PHYSICO-CHEMICAL PARAMETERS AND FISH DIVERSITY OF DOMA RESERVOIR, NASARAWA STATE, NIGERIA

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JANUARY, 2017

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BY

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Ph.D/SCIE/12099/2010-2011

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN FISHERIES

DEPARTMENT OF BIOLOGY

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JANUARY, 2017

DECLARATION

I declare that the work in this dissertation titled physico-chemical parameters and Fish diversity of Doma Reservoir, Nasarawa State, Nigeria has been carried out by me in the Department of Biology, under the supervision of Professor J. Auta, Professor S. J. Oniye and Professor J. K. Balogun. The information derived from the literatures has been duly acknowledged in the text and the list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

_____ _____

Banyigyi Hassan Aforo Date

CERTIFICATION

This dissertation titled 'PHYSICO-CHEMICAL PARAMETERS AND FISH DIVERSITY OF DOMA RESERVOIR; NASARAWA STATE, NIGERIA' by Hassan Aforo BANYIGYI meets the regulation governing the award of the degree of Doctor of Philosophy (Fisheries) of the Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my wife (Blessing Hassan), my children (Abraham, Faith and Sarah) and the entire family of Banyigyi Jezhi Aforo

ACKNOWLEDGEMENTS

I sincerely thank God Almighty for making this work a success, May His mercy endures forever.

I strongly express my thanks and appreciations to my supervisors, Professor J. Auta, Chairman Supervisory Committee, Professor S. J. Oniye, Member Supervisory Committee and Professor J. K. Balogun, Member Supervisory Committee for their criticism, advice and guidance throughout the period of this research work. May God Almighty bless and reward you all abundantly. I also wish to extend my thanks and gratitude to all the lecturers and staff of the Department of Biology, for their advice, suggestion and encouragement in the course of this work.

I highly appreciate the management of Nasarawa State University, Keffi and TETfund for granting me this opportunity and financial assistance to enable me undergo this study.

I'm highly indebted to my wife and children for their understanding, patience and prayers when I was out there in the field collecting data, all these will not be in vain and God will replenish you abundantly. I also appreciate the contribution of every member of Banyigyi family either by prayer, financial and other wise to the success of this work, thanks and God bless you.

I sincerely appreciate my colleagues in the Department of Zoology, Nasarawa State University, Keffi especially J. K. Makpo, A. B. Yako, G. A. Amuga, J. D. C. Toongjura and R. J. Ombugadu (Mrs.) for their advice, suggestions and encouragement, thanks very much.

My profound gratitude goes to Dr. N. Goki of Geology Department, Nasarawa State University, Keffi for assisting me in surveying the Doma Reservoir and producing the map showing locations and the sampling stations of the reservoir. God will continue to grant you that knowledge of understanding, Amen.

My thanks and appreciation to Mr. Joseph Benjami, his wife, children and brothers (especially Danladi) from Doma who despite their tight schedules devoted their time in assisting me in setting nets and collections of other data in the field, God in His infinite mercy will reward you abundantly.

I wish to express my sincere joy and happiness to Mr. and Mrs. Joel Umaru for their kindness and hospitability shown to me all the time I was in Zaria during the course of this work. May the Almighty God continue to bless you abundantly.

ABSTRACT

Study on the physico-chemical parameters and fish diversity of Doma reservoir, Nasarawa State, Nigeria was conducted from July 2012 to June 2014. La Motte Tracer (pocketester) code 1766 was used to determined the values of the pH, salinity, TDS and electrical conductivity while La Motte Fresh Water Aquaculture Test Kit (Model: AQ-2, Code: 3633-03) was used in determining the values of dissolved oxygen (DO), alkalinity, carbon dioxide, chloride, hardness and ammonia-nitrogen. Fish species composition and distribution were determined using a fleet of seven multifilament gill nets in sampling the shore, surface and bottom habitats in the three sampling stations and artisanal catch assessment surveys. The study shows that mean values of the physico-chemical parameters obtained were within the acceptable ranges for safe aquatic lives, though there were monthly and seasonal variations in some physico-chemical parameters of water. The mean dry season values for water temperature, transparency, salinity, total dissolved substances, conductivity, hardness and dissolved oxygen were significantly higher ($P<0.05$) than those of the rainy season while the mean rainy season values for depth, ammonia-nitrogen, alkalinity, carbon dioxide and chloride were higher than those of dry season. The correlation analysis between the physico-chemical parameters studied in Doma Reservoir shows that some parameters exhibited positive relationship while some exhibited negative relationship. Eight families of fish (Cichlidae, Mormyridae, Clariidae, Hepsetidae, Channidae, Cyprinidae, Polypteridae and Mastacembellidae) represented by thirteen species of fish were recorded in both experimental gill net sampling and commercial catches of fishermen in the Doma reservoir. Cichlidae dominated the fish population and *Saratherodon galilaeus* was the most abundant species of fish (72.5%). In term of species

richness, the family Cichlidae has the highest numbers of species represented by five (*Saratherodon galilaeus*, *Tilapia zilli*, *Oreochromis nilotcus*, *Hemichromis fasciatus* and *Pelmatochromis pulcher*) followed by Mormyridae represented by two species (*Hyperopisus bebe occidentalis* and *Gnathonemus niger*) other families were represented by one species each. The fishing gears used by the local fishermen included gill nets, cast nets, Malian traps and hook and line and means of transport was wooden canoe without engine. The diversity indices shows that the Simpson's index (D) was between 0.521 to 0.597, Simpson's index of diversity (1-D) was between 0.403 to 0.479, Simpson's reciprocal index (1/D) was between 1.675 to 1.919, Shannon's index (H) was between 0.858 to 1.007 while Shannon equitability or Evenness (EH) was between 0.391 to 0.437. The length-weight relationship of six fish species study from Doma Reservoir indicated that the fish species exhibited allometric growth pattern and the value of correlation coefficient (r) of fish species were higher than 0.900 which indicates strong relationship between length and weight, that is weight increases with increase in length while condition factors (K) of fish species studied shows the fish were in good conditions. The study also showed that the reservoir was productive with the potential fish yield (Y) of 40.76kgha^{-1} for the first year, 42.63kgha^{-1} for the second and 41.73kgha^{-1} for the combined years estimated from morpho-edaphic indices of the reservoir. The need to monitor human activities and fishing intensity on the reservoir, in order not to destroy the fish diversity is recommended. Regulation of number of fishermen operating on the reservoir and the enforcement of using minimum mesh size of 7.6cm or 3" was also recommended.

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ABBREVIATIONS, DEFINITIONS, GLOSSARIES AND SYMBOLS

Symbol	Definition
%	Percentage
°C	Degree Celsius
µS	micro – semen
APHA	America Public Health Association
Av.	Average
CO_2	Carbon dioxide
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FDF	Federal Department of Fisheries
FEPA	Federal Environmental Protection Agency
gm	gram
kg	Kilogramme
M.E.I	Morpho – Edaphic Index
mg	Milligramme
mm	Millimetre
NH_3- N	Ammonia – Nitrogen
pH	Hydrogen Ion Concentration
ppm	part per million
r	Pearson's Product Moment Correlation
TDS	Total Dissolved Substances
USEPA	United State Environmental Protection Agency
WHO	World Health Organization
Wt.	Weight

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Nigeria lies between Longitudes 2^0 49' and 14^0 37'E and Latitudes 4^0 16' and $13^0$52' N of Equator. It is blessed with vast expanse of inland fresh water and brackish ecosystems from the coastal region to the arid zone. Thirteen lakes and reservoirs with a total surface area of 953600 ha representing about 1% of the country have been reported (Olaosebikan and Raji, 1998). They are of significant importance because they hold populations of diverse fish species. Species that are of great commercial value and importance vary in their composition depending on the water body. These species of fish serve as a source of protein and food in the face of ever increasing population in the developing countries. In addition, the lake fisheries had serve as a source of livelihood to the riparian communities and biodiversity of tremendous conservation values.

There are about 268 different freshwater fish species in Nigeria. They inhabit over 34 well-known fresh water bodies (rivers, lakes and reservoirs) which constitute about 12% of Nigeria's total surface area put about 94,185,000 ha (Ita 1993). Fish stocks in rivers are generally replenished from their adjacent flood plains after each flood season during which fish breed. Therefore, any natural phenomenon as drought or artificial activities such as dam construction, which eventually affect the natural cycle of flooding, will certainly undermine fish species diversity both in lakes and wetlands. Considering this facts, therefore, that lakes, wetlands and reservoirs are supplied with by their inflowing rivers, the rivers will be characterized by higher species diversity (Ita, 1993).

Fish Production from inland water resources (rivers lakes and streams) is under threat from pollution, habitat alteration and degradation, changes in river flows and over exploitation. According to Wotton (1990), material pollution of rivers is caused by toxic pollutants (heavy metals, phenols, insecticides etc) that have direct adverse effect on aquatic biota and by pollutants that indirectly affects aquatic biota like human and animal wastes which are non-toxic but due to bacterial action on them, dissolved oxygen is used up which harms aquatic biota.

Studies on water quality center on fish production and aquatic biotic integrity (Boyd, 1982, Abohweyere 1990, King 1998). The notable important physico- chemical parameters are transparency, temperature, dissolved oxygen, suspended solids and dissolved ions (Karr and Dudley 1981). Mustapha (2008) stated that expanding human population brought about by the opportunities of good water supply, irrigation, fish production, recreation and navigation offered by reservoirs has 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 by on the unique physical and chemical properties of water on which the sustenance of fish that inhabit the reservoir is built as well as the functions of the reservoir. Water quality deterioration in reservoirs usually comes from excessive nutrient inputs, eutrophication, acidification, heavy contamination, organic pollution and obnoxious fishing practices. The effects of these factors do not only affect the socio-economic functions of the reservoir negatively, but also bring loss of structural biodiversity of the reservoir.

1.2 Research Problem

Water is one of the major components of environmental resources that are under threat either from over exploitation or pollution exacerbated by human activities on the earth surface (Efe, 2002). Studies in Nigeria have shown that water resources are easily contaminated from anthropogenic activities in most cities (Kaizer *et al*., 2001, Obasi and Balogun 2001). It has been observed that agricultural wastes, manure, fertilizers and pesticides find their way into streams, rivers and lakes through run-off and therefore enrich the organic content of water bodies (Beadle, 1974 and Gopal *et al*., 1981) and leading to eutrophication (Mitchell, 1975). Eutrophication becomes nuisance in lakes because of impaired water quality which leads to prolific weeds growth, excessive algal blooms and deteriorating fisheries (Gelin, 1978). In Doma reservoir there are three fishing villages around the reservoir and water treatment plant. The villagers around this reservoir are involved in fishing and agricultural activities where herbicides and pesticides are being used. They also used the reservoir for other activities such as bathing and washing of their cloths, pots and plates. All these activities are likely to alter the quality of water in the reservoir which may in turn affect the life of aquatic organisms.

Jamu and Ayinla (2003) reported that the fish yields of most Nigeria inland waters are generally on the decline. The decline of these fisheries has been attributed to a wide range of causes ranging from inadequate management of fisheries resources to environmental degradation of water bodies. Fishing activities in Doma reservoir is so high and it has been observed that the fishermen are found of using different fishing gears including gill nets of smaller mesh sizes and fishing is all year round without opening and closing season, these

activities of fishermen may lead to over-exploitation and possible extinction of certain species.

The length-weight relationship of a fish is basically a measure of its growth pattern or age. Growth is an important component of biological production, which affects overall production directly. Negative changes in growth rates may result in decreased individual health, reproductive success and increased risk of predation and mortality (Onimisi and Oniye, 2010). Information on some aspect of biology of fishes such as Length-weight relationship, fecundity e.t.c of Doma reservoir is scanty.

1.3 Justification

Water quality is determined by the physical and chemical limnology of the reservoir (Sidnei *et al*., 1992) and includes all physical, chemical and biological factors of water that influence beneficial use of the water. The changes in physical characteristics like the temperature, transparency and chemical elements of water such as dissolved oxygen, chemical oxygen demand, nitrate and phosphate provide valuable information on the quality of the water, the source(s) of the variations and their impacts on the functions and biodiversity of the reservoir. Therefore study on the physico-chemical parameters of Doma reservoir will help provide basic information on the quality of water which could be used in the management of water quality of the reservoir.

Survey of fauna and flora of any water body is necessary because it provides a checklist of organisms present in the water for subsequent exploitation, conservation and sustainable management of the resources. Study on the composition of fish species of Doma reservoir will provide information on the type of fish species present in the reservoir, their abundance

diversity and richness which will serve as tool for management of fishery resources of this reservoir.

Length-weight relationships data of fishes are useful tools for biologists in fishery assessment and proper management of fish population. Length-weight relationship permits assessment of the biomass from length observations and conversion of growth-in-length equations to growth-in-weight and also is applied to assess the well-being of individuals (Mazaher *et al*., 2015). Study on Length-weight relationship of fishes of Doma reservoir will help provide knowledge on the sizes of fish species present on the reservoir and their well being. Therefore study on physico-chemical parameters and fish diversity of Doma reservoir will provide information which will serve as a base line for effective management and efficient utilization of its aquatic resources.

1.5 Aim of the Study

The main aim of the research was to study the physico-chemical parameters and fish diversity of Doma reservoir and provide information that may assist in the management and optimum utilization of its aquatic resources.

1.6 Objectives of the Study

The objectives of this study include:

i. To determine the variations in physico-chemical parameters of Doma Reservoir in relation to months and seasons
ii. To assess the monthly and seasonal composition of fish species in Doma Reservoir

iii. To determine the ength-weight relationships and condition factor (K) of fish species of the reservoir.

iv. To determine the fish species diversity of the reservoir

1.4 Research Hypotheses

The research hypotheses are

i. There is no significant variation in monthly and seasonal physico-chemical parameters of water.

ii. There is no significant difference in the monthly and seasonal composition of fish species of Doma reservoir

iii. There is strong relationship between length and weight of fish species studied in the reservoir

iv. The reservoir is not highly diversified in fish species

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Physico-Chemical Properties of Water

Water quality is defined in terms of the chemical, physical and biological contents of water. The water quality of rivers and lakes changes with the seasons and geographical areas, even when there is pollution present. Water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen and carbon dioxide. Others are total suspended and dissolved solids, total alkalinity and acidity and heavy metal contaminants. These parameters are the limiting factors for the survival of aquatic organisms (flora and fauna). Poor water qualities may be caused by low water flow, municipal effluents and industrial discharges (Chitmanat and Traichaiyaporn 2010).

2.1.1 Temperature

Temperature is a limiting factor in the aquatic environment (Odum, 1971 and Boyd, 1979). Water temperature is probably the most important variable. It affects metabolic activities, growth, feeding, reproduction, distribution and migratory behavior of aquatic organisms (Largler *et al*., 1977, Crillet and Queti, 2006, Suski *et al*., 2006). It affects solubility of gases in water in which case gas solubility decreases with increase in temperature. Thus temperature is affected by time of the day in which case high temperatures may be recorded in the daytime and become low in the night. Mean annual surface water temperature of

26.56°C was reported by Oniye *et al*. (2002) in Zaria Dam with the highest values recorded in April, May, June and October and the lowest recorded in December. Mustapha (2008) reported a range of 23.1- 29.6°C in Oyun Reservoir with seasonal variations higher in the dry seasons than rainy seasons. Bala and Bolorunduro (2011) reported a temperature range of 21.24- 31.7°C in Sabke Reservoir, Katsina State with higher mean value in rainy season than dry season. A range of 26.17- 27.50°C was reported in Ona River, Apata, Ibadan by Andem *et al.* (2012). Anago *et al*. (2013) also reported a range of temperature of 24.0-26.5°C in Awba Reservoir with the lowest value recorded in June and the highest value recorded in April.

2.1.2 Transparency

Transparency is a measure of water clarity. Transparency decreases with the presence of molecules and particles that can absorb or scatter light. The transmission of light into a body of water is important, since the sun is the primary source of energy for all biological processes, that is, necessary for photosynthesis a process that produce oxygen and food for consumers (Bellingham, 2012). The clearer the water the deeper sunlight will penetrate. Transparency influences the assemblage of fish species in the water body. Fish species with sensory adaptation to low light are dominant in turbid lakes, whereas those that rely on vision predominates clear lakes (Rodriguez and Lewis, 1997). Works on water transparency include that of Oniye *et al*. (2002) who reported that mean turbidity of Zaria Dam was 50.36cm with highest value in June and lowest in January. Bala and Bolorunduro (2011) reported a range of water transparency of 0.21- 1.69m in Sabke Reservoir with higher transparency in the dry season than wet season, Anago *et al*. (2013) reported a range of 0.2-0.4m in Awba Reservoir with highest value in April and the lowest value in July.

2.1.3 Depth

Depth of various reservoirs has been determined by several workers and they varied from one reservoir to another. The depth of the water body determines whether the reservoir is shallow or deep and can be measured in meters (m) or centimeters (cm). The mean depth obtained from various reservoirs are some times used in determining the morpho-edaphic index of a reservoir which is a biological index used in determining the productivity of the reservoirs. Ibrahim *et al* (2009) working on the physico-chemical parameters of Kontagora reservoir reported that the reservoir has mean depth of 7.74m in rainy season and mean depth of 6.94m in the dry season. Mustapha (2009) reported a mean depth of 2.6m for Oyun reservoir, while Edward (2012) reported a mean depth of 5.23m for Egbe reservoir.

2.1.4 pH

Hydrogen ion concentration or pH is one of the vital environmental characteristics which decide the survival, metabolism, physiology and growth of aquatic organisms. Ramanathan *et al*. (2005) recommended optimum range of pH 6.8-8.7 for maximum growth and reproduction of carp. pH is influenced by the acidity of the bottom sediments and biological activities. High pH may result from high photosynthesis by dense phytoplankton blooms. pH higher than 8.5 according to Abowei (2010) is ideal for biological productivity, but pH <4 is detrimental to aquatic life. pH may be affected by total alkalinity and acidity, run off from surrounding rocks and discharges. Oniye *et al*. (2002) reported annual mean value of pH of 6.65 in Zaria Dam, Mustapha (2008) repoted a range of 6.8- 8.2 in Oyun Reservoir with lowest value rcorded in dry season (January) and the highest values recorded in the wet season (August and September). Bala and Bolorunduro (2011) reported a range of pH

value of 7.14- 8.875 with no significant difference in seasonal variations. Offem *et al*. (2011) reported a mean pH value of 5.8 in Ikwori, South-Eastern Nigeria and there was no significant difference in seasonal variations. Andem *et al*. (2012) reported a pH range of 7.27- 7.47 in Ona River while a pH range of 7.3- 8.4 has also been reported in Awba Reservoir, Ibadan (Anago *et al*., 2013)

2.1.5 Salinity

Salinity is dynamic indicator of the nature of the exchange system. It is expressed as the total concentration of electrically charged ions (cat ions) in water in part per thousand (ppt). It is expressed either as a mass of these ions per unit volume or as milli–equivalent of ions per volume of the water. It determines the distribution of organisms in aquatic environments. The salinity of the water within the estuary tells us how much fresh water has mixed with sea water. Oxygen solubility decreases slightly as salinity increases, but oxygen solubility decreases more as temperature goes up regardless of salinity. The solubility in of oxygen in seawater is 21% less than that of freshwater at 32°F and 17% less than that of freshwater at 100°F. Oxygen solubility in fresh water decreases from 14.6 to 8.24mg/l as temperature rises from 32 to 100 degrees. This is a 46.3% decrease. On the other hand, oxygen solubility in sea water decreases from 11.5 to 6.6.75 mg/l for this same temperature increase, a decrease oxygen solubility of 41.3%. The salt concentration directly affects the salinity which impacts circulation with estuaries and coastal region can derive from or be strongly influenced by the density variation associated with salinity. In effect, dense saline water tends to flow under fresh water. Salinity is an important ecological parameter in its own right, and it is important in some chemical processes. Water salinity range of 0.11- 0.19 has been reported in Awba Reservoir (Anago *et al*., 2013).

2.1.6 Total dissolved solids

Total suspended and dissolved solids affect metabolism and physiology of fish and other aquatic organisms. They are products of run offs. They increase with increased rainfall and have adverse effects on dissolved oxygen and carbon dioxide. Suspended solids in water are directly proportional to dissolved solids. Dissolved solids could directly influence water conductivity, the higher the dissolved solids the higher the conductivity. Rainfall is an important factor in aquatic environment. Substances present in the air affect rain fall. Dust, volcanic gases and natural gases (such as carbon dioxide, oxygen, sulphur dioxide and nitrogen) are all dissolved or entrapped in rain. Toxic chemicals or lead when in the air are also collected in the rain as it falls to the ground. Rain reaches the earth's surface and, as runoff, flows over and through the soil and rocks, dissolving and picking up other substances. For instance, if the soil contains high amount of soluble substances, such as limestone, the runoff will have high concentrations of calcium carbonate. Urban runoff worsen the water quality in rivers and lakes by increasing the concentrations of such substances as nutrients (phosphorus and nitrogen), sediments, animal wastes (faecal coliform and pathogens), petroleum products and road salts (Lawson 2011). Industrial, farming, mining and forestry activities also significantly affect the quality of water. Farming increases concentration of nutrients, pesticides and suspended sediments. Industrial activities also increase concentrations of metals and toxic chemicals, add suspended sediment, increase temperature and lower dissolved oxygen in the water. Each of these effects can have a negative impact on the aquatic ecosystem and/or make water unsuitable for established or potential uses. Mustapha (2008) reported a range of total dissolved solids of 53.9- 119.8mg/l in Oyun Reservoir with higher vlues in wet season than

dry season, Bala and Bolorunduro (2011) reported a range of 30- 60mg/l in Sabke Reservoir with no significant seasonal variations. Offem *et al*. (2011) reported a mean of 103.2mg/l in Ikwori Reservoir with no significant difference in seasonal variations, a range of 459.88- 625.42mg/l was reported in Ona River (Andem *et al*., 2012) while Anago *et al*. (2013) also reported a range of 143.8- 159.5mg/l of total dissolved solids in Awba Reservoir.

2.1.7 Electrical conductivity

Electrical conductivity (EC) in natural water is the normalized measure of the water's ability to conduct electric current (Bellingham, 2012). This is mostly influenced by dissolved salts such as sodium chloride and potassium chloride. The common unit for electrical conductivity is Siemens per centimeter (µS/cm). Most freshwater sources will range between 0.001µS/cm to 0.1µS/cm (Boyd, 1990; Rao, 2005). Ugwu and Wakawa (2012) reported that EC of most freshwater ranged between 0.1µS/cm - 10µS/cm. The source of EC could be traced to abundant dissolved salts, due to poor irrigation management and minerals from runoffs (Bellingham, 2012). Studies on electrical conductivity of various water bodies have conducted by various workers. Mustapha (2008) reported a range of 80.4- 178.8µS/cm EC in Oyun Reservoir, 53.33- 130.00µS/cm EC was reported by Bala and Bolorunduru (2011) in Sabke Reservoir with no significant difference in seasonal variation. Andem *et al*. (2012) reported a range of 270.35- 295.56µS/cm EC in Ona River while a range of 290.8- 391.5µS/cm was reported by Anago *et al*. (2013) inAwba Reservoir with highest value recorded in May and lowest in July.

2.1.8 Ammonia-nitrogen

Ammonia in water occurs in two forms; toxic unionized ammonia (NH_3) and relatively non-toxic ionized form, ammonia ion (NH_4^+). Ammonia is toxic to aquatic life and toxicity is affected by pH. Ammonia-nitrogen has more toxic form at high pH and less toxic form at low pH. Ammonia-nitrogen toxicity also increases as temperature rises. Bala and Bolorunduro (2011) reported a range of 0.3- 1.17mg/l ammonia-nitrogen concentration in Sabke Reservoir with significant seasonal variations where the higher value was recorded in rainy season than dry season. Andem et al. (2012) reported a range of 0.8- 1.7mg/l ammonia-nitrogen concentration in Ona River.

2.1.9 Hardness

Water hardness is similar to alkalinity but represent different measurements. Hardness is chiefly a measure of calcium and magnesium, but other ions such as aluminium, iron, manganese, strontium, zinc and hydrogen ions are also included. When the hardness level is equal to the combined carbonate and bicarbonate alkalinity, it referred to as carbonate hardness. Hardness values greater than the sum of the carbonate and bicarbonate alkalinity are referred to as non-carbonated hardness (LaDon, 1990). Water that has hardness less than 61mg/l is considered soft, 61-120mg/l moderately hard, 121-180 hard; and more than 180mg/l very hard.

2.1.10 Alkalinity

Alkalinity of a water body is a measure of its capacity to neutralize acids to a designated pH [APHA, 1980, and Edokpayi, 2005]. Alkalinity is an indirect measure of the concentration of anions in water. The dissolved anions according to McNeely *et al* (1979)

may be sourced from bicarbonates, carbonates, hydroxides, phosphates, borates or silicates which may be derived from industrial waste, dissolved rocks, salt soils or bottom sediments. Alkalinity between 30 and 500 mg/l^{-1} is generally acceptable to fish and shrimp production (McNeely *et al.*, 1979; Abowei and George, 2010), between 20 to 50 mg/L^{-1} according to Boyd (1982) will permit plankton production for fish culture. High alkalinity results in physiological stress on aquatic organisms and may lead to loss of biodiversity. Andem *et al*. (2012) reported that the alkalinity of Ona River range between 67.76-82.64mg/l, while Anago *et al*. (2013) reported a range of 0.8- 1.7mg/l alkalinity in Awba Reservoir.

2.1.11 Carbon dioxide

Carbon forms two important oxides namely carbon dioxide (CO_2) carbon monoxide (CO). The atmosphere contains 0.03% by volume of carbon dioxide. A small percentage of CO_2 is also present in the dissolved form in water. In combined form, it is present mainly as metallic trioxocarbonate (IV) in the earth crust especially in limestones region and coral reefs (Ekubo and Abowei, 2011). Carbon dioxide is not active chemically; it dissolved in water to form to form carbonic acid (soda water). This is a weak basic acid which ionized slightly. Increase in CO_2 result in the decrease of dissolved oxygen in natural waters. Tropical fishes can tolerate CO_2 levels of over 100mg/l. But the ideal level of CO_2 in fish pond is less than 10mg/L (Ekubo and Abowei, 2011). Apart from being by-product of respiration and source of carbon fixation (photosynthesis), CO_2 combined with haemoglobin instead of oxygen, this can reduce oxygen supply in pond organism (Ekubo and Abowei, 2011). Mustapha (2008) reported monthly mean CO_2 concentration to be between 1.6- 3.0mg/l in Oyun Reservoir with seasonal variation higher dry season than wet

season. Andem *et al*. (2012) also reported a range of 59.38- 68.18mg/l CO_2 concentration in Ona River.

2.1.12 Chloride

The major anthropogenic sources of chloride in surface water are deicing salt, urban and agricultural runoff, and discharges from municipal waste water plants, industrial plants, and drilling oil and gas wells (Hunt *et al.*, 2012). The concentration of chloride ion is used as an indicator of pollution and considered as symptomatic of anthropogenic effects. Enrichment of water bodies with chloride to high levels have reported by several researchers. High chloride concentration in freshwater can harm aquatic organisms by interfering with osmoregulation, the biological processes by which they maintain the proper concentration of salts and other solutes in their bodily fluids. Difficulty with osmoregulation can hinder survival, growth and reproduction (Hunt *et al*., 2012). Work on chloride concentration in water bodies have been conducted by some workers. Oniye et al. (2002) reported a mean value of chloride concentration of 2.60mg/l in Zaria Dam which varied with seasons with higher concentration during the dry season than rainy season. The highest concentration (2.78mg/l) was recorded in March and the lowest concentration (2.50mg/l) was recorded in the months of August to November.

