55*	-0.10	1.00

* - strong positive or negative correlation.

4.4 Fish Composition of Dadin-Kowa Reservoir

The checklist of fish species identified is presented in Table 4,4. A total of thirty (30) fish speciesrepresenting eleven (11) families were identified. The result showed that family Mormyridae

hadthe highest number of species (6) followed by the family Mochokidae (5) then the familiesAlestidae, Cyprinidae, Clariidae and Claroteidae had three (3) species each, followed by thefamilies Bagridae and Cichlidae while the families Malapteruridae, Polypteridae and Schilbeidaeeach had the least number of species.

Table 4.5 shows the percentage composition of the eleven (11) families of fish species identified.The highest percentage of 20.0% occurred in the family Mormyridae. The family Mochokidaehad 16.7%. The families Alestidae, Cyprinidae, Claroteidae and Clariidae had 10.0% each,with thefamilies; Cichlidae and Bagridae composed of 6.7% each. The Malapteruridae, Polypteridae and Schilbeidae represented 3.3% each of the species. Plates I –XXX showed the various fish species identified.Out of the total of 690 fish species identified, *Mormyrops anguilloides, Clarias anguillaris*and *Schilbe mystus* represented 14.5%, 8.7% and 8.6% respectively of the total fish speciesidentified. *Labeosenegalensis* and *Synodontis budgetti*made up 6.9%and 5.8% respectively. While the remaining fish species represented lessthan 5% of the total fish species. Table 4.6 shows the relative abundance of various fishspecies identified throughout the study period. The month of February had the highest number offish catch, representing 17.97% of the total catch. The lowest fish catch was in May with 7.68%.The other months showed moderate number of fish species.

Table 4.4: Checklist of Fish species identified in Dadin-Kowa Reservoir

Family	**Genus**	**Species**
Clariidae	*Heterobranchus*	*Heterobranchus bidorsalis* (Geoffrey St. Hilaire, 1809)

	Clarias	*Clarias gariepinus* (Burchell, 1822)
		Clarias anguillaris (Linnaeus, 1758)
Schilbedae	*Schilbe*	*Schilbe mystus* (Linnaeus, 1758)
Malapteruridae	*Malapterurus*	*Malapterurus minjiriya*(Sagua, 1987)
Mochokidae	*Synodontis*	*Synodontis clarias* (Linnaeus, 1758)
		Synodontis budgetti (Boulinger, 1911)
		Synodontis vermiculatus(Daget, 1954)
		Synodontis melanopterus(Rüppell, 1832) *Synodontis nigrita* (Valenciennes, 1840)
Bagridae	*Bagrus*	*Bagrus docmak*(Forskål, 1775)
		Bagrus bajad (Forskal, 1775)
Claroteidae	*Chrysichthys*	*Chrysichthys auratus longifilis* (Geoffroy Saint-Hilaire, 1808)
		Chrysichthys nigrodigitatus (Lacepède, 1803)
	Auchenoglanis	*Auchenoglanis occidentalis* (Valenciennes, 1840)
Polypteridae	*Polypterus*	*Polypterus senegalus* (Curvier,1829)
	Hydrocynus	*Brycenus nurse* (Pellegrin, 1935) *Hydrocynus vittatus* (Castelnau, 1861)
Cichlidae	*Coptodon*	*Tilapia zilli* (Gervais, 1848)
	Oreochromis	*Oreochromis niloticus* (Linnaeus, 1758)
Alestidae	*Alestes*	*Brycinus macrolepidotus* (Valenciennes, 1850)
Cyprinidae	*Barbus*	*Labeocoubie* (Blache and Miton, 1960)
	Labeo	*Labeo senegalensis* (Valenciennes, 1842) *Barbus bynni occidentalis* (Boulenger, 1911)
Mormyridae	*Mormyrus*	*Mormyrus rume* (Valenciennes, 1846)
		Mormyrus hasselquistii (Pellegrin, 1926) *Mormyrus macrophthalmus* (Günther, 1866)
	Hyperopisus	*Hyperopsus bebe* (Lacepede, 1803)
	Mormyrops	*Mormyrops anguilloides* (Linnaeus, 1758) *Petrocephalus ansorgii* (Boulenger, 1902)
	Petrocephalus	

Table 4.5: Percentage Composition of fish families and species identified in Dadin-Kowa Reservoir

Family/Species	**Total Number**	**Percentage (%)**
CLARIIDAE	**3**	**10.0**
Clarias anguillaris	60	8.7
Clarias gariepinus	20	2.9
Heterobranchus bidorsalis	32	4.6
SCHILBEIDAE	**1**	**3.3**
Schilbe mystus	59	8.6
MALAPTERURIDAE	**1**	**3.3**
Malapterurus minjiriya	5	0.7
MOCHOKIDAE	**5**	**16.7**
Synodontis nigrita	30	4.3
Synodontis melanopterus	20	2.9
Synodontis budgetti	40	5.8
Synodontis clarias	18	2.6
Synodontis vermiculatus	07	1.0
BAGRIDAE	**2**	**6.7**
Bagrus bajad	20	2.9
Bagrus docmak	8	1.2
CLAROTEIDAE	**3**	**10.0**