2.1.13 Dissolved oxygen (DO)

Dissolved oxygen (DO) affects the solubility and availability of nutrients. Its low levels can results in damages to oxidation state of substances from the oxidized to reduced form thereby increasing the levels of toxic metabolites. Dissolved carbon dioxide in aquatic environment increases with decreased in dissolved oxygen. It is important parameter in

primary production and phytoplankton biomass. Water acidity increases with increased dissolved carbon dioxide. High rate of dissolved carbon dioxide is detrimental to survival, physiology and metabolic activities of aquatic animals including fish. Annual mean DO concentration of 0.17mg/l was reported in Zaria Dam (Oniye *et al*., 2002), Mustapha reported a range of DO concentration of 4.8- 8.2mg/l in Oyun Reservoir with higher value in wet season than dry season. Bala and Bolorunduro (2011) reported a range of 4.7-9.8mg/l in Sabke Reservoir with no significant variations in seasonal concentration. Offem *et al*. (2011) reported annual mean concentration of 3.3mg/l with no seasonal variations in the concentration, a concentration range of 2.24- 3.46mg/l of DO was reported in Ona River while Anago *et al*. (2013) reported a concentration range of 0.7- 1.8mg/l in Awba Reservoir with highest concentration in June and lowest in April.

2.2 Studies on Fish Composition and Diversity

Boulenger (1916) published a list of fishes to include 976 species, referable to 185 genera and 43 families. Reed *et al*. (1967) also identified and described 160 fish species within the then Northern Nigeria. Tobor (1973) reported about 46 species of fish for Hadeja/Nguru wetlands. A total of about 40 species of fish have been recorded in Oguta Lake in Imo state (Ita and Balogun 1983). Bukar and Gubio (1985) conducted a survey in Lake Chad and observed about 19 species of fish. The report also revealed that Anambra, Kaduna and Sokoto/Rima rivers have 23, 28 and 22 species of fish respectively in them. Cross river, Ogun and Osun rivers have 39, 23, and 23 fish species respectively (Ita 1993). Ita (1993) also reported that an estimated 230 species of fish have been recorded from the rivers of Nigeria.

Petr (1969) and Lawson (1969), in the study of distribution patterns and abundance of fish population during the filling phase of Lake Volta, Ghana, reported that Characids and Mormyrids were unable to exploit the change conditions and decreased in the fishermen's catch soon after the creation of the Lake. The Cichlid fish increased and Tilapia was reported to be of commercial importance. Dadzie (1980) reported a similar observation in Lake Kamburu, Kenya. Petr (1974) recorded *Alestes* species to be of commercial importance, ten years after the creation of Lake Volta. Vandepruyer (1982), in the study of the distribution and abundance of fish stock in Lake Volta, reported that fish abundance was high in the southern part of the Lake. Harding (1966), observed an initial increased in fish populations, followed by a decline in the fish composition of Lake Kariba, Zambia. He recorded 29 species out of which nine was found to be of commercial importance. The species included *Distichodus mossambicus, Distichodus sehenga Labeo congoro*, *Clarias mossambicus*, *Tilapia mossambicus*, *Tilapia melanopleura*, *Hydrocynus vittalus* and *Sargochromis condrington*. Barley (1978) studied the ecology of fishes in Nyumba, Yamungu Reservoir, Tanzania and recorded 20 species of fish with a large number of them living in the littoral and the broad shallow upstream region of the Lake.

Sagua (1979) reported that Kainji Lake was the most thoroughly studied man-made lake in Nigeria. The possible trend in fish population changes in the Lake was found to be the family Citharinidae being the most abundant, followed by Mochokidae, Characidae and Mormyridae. He also reported the most important commercial families to be the Citharinidae, followed by Characidae, Centropomidae and Mochokidae. Lewis (1974) obtained a similar result with the family Mormyridae being the least abundant, in the study

of the effect of lake formation upon indigenous fish population. The population of most the Mormyrids continued to decline and some even disappeared altogether (Blake, 1977).

Similar studies made on other man-made Lakes in Nigeria include work of Moriaty (1979), during the ichthyological survey of IITA Reservoir, Ibadan. He recorded six species of fish; they were *Hepsetus odoe*, *Clarias lazera*, *Pelmatochromis guentheri*, *Hemichromis fasciatus* and *Sarathoredon galilaeus*. *Sarathoredon galilaeus* was more abundant with a percentage composition of 93.96 % and the least abundant species *Hepsetus odoe* recorded was 0.07%. Ita (1979) reported 23 species of fish for Tiga Lake, Kano, with the most abundant family being Cichlidae, followed by Bagridae. Anthony *et al*. (1986) in the study of Quree Reservoir, Plateau state recorded four species , *Oreochromis niloticus*, *Tilapia zillii, Oreochromis galilaeus* and *Lates nilotcus* with percentage composition of 33.3%, 42.6%, 19.5% and 4.6% respectively.

Ita *et al*. (1985), in a preliminary report on the immediate post impoundment fishery survey of Shiroro Reservoir, recorded that the family Cichlidae dominated the catch. *Lates niloticus* ranked third in terms of abundance in the experimental sample, and forth in commercial landing. Biological survey of the fishes of Kamgimi Reservoir, Kaduna State conducted by Abdullahi (1987), showed that there were ten families of fish made up of 16 genera and 25 species. The family Cichlidae was the most abundant while Bagridae and Mochokidae were the least. Balogun *et al.* (2000) in the study of Zaria Reservoir recorded 18 species of fish belonging to the nine families. Fourteen of the species are of major economic importance which includes *Oreochromis niloticus, Sarotherodon galilaeus, Alestes macrolepidotus, Schilbe mystus*, *Lates niloticus* and *Petrocephalus bane*. Others are *Mormyrus rume, Auchenoglanis occidentalis, Mormyrus deliciosus*, *Marcusenius psittacus*,

Synodontis membraneceous and *Clarias gariepinus*. In terms of number, the family Latidae represented only by *Lates niloticus* dominated, while in terms of weight of fish, family Mormyridae dominated followed by fish family Latidae. In terms of habitat distribution, the family Schilbidae dominated in the shore by number but by weight it was the family Mormyridae, while in the surface and botton habitats, the fish family Latidae dominated by number and weight. Balogun and Auta (2001), recorded nine fish families with 19 species in the study of fishery potential of Kamgimi Lake, Kaduna state, the fish family Cichlidae was found to be most dominant in terms of number and weight. In terms of habitat distribution, the fish family Cichlidae dominated the shore by number and by weight, while the fish family Cyprinidae dominated the surface by followed by the family Schilbidae, and family Mochokidae dominated the surface by weight, followed by the fish family Bagridae. In the botton habitat, the fish family Cyprinidae dominated by number with the fish family Cichlidae dominated by weight. Among the member of the family Cichlidae *Hemichromis fasciatus* dominated followed by *Hemichromis bimaculatus*. The fish family Cyprinidae was dominated by *Barilius spp*, while the Schilbeidae was represented by *Schilbe mystus*. *Marcusenius psittatus* dominated members of Mormyridae. Unlike the dominance of *Sarotherodon galileaus* and *Oreochromis niloticus* in Lake Kainji, Tiga and Bakolori, *Hemichromis fasciatus* dominated the Cichlidae in Kagimi Lake. The dominance of the surface habitat by the family Cyprinidae by number, followed by Schilbeidae in Lake Kangimi was similar to situation in other African Lakes e.g Kainji Lake, however, the dominance of fish family Cyprinidae in the bottom habitat was different from other Lakes. For example, in Kainji Lake, the bottom habitat was dominated by the fish family Mochokidae (Balogun, 1986). The dominance of fish family Cichlidae showed that the Lake was productive and compare favourably with the dominance of fish family Cichlidae

in Lake Kainji, Tiga, Bokolori and other African Reservoirs, where Cichlids are known to dominate (Reynoid, 1973; Ita, 1979; Ita *et al*. 1982; and Balogun, 1986).

Biodiversity is a measured of the number of species that make up a biological community and is considered to be one of the most aspects of community organization and structure. Species richness and relative abundance describe the key elements of biodiversity. Species richness is the fundamental unit in which to assess the homogeneity of an environment and commonly used in conservation studies to determine the sensitivity of ecosystems and their resident species, while the relative abundance describes how common or rare a species is relative to other species in a given community and are usually describe for a single trophic level (Lawson and Olusanya, 2010).

Yem *et al*. (2011) on the analysis of Ichthyofaunal diversity and peculiarities of some Lakes in Nigeria determined the fish species richness and peculiarities of seven Lakes from different zones of the country. A total of ninety species from twenty-five families were reported for these Lakes. Asejire had the highest number of species (41) while the lowest was recorded from Opi (13). Oguta had the highest number of families (17) and lowest being Tiga (8). Similarities and peculiarities of the fish fauna of these Lakes showed that *Tilapia zillii* was common to all the Lakes. Asejire had the highest restricted species (6) and Tiga with the lowest species (2). The family Polypteridae is restricted to Dadin Kowa, Osteoglossidae and Palaemonidae to Oyan while Notopteridae to Oguta Lake. Diversity index was highest in Oguta (0.5) and lowest in Opi (0.1) which was significantly different ($P<0.05$). Size of water body, Physico-chemical parameters and geographical location amongst other factors were found to affect species richness and peculiarities of the Lakes. Lawson and Olusanya (2011) conducted a study on fish diversity in three tributaries of

River Ore, South West Nigeria. The fish composition comprised 11 species from 10 families and 10 genera. A total of 103,111 and 96 individuals were caught from Igbesa, Itele and Iba stations respectively. The fish diversity range from typically fresh water fishes such as Tilapia and Clarias to brackish species such as *Chrysichthys nigrodigitatus*. The most abundant group fish was clariids. The dominant species *Clarias gariepinus* consisted of 32.26% of the population. *Heterotis niloticus*, a rare species and least abundant species was 0.32%. Fimgerlings, juveniles and sub-adults were among the catch, smallest being *Tilapia mariae*, while the largest was *Heterotis niloticus*. The indices of diversity include d= 0.155, 0.257 and 0.740; H= 2.05, 1.899 and 1.896; E= 0.740, 0.659 and 0.600 respectively for tributaries at Igbesa, Itele and Iba. Estimates from these indices were indication of low fish species composition and richness and unevenness in the population of fish in River Ore. Adeosun *et al*. (2011) carried out a study of fishes on the Ikere Gorge drainage system in Ikere, Oyo State. The work was based on the taxanomy and distribution of fishes. A total of 5736 fish specimens were caught during the study period. These were identified and classified into 34 species belong to 13 families. The percentage species composition of the harvest by number and weight for all fish species that contributed more than 1% in all the stations combined were computed. The most consistently represented genera in all the stations was Cichlids, with *Sarotherodon galilaeus*, contributing 30.6% by number and 36.0% by weight, *T. melanopleura*, 43.0% by number and 56.2% by weight, *T. melanotheron* 28.8% by number and 7.5% by weight while *Tilapia zilli* contributing 2.66% 3.01% by number and weight respectively. *Chrysichthys nigrodigitatus* was well represented in all the four stations contributing 96.7% by number and 13.4% by weight, while *Clarias gariepinus* represented 2.8% by number 23.7% by weight, *Parachama obscura* as 2.1% by number and 15.4% by weight. Based on the total number of fish

species encountered in all the harvest analysed fish diversity was highest in station III (29) i.e. the river channel, which consisted of the flooded bush patches; followed by station IV (27) i.e. deepest central axis of the Gorge. Station I, the shallow bays of the gorge, which consisted of the intake tower of the Gorge, had 26. The lowest fish diversity (24) was obtained in station II i.e. open water that covers the inshore and offshore area occupied by the central or middle portion of the Gorge.

Fapohunda and Godstates (2007) conducted a study on biometry and composition of fish species in Owena Reservoir, Ondo State, Nigeria. 14 fish species beolonging to seven families were recorded. Two families namely Characidae and Clariidae constituted the dominant fish families in the Reservoir. Among the Characidae, *Brycinus nurse* (23.1%) and among Clariidae family *Clarias gariepinus* (22.8%) were dominant. Other fish species with significant abundance were *Sarotherodon galilaeus* (9.3%), *Parachanna obscura* (8.0%), *Clarias anguillaris* (7.7%) and *Oreochromis niloticus* (6.4%). The meristic features of the abundant fish species caught are as follows; *Brycinus nurse* had two dorsal fins, two anal spines with eleven anal fins, 25 caudal fins, one pectoral spine and 13 pectoral fins and two ventral spines with seven ventral fins. *Clarias gariepinus* had 75 dorsal fins, 31 anal fins, 10 caudal fins, six pectoral fins and five ventral fins. The morphometric features of two most abundant fish species are; *Brycinus nurse*, total length 312mm, standard length 255mm, head length 60mm, body length 90mm and girth 190mm. *Clarias gariepinus*; total length 265mm, standard length 240mm, head length 62mm, body length 62mm and body girth 130mm. Work on fish species abundance and morphometry on Anambra River Basin was also conducted by Gregory *et al*. (2009). 52 fish species belong to 17 families were recorded; 171,236 and 169 individuals at Ogurugu, Otuocha and Nsugbe stations

respectively. Two families, Claridae, 19.5% and Mochokidae, 11.8%, constituted the dominant fish families in the River. The dominant fish species were *Citharinus citharinus*, 9.02% and *Alestes nurse*, 7.1%. Others fish species with significant abundance were *Synodontis clarias* 6.9%, *Macrolepidotus curvier* 5.7%, *Labeo coubie* 5.4%, *Distichodus rostritus* 4.9% and *Schilbe mystus* 4.5%. The meristic features of the two most abundant fish species caught are as follows; *Citharinus citharinus* dorsal fins 20, anal fins 30, caudal fins 21, pectoral fins 9, and 8 ventral fins. *Alestes nurse* 10 dorsal fins, 14 anal fins, 31 caudal fins, 7 pectoral fins and 6 ventral fins. The morphometric features of the two most abundant fish species are; *Citharinus citharinus*, total length 300mm, standard length 231mm, head length 69mm, body length 101mm, body girth 176mm and body weight 900mg. *Alestes nurse*, total length 200mm, standard length 140mm, head length 60mm, body length 80mm, body girth 120mm and body weight 400mg.

Monthly and seasonal variations in fish composition, abundance and distribution have been observed by many researchers. Higher fish abundance was recorded in dry season than rainy season in Lower Bonny Estuary by Chindah and Osuamkpe (1994), mangrove habitat of Lagos by Nwadukwe (1995) and Urie creek, Niger Delta by Meye and Ikomi (2008). Iorchor *et al*. (2007) recorded higher fish abundance in wet season, though predominantly juveniles than dry season in the main channel of the Lower Benue River. Higher abundance of *Paraillia pelucida* during rainy season in the fresh water reaches of Num River, Niger Delta was reported by Allison *et al*. (2007).

Ayoola and Kuton (2009) reported that Cichlids contributed the highest number of fish in the two seasons in Lagos lagoon, Nigeria. Fish were more evenly distributed in the dry season than wet season. Species eveness for wet and dry seasons was 0.40 and 0.43

respectivily. Adeyemi (2011) observed that the fish landing in a ssmi oxbow lake of Gbedikere, North central, Nigeria were highest in January, February and December with 38.6%, 38.5% and 35.9% respectively. Komolafe and Arawamo (2011) reported seasonal variation in the sex ratio of the fish species in Erinle Lake, Osun State. *S. galilaeus* and *H. fasciatus* had sex ratios of 1:0.9 (male to female) which tended unity, *G. cyprnoides* and *S. mystus* had sex ratios of 1:1.4 and 1:1.2 (male to female). Similarly Offem *et al*. (2011) reported seasonal differentiation in the richness and diversity indices of Plankton and fish species of Ikwori Lake with higher values for dry season samples than wet season. Yakub (2012) reported higher fish total abundance (1061), species number (38) and diversity levelin rainy season than dry season when a total abundance of 358 and 28 species were recorded in Lower Ogun River, Ishasi, and Ogun Stae. Falaye *et al.* (2015) reported seasonal variation in catch composition of fish species in Erelu Reservoir with highest number of fish obtained in dry season (4014) while the lowest was observed in wet season (2913) samples. Overall mean abundance of fish was obseverd to be significantly higher (57.95%) in the dry season than wet season (42.05%)

2.3 Length-Weight Relationships and Condition Factor

Knowledge of some quantative aspects such as length-weight relationship is important in studying fish biology. Length-weight relationship can be used to predict weight from length measurements made in fish yield assessment (Pauly, 1993 and Alex *et al*., 2012). Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change in body shape as organism grows. Negative allometric growth implies the fish becomes more slender as it increases in weight while

positive allometric growth implies the fish becomes relatively stouter or deeper bodied as it increases in length (Riedel *et al*., 2007).

Condition factor (K) is an important biological parameter, which indicates the suitability of a specific water body for growth of fish and an index of species average size (Alam *et al*., 2014 and Mazaher *et al*., 2015). 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 feeding condition (Alex *et al.*, 2012). When condition factor value is higher than 1 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 feed and other water quality parameters (Khallaf *et al*., 2003).

Recent works on length-weight relationship and condition factor of some fish include that of Odedeyi *et al.*, (2007) who study the length-weight relationship and condition factor of the elephant fish (*Mormyrus rume*) in river Ose, South Western Nigeria. The study of length-weight relationships and condition factor of five species fish from Nkoro River, Niger Delta was conducted by Abowei *et al*., (2009). Iman *et al*., (2010) conducted a study on length-weight relationships and condition factor of four fish species from Wassai Reservoir in Kano, Nigeria. Similarly Dan-Kishiya (2013) studied the length-weight relationships and condition factor of five fish species from a tropical water supply reservoir in Abuja, Nigeria.

2.4 Reservoir Productivity (MEI)

Several limnological parameters such as conductivity, total dissolved solids, water quality, phytoplanktons and reservoir morphometry have been used in estimating potential fish yield from reservoirs. The most widely accepted method was the morpho-edaphic index (M.E.I) developed by Ryder (1965). Morpho-edaphic index is calculated by dividing the value of total dissolved solids or electrical conductivity by the mean depth (m) of water body. This methodoloy have been applied in some of the tropical African reservoir. Balogun and Aduku (2004) used this on the study of the fishery potential of Kubanni Reservoir, Ahmadu Bello University, Zaria and recorded an estimated yield of 38kg/ha during the dry season, using Morpho- Edaphic Index (M.E.I). This estimate does not cover the rainy season when the yield was expected to decline as a result of increase in the mean depth. The Morpho- Edaphic Index (M.E.I) of Bakolori Reservoir was put at 23µmhos/cm, corresponding to a potential of 50kg/ha which was above the observed standing crop of 32kg/ha (Ita *et al*. 1982). Thus, the higher the M.E.I. value, the greater the yield. Adeniji (1981) also estimated the potential fish production of about 25 to 40kg/ha for Bokolori Lake, using the M.E.I. method. The value was also lower than the potential yield of 50kg/ha obtained by Ita *et al*. (1982). According to Ita *et al*. (1982) on the basis of morpho-edaphic Index (M.E.I), Kainji Lake recorded a higher yield per hectare of 60kg/ha than Lake Volta, Nasser and Kariba with 50, 20 and 8kg/ha respectively, even though these other Lakes are richer in nutrients. Kainji Lake has advantage of having the lowest mean depth value. Daddy and Falaye (2004), in the study of Tatabu flood plain, North Jebba estimated 88.24kg/ha fish yield and recorded 26 fish species that belong to 15 families.

Mochokidae species was the most dominant, followed by Cichlidae, Claridae and Characidae.

The work on Lake Volta and Kainji by Reynolds (1973) and Imevbore and Okpo (1975), respectively have shown that the build up and maintenance of fish populatios in Lakes depends on the food available, the fish breeding period, the sex ratio and the physical factors necessary for successful spawning. Everhart *et al*. (1975), Ita (1979) and Henderson (1979) in their reviews of the factors affecting fish production in lakes and reservoirs, reported that fisheries productivity depends on their morphology, fertility and climate.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Doma Reservoir is located about 6km away from Doma town, the headquarters of Doma Local Governmet Area of Nasarawa State. It is about 30 kilometres away from Lafia the State capital. The Reservoir lies in the northern Guinea Savanna zone of Nigeria between latitude $8^0 18' 0''$ and $8^0 21' 20''$N and longitude $8^0 17' 24''$ and $8^0 21' 54''$E (Figure3.1). Doma reservoir is a man-made reservoir meant for irrigation. The reservoir was also supposed to serve the purposes of fisheries and water supply to the host communities. It was constructed across River Ohina which links the communities of Ohina, Aragye, Gongon Lemu, Ruwan Bake and Umaku in the present day Doma, Nasarawa State. The storage capacity of the reservoir is over 30 million cubic metres of water and a surface area of 1535.45 hectares (15.3545km^2). It provides a natural habitat for various aquatic lives including fish. The reservoir is flooded during the rainy season and the climate is characterized by distinct dry and rainy seasons. The immediate area around the reservoir is hilly with thick vegetation. The human communities around the reservoir are involved in fishing activities and rainy season farming; the reservoir also serves as grazing area and watering point for livestock.

The reservoir was commissioned in 1988 by the Federal Government with the aim of irrigating about 2000 hectares of land using sprinkler system.

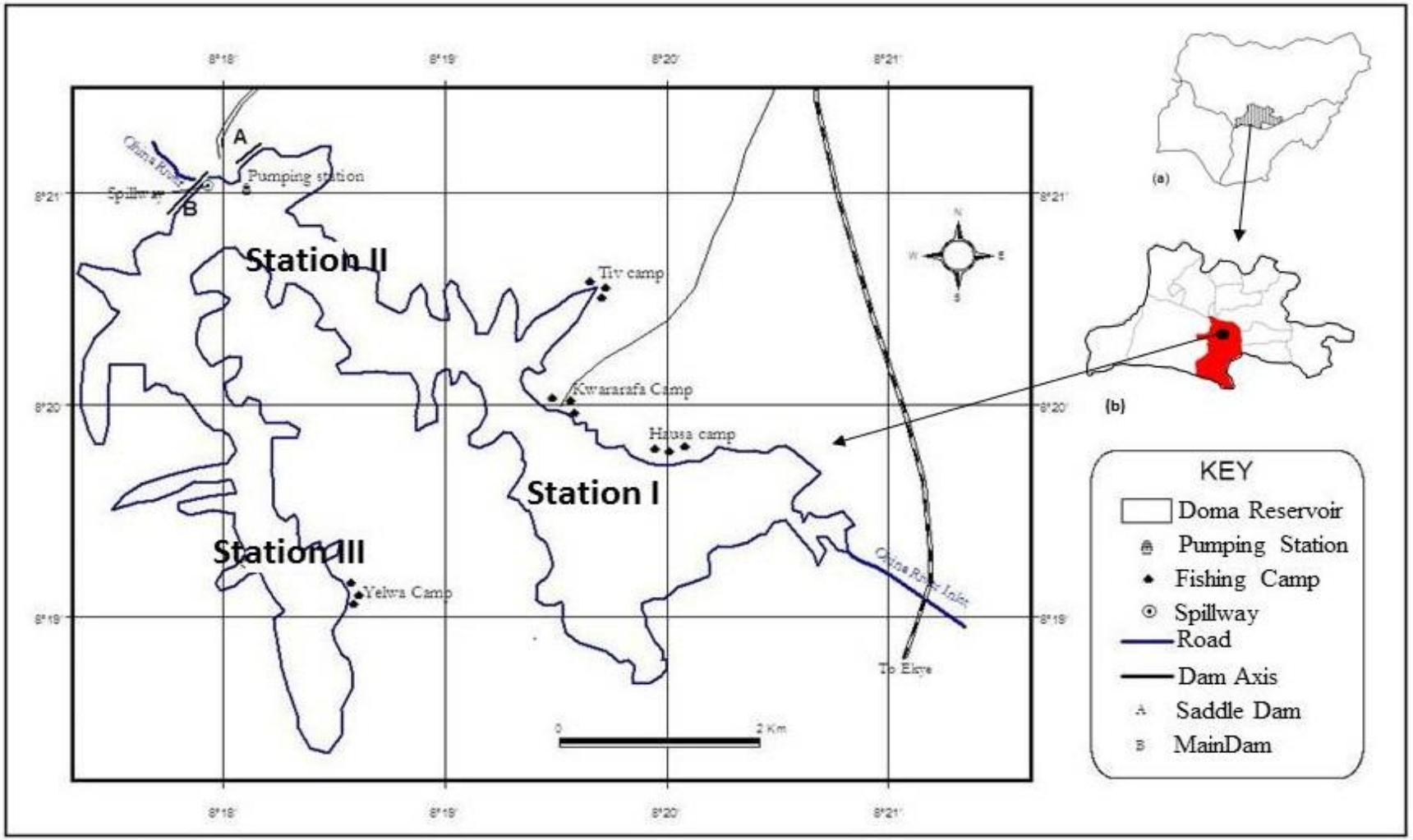


Figure 3.1: Sampling Sites in Doma Reservoir.

3.2 Sampling Stations

Three sampling stations were selected for this study as shown in Figure 3.1. Station I is around Kwararafa village where the community are engaged in fishing activities and rainy season farming. Station II is closed to the Main Dam where the water treatment plant and staff quarters of water board is located and fishing activity is low, while Station III is around Yelwa fishing village, where the community are also engaged in rain-fed farming.

3.3 Determination of Physico-chemical Parameters.

The Physico-Chemical parameters of water were determined using La Motte Tracer (pocketester) code 1766 and LaMotte Fresh Water Aquaculture Test Kit (Model: AQ-2, Code: 3633-03). Water temperature, water transparency, water depth, pH of water, salinity, total dissolved solids (TDS), electrical conductivity, dissolved oxygen (DO), alkaliniy, carbon dioxide, chloride, hardness and ammonia-nitrogen were determined.

3.3.1 Temperature

Air temperature was determined by holding the thermometer calibrated in degree centigrade under the shade at bank of the reservoir for about 2-4 minutes before reading and value recorded, while the water temperature was determined by lowering the thermometer into the water body and retained inside for about 2-4 minutes before reading while in water and value recording thereafter.

3.3.2 Water transparency

The transparency of water was measured using a Secchi disc which was lowered into water with a graduated cord. The depth at which the disc disappeared from sight was recorded

and the depth at which it reappeared was also recorded. The average of the depths in centimeters was recorded as the water transparency.

3.3.3 Depth

The depth of water at each sampling station was measured using calibrated tape in meter and weighted with heavy metal at the bottom. The tape was lowered from the boat into the water until it reached the bottom of the reservoir, the point at which it reached the bottom was marked and then removed; the value was then recorded as the depth of water in meters (m).

3.3.4 Determination of pH, Salinity, Total Dissolve Solids (TDS) and Electrical Conductivity

They were determined using La Motte Tracer (pocketester) code 1766. The readings were taken by changing the mode of the tracer and the values recorded for each of these properties. The salinity and TDS of water were expressed in part per million (ppm), while the electrical conductivity was expressed in micro- siemen per second (μs^{-1})

The LaMotte fresh water aquaculture test kit uses two basic analytical procedures common to field test kits; the colorimetric and titrimetric procedures.

Colorimetric Procedure- In a visual colorimetric test, samples was treated with reagent(s) to produce a colour reaction, generally in proportion to the amount of the test factor present. The sample colour was then compared against colour standards representing known concentrations of the factor being tested over a specific range. The all-plastic Octa-Slide Viewer allows for unique one-on-one colour matching system.