Chrysichthys nigrodigitatus	7	1.0
Chrysichthys auratus longifilis	21	3.0
Auchenoglanis occidentalis	8	1.2
POLYPTERIDAE	**1**	**3.3**
Polypterus senegalus	10	1.4
CICHLIDAE	**2**	**6.7**
Oreochromis niloticus	29	4.2
Coptodon zillii	30	4.3
ALESTIDAE	**3**	**10.0**
Brycinus nurse	13	2.0
Brycinus macrolepidotus	14	1.9
Hydrocynus vittatus	10	1.4
CYPRINIDAE	**3**	**10.0**
Barbus bynni occidentalis	9	1.3
Labeo senegalensis	48	6.9
Labeo cuobie	15	2.2
MORMYRIDAE		
Mormyrus rume	20	2.9
Mormyrus hasselquistti	10	1.4
Marcusenius macrophthalmus	6	0.9
Mormyrops anguilloides	100	14.5
Petrocephelus ansorgii	11	1.6

Table 4.6: Relative abundance of fish species identified in Dadin-Kowa Reservoir

Fish species	**MONTHS**								
	OCT	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**TOTAL**
Hyperopisus bebe	-	-	3	2	4	1	-	-	**10**

Mormyrus rume	2	4	-	1	3	5	2	3	**20**
Mormyrus hasselquistti	2	1	-	-	2	1	2	2	**10**
Marcusenius macrophthalmus	2	-	-	-	1	2	-	1	**6**
Mormyrops anguilloides	20	10	15	10	25	5	10	5	**100**
Petrocephalus ansorgii	-	2	1	-	4	3	1	-	**11**
Bagrus bajad	3	2	-	5	3	1	4	2	**20**
Chrysichthys nigrodigitatus	-	-	-	4	2	-	1	-	**7**
Bagrus docmak	2	-	-	1	-	3	2	-	**8**
Chrysichthys auratus longifilis	5	2	1	4	-	6	3	-	**21**
Auchinoglanis occidentalis	-	-	2	1	2	3	-	-	**8**
Clarias anguillaris	10	15	5	7	10	3	4	6	**60**
Clarias gariepinus	3	2	1	2	3	4	3	2	**20**
Heterobranchus bidorsalis	10	5	4	3	6	2	1	1	**32**
Brycinus macrolepidotus	3	-	-	2	3	4	1	-	**13**
Brycinusnurse	2	-	1	3	4	2	2	-	**14**
Hydrocynus vittatus	1	-	-	4	-	1	3	1	**10**
Tilapia zillii	5	4	-	3	4	10	4	-	**30**
Oreochromis niloticus	-	5	4	3	6	9	2	-	**29**
Barbus occidentalis	5	-	-	-	-	-	2	2	**9**
Labeo senegalensis	-	8	10	5	7	8	5	5	**48**
Labeo cuobie	3	5	-	-	3	2	-	2	**15**
Synodontis nigrita	-	4	10	4	3	-	4	5	**30**
Synodontis melanopterus	2	4	1	3	5	-	3	2	**20**
Synodontis budgetti	-	5	7	-	11	4	7	6	**40**
Synodontis clarias	-	8	-	-	2	4	3	1	**18**
Synodontis vermiculatus	-	-	-	2	1	3	1	-	**7**
Polypterus senegalus	2	-	-	3	2	1	-	2	**10**
Schilbe mystus	-	9	15	10	5	8	7	5	**59**
Malapterurus minjiriya	-	-	-	2	1	1	1	-	**5**