3.3.5 Ammonia Nitrogen

Ammonia-nitrogen was determined by using colorimetric method. 5ml of sample water in a test tube was used to determine the ammonia-nitrogen, 4 drops of Ammonia Nitrogen reagent (1) was added, capped and mixed, waited for 1minute and 12 drops Ammonia Reagent (2) was added capped and mixed and waited for 5 minutes. Ammonia Nitrogen Octa-Slide bar was inserted into Octa-Slide Viewer. The test tube was inserted into Octa – Slide Viewer, sample colour were matched to colour standard and then recorded as ppm Ammonia Nitrogen.

Titrimetric Procedure- In a titrimetric method, titrating solution (or titrant) was added to a treated sample until a colour change occurs. The volume of titrant required to reach this end point is proportional to the concentration of the factor being tested. Direct Reading Titrator provides results directly in the appropriate concentration for the test.

3.3.6 Hardness

The water hardness was determined by using 12.9ml sample water, 5 drops of hardness reagent were added capped and swirled to mix, 5drops of hardness reagent were again added, capped and swirled to mix the colour of solution turns red. Direct Reading Titrator was filled hardness reagent and inserted into the centre hole of the test tube cap. While gently swirling the tube the plunger was slowly pressed to titrate until the red colour changes to clear blue. The test result was read directly from the scale where the large ring on the titrator meet the titrator barrel and recorded as ppm total hardness as $CaCO_3$.

3.3.7 Alkalinity

5ml of sample water was used determined the alkalinity of water and 4drops alkalinity indicator were added, capped and mixed for the solution to turn blue-green. Direct Reading Titrator was filled with alkalinity titration reagent. The titrator was inserted into the centre hole of the test tube cap. While gently swirling the test tube, the plunger was slowly pressed to titrate until blue-green colour changes to pink. The test result was read directly from the scale where the large ring on titrator meet the titrator barrel and recorded as ppm total alkalinity as calcium carbonate ($CaCO_3$)

3.3.8 Carbon dioxide

Carbon dioxide was determined by using 20ml of sample water, 2 drops of phenolphthalein indicator (1%) were added. Direct Reading Titrator was filled with carbon dioxide reagent and inserted into the centre hole of the test tube cap. While gently swirling the test tube the plunger was slowly pressed to titrate until faint pink colour developed and persist for 30 seconds. The test result was read directly from scale where the large ring on the titrator meet the titrator barrel and recorded carbon dioxide expressed as ppm free CO_2.

3.3.9 Chloride

15ml of sample water was filled to the test tube; one drop of phenolphthalein indicator (1%) was added. If the sample turns pink and sulfuric acid (0.5N) one drop at time mixing after each drop until pink colour disappears. 3 drops of chloride reagent were added capped and swirled to mix the solution turns yellow. Direct Reading Titrator was filled with chloride reagent and inserted into the centre hole of the test tube cap. Gently swirling the tube the plunger was slowly pressed to titrate until yellow colour changed from yellow to

orange or orange-red. The test result was read directly from the scale where the large ring on the titrator meets the titrator barrel and recorded as ppm Chloride.

3.3.10 Dissolved Oxygen (DO)

Water sampling bottles were rinsed thoroughly with sample water and tightly capped. The bottles were submerged to a desire depth; the cap was removed and filled with sample water. 8 drops of manganous sulfate solution were added, and 8 drops of alkaline potassium iodide azide reagent added, capped and mixed by inverting several times. A precipitate was formed and allowed to settle below the shoulder of the bottle. 8 drops of sulfuric acid acid were added cap and gently shaken until the precipitate dissolved. A clear- yellow to brown-orange colour was developed. The titration tube was filled to the 20mL line with the sample water and cap. The Direct Reading Titrator was filled with sodium thiosulfate (0.025N). The titrator was inserted into the centre hole of the tube cap. While gently swirling the tube, the plunger was slowly pressed to titrate until yellow-brown colour was reduced to a very a faint yellow. Titrator and cap were removed and 8 drops of starch indicator solution were added. The solution turn blue, the cap and titrator was replaced and titration continued until the blue colour disappeared. The test result was read directly from the scale where the large ring on the titrator meet titrator barrel and recorded as ppm Dissolved Oxygen.

3.4 Determination of Morpho-edaphic index (M.E.I) and Potential Fish Yield (Y)

Morpho-edaphic index is measure of biological productivity in water bodies. This can be used to estimate the fish yield of the water body. The following relationship was used to calculate the Morpho-Edaphic Index (M.E.I) of Doma reservoir.

Morpho-edaphic index (M.E.I) = $\frac{\text{Electrical conductivity } (\mu S^{-})}{\text{Mean depth (m)}}$

Potential fish yield of the reservoir was calculated using the following relationship:

Potential fish yield (Y) = $23.281 M.E.^{I0.447}$ (Marshall 1984)

Where Y = yield in $kgha^{-1}$

3.5 Survey of Fish Species Composition

The survey of the fishes in Doma Reservoir took place at three sampling stations at Kurarafa, Main Dam and Yelwa areas by employing experimental fish sampling and artisanal fishery survey. The period of the survey covered 24 months (July 2012 to June 2014) and data were collected on the monthly bases.

3.5.1 Experimental fish sampling

A fleet of gillnets made up of seven multifilament nets of 38.1mm(1.5”), 57.15mm(2.25”), 76.2mm(3.0”), 101.6mm(4.0”), 127.0mm(5.0”), 152.4mm(6.0”) and 177.8mm(7.0”) stretched meshes were used to sample the shore, surface and bottom water habitats at the three sampling stations. Each net measured 30 meters long and 3 meters deep. The nets were set simultaneously to sample the shore, surface and bottom habitats at about 5pm and were checked at about 8am the next day. The fish caught in each net were removed, transferred into labeled plastic bowls and sorted into different mesh sizes. There was separate bowl for each net. Each fish was weighed (g) and measured for standard and total length (cm). The total sampling was 216 for the period of twenty-four months.

3.5.2 Artisanal fisheries survey

The artisanal fishery survey involved the use of statistical frame survey and catch assessment survey.

3.5.2.1 Statistical frame survey

This involved total count of the fishermen and boats operating on the reservoir water, and recording of the fishing gears and craft used, as described by Balogun and Auta (2001).

3.5.2.2 Catch assessment survey

This involved the actual count and weighing of the fishes caught by the local fishermen at the reservoir site for 24 calendar months as described by Balagun and Auta (2001). The total weight of fish caught by each fisherman was obtained by the use of weighing balance (gm). All fish species were identified using relevant reference texts by Olaosebikan and Raji (1998) and Idodo-Umeh (2003).

3.6 Determination of biodiversity indices and Catch per unit effort (CPUE)

3.6.1 Biodiversity indices

Simpson's index (D), Simpson's index Diversity (1 – D), Simpson's reciprocal index (1/D), Shannon-Weinner index (H) and Shannon's equitability (evenness) (E_H) were employed to evaluate species diversity.

Simpson's index = $D = \sum (n/N)^2$

Where n = the total number of organisms of a particular species, N = the total number of organisms of all species

Shannon's index = $H = \sum (PI) [\ln P_I]$

Where P_I is the proportion of the total number of individuals in the population that in species "I"

Shannon's eveness (E_H) = H / lnS

Where S is the total number of species in the community (richness), ln is natural logarithms

3.6.2 Catch per unit effort (CPUE)

Catch per unit effort was determine using the formula

$$CPUE = \frac{\text{Total catch (number, weight)} \times 100}{\text{Total number of sampling}}$$

3.7 Biometric Data

3.7.1 Fish weight determination

The weights of the fish were determined using electronic weighing balance with the capacity of 10,000g (model: SF-400).

3.7.2 Length determination

The standard and total length of each fish was determined using a measuring board. The total length was measured from the tip of snout to the longest lobe of the filament of the caudal fin. The margin of lobes was pressed together before measurement. The standard length was measured from the tip of the snout to the point of attachment of the caudal rays.

3.7.3 Determination of Length-weight relationship

The length-weight relationship for more occurring fish species was determined using the formula described by Le cren (1951), Wang *et al*. (2012) and Kahraman *et al*. (2014) as follow:

$W = aL^b$ ---------- (1)

The above equation (1) and the data were transformed in to logarithms before calculation. Therefor equation becomes:

Log W = a + b Log L ---------- (2)

Where W = weight in grams

L = total length in centimeter

a = constant/intercept

b = an exponent/slope

The 95% confidence interval (CI) of b was computed using the equation:

CI = b ± (1.96 x SE) ---------- (3)

Where SE is the standard error of b

3.7.4 Determination of Condition factor (K)

The condition factors (K) were estimated for individual fish species using the formula by Le cren (1951), Pauly (1993) and Froese (2006) as follow:

$$K = \frac{100W}{L^3} \text{ ---------- (4)}$$

Where W = weight

L = total length

3.8 Data Analyses

Analysis of data was based on monthly data collection. Data obtained from identification, counting and weighing of fish were used to compute fish composition, distribution and abundance for each station, habitat, months and seasons in percentages as well as for the entire reservoir. For seasonal composition and distribution of fish fauna, data obtained from July to October 2012 and 2013 and May to June 2013 and 2014 were pooled for rainy season, while data pooled from November to December 2012 and 2013 and January to April 2013 and 2014 were used for dry season. Analyses of variance (ANOVA), T-test and Pearson's product moment correlation coefficient (r) were used to analyse the data collected using SPSS version 20. In the statistical analysis a 95% confidence level or 5% level of significance ($P \leq 0.05$) was used in interpreting relationship between factors studied

CHAPTER FOUR

4.0 RESULTS

4.1 Physico-Chemical Parameters of Doma Reservoir

4.1.1 Air temperature (°C)

The variations in the physico-chemical parameters of study area of Doma Reservoir were presented in Table 4.1. The air temperature of Doma Reservoir varied throughout the sampling period. The mean air temperature ranged between 29.05°C in the Main Dam to 29.25°C in Yelwa (Table 4.1). Air temperature variation between the stations were not significantly different (P≥0.05) while variation between months showed significant different (P≤ 0.05) with the highest air temperature (34.2°C) recorded in February 2013 at Yelwa and the lowest value (24.6°C) recorded in December 2013 at Kwararafa (Figure 4.1). Pearson's correlation analysis shows that air temperature was positively correlated with water temperature (r = 0.762), transparency (r = 0.341), pH (r = 0.422) and Salinity (r = 0.287) and negatively correlated with Ammonium-Nitrogen (r = -0.363) and Carbon dioxide (r = -0.355) (Appendix i) but showed no correlation with others physico-chemical parameters.

4.1.2 Water temperature (°C)

The mean water temperature ranged between 27.98- 28.24°C. Analysis of variance (ANOVA) showed no significant difference (P≥0.05) in water temperature variation between stations, but showed significant difference (P≤ 0.05) for months with the highest value

Table 4.1: Mean Variations in Physico-chemical Parameters of Study Stations of Doma Reservoir from July 2012 to June 2014

Parameters	Kwararafa	Main Dam	Yelwa	P-value ANOVA Stations	Months
Air temperature (°C)	29.13 ± 0.42[a] (24.60-32.40)	29.05 ± 0.39 [a] (26.00-32.200)	29.25 ± 0.47 [a] (25.30-34.20)	.940	.000*
Water temperature (°C)	28.24 ± 0.32 [a] (25.20-31.20)	27.98 ± 0.39 [a] (24.20-31-00)	28.22 ± 0.41[a] (24.50-32.50)	.869	.000*
Transparency (cm)	65.38 ± 6.59 [a] (23.00-125)	63.61 ± 6.43 [a] (23.00-120.80)	63.35 ± 6.27[a] (23.00-125.50)	.971	.000*
Depth (m)	11.07 ± 0.25 [a] (9.20-13.40)	15.71 ± 0.22[b] (14.1-17.900	9.47 ± 0.20[c] (8.20-11.30)	.000*	.976
pH	7.03 ± 0.89 [a] (6.50-8.10)	7.05 ± 0.11[a] (6.00-8.40)	7.05 ± 0.12[a] (6.00-8.20)	.982	.000*
Salinity (ppm)	16.67 ± 0.98 [a] (10.00-20.00)	17.50 ± 0.90 [a] (10.00-20.00)	17.92 ± 1.04 [a] (10.00-30.00)	.656	.001
TDS (ppm)	26.25 ± 1.00 [a] (20.00-30.00)	26.25 ± 1.18 [a] (20.00-40.00)	27.08 ± 1.22 [a] (20.00-40.00)	.828	.042
Conductivity (µS)	43.75 ± 0.80 [a] (38.30-51.20)	45.09 ± 1.03 [a] (38.00-61.50)	44.51 ± 1.12 [a] (31.00-63.80)	.635	.185
Ammonium-Nitrogen (ppm)	0.48 ± 0.03 [a] (0.20-0.80)	0.49 ± 0.04 [a] (0.20-0.80)	0.50 ± 0.04 [a] (0.20-0.80)	.953	.000*
Alkalinity (ppm)	28.67 ± 1.15 [a] (20.00-48.00)	26.67 ± 0.91[a] (20.00-36.00)	28.17 ± 0.82 [a] (20.00-36.00)	.321	.168
Carbon dioxide (ppm	5.54 ± 0.42 [a] (3.00-13.00)	6.04 ± 0.45 [a] (3.00-12.00)	6.33 ± 0.62 [a] (3.00-15.00)	.533	.000*
Chloride (ppm)	9.75 ± 0.40 [a] (8.00-12.00)	8.83 ± 0.42 [a] (4.00-12.00)	8.33 ± 0.54 [a] (4.00-16.00)	.268	.688
Hardness (ppm)	18.75 ± 0.88 [a] (12.00-28.00)	19.16 ± 0.90 [a] (12.00-36.00)	18.33 ± 0.82 [a] (12.00-32.00)	.937	.001*
Dissolved oxygen (ppm)	6.79 ± 0.11 [a] (5.80-7.80)	6.52 ± 0.18 [a] (4.20-7.80)	6.70 ± 0.16 [a] (5.00-8.00)	.451	.039*
Morpho-edaphic index (M.E.I)	4.01 ± 0.14 [a] (2.93-5.28)	2.89 ± 0.08[b] (2.14-3.89)	4.76 ± 0.16[c] (2.86-6.79)	.000*	.544

Note: values in parenthesis are minimum and maximum. Values with different superscripts along the rows were significantly different ($P \leq 0.005$). * indicates significantly calculated P-value.

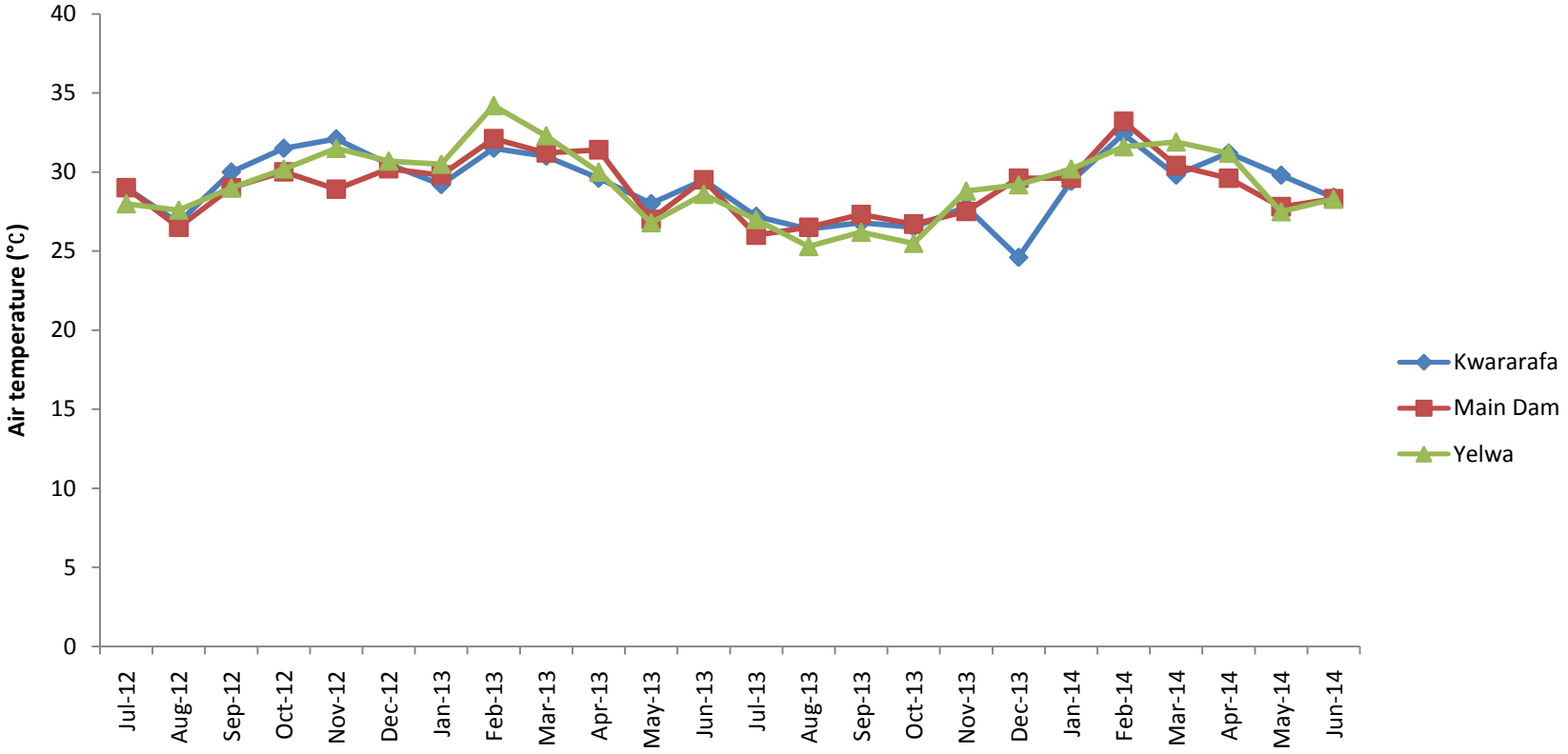


Figure4. 1 Mean monthly variations in air temperature of Doma Reservoir from July 2012 to June 2014

(33.5°C) recorded in February 2013 at Yelwa and lowest value (24.2°C) recorded in July 2013 at Main Dam (Figure 4.2). Student t-test also shows significant difference ($P \leq 0.05$) in the variation of water temperature between seasons with the mean value of 29.01°C in dry season and 27.28°C in rainy season (Table 4.2). The correlation coefficient analysis between water temperature and other parameters showed that water temperature had positive correlation with transparency (r =0.319) and pH (r = 0.503) and negative correlation with Ammonium-nitrogen (r = -0.554) and Carbon dioxide (r = -0.500) (Appendix i) and no correlation with other physico-chemical parameters.

4.1.3 Transparency (cm)

Water transparency of Doma Reservoir varied throughout the study period, the mean value of transparency ranged between 63.35- 65.38cm. There was no significant different ($P \geq 0.05$) in water transparency between stations but significant difference ($P \leq 0.05$) existed between months (Table 4.1). The highest value (125.5cm) of transparency was recorded in March 2014 at Yelwa and the lowest value (23.0cm) was observed in September 2012 in three sampling station (Figure 4.3). T-test analysis showed significant different ($P \leq 0.05$) in water transparency between seasons (Table 4.2) with the highest mean value (77.13cm) recorded in the dry season and the lowest mean value (51.10cm) in rainy season. Correlation analysis indicated highly positive relationship of transparency with air temperature (r = 0.341), water temperature (r =0.319), pH (r =0.575), TDS (r = 0.304), Dissolved oxygen (r = 0.356) and M.E.I (r = 0.339), positive relation with Salinity (r = 0.266) and Hardness (r = 0.233) but showed highly negative relationship with Ammonium-nitrogen (r = -0.388) and Carbon dioxide (r = -0.522) (Appendix i).

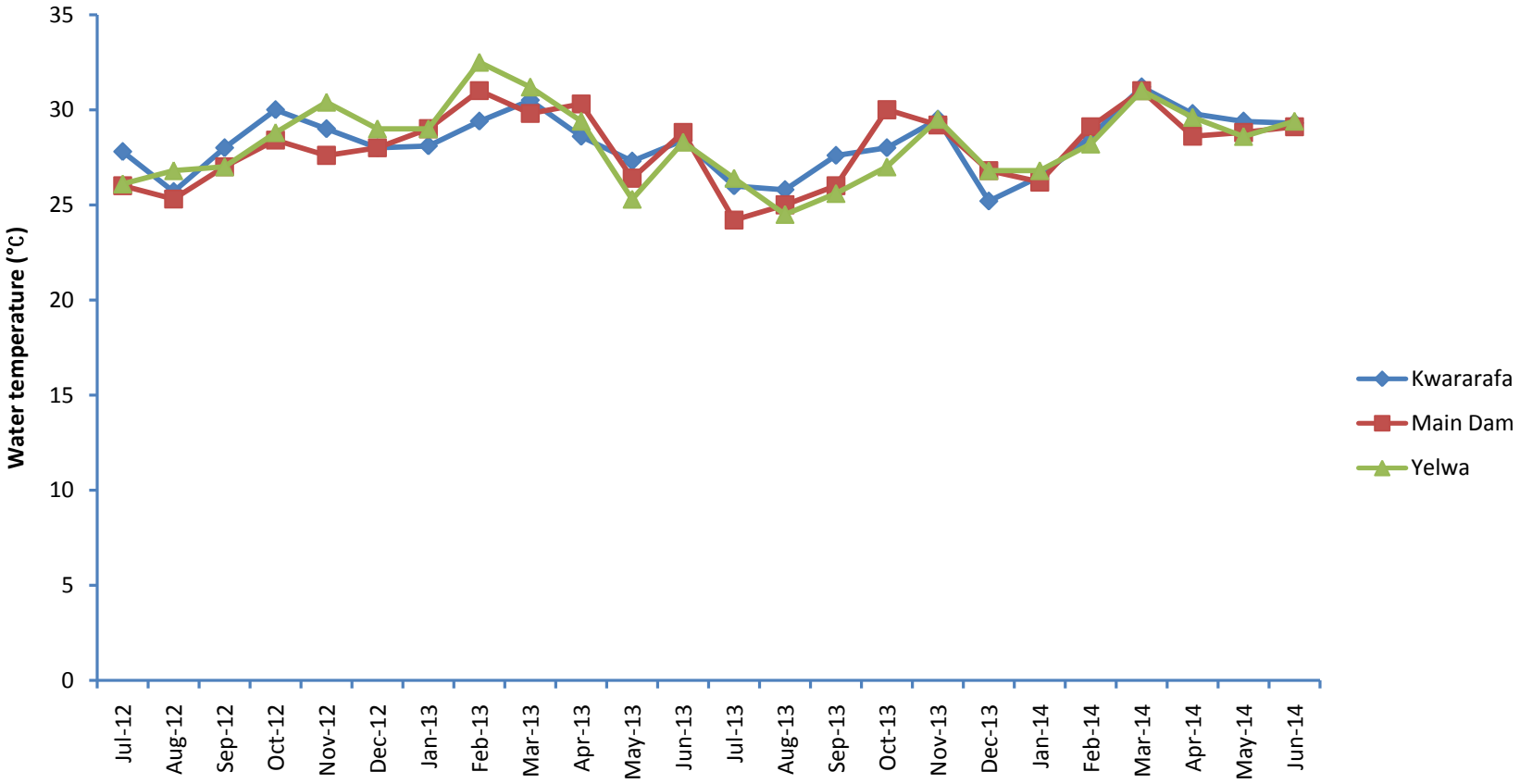


Figure 4.2: Mean monthly variations in water temperature of Doma Reservoir from July 2012 to June 2014

Table 4: 2 Mean Seasonal variations of physico-chemical parameters of Doma Reservoir

from July 2012 to June 2014

Parameters	Season		T-test value
	Dry	Rainy	
Air temperature (°C)	30.41 ± 0.29 (24.60-34.20)	27.88 ± 0.25 (25.30-31.50)	6.65*
Water temperature (°C)	29.01 ± 0.27 (26.20-32.50)	27.28 ± 0.27 (24.20-30.00)	4.55*
Transparency (cm)	77.13 ± 4.67 (40.00-125.50)	51.10 ± 4.98 (23.00-120.00)	3.89*
Depth (m)	11.59 ± 0.47 (8.20-17.00)	12.78 ± 0.48 (8.30-17.90)	-4.45
pH	7.31 ± 0.09 (6.50-8.40)	6.78 ± 0.06 (6.00-7.30)	4.98*
Salinity (ppm)	18.16 ± 0.71 (10.00-30.00)	16.11 ± 0.82 (10.00-20.00)	2.30*
TDS (ppm)	27.22 ± 0.86 (20.00-40.00)	25.83 ± 0.92 (20.00-40.00)	1.10
Conductivity (µS)	45.06 ± 0.78 (38.80-63.80)	43.84 ± 0.83 (31.50-61.50)	1.07
Ammonium-Nitrogen (ppm)	0.45 ± 0.03 (0.20-0.80)	0.53 ± 0.03 (0.20-0.80)	-1.96
Alkalinity (ppm)	27.67 ± 0.71 (20.00-36.00)	28.00 ± 0.87 (20.00-48.00)	-0.30
Carbon dioxide (ppm	5.11 ± 0.38 (3.00-13.00)	6.83 ± 0.39 (3.00-15.00)	-3.17*
Chloride (ppm)	8.89 ± 0.36 (4.00-12.00)	9.39 ± 0.39 (4.00-16.00)	-0.94
Hardness (ppm)	20.39 ± 0.76 (16.00-36.00)	17.44 ± 0.53 (12.00-24.00)	3.16*
Dissolved oxygen (ppm)	6.68 ± 0.13 (4.20-8.00)	6.66 ± 0.12 (4.20-7.80)	0.09
Morpho-edaphic index (M.E.I)	4.11 ± 0.18 (2.35-6.79)	3.67 ± 0.15 (2.14-5.68)	1.90

Note: values in parenthesis are minimum and maximum, ***** significant at $P \leq 0.05$

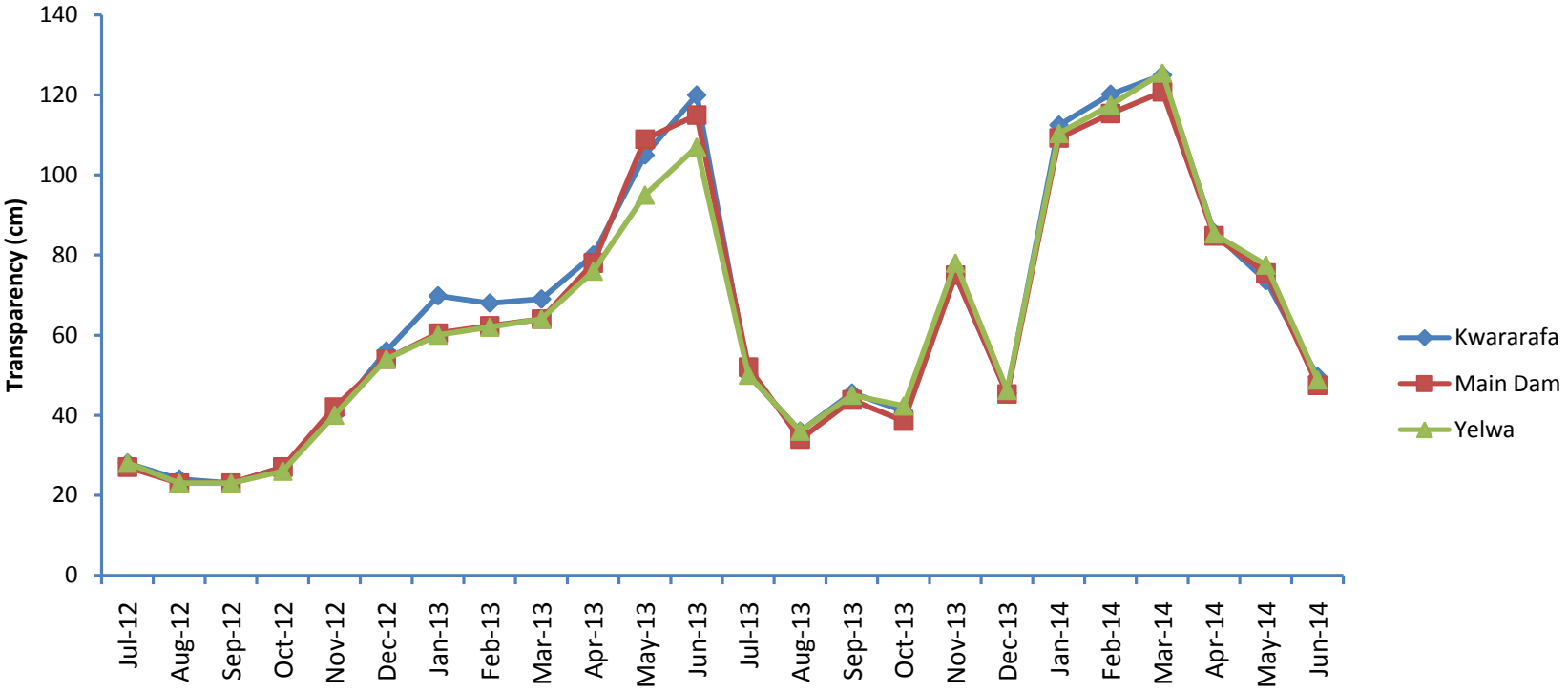


Figure 4.3: Mean monthly variations of water transparency of Doma Reservoir from July 2012 to June 2014

4.1.4 Depth (m)

The depth of reservoir varied significantly (P≤ 0.05) between stations with highest mean depth (15.71m) at the Main Dam and the lowest mean depth (9.47m) at Yelwa (Figure 4.1). Though there were no significant difference (P≥0.05) in temporal variation between months the highest depth (17.9m) was recorded in September 2012 at Main Dam and the lowest depth (8.2m) recorded in June 2013 at Yelwa (Figure 4.4). T-test analysis did not indicate any significant difference (P≥0.05) in water depth between seasons (Table 4.2). Correlation analysis showed that depth was highly negatively related with M.E.I (r = -0.882) and negatively related to transparency (r = -0.281) and Dissolved oxygen (r = -0.283) (Appendix i).

4.1.5 pH

The mean pH of Doma Reservoir ranged between 7.03- 7.05 and there was no significant difference between the sampling stations. Analysis variance (ANOVA) showed significant variation (P≤).05) in monthly pH values. The highest pH value (8.4) was recorded in February 2013 at Main Dam and lowest value (6.0) recorded in July and September 2012 at Yelwa and Main Dam respectively (Figure 4.5). T-test analysis also indicated significant difference (P≤ 0.05) in pH values between seasons with higher mean value (7.31) in dry season and lower mean value (6.78) recorded in the rainy season (Table 4.2). Correlation analysis showed highly positive relationship of pH with air temperature (0.422), water temperature (r = 0.503), transparency (r = 0.575), Hardness (r =0.359) and Dissolved oxygen (r = 0.325), positive relation with M.E.I. (r = 0.225) and highly negativerelationship with Ammonium-nitrogen (r = -0.416) and Carbon dioxide (r = -0.530) (Appendix i).

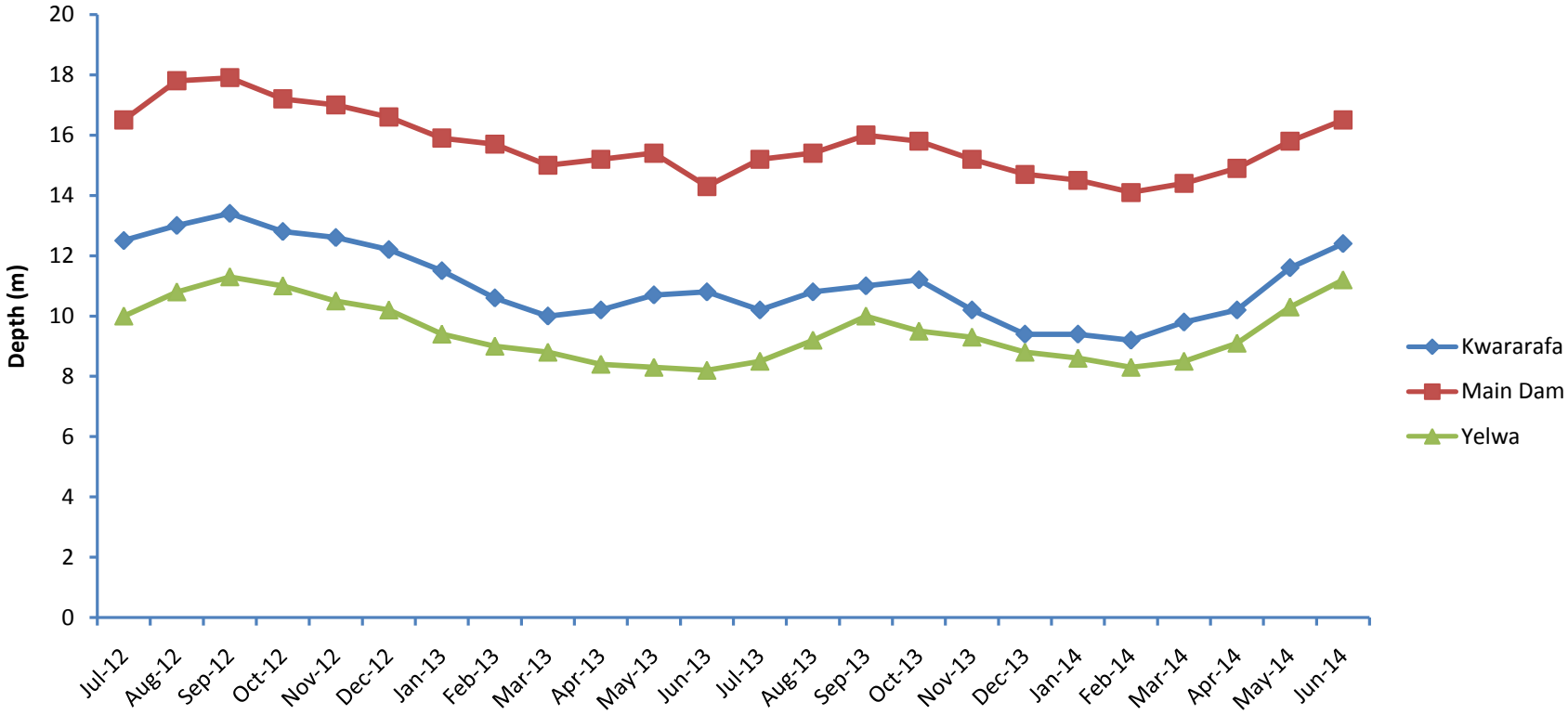


Figure 4.4: Mean monthly variations of water depth of Doma Reservoir from July 2012 to June 2014

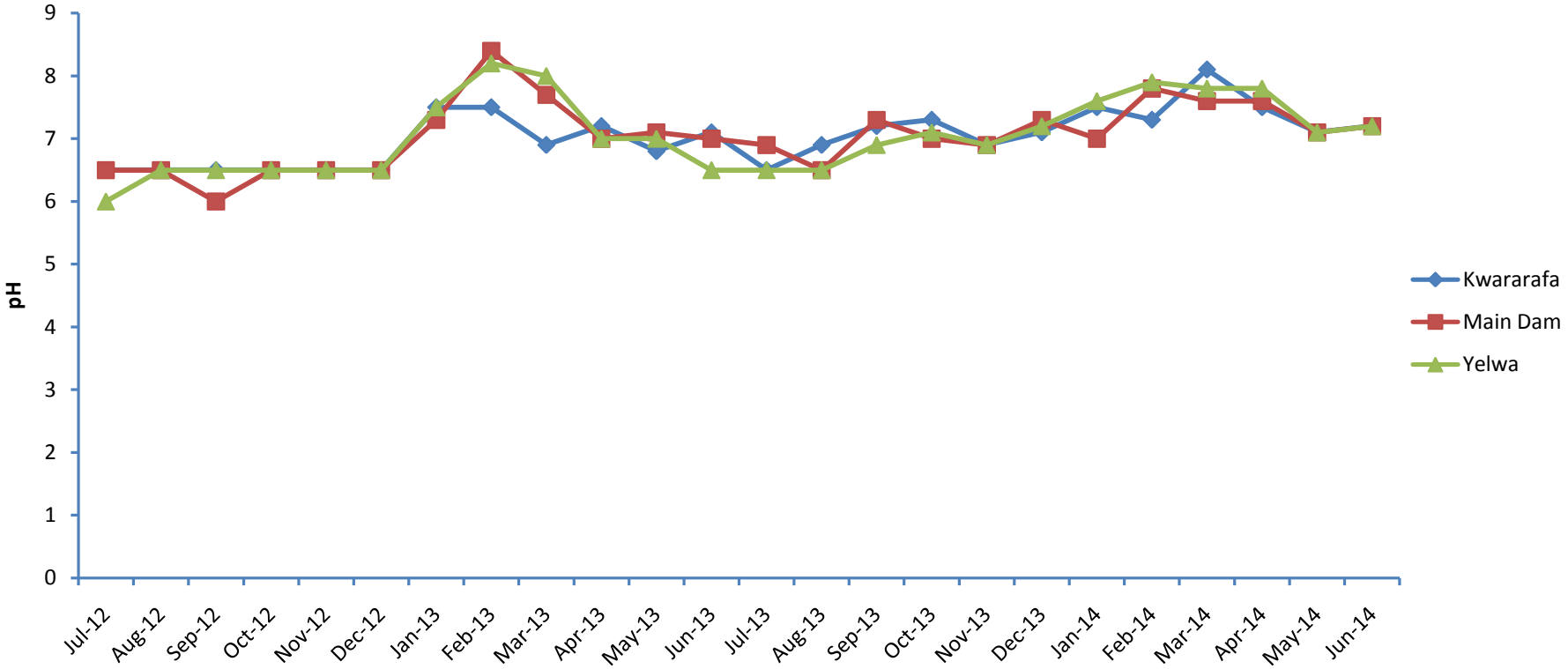


Figure 4.5: Mean monthly variations in water pH of Doma Reservoir from July 2012 to June 2014

4.1.6 Salinity (ppm)

The mean value of salinity of Doma Reservoir varied between 16.67- 17.92ppm and there was no significant difference ($P \geq 0.05$) in the salinity of water between the sampling stations (Table 4.1). There was significant variation ($P \leq 0.05$) in the monthly values of salinity, the highest value (30.00ppm) was observed in January 2013 at Yelwa (Figure 4.6). Significant difference ($P \leq 0.05$) also existed in the values salinity of water between seasons with higher mean value (18.61ppm) recorded in the dry season and lower value recorded (16.11ppm) in the rainy season. Salinity was shown to be highly positive related to TDS ($r = 0.799$), Conductivity ($r = 0.671$) and M.E.I ($r = 0.405$), positively related to air temperature ($r = 0.287$) and transparency ($r = 0.266$) and negatively related to Carbon dioxide ($r = -0.285$)

4.1.7 Total dissolved solids (TDS)

The mean value of total dissolved solids (TDS) ranged between 26.25- 27.08ppm. Statistical analysis showed that there were no significant difference ($P \geq 0.05$) between stations, months and seasons, however the highest value of TDS (40.00ppm) were recorded in January and October 2013 at Yelwa and Main Dam respectively (Figure 4.7). There were highly positive correlation of TDS with transparency ($r = 0.304$), salinity ($r = 0.799$), conductivity ($r = 0.781$) and M.E.I ($r = 0.485$) but no relationship with air temperature, water temperature, depth, pH, Ammonium-nitrogen, Alkalinity, Carbon dioxide, Chloride, Hardness and Dissolved oxygen (Appendix i).

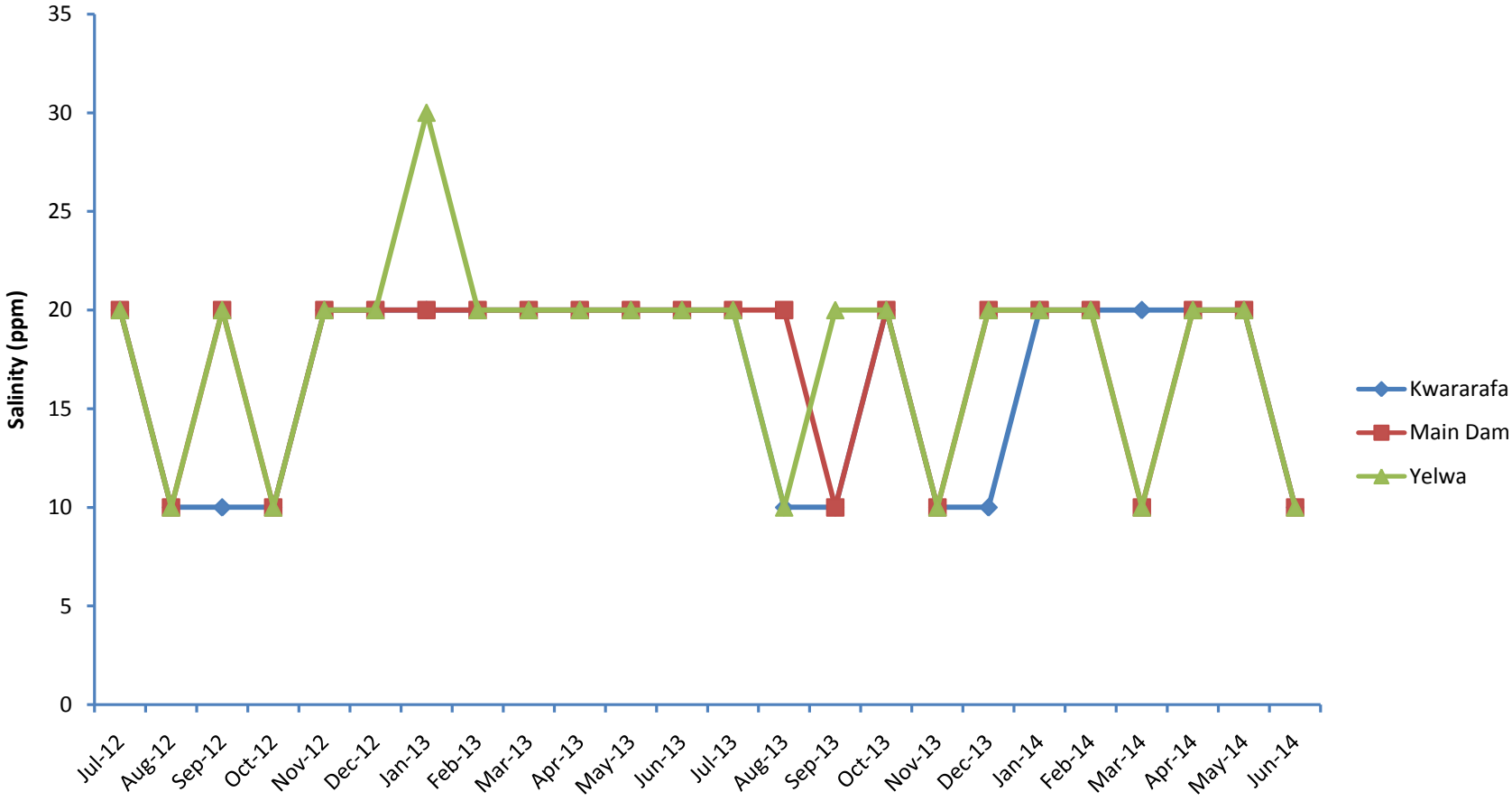


Figure 4.6: Mean monthly variations in water salinity of Doma Reservoir from July 2012 to June 2014

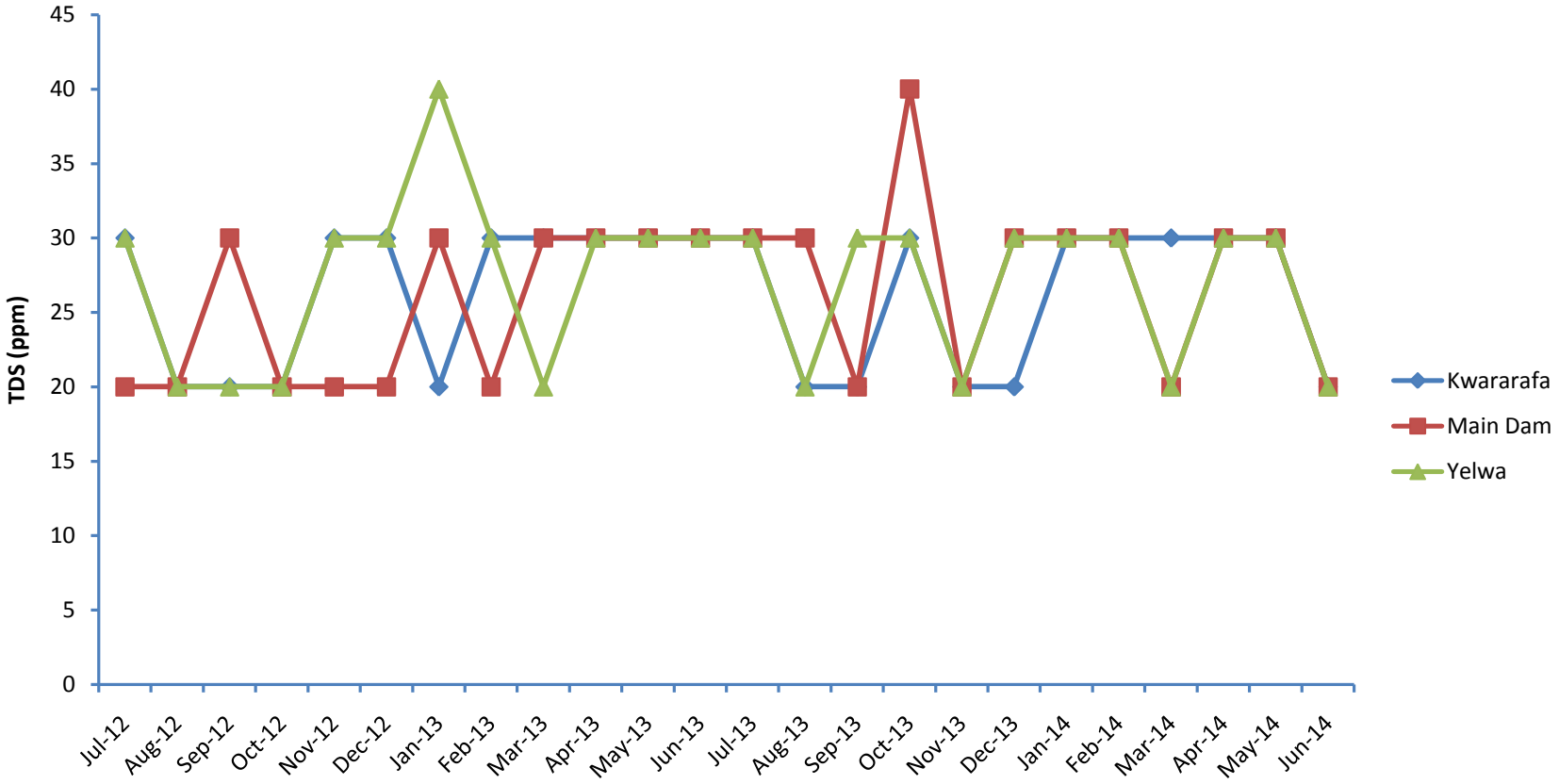


Figure 4.7: Mean monthly variations in total dissolved solids (TDS) of Doma Reservoir from July 2012 to June 2014

4.1.8 Conductivity

Mean value of conductivity of Doma Reservoir ranged between 43.75- 45.09μS^{-}. Though there were no significant difference ($P \geq 0.05$) in electrical conductivity between the sampling stations months and seasons (Table 4.1), however the highest value (63.8μS^{-}) and the lowest value (31.50μS^{-}) were observed at Yelwa in January 2013 and October 2012 (Figure 4.8). The mean value of conductivity was also higher (45.06) in the dry season than rainy season (43.84). Correlation matrix showed highly positive correlation of conductivity with salinity (r = 0.671), TDS (r = 0.781) and M.E.I (r = 0.467) but no relationship with other physico-chemical parameters.

4.1.9 Ammonia-nitrogen

The mean value of Ammonium-nitrogen of Doma Reservoir varied between 0.48- 0.50ppm. There was no significant variation ($P \geq 0.05$) in values of Ammonia-nitrogen between sampling stations and seasons. ANOVA showed significant variation ($P \leq 0.05$) in Ammonia-nitrogen values between months and the highest value (0.8ppm) were recorded in July, August, September, December (2012), July, December (2013) and January 2014 (Figure 4.9). Correlation Matrix showed that Ammonia-nitrogen had highly positive relationship with Carbon dioxide (r = 0.538) and highly negative correlation with air temperature (r = -0.363), water temperature (r = -0.554), transparency (r =-0.388) and pH (r = -0.416) but had no relationship with depth, salinity, TDS, conductivity, chloride, hardness and Dissolved oxygen (Appendix i).

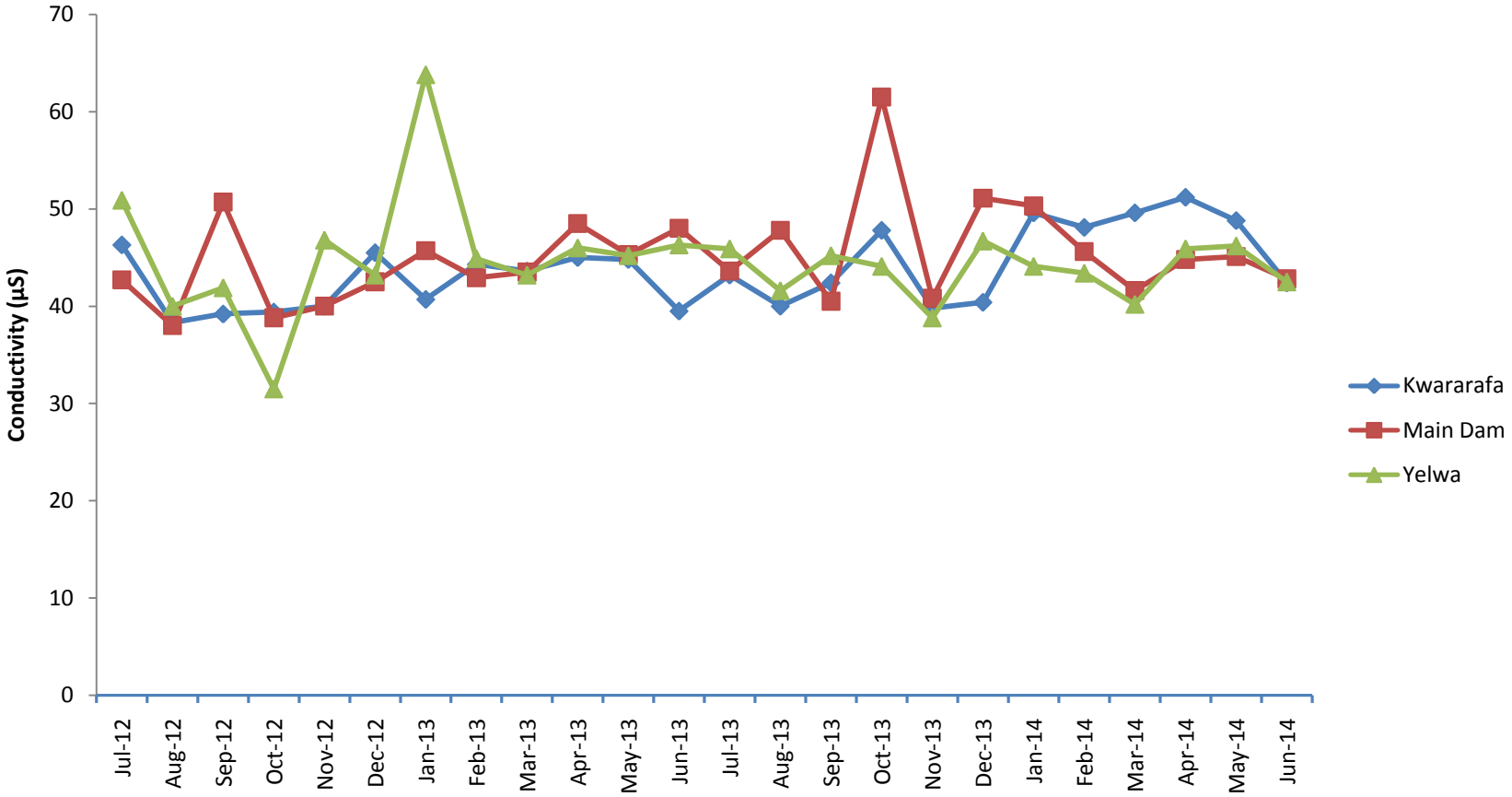


Figure 4.8: Mean monthly variations in water electrical conductivity of Doma Reservoir from July 2012 to June 2014

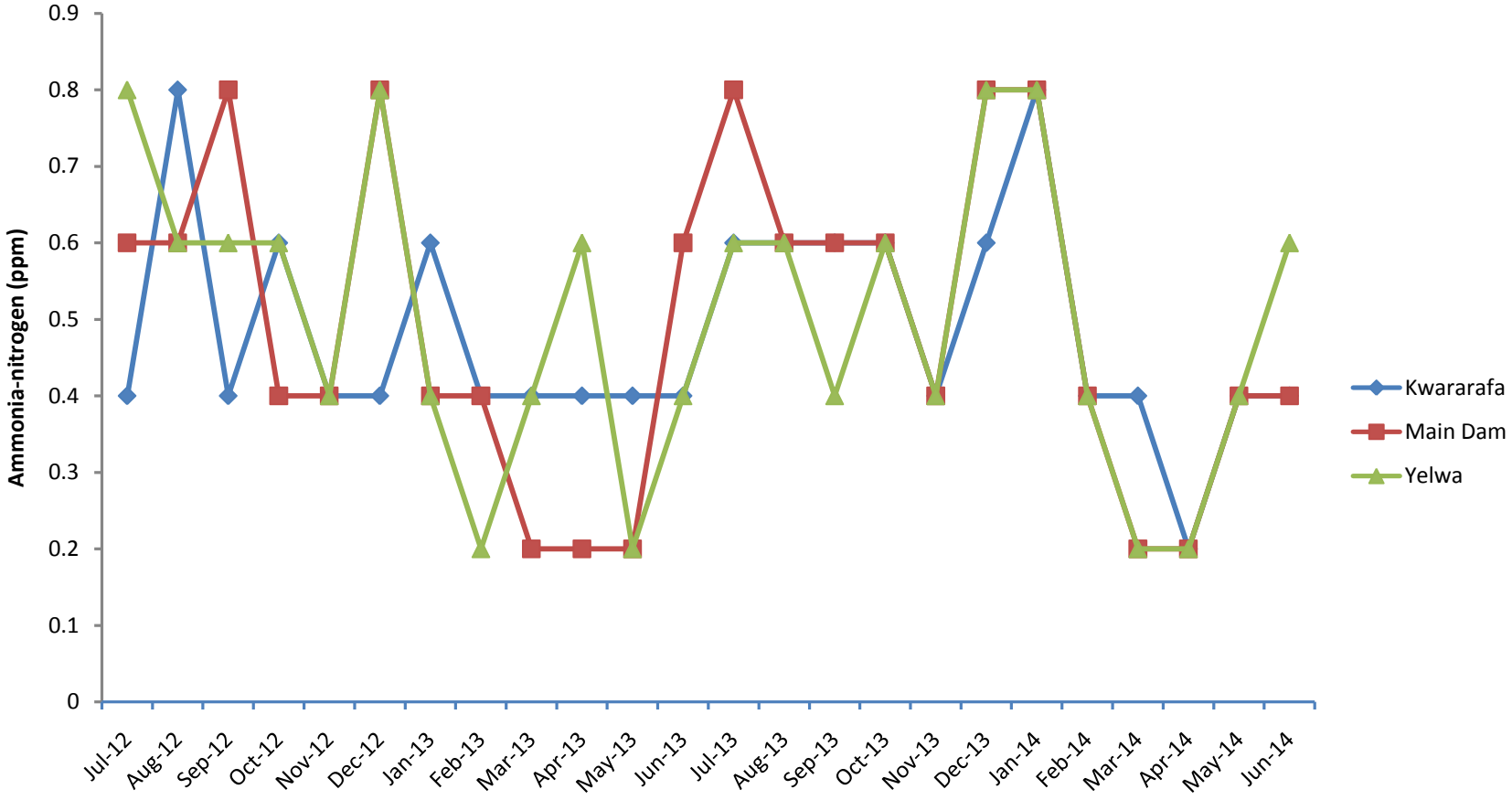


Figure 4.9: Mean monthly variations in Ammonia-Nitrogen of Doma reservoir from July 2012 to June 2014

4.1.10 Hardness

The mean value of water varied between 18.33 -19.16ppm. There was no significant difference ($P \geq 0.05$) in water hardness between stations but significant difference ($p \leq 0.05$) existed between months and seasons. The highest value (36.00ppm) of water hardness was recorded in December 2013 at Main Dam and lowest value (12.00ppm) was observed in July, August and September 2012 at Kwararafa and Yelwa (Figure 4.10). Mean value was also in dry season than the rainy season. Correlation matrix shows that there was no correlation of water hardness with other physico-chemical parameters except for transparency and and pH for this study (Appendix i).