TOTAL	**82**	**95**	**80**	**84**	**124**	**96**	**76**	**53**	**690**



Plate I: Ventro-lateral view of *Hyperopisus bebe*



Plate II:Ventro-lateral view of *Mormyrus rume*



Plate III: Ventro-lateral view of *Mormyrus hasselquistti*



Plate IV:Ventro-lateral view of *Mormyrus macrophthalmus*

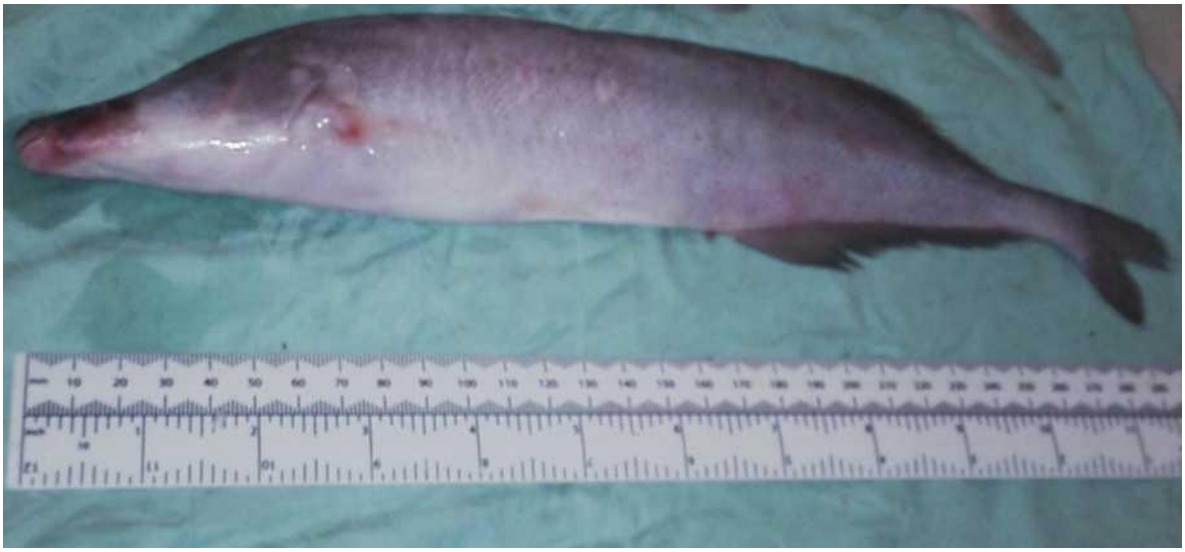


Plate V: Ventro-lateral view of *Mormyrops anguilloides*



Plate VI : Ventro-lateral view of *Petrocephalus ansorgii*



Plate VII: Dorso-lateral view of *Bagrus bajad*



Plate VIII: Dorso-lateral view of *Bagrus docmak*



Plate IX: Dorso-lateral view of *Chrysichthys nigrodigitatus*



Plate X: Dorso-lateral view of *Chrysichthys auratus longifilis*



Plate XI: Dorso-lateral view of *Auchenoglanis occidentalis*



Plate XII: Dorso-lateral view of *Clarias anguillaris*



Plate XIII: Lateral view of *Clarias gariepinus*



Plate XIV: Dorso-lateral view of*Heterobranchus bidorsalis*



Plate XV: Lateral view of *Brycinus macrolepidotus*



Plate XVI: Lateral view of *Brycinus nurse*



Plate XVII: Lateral view of*Hydrocynus vittatus*



Plate XVIII: Lateral view of *Coptodon zillii*



Plate XIX: Lateral view of *Oreochromis niloticus*



Plate XX: Lateral view of *Barbus occidentalis*



Plate XXI: Lateral view of *Labeo senegalensis*



Plate XXII: Dorso-lateral view of*Labeo coubie*



Plate XXIII: Dorso-lateral view of*Synodontis nigrita*



Plate XXIV: Dorso-lateral view of*Synodontis melanopterus*



Plate XXV: Dorso-lateral view of*Synodontis budgetti*



Plate XXVI: Dorso-lateral view of*Synodontis clarias*



Plate XXVII: Dorso-lateral view of*Synodontis vermiculatus*



Plate XXVIII:Dorso-lateral view of*Polypterus senegalus*



Plate XXIX: Lateral view of*Schilbe mystus*



Plate XXX:Dorso-lateral view of*Malapterurus minjiriya*

4.5 Monthly variation in Fish Species in Dadin-Kowa Reservoir

There was significant variation ($P \leq 0.05$) in the number of fish species sampled monthly in thereservoir. February and March had higher number of fish species (26) and the lowest was obtained in December (Figure 4.11). The months of February, March and April showed significant differences ($P \leq 0.05$) with October, November and December. There were significantdifferences between March with February and May, April and May and also December withJanuary.

4.6 Fish catch and Diversity of Dadin-Kowa Reservoir

The highest catch was in the family Bagridae with 167 fish followed by *Claridae* with 112. The family Malapteruridae with 5individuals had the least catch (Table 4.7).Of the total of 690 fish sampled, the highest number of 131 fish belongs to the genus *Petrocephalus*, followed by *Heterobranchus*with 112. The least catch was in the genus *Malapterurus* with 5 (Table 4.8).The Shannon- Weiner Diversity Index (H) and evenness of fish families from thereservoir is represented in Table (4.9). The highest diversity index of 2.056 was in thefamily Cyprinidae while the least of 1.32 was obtained in the familyClaroteidae. The degree of evenness of the families was lowest (0.8296) in Alestidaeand highest (0.976) in Cyprinidae. The family Malapteruridae with the leastindividuals showed the least dominance while the family Cichlidae had the highest valueof0.188.The genera *Hyperopisus*, *Mormyrops* and *Malapterurus* had the lowest indices while*Petrocephalus, Clarias, Barbus* and *Oreochromis* had the highest Shannon- Weinerdiversity (Table 4.10).



Fig. 4.11: Monthly variation in number of fish species present in Dadin-Kowa Reservoir

Table 4.7: Monthly total number of fish species caught in the different families in Dadin-Kowa Reservoir

Families	October	November	December	January	February	March	April	May	Total
Mormyridae	6 (13.04)	5 (10.87)	3 (6.52)	3 (6.52)	10 (21.74)	9 (19.57)	4 (8.70)	6 (13.04)	46
Bagridae	30 (17.96)	16 (9.58)	17 (10.18)	24 (14.37)	34 (20.36)	18 (10.78)	21 (12.57)	7 (4.19)	167
Claroteidae	0 (0.00)	0 (0.00)	2 (25.00)	1 (12.50)	2 (25.00)	3 (37.50)	0 (0.00)	0 (0.00)	8
Claridae	23 (20.54)	22 (19.64)	10 (8.93)	12 (10.71)	19 (16.96)	9 (8.04)	8 (7.14)	9 (8.04)	112
Alestidae	6 (16.22)	0 (0.00)	1 (2.70)	9 (24.32)	7 (18.92)	7 (18.92)	6 (16.22)	1 (2.70)	37
Cichlidae	5 (8.47)	9(15.25)	4 (6.78)	6 (10.17)	10 (16.95)	19 (32.20)	6 (10.17)	0 (0.00)	59
Cyprinidae	5 (8.77)	8 (14.04)	10 (17.54)	5 (8.77)	7 (12.28)	8 (14.04)	7 (12.28)	7 (12.28)	57
Mochokidae	5 (7.69)	13 (20.00)	11 (16.92)	7 (10.77)	11 (16.92)	2 (3.08)	7 (10.77)	9 (13.85)	65
Polypteridae	0 (0.00)	13 (20.00)	7 (10.77)	2 (3.08)	14 (21.54)	11 (16.92)	11 (16.92)	7 (10.77)	65
Schilbeidae	2 (2.90)	9 (13.04)	15 (21.74)	13 (18.84)	7 (10.14)	9 (13.04)	7 (10.14)	7 (10.14)	69
Malapteruridae	0 (0.00)	0 (0.00)	0 (0.00)	2 (40.00)	1 (20.00)	1 (20.00)	1 (20.00)	0 (0.00)	5