4.1.11 Alkalinity

The mean value of alkalinity was between 26.67- 28.67ppm in Doma Reservoir, ANOVA and t-test analysis indicated that there were no significant difference ($P \geq 0.05$) in the values of alkalinity between sampling stations, months and seasons (Table 4.1). However the highest value (48.00ppm) was recorded in July 2012 at Kwararafa and the lowest value (20.00ppm) were recorded at Main Dam in September and October 2012 and at Yelwa November 2012 and January 2013 (Figure 4.10). Correlation analysis showed that water alkalinity had no relationship with other physico-chemical parameters studied in Doma Reservoir (Appendix i)

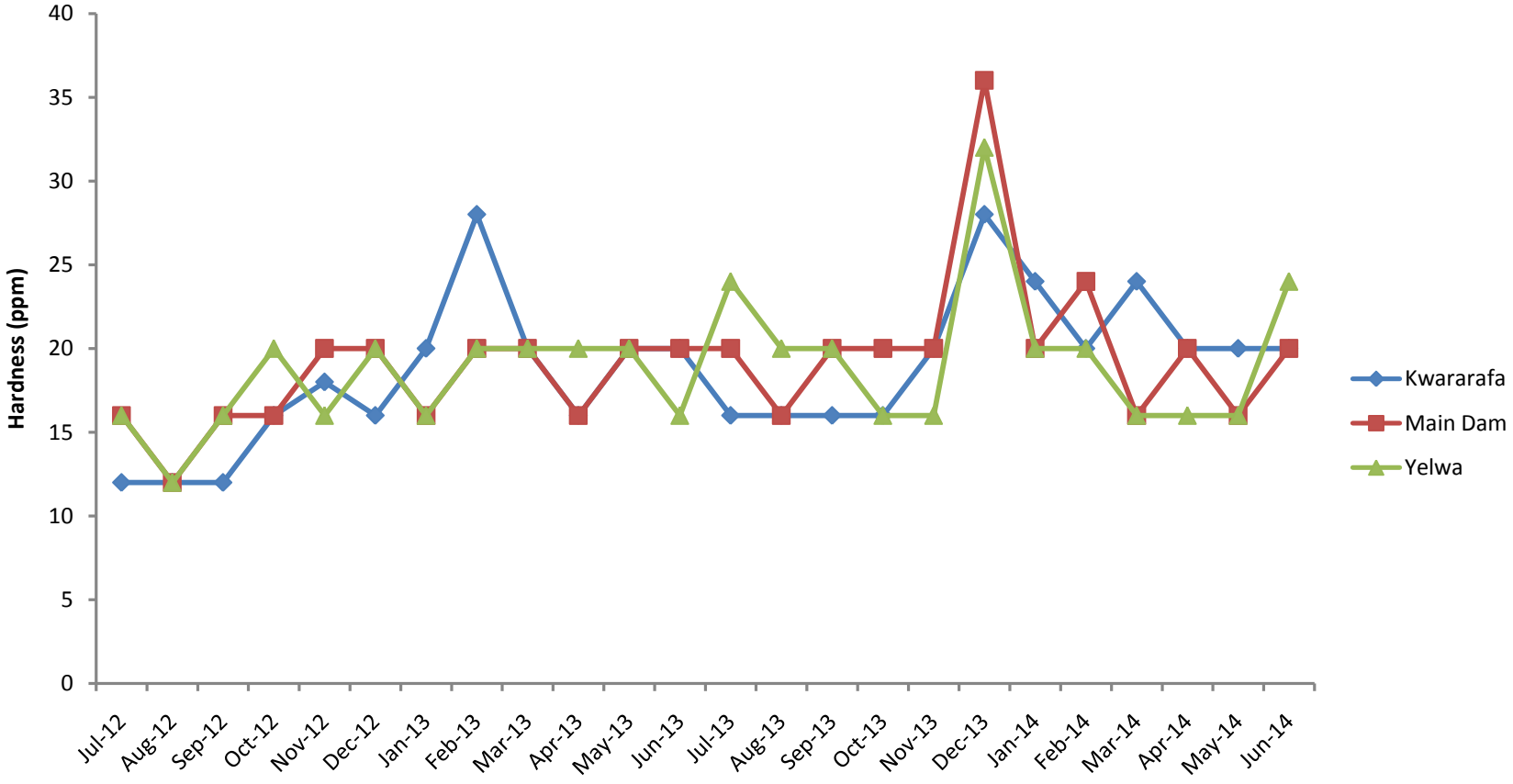


Figure 4.10: Monthly variations in water hardness of Doma Reservoir from July 2012 to June 2014

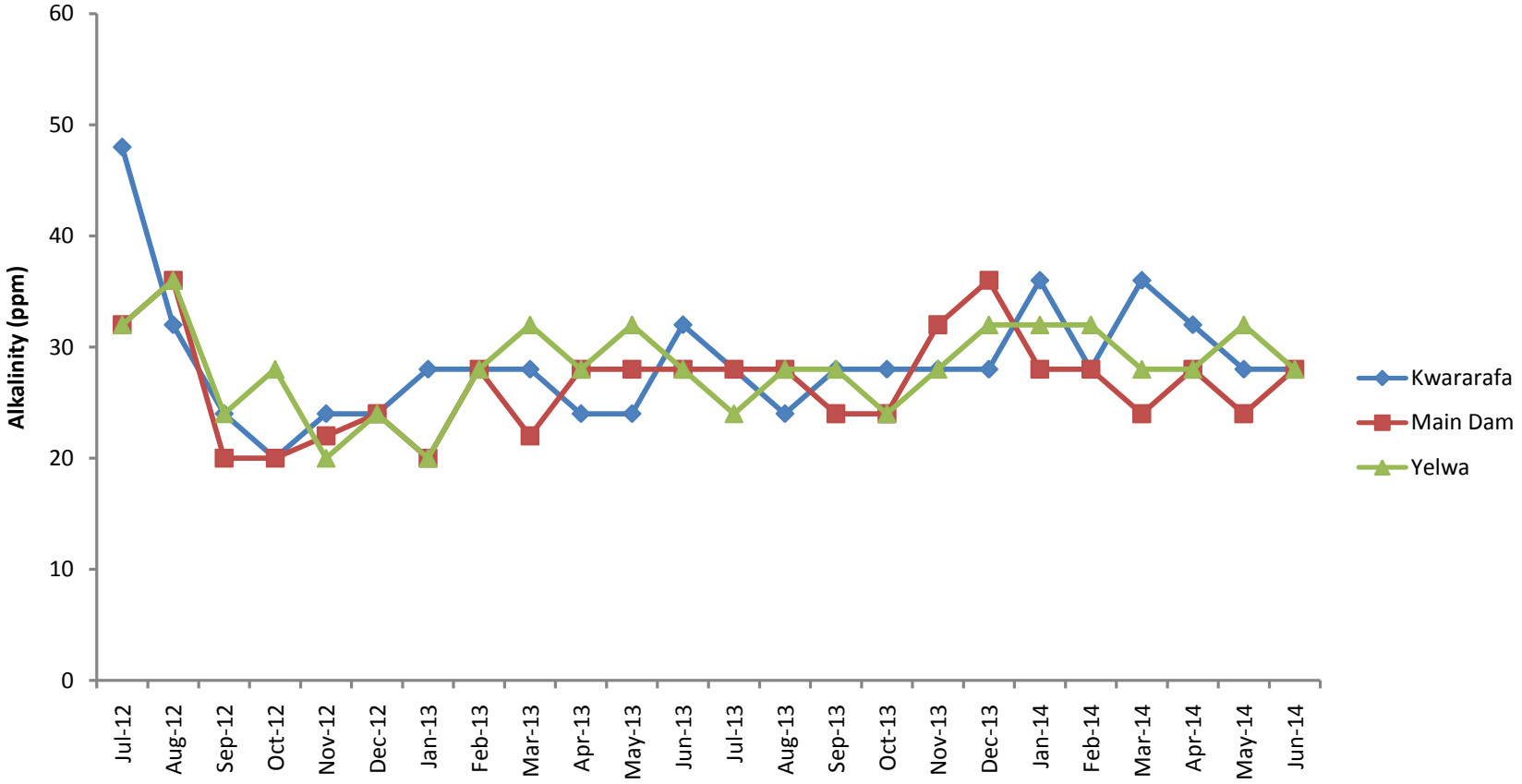


Figure 4.11: Monthly variations in alkalinity of Doma reservoir from July 2012 to June 2014

4.1.12 Carbon dioxide

The mean Carbon dioxide of Doma Reservoir varied between 5.54- 6.33ppm, there was no significant different ($P \geq 0.05$) between stations but significant difference ($P \leq 0.05$) exists between months and seasons (Fig4.1). The highest value (15.00ppm) of carbon dioxide was observed in July 2012 at Yelwa, while lowest value (3.00ppm) were recorded at Yelwa in January, February 2013, March, April and May 2014 and at Main Dam in April 2013 and February 2014 (Figure 4.11). Correlation analysis showed that carbon dioxide was highly positive related to Ammonia-nitrogen ($r = 0.538$), highly negative related to air temperature ($r = -0.355$), water temperature ($r = -0.500$), transparency ($r = -0.522$), pH ($r = -0.530$) and dissolved oxygen ($r = -0.408$) and negatively related with salinity ($r = -0.285$) but has no correlation with other physico-chemical parameters (Appendix i).

4.1.13 Chloride

The mean value of chloride ranged from 8.33- 9.75ppm for sampled stations. There were no significant variations ($P \geq 0.05$) in the mean values between stations, months and seasons. However the highest value (16.00ppm) was recorded in July 2012 at Yelwa and the lowest values (4.00ppm) were recorded at Yelwa in December 2012, January 2013 and at Main Dam in August 2013 (Figure 4.12). Correlation matrix indicated that chloride had no correlation with other physico-chemical parameters studied in Doma Reservoir (Appendix i).

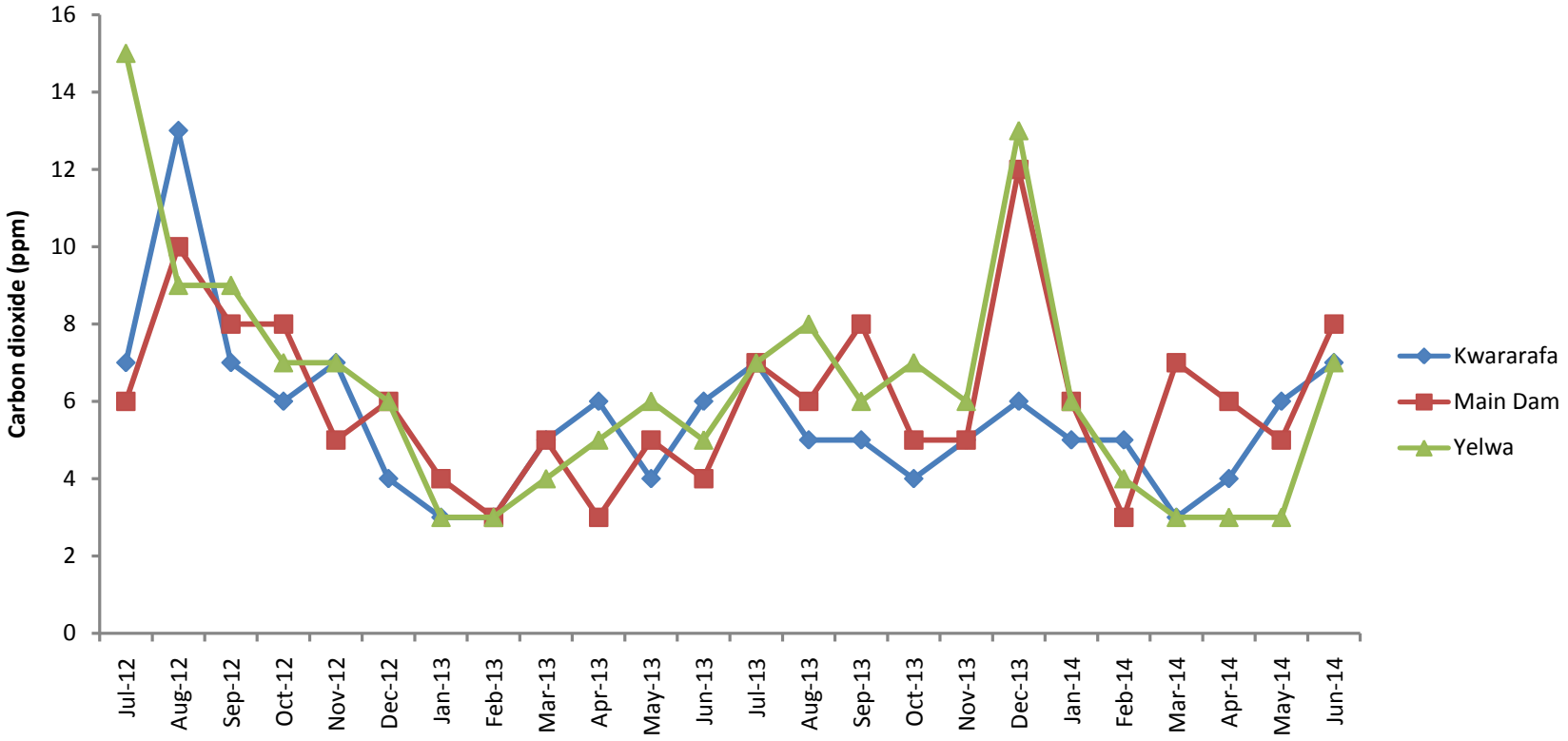


Figure 4.12: Monthly variations in Carbon dioxide of Doma Reservoir from July 2012 to June 2014

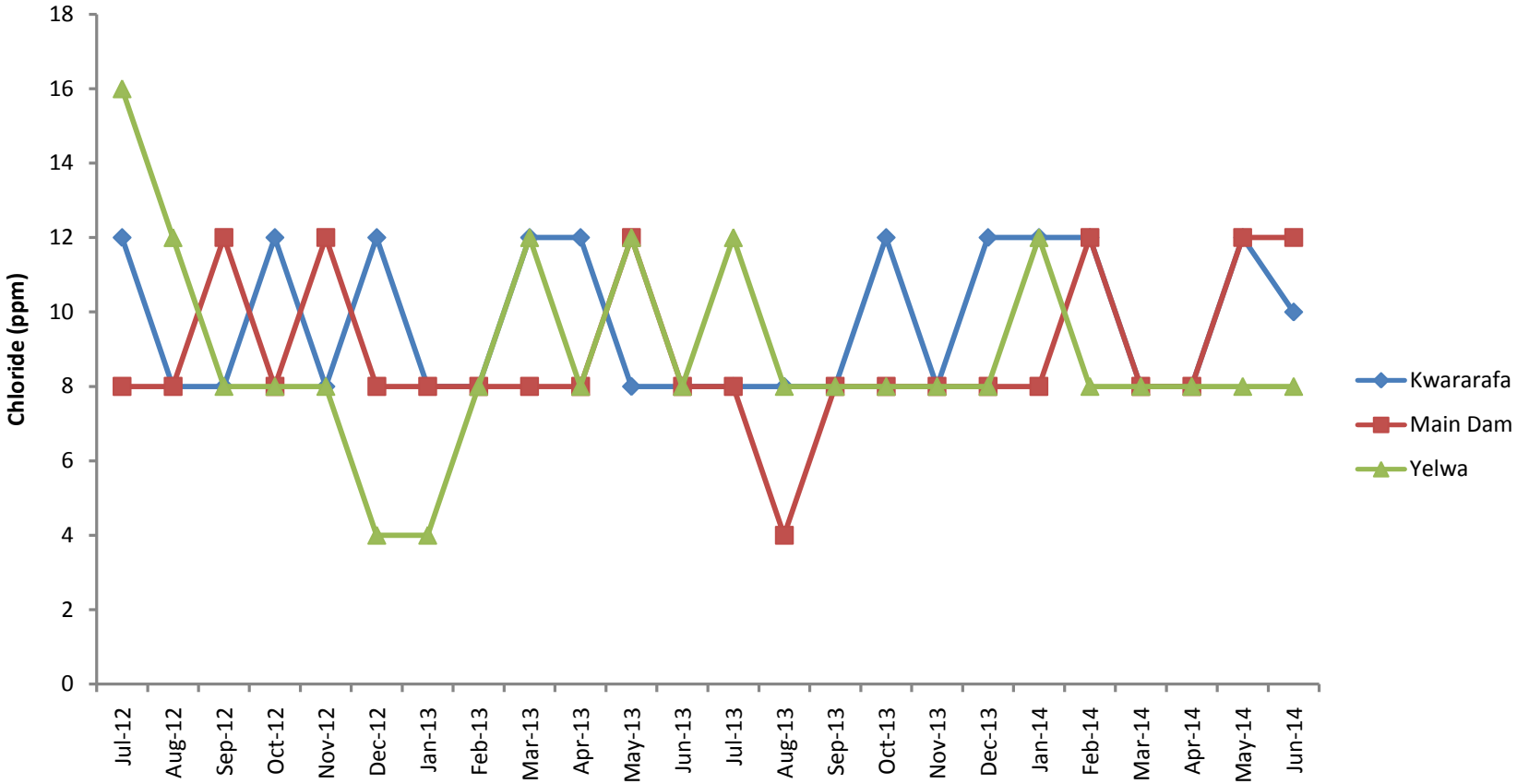


Figure 4.13: Monthly variations in chloride of Doma Reservoir from July 2012 to June 2014

4.1.14 Dissolved oxygen

The mean value of dissolved oxygen varied between 6.52- 6.79ppm for the stations. Analysis of variance (ANOVA) an student t-test showed that there were no significant difference ($P \geq 0.05$) in dissolved oxygen distribution between stations and seasons, but there was significant difference ($P \leq 0.05$) in oxygen distribution between months (Table 4.1). The highest value (8.00ppm) of dissolved oxygen was recorded in February 2013 at Yelwa and lowest value (4.2ppm) observed in September 2012 and December 2013 at Main Dam (Figure 4.14). Correlation analysis showed dissolved oxygen to be highly positive correlated with transparency (r = 0.356) and pH (r = 0.325), positively correlated with M.E.I (r = 0.393), highly negative correlated with carbon dioxide (r = -0.408) and negatively correlated with depth (r = -0.283) but not correlated with air temperature, water temperature, salinity, TDS, conductivity, Ammonium-nitrogen and alkalinity (Appendix i).

4.2 Morpho-Edaphic Index (M.E.I) and Potential Fish Yield

The mean value of M.E.I shows monthly variation throughout the study period. The highest value (4.63) of M.E.I was observed in January 2014 and the lowest value (2.73) observed in October 2012 (Figure 4.15). The estimated potential fish yield of Doma reservoir (Y) from morpho-edaphic indices (MEI) was $40.76 kgha^{-1}$ for the year, $42.63 kgha^{-1}$ for the second year and $41.73 kgha^{-1}$ for the combined years (table 4.3).

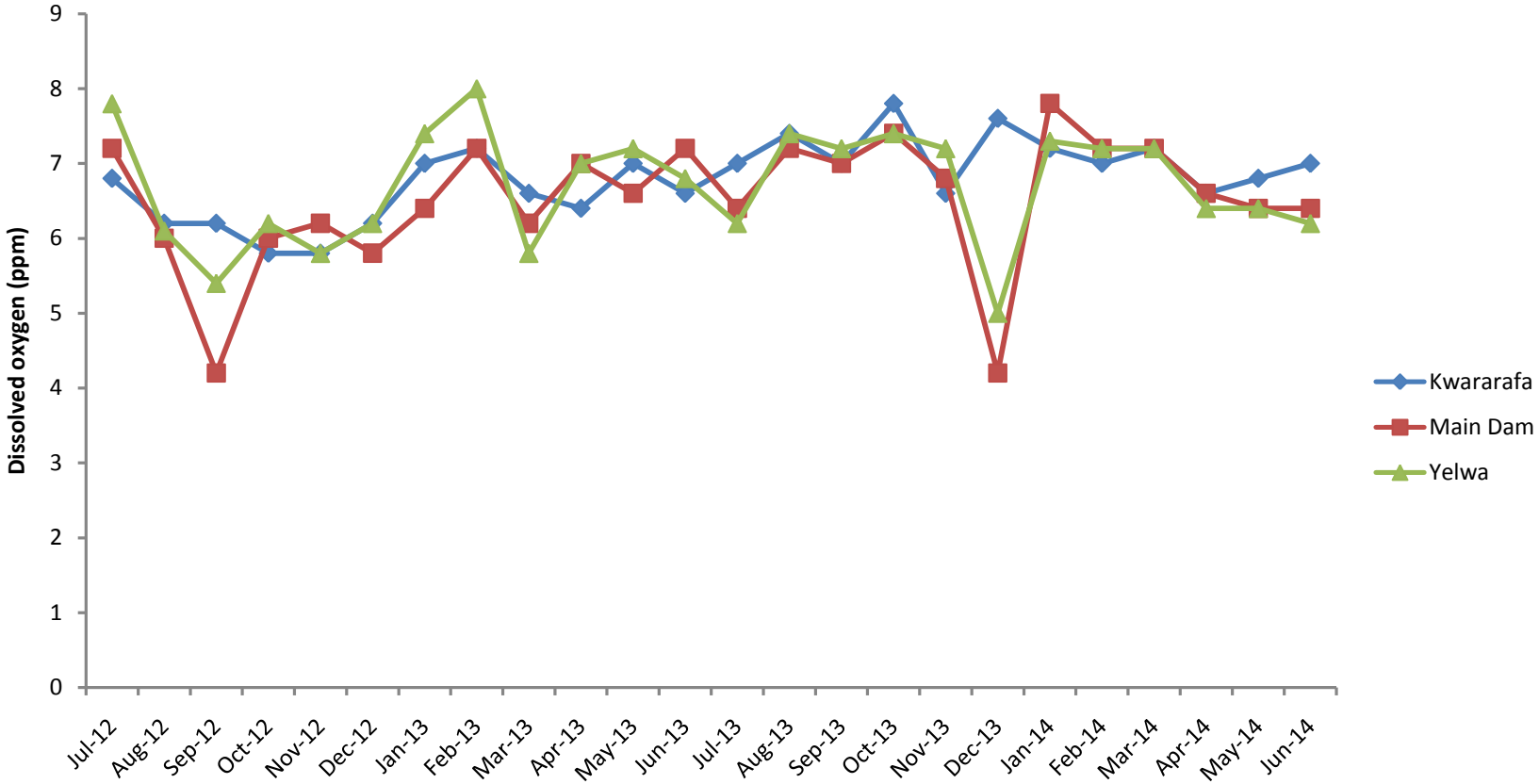


Figure 4.14: Mean monthly variations in dissolved oxygen of Doma Reservoir from July 2012 to June 2014

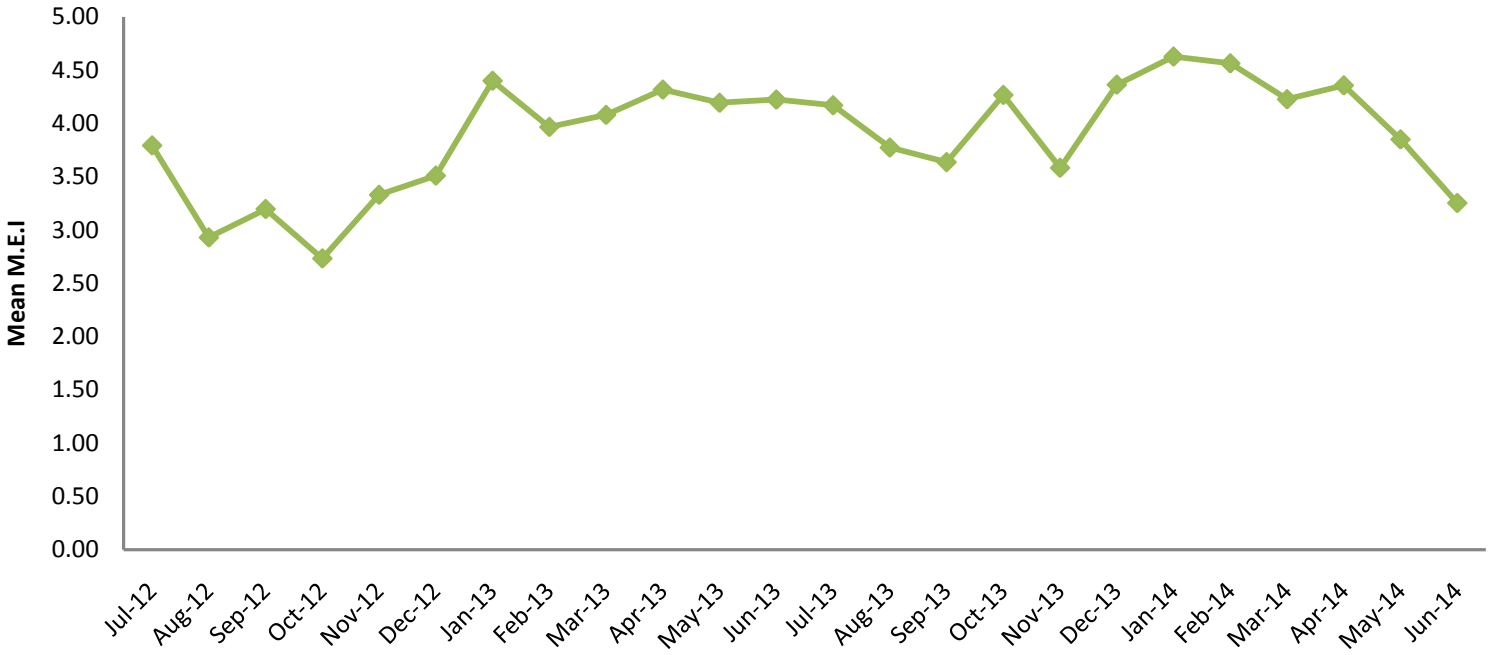


Figure 4.15 Mean monthly variations in morpho-edaphic index (M.E.I) from July 2012 to June 2014

Table 4.3: Potential fish yield (Y) from Doma reservoir from estimated MEI indices

Year	Mean electrical conductivity	Mean Depth of water	MEI	Potential fish yield (Y) ($kgha^{-1}$)
First year	43.80	12.52	3.50	40.76
Second year	45.09	11.64	3.87	42.63
Combined year	44.57	12.08	3.69	41.73

4.3 Fish Abundance and Distribution in Experimental Gillnet Sampling

Eleven fish species belonging to six families were recorded in Doma Reservoir from July 2012 to June 2014. The fish Families recorded were Cichlidae, Mormyridae, Clariidae, Hepsetidae, Channidae and Cypridae. Cichlidae was represented by five species of fish, Mormyridae represented by two species of fish while the rest of the other families were represented by one species of fish each. The family Cichlidae was represented by the following species of fish, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hemichromis fasciatus* and *Pelmatochromis pulcher*; Mormyridae was represented by *Hyperopisus bebe* and *Gnathonemus niger*, Clariidae represented by *Clarias gariepinus*, Hepsetidae represented by *Hepsetus odoe*, Channidae represented *Channa obscura* and Cyprinidae represented by *Labeo senegalensis*.