Note: Percentages in parenthesis

Fish Genus	October	November	December	January	February	March	April	May	Total
Hyperopisus	0 (0.00)	0 (0.00)	3 (30.00)	2 (20.00)	4 (40.00)	1 (10.00)	0 (0.00)	0 (0.00)	**10**
Mormyrus	4 (13.33)	5 (16.67)	0 (0.00)	1 (3.33)	5 (16.67)	6 (20.00)	4 (13.33)	5 (16.67)	**30**
Marcusenius	2 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	2 (33.33)	0 (0.00)	1 (16.67)	**6**
Petrocephalus	23 (17.56)	14 (10.69)	16 (12.21)	15 (11.45)	32 (24.43)	9 (6.87)	15 (11.45)	7 (5.34)	**131**
Chrysichthys	2 (13.33)	0 (0.00)	0 (0.00)	5 (33.33)	2 (13.33)	3 (20.00)	3 (20.00)	0 (0.00)	**15**
Auchenoglanis	5 (23.81)	2 (9.52)	1 (4.76)	4 (19.05)	0 (0.00)	6 (28.57)	3 (14.29)	0 (0.00)	**21**
Clarias	0 (0.00)	0 (0.00)	2 (25.00)	1 (12.50)	2 (25.00)	3 (37.50)	0 (0.00)	0 (0.00)	**8**
Heterobranchus	23 (20.54)	22 (19.64)	10 (8.93)	12 (10.71)	19 (16.96)	9 (8.04)	8 (7.14)	9 (8.04)	**112**
Brycinus	6 (16.22)	0 (0.00)	1 (2.70)	9 (24.32)	7 (18.92)	7 (18.92)	6 (16.22)	1 (2.70)	**37**
Hydrocyon	5 (8.47)	9(15.25)	4 (6.78)	6 (10.17)	10 (16.95)	19 (32.20)	6 (10.17)	0 (0.00)	**59**
Coptodon	5 (55.56)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (22.22)	2 (22.22)	**9**
Oreochromis	0 (0.00)	8 (16.67)	10 (20.83)	5 (10.42)	7 (14.58)	8 (16.67)	5 (10.42)	5 (10.42)	**48**
Barbus	5 (7.69)	13 (20.00)	11 (16.92)	7 (10.77)	11 (16.92)	2 (3.08)	7 (10.77)	9 (13.85)	**65**
Labeo	0 (0.00)	5 (12.50)	7 (17.50)	0 (0.00)	11 (27.50)	4 (10.00)	7 (17.50)	6 (15.00)	**40**
Synodontis	0 (0.00)	8 (32.00)	0 (0.00)	2 (8.00)	3 (12.00)	7 (28.00)	4 (16.00)	1 (4.00)	**25**

Polypterus	2 (20.00)	0 (0.00)	0 (0.00)	3 (30.00)	2 (20.00)	1 (10.00)	0 (0.00)	2 (20.00)	**10**
Schilbe	0 (0.00)	9(15.25)	15 (25.42)	10 (16.95)	5 (8.47)	8 (13.56)	7 (11.86)	5 (8.47)	**59**
Malapterurus	0 (0.00)	0 (0.00)	0 (0.00)	2 (40.00)	1 (20.00)	1 (20.00)	1 (20.00)	0 (0.00)	**5**

Table 4.8: Monthly total number of fish species sampled in the different genera in Dadin-Kowa Reservoir

Table 4.9: Shannon- Weiner Diversity Index (H) and evenness of fish families in Dadin-Kowa Reservoir

Families	**Total**	**%**	**Dominance**	**Simpson Diversity Index**	**Shannon Diversity Index**	**Evenness**
Mormyridae	46	6.67	0.15	0.85	1.99	0.92
Bagridae	167	24.20	0.14	0.86	2.00	0.93
Claroteidae	8	1.16	0.28	0.72	1.32	0.94
Clariidae	112	16.23	0.15	0.85	1.99	0.92
Alestidae	37	5.36	0.19	0.82	1.76	0.83
Cichlidae	59	8.55	0.19	0.81	1.81	0.87
Cyprinidae	57	8.26	0.13	0.87	2.06	0.98
Mochokidae	65	9.42	0.15	0.85	1.98	0.91
Polypteridae	65	9.42	0.17	0.83	1.84	0.90
Schilbeidae	69	10.00	0.15	0.85	1.98	0.90
Malapteruridae	5	0.72	0.28	0.72	1.33	0.95
Total	**690**					

Table 4.10: Shannon -Weiner Diversity Index (H) and evenness of fish genera inDadin-Kowa Reservoir

Fish Genus	Total	%	Dominance	Simpson Diversity Index	Shannon Diversity Index	Evenness
Hyperopisus	10	1.45	0.30	0.70	1.28	0.90
Mormyrus	30	4.35	0.16	0.84	1.87	0.93
Mormyr	6	0.87	0.28	0.72	1.33	0.95
Petrocephalus	131	18.99	0.15	0.85	1.98	0.91
Bagrus	15	2.17	0.23	0.77	1.55	0.94
Chrysichthys	21	3.04	0.21	0.79	1.66	0.88
Auchenoglanis	8	1.16	0.28	0.72	1.32	0.94
Clarias	112	16.23	0.15	0.85	1.99	0.92
Heterobranchus	37	5.36	0.19	0.82	1.76	0.83
Brycinus	59	8.55	0.19	0.81	1.81	0.87
Hydrocyon	9	1.30	0.41	0.59	1.00	0.90
Oreochromis	48	6.96	0.15	0.85	1.91	0.97

Barbus	65	9.42	0.15	0.85	1.98	0.91
Labeo	40	5.80	0.19	0.82	1.74	0.95
Synodontis	25	3.62	0.23	0.77	1.60	0.83
Polypterus	10	1.45	0.22	0.78	1.56	0.95
Schilbe	59	8.55	0.16	0.84	1.88	0.93
Malapterurus	5	0.72	0.28	0.72	1.33	0.95
Total	**690**					

4.7 Morphometric indices and condition factor of fish in Dadin-Kowa Reservoir

The condition factors of fish species from the reservoir (Table 4.11) ranged between 0.30 and 1.09. High condition factors of 1.01 and 1.09 were observed in *Brycinusmacrolepidotus* and *Malapterurus minjiriya,* respectively. Lower values of 0.31 and 0.30were obtained in *Bagrus bajad*and*Marcusenius macrophthalmus*respectively.Figure 4.12 shows the relationship between the length and weight of sampled fish species inthe reservoir. There was high positive relationship in every change in weight of fish tocorresponding change in fish length.

Table 4.11: Morphometrics and condition factor of fish species in Dadin-KowaReservoir.

Fish species	**Length (cm)**	**Weight (g)**	**Condition Factor (K)**
Hyperopsusbebe	21.5	500	0.50

Mormyrusrume	24.4	600	0.41
Mormyrushasselquisti	25.3	600	0.37
Marcusenius macrophthalmus	28.5	700	0.30
Mormyrops anguilloides	28.7	780	0.3.3
Petrocephalus ansorgii	26.1	680	0.38
Bagrus bajad	26.0	550	0.31
Bagrus docmak	26.5	650	0.35
Chrysichthys nigrodigitatus	20.3	440	0.52
Chrysichthys auratus	18.1	500	0.84
Auchenoglanis occidentalis	21.6	530	0.53
Clarias anguillaris	21.0	530	0.57
Clarias gariepinus	20.4	440	0.32
Heterobranchus bidorsalis	21.2	570	0.60
Brycinus macrolepidotus	22.2	610	0.56
Alestes nurse	16.2	430	1.01
Hydrocyon vittatus	16.9	410	0.85
Coptodon zillii	15.6	390	1.03
Oreochromis niloticus	21.2	480	0.50
Barbusoccidentalis	22.6	590	0.51
Labeo senegalensis	20.4	480	0.57
Labeo pseudocoubie	16.9	390	0.81
Synodontis nigrita	17.3	400	0.77
Polypterussenegalus	19.0	490	0.71
Synodontis budgetti	18.1	450	0.76
Synodontis clarias	18.3	360	0.59
Synodontis vermiculata	19.0	400	0.58
Schilbemytus	17.7	400	0.72
Malapterurusmijiriya	14.6	340	1.09
Bagrus docmak	29.6	850	0.33