4.2.1 Fish abundance (%) in gillnet sampling

A total of 2717 fish individuals weighing 197065g were recorded in the reservoir as presented in Table 4.4. The family Cichlidae has the highest number of individuals and weight followed by Mormyridae both in number and weight while Cypridae recorded least number of individuals and weight. *Sarotherodon galilaeus* recorded the highest number (72.5%) of individuals and weight (67.5%) followed by *Tilapia zillii* in number (15.0%) and weight (11.27%) and the least abundance was represented *Gnathonemus niger* both in number and weight (Table 4.3).

Table 4.4: Fish abundance (%) in gillnets sampling in Doma Reservoir, Nasarawa State

Family/Species	No	%	Wt(g)	%
Cichlidae				
Sarotherodon galilaeus	1970	72.5	133099	67.5
Tilapia zillii	407	15	22031	11.27
Oreochromis niloticus	156	5.7	13845	7
Hemichromis fasciatus	11	0.4	299	0.2
Pelmatochromis pulcher	8	0.3	137	0.1
Mormyridae				
Hyperopisus bebe	109	4	17569	8.9
Gnathonemus niger	1	0.0	27	0.0
Clariidae				
Clarias gariepinus	39	1.4	7345	3.7
Hepsetidae				
Hepsetus odoe	7	0.3	1331	0.7
Channidae				
Channa obscura	6	0.2	995	0.5
Cyprinidae				
Labeo senegalensis	3	0.1	387	0.2
Total	2717	100	197065	100

4.2.2 Monthly fish abundance in gillnets sampling

The monthly fish abundance in gillnets sampling from July 2012 to June 2014 in Doma Reservoir is shown in Table 4.5. The highest number of fish catch was in November (470) followed by February (468) and the least recorded in April (95). *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus* and *Hyperopisus bebe* were presented in the all months, *Clarias gariepinus* was represented in other months except June while *Gnathonemus niger* was absent in other months but represented in November. Other species of fish were recorded as follows *Hemichromis fasciatus* in August, December, January, February, April and June, *Pelmatochromis pulcher* in December, January and March, *Hepsetus odoe* in September, November and June, *Channa obscura* in July, October, November and January while *Labeo senegalensis* was recorded in August, October and May. *Sarotherodon galilaeus* recorded the highest percentage number throughout the months.

4.2.3 Seasonal fish abundance in gillnets sampling

Table 4.6 presented seasonal fish abundance in gillnets sampling from July 2012 to June 2014 in Doma Reservoir. 1543 fish with the weight of 91608g were recorded in dry season and 1174 fish with the weight of 105457 were recorded in the rainy season. *Sarotherodon galilaeus* was observed to have the highest percentage number (77.58%) and weight (72.59%) in the dry season followed by *Tilapia zillii* in number (13.09%) and weight

Table 4.5 Monthly fish abundance in gillnets sampling in Doma Reservoir, Nasarawa State, Nigeria

Family/Species	July	August	September	October	November	December	January	February	March	April	May	June
	% No.	% No.	% No.	% No.	% No.	% No.	% No.	% No.	% No.	% No.	% No.	% No.
Cichlidae												
Sarotherodon galilaeus	60.57	87.14	78.07	85.11	84.68	61.76	55.65	86.11	72.55	72.63	55.29	40.66
Tilapia zillii	10.98	1.90	6.14	6.38	7.45	29.41	12.10	10.47	16.99	15.79	30.00	39.83
Oreochromis niloticus	23.58	5.71	7.89	1.06	4.26	0.42	7.26	0.64	3.92	2.11	2.35	12.45
Hemichromis fasciatus	-	1.43	-	-	-	1.26	0.81	0.42	-	1.05	-	0.41
Pelmatochromis pulcher	-	-	-	-	-	0.84	4.03	-	0.65	-	-	-
Mormyridae												
Hyperopisus bebe	2.85	0.48	3.51	3.72	1.49	5.46	14.52	1.50	5.23	7.37	10.59	4.98
Gnathonemus niger	-	-	-	-	0.21	-	-	-	-	-	-	-
Clariidae												
Clarias gariepinus	1.63	2.86	3.51	2.13	1.28	0.84	4.03	0.85	0.65	1.05	1.18	-
Hepsetidae												
Hepsetus odoe	-	-	0.88	-	0.43	-	-	-	-	-	-	1.66
Channidae												
Channa obscura	0.41	-	-	1.06	0.21	-	1.61	-	-	-	-	-
Cyprinidae												
Labeo senegalensis	-	0.48	-	0.53	-	-	-	-	-	-	0.59	-
Total	246 (100)	210 (100)	114 (100)	118 (100)	470 (100)	238 (100)	124 (100)	468 (100)	153 (100)	95 (100)	170 (100)	241 (100)

- - Absence of fish species

Table 4.6: Seasonal fish abundance (%) in gillnet sampling in Doma Reservoir, Nasarawa State, Nigeria

Family/Species	Dry season				Rainy season			
	No	%	Wt	%	No	%	Wt	%
Cichlidae								
Sarotherodon galilaeus	1197	77.58	66498	72.59	773	65.84	66601	63.15
Tilapia zillii	202	13.09	10151	11.08	202	17.21	11880	11.27
Oreochromis niloticus	41	2.66	2740	2.99	115	9.80	11105	10.53
Hemichromis fasciatus	7	0.45	222	0.24	4	0.34	77	0.07
Pelmatochromis pulcher	8	0.52	137	0.15	-	-	-	-
Mormyridae								
Hyperopisus bebe	60	3.89	7428	8.11	49	4.17	10141	9.62
Gnathonemus niger	1	0.06	27	0.03	-	-	-	-
Clariidae								
Clarias gariepinus	19	1.23	3310	3.61	20	1.70	4035	3.83
Hepsetidae								
Hepsetus odoe	2	0.13	507	0.55	5	0.43	824	0.78
Channidae								
Channa obscura	3	0.19	588	0.64	3	0.26	407	0.39
Cyprinidae								
Labeo senegalensis	-	-	-	-	3	0.26	387	0.37
Total	1543	100	91608	100	1174	100	105457	100

- - Absence of fish species

(72.59%) in the dry season followed by *Tilapia zillii* in number (13.09%) and weight (11.08%) and least percentage number (0.06%) and weight (0.03%) was recorded by *Gnathonemus niger*. *Sarotherodon galilaeus* also dominated by highest percentage number (65.84%) and weight (63.15) in the rainy season, followed by *Tilapia zillii* by percentage number (17.21%) and weight (11.27%) and the least number (0.26%) was recorded by *Channa obscura* and *Labeo senegalensis* and least weight (0.37%) recorded by *Labeo senegalensis*. All species of fish were recorded in dry season except *Labeo senegalensis* and in rainy season *Pelmatochromis pulcher* and *Gnatheneus niger* were not recorded while other species of fish were recorded.

4.2.4 Fish abundance in gillnets sampling at the sampling stations

The fish abundance in gillnets sampling at the sampled stations was presented in Table 4.7. The highest number of fish individuals was recorded in Yelwa (1021) followed by Kwararafa (950) and least recorded in the Main Dam. *Sarotherodon galilaeus* dominated by percentage number in the three sampled stations with 69.68% in Kwararafa, 74.13% in the Main Dam and 75.90% in Yelwa respectively followed *Tilapia zillii* in all the sampled stations with 17.05% in Kwararafa, 15.55% in Main Dam and 12.63% in Yelwa, the least percentage number were recorded by *Labeo senegalensis* (0.11%) in Kwararafa, *Channa obscura* (0.13%) in Main Dam, Hepsetus odoe and *Labeo senegalensis* (0.20%) in Yelwa. *Gnathonemus niger* was not recorded in Kwararafa while other species were recorded, *Gnathonemus niger* and *Labeo senegalensis* were not represented in Main Dam other were recorded while in Yelwa all species were recorded except *Pelmatochromis pulcher* and *Channa obscura*.

Table 4.7: Fish abundance (%) in gill net sampling at three sampling stations

Family/Species	Kwararafa		Main Dam		Yelwa	
	No	%	No	%	No	%
Cichlidae						
Sarotherodon galilaeus	662	69.68	553	74.13	775	75.90
Tilapia zillii	162	17.05	116	15.55	129	12.63
Oreochromis niloticus	58	6.11	37	4.96	61	5.97
Hemichromis fasciatus	6	0.63	2	0.27	3	0.29
Pelmatochromis pulcher	3	0.32	5	0.67	-	-
Mormyridae						
Hyperopisus bebe	39	4.11	35	4.69	35	3.43
Gnathonemus niger	-	-	-	-	1	0.10
Clariidae						
Clarias gariepinus	11	1.16	15	2.01	13	1.27
Hepsetidae						
Hepsetus odoe	3	0.32	2	0.27	2	0.20
Channidae						
Channa obscura	5	0.53	1	0.13	-	-
Cyprinidae						
Labeo senegalensis	1	0.11	-	-	2	0.20
Total	950	100	746	100	1021	100

- - Absence of fish species

4.2.5 Seasonal fish abundance in gillnets sampling at various sampling stations

Seasonal fish abundance in gillnets sampling at various sampling stations is shown in Table 4.8. 546 fish were recorded in dry season and 404 recorded in rainy season at Kwararafa. *Sarotherodon galilaeus* recorded the highest percentage number in both dry season (77.47%) and rainy season (59.16%) followed by *Tilapia zillii* both in dry and rainy seasons with 12.82% and 22.77% respectively the least percentage (0.55%) were recorded by *Hemichromis fasciatus, Pelmatochromis pulcher, Clarias gariepinus* and *Channa obscura* in dry season and 0.25% recorded by *Labeo senegalensis*. *Gnathonemus niger, Hepsetus odoe* and *Labeo senegalensis* were not recorded in the dry season while *Pelmatochromis pulcher* and *Gnathonemus niger* were absent in the rainy season at Kwararafa.

350 fish was recorded in dry season and 396 fish recorded in rainy season at the Main Dam (Table 4.8). *Sarotherodon galilaeus* dominated by percentage number in both dry and rainy season with 70.86% and 71.97% respectively, followed by *Tilapia zillii* in both seasons. *Gnathonemus niger, Channa obscura* and *Labeo senegalensis* were not recorded in the dry season while in the rainy season *Pelmatochromis pulcher, Gnathonemus niger, Hepsetus odoe* and *Labeo senegalensis* were not recorded. In Yelwa 624 fish were recorded in dry season and 397 recorded in the rainy season. *Sarotherodon galilaeus* dominated by percentage number for both seasons and was followed by *Tilapia zillii* for both dry and rainy season (Table 4.8). *Pelmatochromis pulcher* and *Channa obscura* were not recorded for both season at Yelwa. *Hepsetus odoe* and *Labeo senegalensis* were not observed in the dry season and in the rainy *Hemichromis fasciatus* and *Gnathonemus niger* were absent.

Table 4.8 Seasonal fish abundance (%) in gillnet sampling at various sampling stations in Doma Reservoir, Nasarawa State, Nigeria

Family/Species	Kwararafa				Main Dam				Yelwa			
	Dry		Rainy		Dry		Rainy		Dry		Rainy	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cichlidae												
Sarotherodon galilaeus	423	77.47	239	59.16	248	70.86	285	71.97	505	80.93	270	68.01
Tilapia zillii	70	12.82	92	22.77	67	19.14	49	12.37	66	10.58	63	15.87
Oreochromis niloticus	18	3.30	40	9.90	6	1.71	31	7.83	17	2.72	44	11.08
Hemichromis fasciatus	3	0.55	3	0.74	1	0.29	1	0.25	3	0.48	-	-
Pelmatochromis pulcher	3	0.55	-	-	5	1.43	-	-	-	-	-	-
Mormyridae												
Hyperopisus bebe	23	4.21	16	3.96	13	3.71	22	5.56	24	3.85	11	2.77
Gnathonemus niger	-	-	-	-	-	-	-	-	1	0.16	-	-
Clariidae												
Clarias gariepinus	3	0.55	8	1.98	8	2.29	7	1.77	8	1.28	5	1.26
Hepsetidae												
Hepsetus odoe	-	-	3	0.74	2	0.57	-	-	-	-	2	0.50
Channidae												
Channa obscura	3	0.55	2	0.50	-	-	1	0.25	-	-	-	-
Cyprinidae												
Labeo senegalensis	-	-	1	0.25	-	-	-	-	-	-	2	0.50
Total	546	100	404	100	350	100	396	100	624		397	100

- - Absence of fish species

4.2.6 Fish distribution in gillnets sampling in the shore, surface and bottom habitats

A total 1801fish were recorded in the shore, 645 fish recorded in the surface and 271 fish recorded in the bottom habitat of Doma Reservoir (Table 4.9). *Sarotherodon galilaeus* has the highest percentage number of fish species in the shore (69.02%), surface (81.86%) and bottom habitat (73.43%) of the reservoir, it was followed by Tilapia in the shore (18.10%) and surface (8.84%) and *Clarias gariepinus* in the bottom (13.28%), the least percentage in the shore was recorded by *Gnathonwmus niger* (0.06%), in the surface the least percentage (0.16%) were recorded by *Clarias gariepinus* and *Channa obscura* while in the bottom the least percentage was recorded by *Hyperopisus bebe* (0.37%). All species of fish were represented in the shore, *Hemichromis fasciatus*, *Pelmatochromis pulcher*, *Gnathonemus niger* and *Labeo senegalensis* were not recorded in the surface and bottom habitat but others recorded, *Hepsetus odoe* was also absent in the bottom.

4.2.7 Seasonal fish distribution at shore, surface and bottom habitats

Seasonal fish distribution at shore, surface and bottom habitats of Doma Reservoir was presented in Table 4.10. 1069 fish were recorded in the dry season and 732 fish in the rainy season in the shore. *Sarotherodon galilaeus* recorded the highest percentage number of fish species in dry (72.68%) and rainy season (64.07%) followed by *Tilapia zillii* both dry season (18.24%) and rainy season (17.90%) and least percentage (0.09%) was recorded by *Gnathonemus niger* in the dry season and 0.27% recorded by *Clarias gariepinus* in the rainy season. *Clarias gariepinus, Hepsetus odoe* and *Labeo senegalensis* were not recorded

Table 4.9: Fish distribution (%) in gillnet sampling in the shore, surface and bottom habitats of Doma Reservoir, Nasarawa State

Family/Species	Shore		Surface		Bottom	
	No	%	No	%	No	%
Cichlidae						
Sarotherodon galilaeus	1243	69.02	528	81.86	199	73.43
Tilapia zillii	326	18.10	57	8.84	24	8.86
Oreochromis niloticus	119	6.61	28	4.34	9	3.32
Hemichromis fasciatus	11	0.61	-	-	-	-
Pelmatochromis pulcher	8	0.44	-	-	-	-
Mormyridae						
Hyperopisus bebe	80	4.44	28	4.34	1	0.37
Gnathonemus niger	1	0.06	-	-	-	-
Clariidae						
Clarias gariepinus	2	0.11	1	0.16	36	13.28
Hepsetidae						
Hepsetus odoe	5	0.28	2	0.31	-	-
Channidae						
Channa obscura	3	0.17	1	0.16	2	0.74
Cyprinidae						
Labeo senegalensis	3	0.17	-	-	-	-
Total	1801	100	645	100	271	100

- - Absence of fish species

Table 4.10 Seasonal fish distribution (%) at shore, surface and bottom habitats of Doma Reservoir, Nasarawa State, Nigeria

Family/Species	Shore				Surface				Bottom			
	Dry		Rainy		Dry		Rainy		Dry		Rainy	
	No	%	No	%	No	%	No	%	No	%	No	%
Cichlidae												
Sarotherodon galilaeus	777	72.68	469	64.07	297	91.95	231	71.74	105	82.03	94	65.73
Tilapia zillii	195	18.24	131	17.90	6	1.86	51	15.84	2	1.56	22	15.38
Oreochromis niloticus	38	3.55	81	11.06	1	0.31	27	8.39	2	1.56	7	4.90
Hemichromis fasciatus	7	0.65	4	0.55	-	-	-	-	-	-	-	-
Pelmatochromis pulcher	8	0.75	-	-	-	-	-	-	-	-	-	-
Mormyridae												
Hyperopisus bebe	43	4.02	37	5.05	17	5.26	11	3.42	1	0.78	-	-
Gnathonemus niger	1	0.09	-	-	-	-	-		-	-	-	-
Clariidae												
Clarias gariepinus	-	-	2	0.27	-	-	1	0.31	19	14.84	17	11.89
Hepsetidae												
Hepsetus odoe	-	-	5	0.68	2	0.61	-	-	-	-	-	-
Channidae												
Channa obscura	3	0.28	-	-	-	-	1	0.31	-	-	2	1.40
Cyprinidae												
Labeo senegalensis	-	-	3	-	-	-	-	-	-	-	-	-
Total	1069	100	732	100	323	100	322	100	128	100	143	100

- - Absence of fish species

in dry season while *Pelmatochromis pulcher*, *Gnathonemus niger* and *Channa obscura* were not recorded in the rainy season in the shore.

In the surface habitat 323 fish were recorded in the dry season and 322 fish recorded in the rainy season. *Sarotherodon galilaeus* dominated by percentage number both in dry season (91.95%) and rainy season (71.74%) followed by *Hyperopisus bebe* (5.26%) in the dry season and *Tilapia zillii* (15.84%) in the rainy season. *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisus bebe occidentalis* and *Hepsetus odoe* were recorded in the dry and others not recorded, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisus bebe*, *Clarias gariepinus* and *Channa obscura* were recorded in the rainy season and others not recorded in the surface (Table 4.9).

In the bottom 128 fish were recorded in the dry season and 143 recorded in the rainy season. *Sarotherodon galilaeus* has the highest percentage number in both dry (82.03%) and rainy season (65.73%) followed *Clarias gariepinus* (14.84%) in dry season and Tilapia zilli (15.38%) in rainy season. *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisu bebe* and *Clarias gariepinus* were recorded in the dry season and others not recorded, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Clarias gariepinus* and *Channa obscura* were recorded in the rainy season and others not recorded (Table4.10)

4.2.8 Fish distribution in gillnets sampling in the shore, surface and bottom habitats

Table 4.11 shows fish distribution in gillnets sampling at the three stations in the shore, surface and bottom habitats from July 2012 to June 2014 of Doma Reservoir. 606 fish were recorded in shore, 245 fish recorded in the surface and 99 fish recorded in the bottom

habitat at Kwararafa, all species of fish were recorded in the shore except *Gnathonemus niger*, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisus bebe* and *Clarias gariepinus* were the only fish recorded in the surface and others not recorded while in the bottom only *Sarotherodon galilaeus*, *Tilapia zilli*, *Oreochromis niloticus*, *Clarias gariepinus* and *Channa obscura* were recorded Kwararafa and others not recorded.

In the Main Dam 490 fish were recorded in the shore, 178 fish recorded in the surface and 78 fish recorded in the bottom, only *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hemichromis fasciatus*, *Pelmatochromis niloticus* and *Hyperopisus bebe* were recorded in the shore and others not recorded, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisus bebe occidentalis*, *Hepsetus odoe* and *Channa obscura* were recorded in the surface while only *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus* and *Claris gariepinus* were recorded in the bottom and others not recorded at the Main Dam.

In Yelwa 705 fish recorded in the shore, 222 fish recorded in the surface and 94 fish recorded in the bottom, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hemichromis fasciatus*, *Hyperopisus bebe occidentalis*, *Gnathonemus niger*, *Hepsetus odoe* and *Labeo senegalensis* were recorded in the shore, *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus* and *Hyperopisus bebe* were the only fish species recorded in the surface while only *Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hyperopisus bebe* and *Clarias gariepinus* were recorded in the bottom at Yelwa.

Table 4.11: Fish distribution (%) in gillnets sampling at the three stations in the shore, surface and bottom habitats of Doma Reservoir, Nasarawa State, Nigeria

Family/Species	Kwararafa			Main Dam			Yelwa		
	Shore	Surface	Bottom	Shore	Surface	Bottom	Shore	Surface	Bottom
Cichlidae									
Sarotherodon galilaeus	63.69	83.27	72.73	68.16	80.33	71.79	74.18	81.53	75.53
Tilapia zillii	21.62	7.75	12.12	19.80	7.30	7.69	13.90	11.26	6.38
Oreochromis niloticus	6.93	4.49	5.05	5.51	5.17	1.28	7.09	3.60	3.19
Hemichromis fasciatus	0.99	-	-	0.41	-	-	0.43	-	-
Pelmatochromis pulcher	0.50	-	-	1.02	-	-	-	-	-
Mormyridae									
Hyperopisus bebe	4.79	4.08	-	5.10	5.62	-	3.69	3.60	1.06
Gnathonemus niger	-	-	-	-	-	-	0.14	-	-
Clariidae									
Clarias gariepinus	0.33	0.41	8.08	-	-	19.23	-	-	13.83
Hepsetidae									
Hepsetus odoe	0.50	-	-	-	1.12	-	0.28	-	-
Channidae									
Channa obscura	0.50	-	2.02	-	0.56	-	-	-	-
Cyprinidae									
Labeo senegalensis	0.17	-	-	-	-	-	0.28	-	-
Total (%)	606 (100)	245 (100)	99(100)	490 (100)	178 (100)	78 (100)	705 (100)	222 (100)	94 (100)

- - Absence of fish species

4.2.9 Abundance of fish catches by different gill net mesh sizes in the shore, surface and bottom water habitats

The percentage number of fish caught by different gill net mesh sizes in the shore, surface and bottom habitats of Doma reservoir for the period between July 2012 and June 2014 is shown in Fig 4.16. Gill net of mesh size 38.1mm caught the highest number of fish in the shore followed by the gill net mesh size of 57.15mm and the least number of fish was caught by gill net mesh size of 101.6mm. In the surface habitat gill net mesh size of 101.6mm caught the highest number of fish followed by gill net mesh size of 76.2mm and least number was caught by gill net mesh size of 38.1mm, while in the bottom habitat the gill net mesh size of 76.2mm caught the highest number of fish followed by the gill net mesh size of 101.6mm and the least number caught by gill net mesh sizes of 38.1mm.

4.2.10 Diversity indices of fish species at the three sampling stations

The diversity indexes of fish species in the three sampling stations of Doma Reservoi from July 2012 to June 2014 was presented in the Table 4.12; it revealed low species diversity indices in Doma Reservoir. The diversity indices for the combined years shows that 6 families were recorded in Kwararafa with 10 species and 5 families with 9 species each were recorded in the Main Dam and Yelwa, Simpson's index (D) were 0.521 for Kwararafa, 0.578 for Main Dam and 0.597 for Yelwa, Simpson's index of diversity (1-D) were 0.479 for Kwararafa, 0.422 for Main Dam and 0.403 for Yelwa, Simpson's reciprocal index (1/D) were 1.919 for Kwararafa, 1.730 for Main Dam and 1.675 for Yelwa, Shannon's index (H) values were 1.007 for Kwararafa, 0.959 for Main Dam and 0.858 for

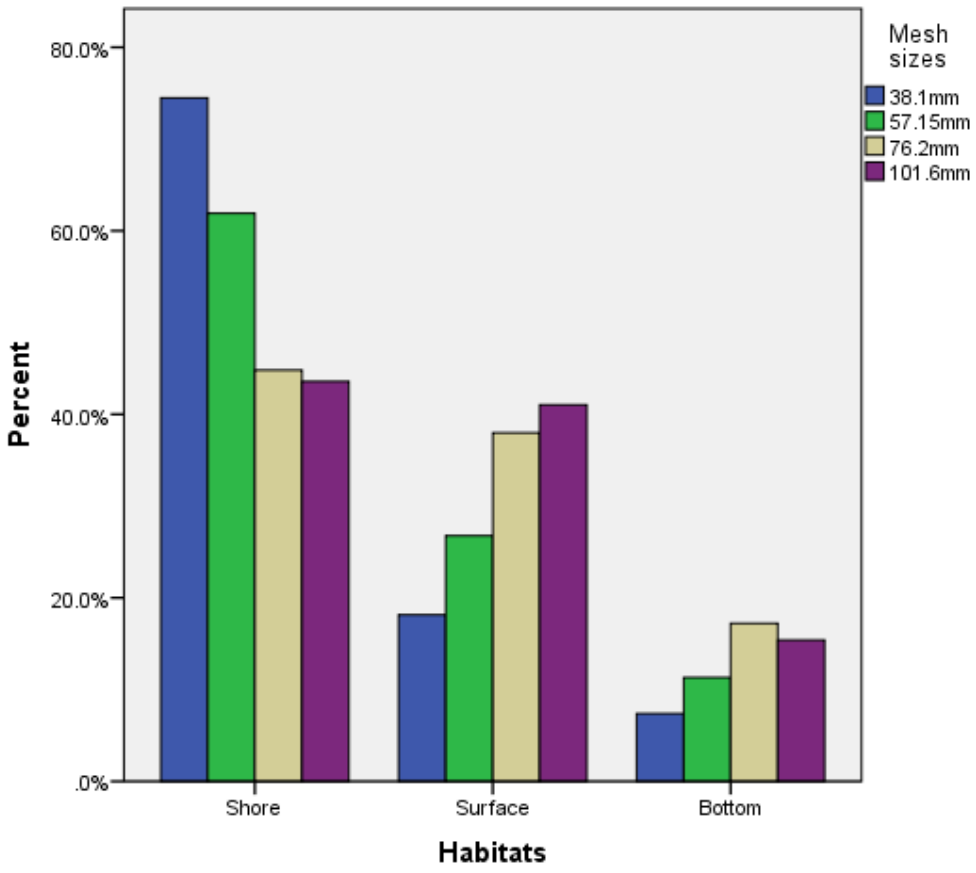


Fig.4.16: Percentage fish catch by different gillnets mesh size in the shore, surface and bottom habitats

Table 4.12: Diversity indices of fish species in gillnet sampling at the three sampling stations of Doma Reservoir from July 2012 to June 2014

Diversity index	Kwararafa	Main Dam	Yelwa
Total number of families	6	5	5
Total number of species	10	9	9
Total number of individual fish	950	746	1021
Simpson's index (D)	0.521	0.578	0.597
Simpson's index of diversity (1- D)	0.479	0.422	0.403
Simpson's reciprocal index (1/D)	1.919	1.730	1.675
Shannon's index (H)	1.007	0.959	0.858
Shannon equitability or Evenness (E_H)	0.437	0.437	0.391

Yelwa while the Shannon's evenness (E_H) values were 0.437 for Kwararafa, 0.437 for Main Dam and 0.391 for Yelwa.