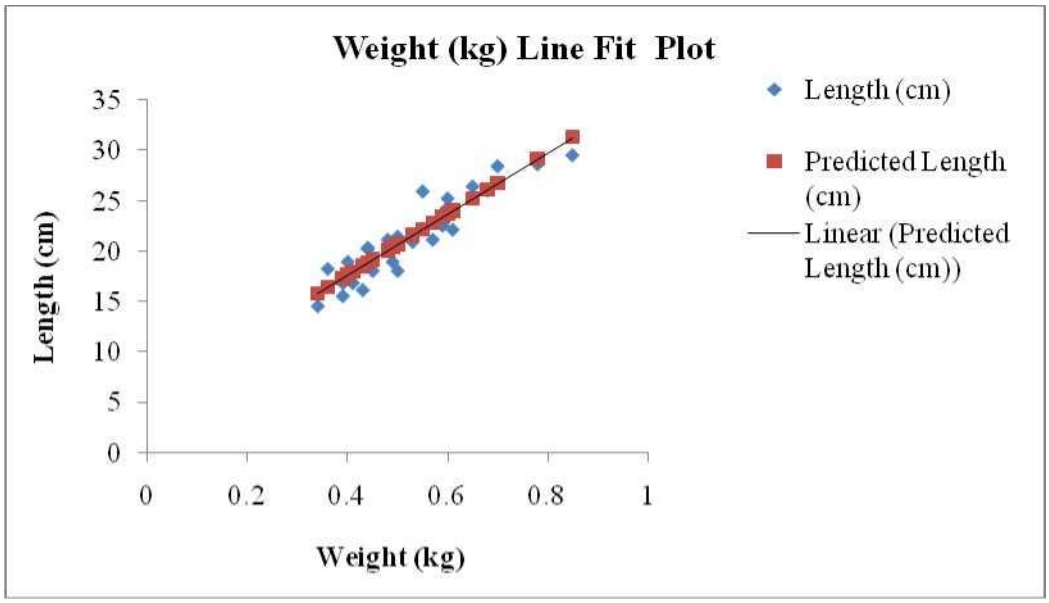


Fig. 4.12: Length-weight relationship of fish species in Dadin-KowaReservoir

CHAPTER FIVE

DISCUSSION

5.1 Physicochemical Parameters of Dadin-Kowa Reservoir

Water quality is determined by various physico-chemical and biological factors, as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983; El-Nemaki *et al*., 2008). The significant variation in the physical and chemical parameters observed during this study period could be attributed to changes in weather conditions and anthropogenic activities in and around the reservoir.

The highest mean value of 34.40±0.17^{o}C for water temperature recorded in the month of April, may be as a result of the intense solar radiation that characterized the month. The high temperature exceeds the normal range of temperature (8^{o}C-30^{o}C) in the tropics for normal physiological activities by fish. Such high temperature could impair fish growth and development. Lower temperatures observed in the month of December and January coincided with the harmattan season in the study area, when atmospheric temperature is very low due to reduced sunlight intensity.Sawyer*et al*.,(1994) and Adebowale*et al*.,(2008) reported that variation in water temperature is related to

atmospheric temperature as well as weather conditions of an area.As fish is a cold blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production. Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and subsequent increase in oxygen demand (Bhatnagar and Devi, 2013).

The significant gradual increase in transparency from the months of November to February may be related to onset of the dry season and decreased water current at Dadin-Kowa. The transparency values from this study are withinthe range of 27.71 to 79.70cm and similar to what was reported for Alau Lake (Usman*et al.*, 2013), in the same ecological zone with Dadin-Kowa reservoir. Liu and Yu (1992) observed lower transparency during the rainy season than in the dry season in reservoirs in China.

A transparent water is important as light is an important factor for aquatic organisms to develop. Turbid water that carries too much suspended matter, soil particles are not suitable for fish culture (Bolorunduro and Abdullah, 1998). The lack of variation in water depth in the reservoir during this study may be as a result of the geomorphological features of the reservoir.

The monthly pH range (6.3-7.67) in the study falls within the values of 6.5-9.0 water pH stipulated by world quality standard for fish production (WHO, 1990; EPA, 2001). Any range outside which may affect fish productivity. Biological activities, temperature changes (Adebowale*et al.*, 2008) in surface runoff and decaying vegetation could result in water pH variation. Fish have an average blood pH of 7.4, a little deviation from this value, generally from 7.0 to 8.5 is optimal and conducive to fish life (Bhatnagar and Devi, 2013**)**.The pH value between7 to 8.5 is considered ideal for biological productivity. WaterpH in the rangeof 4.0 to 6.5 and 9.0 to 11.0, can cause stress in fishes and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011).

The electrical conductivity values obtained in the study varied according to season.The range of 20 µs/cm to 68 µs/cm in this study was lower than the range (177 µs/cm -214 µs/cm) reported by Tukura*et al.*,(2012), and higher than the 0.02 µs/cm – 0.13 µs/cm observed by Liu and Yu, (1992).The EC values of the water in Dadin-Kowa are within the range of 10 - 1000 µs/cm for surface freshwater reported in Calabar, Nigeria (Asuquo, 1999). Conductivity can be used as indicator of primary production (chemical richness) and thus fish production. Fish are known to differ in their ability to maintain osmotic pressure,therefore the optimum conductivity for fish production differs from one species to another (Bhatnagar and Devi, 2013**)**. Enrique (1992) also observed that ground water and surface runoff from ground and surrounding farmlands leading to increased ionic substances and reduced water volume (Chia,*et al.*,2011), could result in high EC values. Kadiri (1988) reported lower transparency in reservoirs during the rainy season than the dry season. The highest TDS value in the Dadin-Kowa reservoir at the peak of the dry season agrees with the findings of Chia*et al.*(2011) in water bodies in Zaria and Tukura *et al*., (2012) in Mada river in Nasarawa, Nigeria. The levels of TDS in abroad sensereflect the burden of aquatic systems.Pandey*et al.,* (2012) reported that high dissolved solids in water could have organo-trophic implication and can cause suffocations to aquatic fauna and impair gill function.

The biochemical oxygen demand (BOD) is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage (Bhatnagar and Devi, 2013). This study showed consistency in the BOD (2.6-5.4 mg/l) of the waterbody over the months of the study. This BOD range makes the reservoir to be slightly polluted. Clair *et al.*,(2013) reported that water bodies with BOD in the range of 2-8 mg/l are moderately polluted. Important factor influencing BOD include organic matter content, pH, reduction in organic matter, nitrification and types of microorganisms (Kumar and Bahader, 2009). Higher level of BOD could be as a result ofincrease in phosphate from anthropogenic activities such as washing and high organic load from cattle using the reservoir as water drinking points. The dissolved oxygen (DO)

range of 3.3 – 9.5 mg/l of the reservoir could be considered good for aquatic life compared to the range reported of 4.3 – 8.8 mg/l for lake Alau (Ahmed and Lawal, 2014), 3.9 – 8.0 mg/l of WateriLake (Haruna, 2005), 0.3 – 3.2 in Jakara Lake in Kano, Nigeria (Haruna, 1992), and the value of 3.0mg/l recorded for water quality, abundance of fish and plankton species of Ikwori Lake, Nigeria (Offem, *et al.,* 2011).

Tropical fishes have more tolerance to low DO than temperate fishes (Bhatnagar and Devi, 2013**)**. According to Bhatnagar and Singh (2010) and Bhatnagar*et al*., (2004) DO level >5ppm is essential to support good fish production.The minimum DO (3.3 mg/l) from station A in the month of November is lower than minimum of 6.37 mg/l reported in Ahmed and Lawal, 2014 and can be considered low. This could slow down growth and development of fishes after prolonged exposure (Andem*et al.,* 2012). Phytoplankton diversities, rates of mixing in upper and lower layers and organic matter decay could influence oxygen saturation percentage of a water body (Clarke and Warwick, 1994).

The carbon dioxide(CO_2) content of the reservoir is consistent throughout the study period. Dissolved CO_2 is constituted mainly by respiration from aquatic fauna, decomposition of organic matter and from atmospheric gases. Carbondioxide concentrations are known to increase when dissolved oxygen concentration are reduced. Free carbon dioxide, a highly soluble gas in water, main source of carbon pathway in nature, is contributed by the respiratory activity of animals and can exist in water as bicarbonate or carbonates. When CO_2 dissolves in water it forms carbonic acid which decreases the pH of any system and can be harmful to aquatic organisms (Bhatnagar and Devi, 2013).

Water hardness is important to fish culture and is a commonly reported aspect of water quality. The water hardness values in this study fall within the range of 30 – 60 mg/l for moderately soft water.Bhatnagar*et al*. (2004) reported hardness values less than 20ppm to cause stress, 75-150 ppm is optimum for fish culture and >300 ppm is lethal to fish life as it increases pH, resulting in non-

availability of nutrients. However, Swann (1997) recommended ideal value of hardness for fish culture to be higher than 20 mg/l and range within 30-180 mg/l (Santhosh and Singh, 2007).

5.2 Fish Species Composition and Diversity

The fish composition of Dadin-Kowa reservoir comprised a total of thirty (30) fish species representing eleven(11) families sampled and identified during the study period. These species constitute 13% of the estimated 230 species of fish in Nigeria Rivers reported by Ita (1993). Reports byOdo *et al.*,(2009) estimated 52 fish species in 17 families in Anambra River while 37 fish species in 21 families from Badagrylagoon was reported by Soyinka *et al*., (2010). David *et al.*(2015) reported 21 species in 10 families in Kiri Lake.Adaka*et al.* (2014) reported an estimate of 25 fish species, 15 genera, 21 families and six orders from Oramiri-Ukwa River, south-east Nigeria.Uttah (2012) also reported 70 fish species in 31 families in IkotAbasi, Nigeria. Fluctuations in fish species composition of Nigeria inland water bodies have been documented. Jamu and Ayinla (2003) reported environmental degradation and poor management of fishing resources to be responsible for the decline in fish yield of Nigeria inland waters.Gulland (1991) attributed variation in catchability to the type of gear used, the weather or other environmental conditions, and the time of catch.

The dominance by the family Mormyridaewith six (6) species in Dadin-Kowa reservoir could be that the ecological resources in the reservoir favored the species. The modifications of the mouthparts in the Mormyridae facilitate feeding on small invertebrate buried in muddy substrates. Fish, especially on tilapias, and crustaceans form part of the diet while young fishes in the family prey on benthic invertebrates, mostly aquatic insects (Kouamela, *et al.*, 2000).Nazeef and Abubakar (2013) reported the family Mormyridae had the highest number of three (3) species in Dadin-Kowa reservoirThe family Mormyridae was also reported as the dominant taxon with nine (9) species in Nguru wetlands of Nigeria (Abubakar *et al*., 2015). However, this report is contrary to the findings of Balogun (2005), Dankishiya and Abdulrahman (2007), Mustapha (2008) and Dankishiya*et al*(2013) that reported the family Cichlidae as the most dominant in quite a number of Nigeria reservoirs. The

dominance by Cichlidae has been attributed to the high prolific breeding nature of the member of the family (Atagubae*t al.*, 2014).