4.2.11 Catch per unit effort at the shore, surface and bottom water habitats

The total fish caught by number and weight (g), and catch per unit effort (CPUE) in the shore, surface and bottom water habitats of Doma reservoir is shown in Table 4.13. The table shows that the highest number of fish occurred in the shore (1801) followed by surface (645) and the least in the bottom (271), the largest weight was also recorded in shore (115954), followed by surface (53711) and the lowest recorded by bottom habitat (27400). Similar observation was seen in the catch per unit effort (CPUE) where catch per unit effort by number was highest in shore with 25.01, followed by the surface with 8.96 and least recorded by bottom habitat with 3.76, the largest weight by catch per unit effort was also recorded in the shore (1610.47) followed by surface (745.99) and the lowest (380.56) recorded in the bottom habitat. The total average weight catch were 64.37 for shore, 83.16 for surface and 101.48 for bottom.

4.3 Artisanal Fish Catch Assessment in Doma Reservoir

4.3.1 Statistical frame survey

The number of artisanal fishermen in Doma reservoir and their fishing gears and craft for the first year (July 2012 to June 2013) and the second year (July 2013 to June 2014) is shown in Table 4.14. The Table shows that there were 47 full-time fishermen and 7 part-time fishermen operating in Doma reservoir and 44 wooden canoes counted during the statistical frame survey in the first year. 43 full-time fishermen and 7 part-time fishermen

Table 4.13: Total Fish Catch and Catch per Unit Effort at the Shore, Surface and Bottom Water Habitats of Doma Reservoir

	Shore habitat		Surface habitat		Bottom habitat	
	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)
Total catch (Number, Weight)	1801	115954	645	53711	271	27400
CPUE (Number, Weight)	25.01	1610.47	8.96	745.99	3.76	380.56
Average weight of fish (g)		64.37		83.16		101.48

Table 4.14: Number of Artisanal Fishermen in Doma Reservoir and Their Fishing Gears and Craft from July 2012 - June 2014

Fishing camp	Full time fishermen		Part time fishermen		Number of wooden canoe		Fishing gears used
	First year	Second year	First year	Second year	First year	Second year	
Kwararafa	27	23	03	03	25	20	Gill net, cast net, Malian trap and hook and line
Main dam	-	-	04	04	02	02	Gill net, cast net and Malian trap
Yelwa	20	20	-	-	17	17	Gill net, cast net, Malian trap and hook and line
Total	47	43	07	07	44	39	

Note: First year is from July 2012 to June 2013, Second year is from July 2013 to June 2014

were counted and 39 wooden canoes recorded for the second year in the statistical frame survey. Kwararafa fishing camp recorded highest number of fishermen and least were recorded in the Main Dam with only part-time fishermen and no full-time fishermen. The fishing gears found to be used by the fishermen include gill nets, cast nets, Malian traps and hook and line.

4.3.2 Abundance of fish species

A total of 87859 fish with 646431g weight were caught in artisanal catch assessment survey. Twelve species of fish belonging to seven families were recorded, five of these families (Cichlidae, Mormyridae, Clariidae, Hepsetidae, and Cyprinidae) were recorded in the experimental gillnets sampling while Polypteridae (represented by Polypterus senegalus senegalus) and Mastacembelidae (represented by Mastacembelus loennbergii) were not recorded in experimental gillnets sampling but recorded in artisanal catch assessment survey, the family Channidae was not recorded in the artisanal catch assessment survey.

The percentage number of fish species landing in the artisanal catch assessment survey of Doma reservoir was presented in Figure 4.17 the Figure reveals that *T. zillii* has the highest percentage number of fish species landing by the local fishermen in Doma reservoir, followed by *O. niloticus, S. gariepinus, P. pulcher, H. odoe, P. senegalus senegalus, H. fasciatus, H. bebe, G. niger, L. senegalensis, C. gariepinus,* in that order and least percentage number was recorded by *M. loennbergii*.

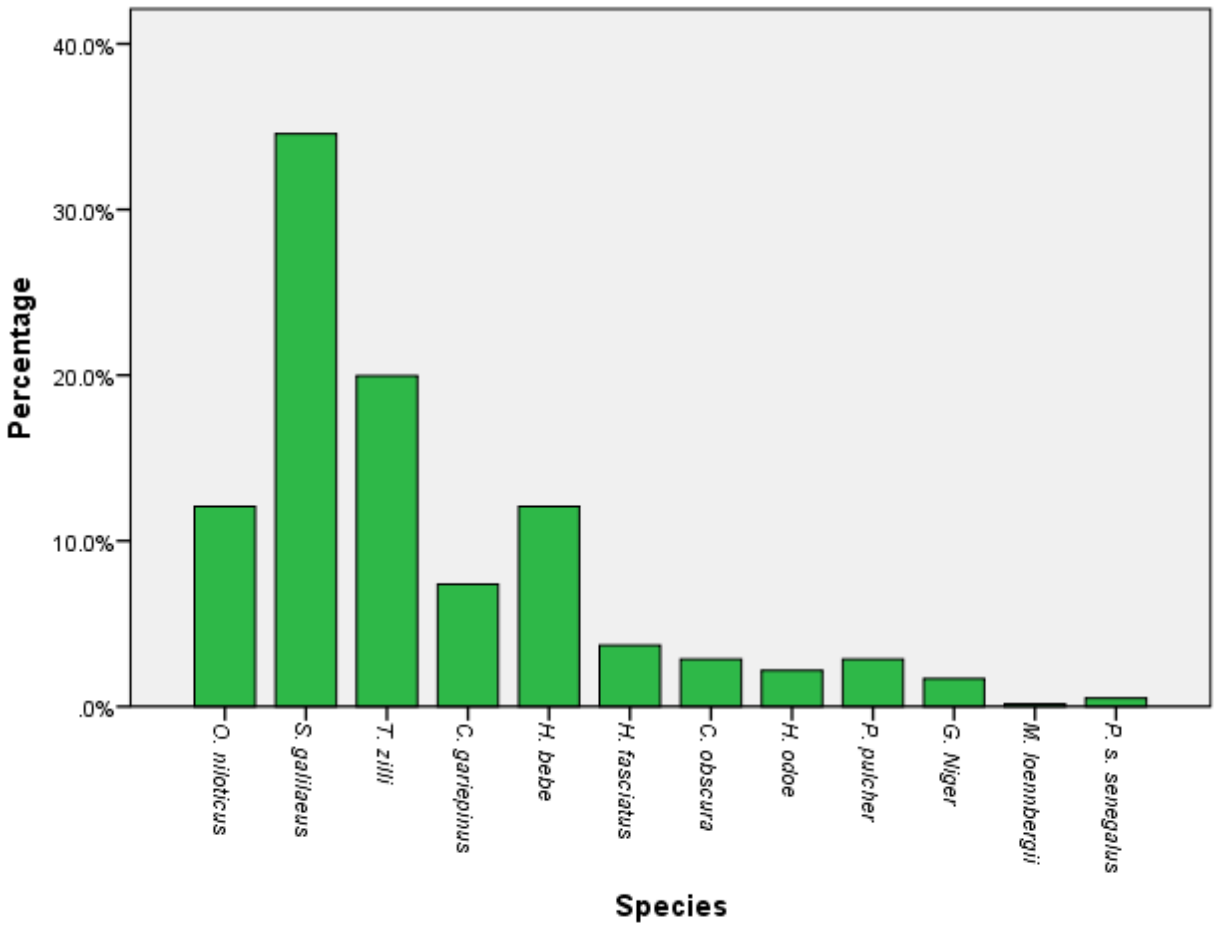


Figure 4.17: Abundance of fish species catch in artisanal catch assessment survey from of Doma Reservior.

4.3.3 Monthly abundance of fish catches

Figure 4.18 showed monthly abundance of fish catches in artisanal assessment survey of Doma Reservoir. The figure revealed that there were variations in monthly catches of fish species by the artisanal fishermen. The highest catch was February followed by July, April, January, August, October, March, June, may, September, November in that order and the least catch recorded in December.

4.3.4 Seasonal abundance of fish catches

Figure 4.19 shows seasonal fish species abundance in the artisanal catch assessment survey of Doma Reservoir. There were variations in the fish species catch with seasons in artisanal survey. Most species of fish recorded more catches in the rainy season than the dry season. *Tilapia zillii, Pelmatochromis pulcher* and *Clarias gariepinus* were more abundant in the dry season than the rainy season, while *Sarotherodon galilaeus, Oreochromis niloticus, Hemichromis fasciatus, Hyperopisus bebe, Gnathonemus niger, Hepsetus odoe, Labeo senegalensis, Mastacembelus loennbergii* and *Polyterus senegalus senegalus* were more abundant in the rainy season than the dry season.

4.3.5 Percentage fish catches by different fishing gears

Figure 4.20 shows the abundance of fish catches by different fishing gears in the artisanal catch assessment survey of Doma Reservoir. There were variations in fish catches by different fishing gears. The gillnet caught the highest percentage of fish landing followed by cast nest, hook and line in that order, and the least percentage was caught by Malian trap.

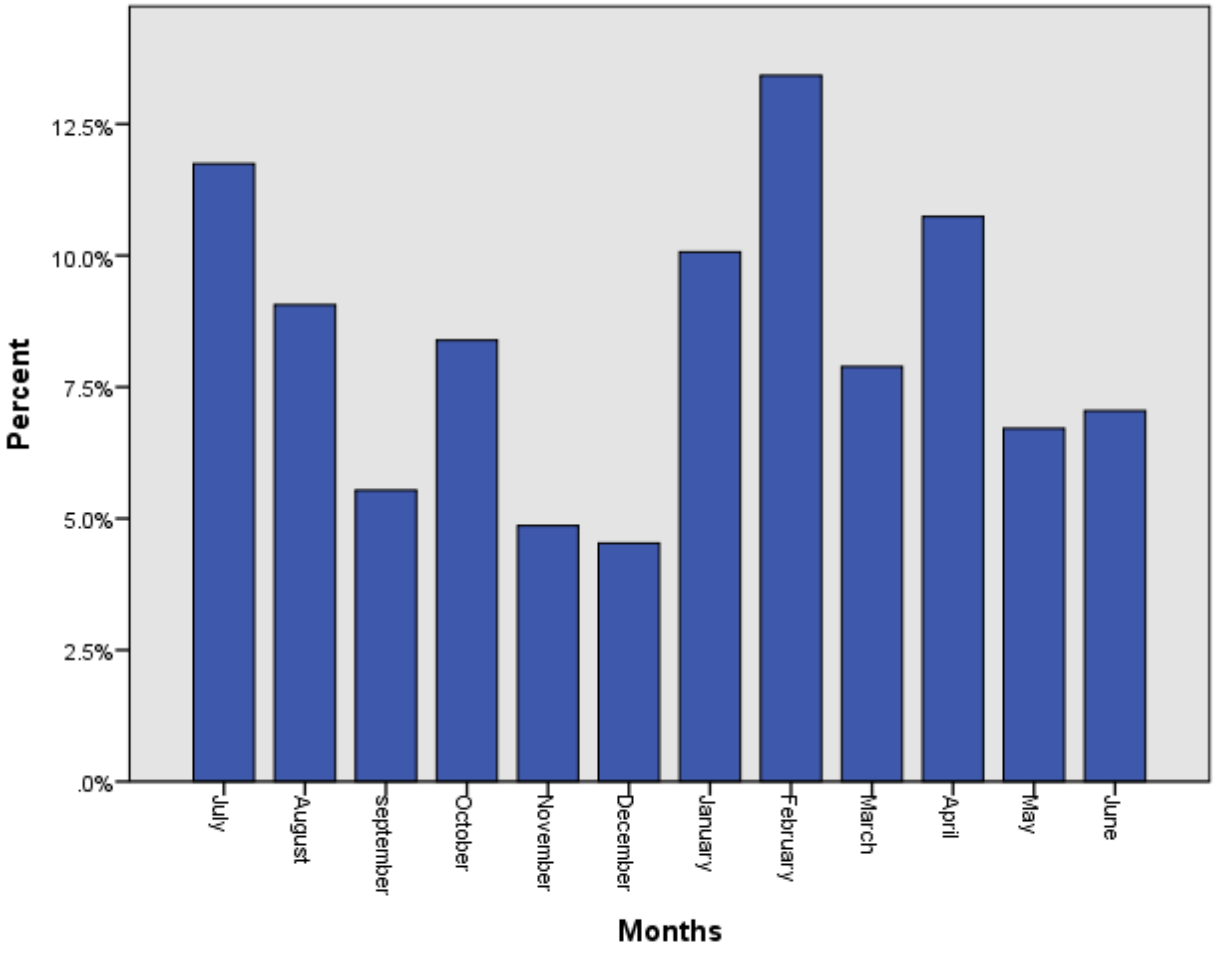


Fig.4.18: Monthly percentage fish catch in artisanal catch assessment survey

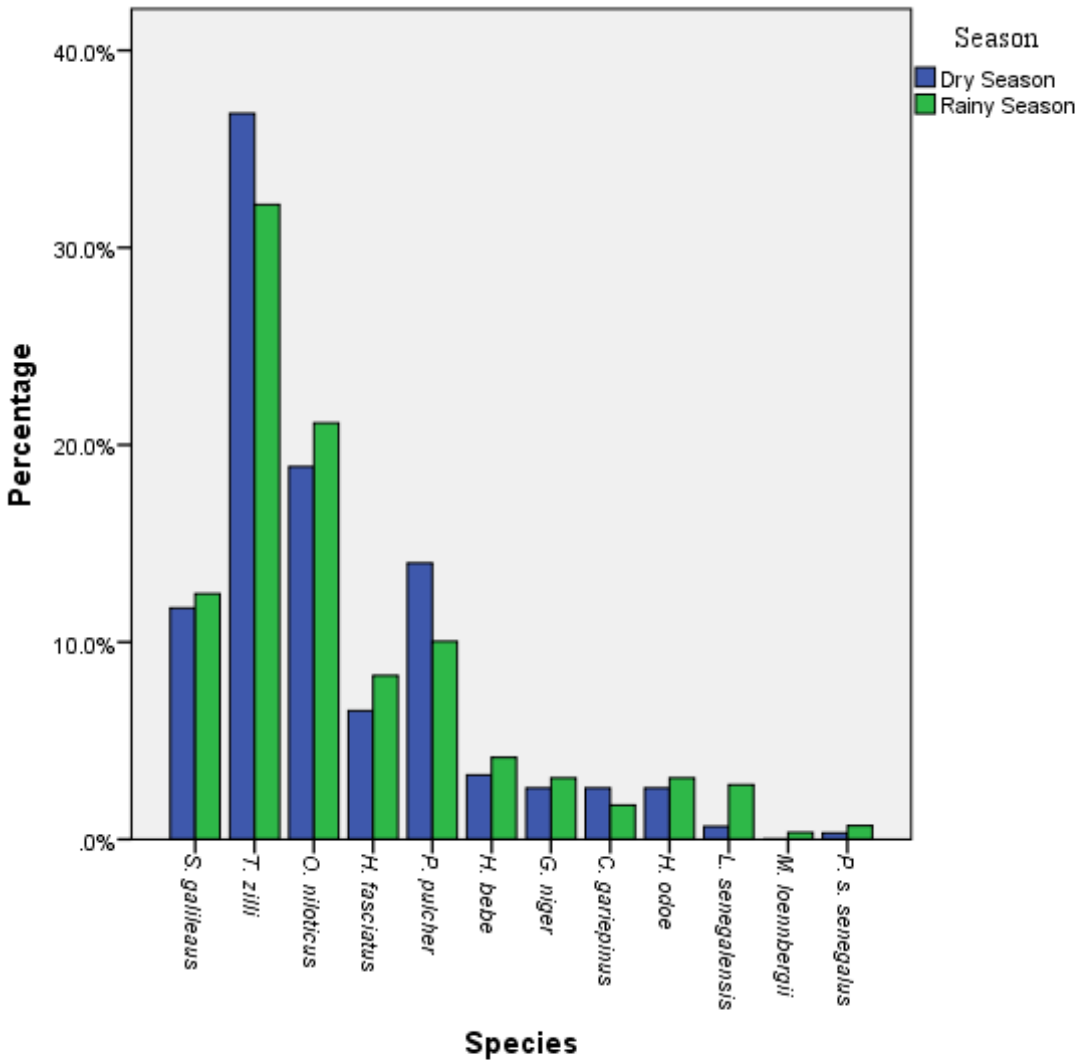


Figure 4.19: Seasonal percentage fish distribution in artisanal catch assessment survey.

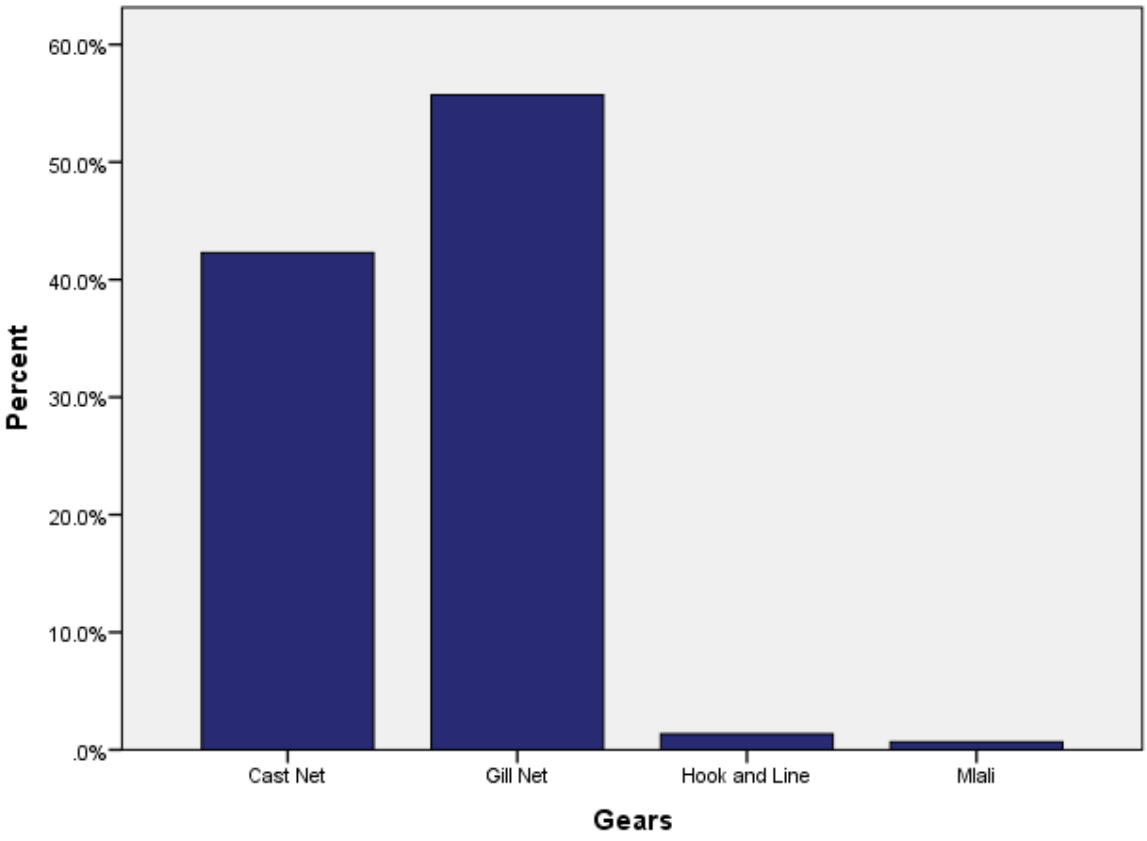


Fig.4.20 Percentage total fish catch by different fishing gears in artisanal catch assessment survey

4.4 Length-Weight Relationships and Condition Factor (K) of Fish Species

4.4.1 Length-weight relationships of six fish species from Doma Reservoir

The estimated parameters of length-weight relationships of the six commonly occurring fish species of Doma Reservoir are presented in Table 4.15. The estimated values of b of the length-weight equations ranged between 2.847 for *S. galilaeus* and 3.378 for *H. fasciatus*. The analysis showed that the b values of *S. galilaeus* (2.847) and *T. zillii* (2.929) were lower than the theoretical value of 3 indicating a negative allometric growth. The b value of *O. niloticus* (3.089) showed isometric growth whereas the b values of *H. fasciatus* (3.378), *H. bebe* (3.115) and *C.gariepinus* (3.258) showed positive allometric growth. The 95% confidence interval values of the exponent 'b' varied between 2.825 and 2.869 for *S. gariepinus*, 2.876 and 2.982 for *T. zilli*, 2.987 and 3.191 for *O. niloticus*, while that of *H. fasciatus* varied between 3.082 and 3.674, for *H. bebe* between 3.029 and 3.203 and for *C. gariepinus* between 3.060 and 3.456. The correlation coefficients (r) of fish species showed positive correlation between total length and the body weight and the relationships were highly significant ($P<0.05$) with r values greater than 0.90 for all the six fish species. Figures 4.21- 4.26 shows the regression graphs of six fish species, the graphs gave straight lines relationships which implied that as the length increases the weight also increased. The relationships were highly significant ($P<0.05$) with r values greater than 0.90 for all the six fish species.

Table 4.15: Length-weight Regression Analysis of Fish Species from Doma Reservoir

Fish species	Number	a	b	SE(b)	95% CI for b	r	p-value	Growth pattern
S. galilaeus	1970	-1.547	2.847	0.011	2.825 – 2.869	0.985	0.000	A-
T. zillii	407	-1.651	2.929	0.027	2.876 – 2.982	0.983	0.000	A-
O. niloticus	156	-1.812	3.089	0.052	2.987 – 3.191	0.979	0.000	A+
H. fasciatus	11	-2.216	3.378	0.151	3.082 – 3.674	0.991	0.000	A+
H. bebe	109	-2.440	3.115	0.045	3.029 – 3.203	0.978	0.000	A+
C. gariepinus	39	-2.475	3.258	0.101	3.060 – 3.456	0.984	0.000	A+

Note: a = Intercept, b = slope, SE= standard error of b, CI= confidence interval, r = correlation coefficient, A- = negative allometric, A+ = positive allometric.

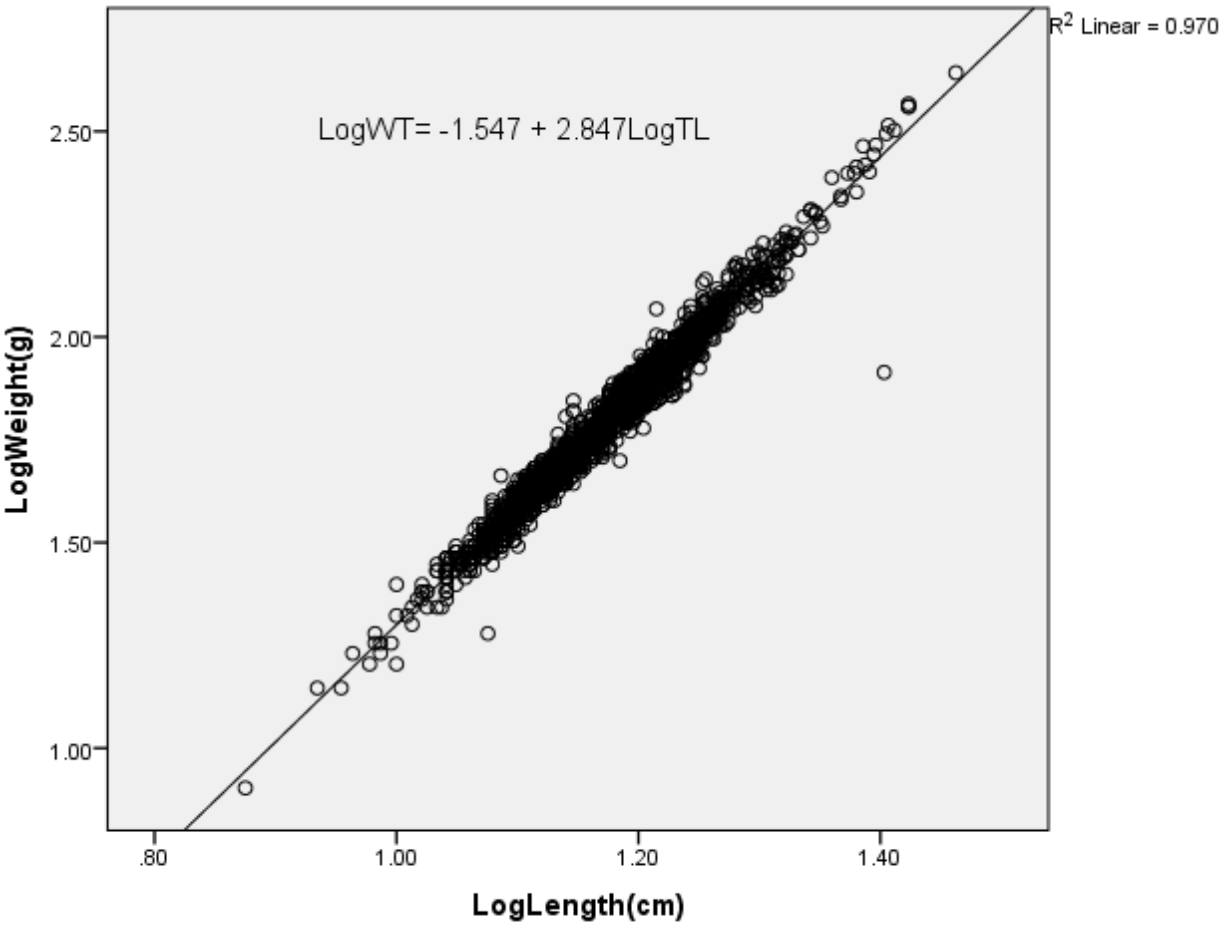


Fig.4.21 Linear regression relationship between logWT and logTL of *Sarotherodon galilaeus*