The families of fish present in Dadin-Kowa reservoir during the study period have been reported to occur in water bodies with similar characteristics across Nigeria (Ita, 1993; Nazeef and Abubakar, 2013; Ekundayo *et al.*, 2014; Abubakare*t al*. 2015). The families Malapteruridae, Polypteridae and Schilbeidae being the rarest in the reservoir could be as a result of narrow tolerance for most of the factors.The highest fish catch in the month of February could be associated with low water level in the reservoir. The lowest fish catch in the month of May could be attributed to increased water levels that marked the on-set of the rainy season.The family Bagridae was more susceptible to catch in the reservoir while Malapteruridae with the least may be associated with the behavior of the species in these findings or the nature of the fishing gears used.Malapteruridae are generally found among rocks or roots in turbid or black waters with low visibility (*Ng, 2000).*

The range of Shannon- Weiner Diversity Index (H)values (1.332-2.056) in this study show good fish family diversity in the reservoir.The H values within the range of 1.809 to 2.015 were reported for three tributaries of Ore River (Lawson and Olusanya, 2010). The range of Shanon -Weiner values obtained in the study is similar to the range of 1.811 to 2.366 reported by Nazeef and Abubakar (2013) in the same reservoir. Although the genera *Barbus* (0.4) and *Clarias* (0.147) had the highest and lowest dominance values. An evenness value of close to 1.0 of the genera is an indication of even distribution in the reservoir.The low degree of evenness observed in the family Alestidae is an indication of low species in the family.Cyprinidae with highest evenness value (0.98) is indication of thehigh density of the family.The highest diversity in the genus *Clarias*and lowest in *Hydrocynus* could be as a result of their respective low and high dominance in the reservoir. Species diversity within a natural community is in part a reflection of the diversity in the physical environment. Smith (1966), stated that the greater the variation in the physical environment the more numerous are the species since there are more numerous microhabitats available and more niches to occupy. Variation

in fish diversity has been attributed to water quality, food composition and exploitation (David *et al*., 2015).

5.3 Length-Weight Relationship and Condition Factor

The length-weight relationship is animportant parameter for stock assessment and understanding of the population dynamics, which could be used to promote the species in the wild. The high condition factor from this study can be considered as morphometric expression of the overall physiological state of the fishes (Onuoha*et al*., 2010). The relatively high condition factor obtained in *Alestesnurse*, *Tilapiazillii* and *Malapterurusminjiriya* was an indication of good well being, isometric growth and expression of proper utilization of environmental resources. The variation in condition factors (K) of the fish species in the reservoir could be as a result of inconsistency in the natural conditions in the reservoir. Lagler (1985) stated the value of K is not constant for individual species or populations.Condition factors greater than 1.0 has been reported in fish species from Dadin-Kowa reservoir (Nazeef and Abubakar, 2013). The condition factor, K, is an index of general well-being or fitness of fish population (Bolger and Cannolly, 1989) and assumes that the heavier fish of a given length is in better condition.

CHAPTERSIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The study on the physico-chemical parameters in Dadin-Kowa reservoir shows that there was marked monthly variation in the mean values obtained during the period of study. There was high significance ($P \leq 0.05$) variation in the physico-chemical parameters with months in the reservoir except for water depth, carbon dioxide and hardness. All of the physico-chemical parameters but

hardness did not vary significantly ($P \geq 0.05$) in the sampling stations. Positive and negative associations were established among the parameters.

A total of thirty fish species representing eleven families were recorded in the reservoir. The highest catch by number was in the family Bagridae with 167 fish of which 131 belong to the genus *Petrocephalus*. The Malapteruridae family represented by the genus *Malapterurus,* had the least catch with 5 individuals. The highest number by species was recorded in the family Mormyridae with 6 while the least number of species was in the Malapteruridae, Polypteridae and Schilbedae with one each. There was significant variation ($P \leq 0.05$) in the number of fish species sampled monthly in the reservoir. The highest diversity was in the family Cyprinidae while the degree of evenness of the families was lowest in Alestidae and highest in Cyprinidae. The highest and least dominance were in Cichlidae and Malapteruridae respectively. The condition factor (K) depicting the wellness of the fish indicated most of the fish were in good condition.

6.2 Conclusions

There was marked significant variation in the ($P \leq 0.05$) mean monthlywater temperature (30.0±0.74) transparency (62.33±2.37), pH (7.03±0.10), electrical conductivity (44.92±2.73), biological oxygen demand (3.63±0.17), total dissolved solids (22.50±1.38) and dissolved oxygen (6.77±0.44) in Dadin-Kowa reservoir. These parameters show positive and negative influence on the fish species in the reservoir. Dadin-Kowa reservoir is rich in fish composition, with important economic families. The family Mormyridae (20.0%) has the highest catch while Malapteruride, Polypteridae Schilbeidae with 3.3% each had the least catch.*Mormyropsanguilloides* (14.5%) and *Malapterurusminjiriya* (0.7%) have the highest and lowest species abundance respectively.The families Bagridae (2.00) andCyprinidae (2.06) had the highest diversity indices while the lowest index of 1.32 was obtained in Claridae. The genera with the highest and lowest diversities were*Clarias* (1.99) and *Hyperopisus* (1.28) respectively. This is an indication ofhighly diversified community structure.Fish species in the reservoir showed a dynamic

variation of condition factor with the lowest value of 0.30 in *Mormyrusmacrophthalmus* and the highest (1.10) in *Alestesnurse*, *Tilapiazilliii*and *Schilbe mystus.*

6.3 Recommendations

1. It is recommended that monitoring of the physico-chemical parameters of water in the reservoir be carried out regularly in order to ensure its suitability for aquatic life.
2. There is the need for proper management strategies to be put in place to ensure sustainability of the reservoir for better and healthier fish output.
3. Educating fishermen through enlightenment campaignson the importance of sustainable use of fisheries resource should be encouraged in order not to undermine the conservation of the reservoir.
4. Fishers should be enlightened on the use of recommended fishing gears, stoppage of under meshed fishing nets. Although not seen, in the course of the study, discouragement of harzardous chemicals for fishing.

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