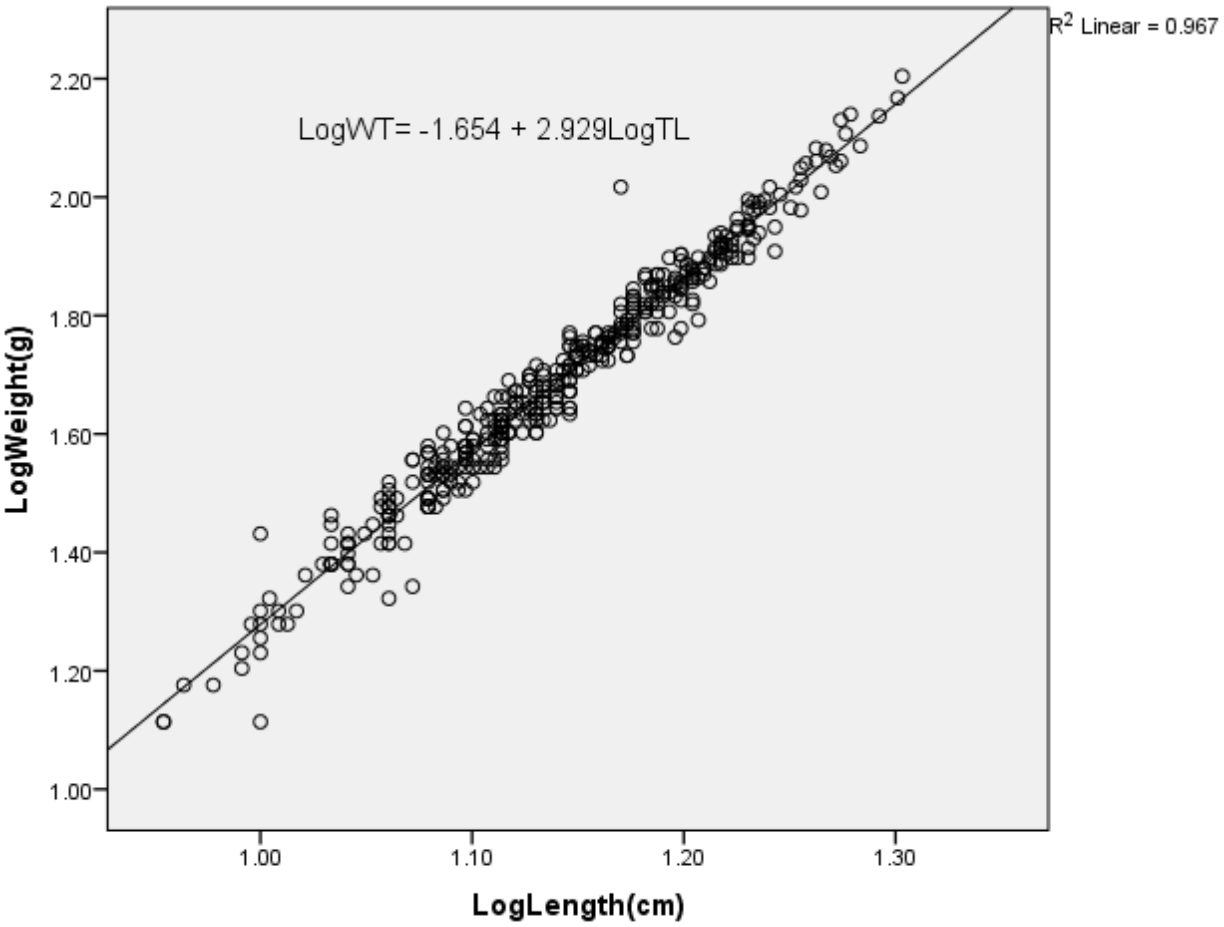


Fig.4.22 Linear regression relationship between logWT and logTL of *Tilapia zillii*

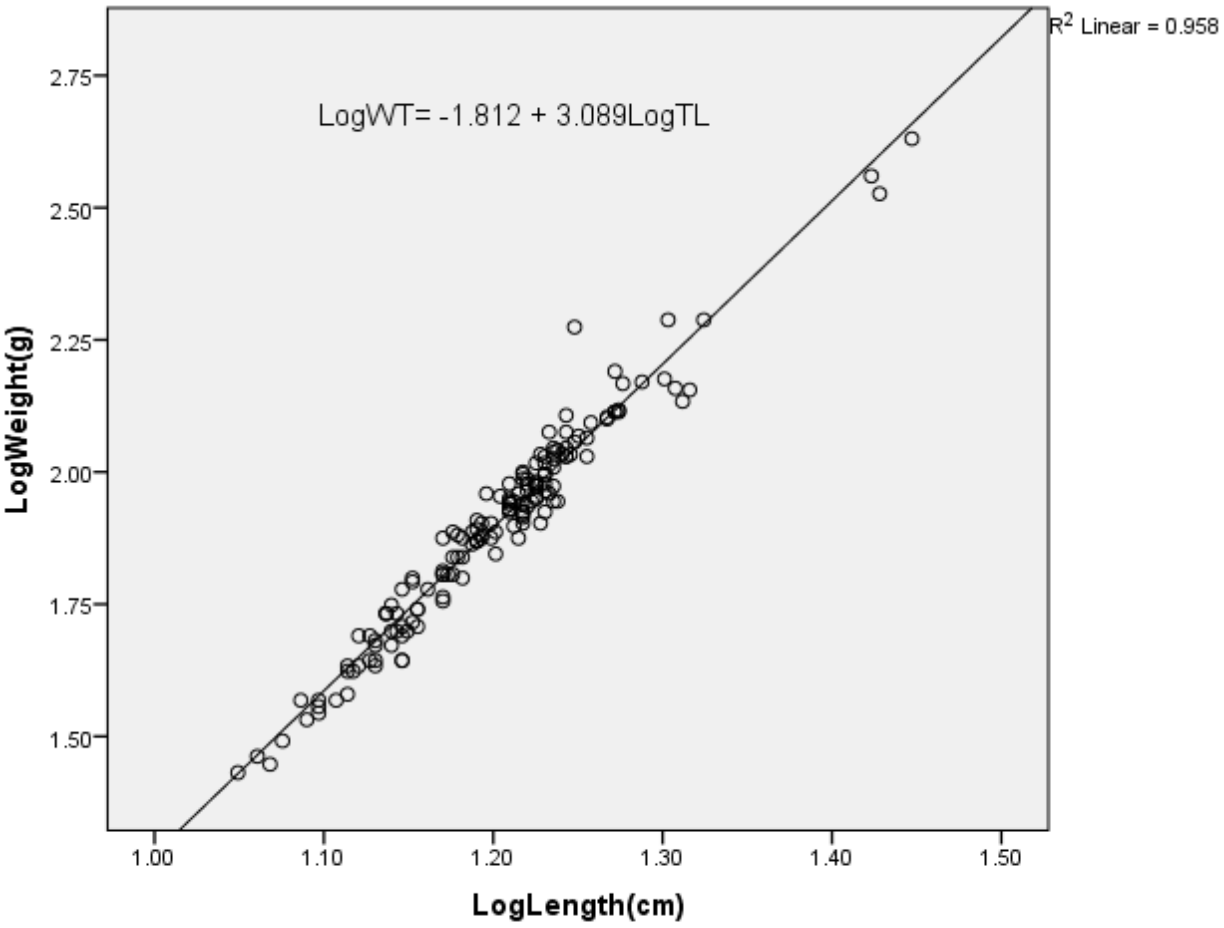


Fig.4.23 Linear regression relationship between logWT and logTL of *Oreochromis niloticus*

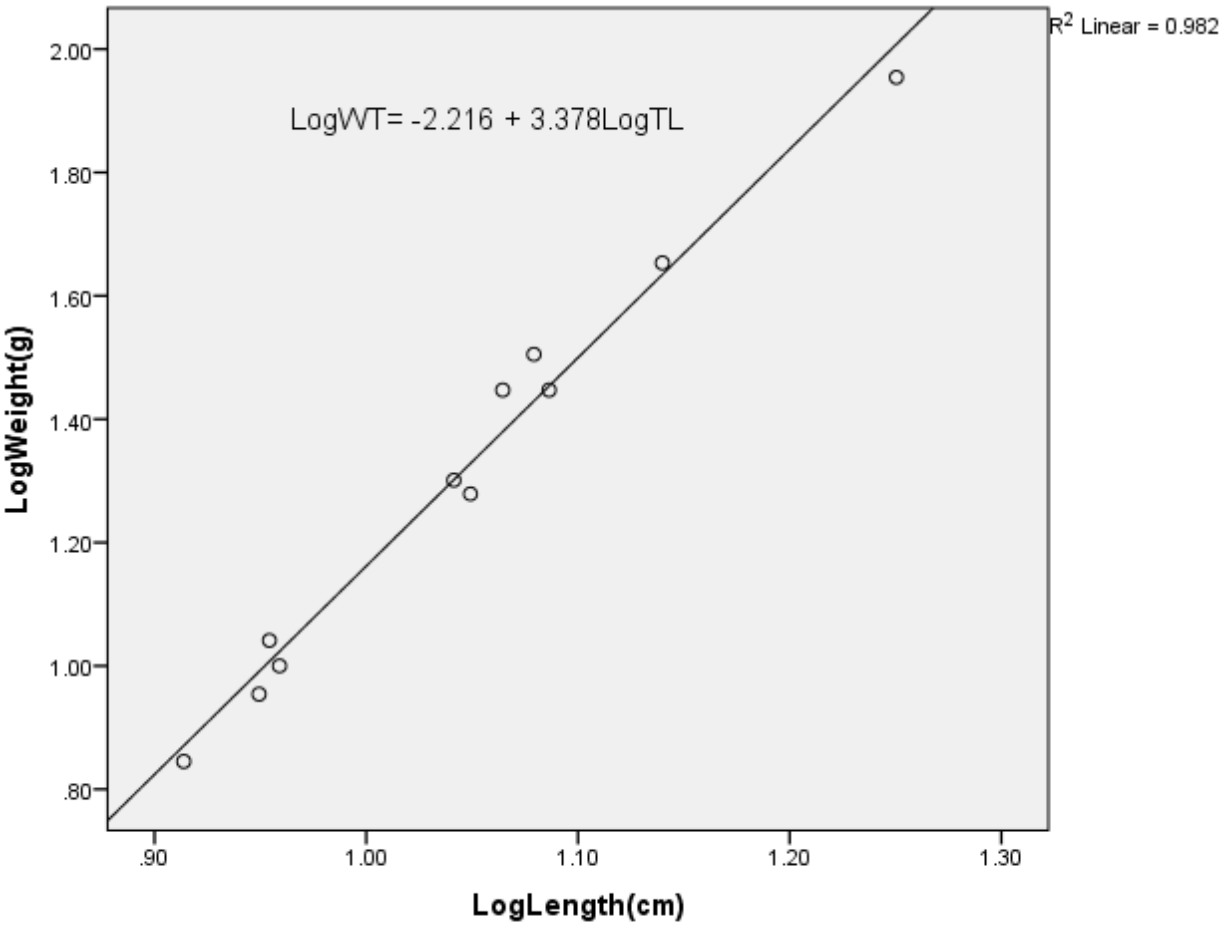


Fig.4.24: Linear regression relationship between logWT and logTL of *Hemichromis fasiatus*

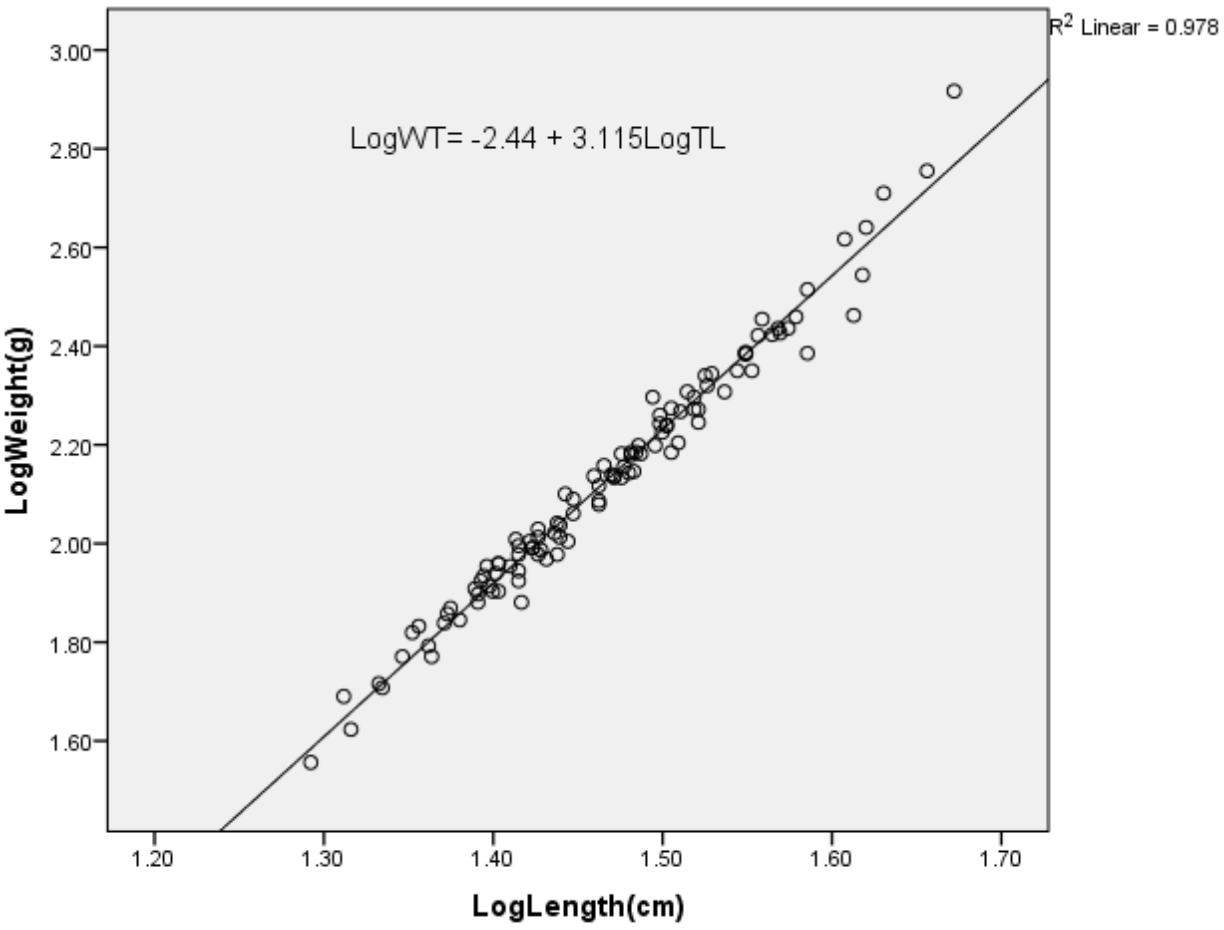


Fig.4.25: Linear regression relationship between logWT and logTL of *Hyperopisus bebe*

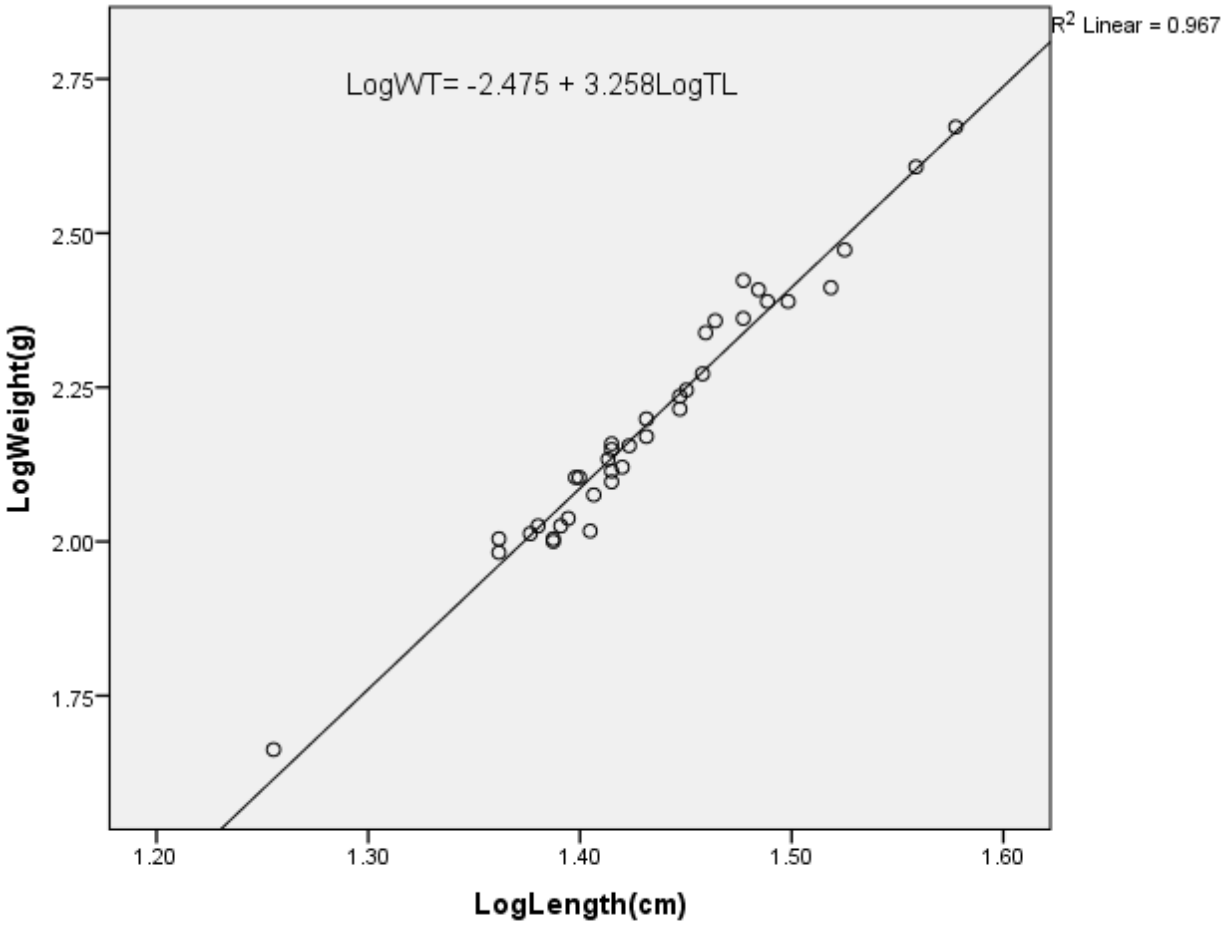


Fig.4.26: Linear regression relationship between logWT and logTL of *Clarias gariepinus*

4.4.2 Condition factor (K) of fish species from Doma Reservoir

The mean weight, length and condition factor (K) of six commonly occurring fish species from Doma Reservoir is shown in Table 4.16. The mean weight of fish species ranged between 27.18g for *H. fasciatus* and 188.33(g) for *C. gariepinus*, *S. galilaeus* had mean weight of 67.56g, *T. zillii* 54.13g and *O. niloticus* 88.75g while the mean weight for *H. bebe* was 161.18g. The mean total length of fish species ranged between 11.35cm for *H. fasciatus* and 29.85cm for *H. bebe*, the mean total length for *S. galilaeus*, *T. zillii*, *O. niloticus* and *C. gariepinus* were 14.95cm, 13.97cm, 16.06cm and 27.90cm respectively. The condition factor values for the fish species ranged from 0.54 for *H. bebe* to 1.98 for *O. niloticus*, while the condition factor values for *S. galilaeus*, *T. zillii*, *H. fasciatus* and *C. gariepinus* were 1.88, 1.86, 1.52 and 0.79 respectively. The values of condition factor for *H. bebe* and *C. gariepinus* were less than 1 indicating that they not in a good state of well-being in the Reservoir, while the values of condition factors for *S.galilaeus*, *T. zillii*, *O. niloticus* and *H. fasciatus* were higher than 1 indicating that they were in a good state of well-being in the Reservoir.

Table 4.16: Mean Weight, Total Length and Condition Factor (K) of Fish Species from Doma Reservoir

Fish species	Number	Weight (g)	Total length (cm)	Condition factor (K)		
		Mean	Mean	Mean	SD	SE
S. galilaeus	1970	67.56	14.95	1.88	0.15	0.003
T. zilli	407	54.13	13.97	1.86	0.16	0.008
O. niloticus	156	88.75	16.06	1.98	0.22	0.018
H. fasciatus	11	27.18	11.35	1.52	0.20	0.062
H. bebe	109	161.18	29.85	0.54	0.05	0.005
C. gariepinus	39	188.33	27.90	0.79	0.07	0.012

Note: SD = Standard deviation of mean; SE = Standard error mean

CHAPTER FIVE

5.0 DISCUSSION

5.1 Physico-chemical Parameters

The physico-chemical parameters of Doma reservoir showed some variation for months and seasons. The water temperature of the Doma reservoir was within the range of $10^{0}C$ - $50^{0}C$ meant for domestic purposes and for fish culture in the tropics (Huet, 1977; WHO, 1984). The water temperature were relatively low in the rainy seasons than the dry seasons in this study, this was similar to the findings of Mustapha (2008) and Anago *et al*, (2013) but differs from other studies where the water temperatures were observed to be low during the dry season (Oladimeji and Wade, 1984; Ibrahim *et al*, 2009b and Andem *et al*., 2012). The variation in water temperature for months and seasons could be attributed to meteorological conditions such as trade winds, sunshine durations and absorption of solar radiation by the reservoir water.

The transparency was low in rainy season than dry season. The low transparency of the reservoir in the rainy season may be attributed to the washing silt, sediments, debris, organic and inorganic suspended particles flushed into the reservoir by flood and surface run-off during rainy season. High water transparency in the dry season could be due to absence of flood water and settling of the particles at the bottom of the reservoir. This result is similar with the findings of Ibrahim *et al*. (2009b), Bala and Bolorunduro (2011) and Anago *et al*. (2013). Lower transparency recorded during rainy season when there was turbulence and high turbidity, has a corresponding low primary productivity, because

turbidity reduces the amount of light penetration, which in turn reduces photosynthesis and hence primary productivity (USEPA, 1991; APHA, 1995).

The hydrogen ion concentration (pH) was near neutral throughout the wet and dry season, and it was within the range for inland waters (pH 6.5 – 8.5) (Antoine and Al-Saadi, 1982) Boyd and Lichtkoppler (1979) and for supporting aquatic life including fish. Environmental Protection Agency (EPA, 1976) recommended pH 6.5 - 8.5 for drinking and 6.0 – 9.0 for aquatic life. Thus the pH range recorded in this study is within the acceptable level of 6.0 - 8.5 for culturing tropical fish species (Huet, 1977) and for drinking water (WHO, 1984). Aquatic organisms are affected by pH because most of metabolic activities are pH dependent (Wang *et al.*, 2002), optimal pH range for suitable aquatic life is pH 6.5 – 8.5 (Murdock *et al.*, 2002). Fresh water ranges of pH 6.0 – 9.0 have been noted to be productive and thus recommended for fish culture (Adeniji, 1981), outside this range, water may have sour taste and could be corrosive to metals. Bala and Bolorunduro (2011), Offem *et al*. (2011), Andem *et al*. (2012) and Anago *et al*. (2013) reported similar findings in some of the Nigeria water bodies.

Salinity values of the surface water of Doma reservoir were low with higher values recorded during dry season than rainy season. Generally the salinity of surface water depends on the drainage area, the nature of its rock, precipitation, human activity in the area and its proximity to marine water (McNeely *et al*., 1979). Variation in the values of salinity observed in this study may be due to the effects of rainfall, evaporation, precipitation and other weather related factors. Anago *et al*. (2013) reported a range of water salinity between 0.11- 0.19ppm in Awba Reservoir, university of Ibadan, Ibadan, Nigeria.

The values of total dissolved substance (TDS) obtained in this study fell within tolerable limits (500mg/l) for drinking water (EPA, 1976). The total dissolved substance which usually consist of inorganic materials dissolved in water (Wetzel, 1983) are essential in the life of aquatic bio-community, and water bodies normally containing 80 to 400mg/L of TDS are unlikely to support good fisheries (Bala and Bolorunduro, 2011). Total dissolved solids act directly on fish swimming in the water, causing death or reduction of growth rate and resistance to diseases; as low TDS could prevent successful development of eggs and larvae and reduce the abundance of food available to fish (Alabaster and Lloyd, 1980). Though the monthly values obtained from this study were lower than what was obtained by Mustapha (2008), Bala and Bolorunduru (2011) and Anago *et al*. (2013).

Conductivity levels below 50µmhos/cm are regarded as low; those between 50-600µmhos/cm are medium while those above 600µmhos/cm are high conductivity (Anago *et al.*, 2013). Thus the range of 40.95- 49.03µs/cm electrical conductivity obtained in this study indicates low conductivity of the reservoir when compared with findings of Mustapha (2008), Bala and Bolorunduro (2011) and Anago *et al*. (2013). A value above 50µS/cm but below 600µS/cm indicates medium conductivity of the Reservoirs. Boyd (1979) reported that natural water normally has conductivity ranges from 20- 1500µS/cm. The TDS and electrical conductivity parameters could be used as Morpho-Edaphic Index to estimate potential fish yield in the reservoir (Jenkins, 1982).

The total ammonia nitrogen values ranges from 0.30 to 0.70ppm in Doma reservoir. Ammonia in water exist in two forms NH_3 (unionized ammonia) and NH_4^+ (ionized ammonium). Therefore total ammonia-Nitrogen is a parameter that measures the un-ionized (NH_3) and ionized (NH_4^+) forms of ammonia in water. NH_3 is the principal form of toxic

ammonia. It has been reported toxic to fresh water organisms at the concentration ranging from 0.53 to 22.8mg/l. Toxic levels are both pH and temperature dependent. Toxicity increases as pH decreases and as temperature decreases. Bala and Bolorunduro (2011) reported a ranged of 0.3- 1.17mg/l ammonia-nitrogen concentration in Sabke Reservoir while a ranged of 0.11- 0.15mg/l concentration was reported in Ona River (Andem *et al*., 2012).

Alkalinity is the measure of the capacity of water to neutralize or buffer acids using carbonate, bicarbonate ions, and in rare cases by hydroxide, thus protecting the organisms from major fluctuations in pH. The alkalinity values recorded in this study were within the recommended values between 5- 500mg/l (Lawson, 1995). High levels of alkalinity were observed in dry season than rainy season by Ibrahim *et al.,* (2009b) and Andem *et al*., (2012). In this study high levels of alkalinity were observed in the month of July and August.

Carbon dioxide (CO_2) is commonly found in water from photosynthesis or water sources originating limestones bearing rocks. Fish can tolerate concentration of 10ppm provided dissolved concentrations are high (LaDon, 1990). The mean value of carbon dioxide obtained in this study range between 3.50 – 8.50ppm falling within the acceptable limit, similarly a range between 1.6 – 3.00mg/l was reported in Oyun Reservoir (Mustapha, 2008) while Andem *et al*. (2012) reported a range 59.38 – 68.8mg/L in Ona River. Chloride may get into surface water from several sources including; waste water from industries and municipalities, effluent from water softening and agricultural run-off. The mean values of chloride from Doma reservoir range between 8.00- 10.67ppm. Oniye *et al*. (2002) reported a mean value of 2.60mg/L chloride concentration in Zaria Dam and observed that the

concentration of chloride ion was higher in dry season than in the rainy season which differ from this study where the mean chloride ion concentration were higher in the rainy season than dry season.

Water hardness is similar to alkalinity but represent different measurements. Hardness is chiefly a measure of Calcium and Magnesium, but other ions such Aluminum, Iron, Manganese, Zinc and Hydrogen ions are also included (LaDon, 1990). The mean range of the total hardness of Doma reservoir was 14.67- 25.33ppm this can be considered soft going by Hanna (2003) hardness scale classification for soft water. This range will support fish (Rottman and Shireman, 1990) and is ideal for drinking water supply (APHA, 1995). Mustapha (2008) recorded a range of 32- 60mg/l total hardness in Oyun reservoir, Offa while Andem *et al.*, (2012) reported range of 99.38 – 122mg/l in Ona River.

Dissolved oxygen (DO) is by far the most important chemical parameter in aquaculture. Low dissolved oxygen levels are responsible for most fish kills, either directly or indirectly, than all other problems combined. The dissolved oxygen value recorded 5.83- 7.30ppm in Doma reservoir indicated the water to be of good quality and will support fish production. Duodoroff and Fry (1959) recommended 5mg/l dissolved oxygen for warm fresh water fish species. Boyd (1979) reported that dissolved oxygen concentration of 3mg/L to 12mg/L will promote the growth and survival of fish in reservoirs. Oniye *et al*., (2002) reported mean oxygen concentration of 0.17mg/l in Zaria Dam, while the following values has also been reported at various reservoirs 4.8 – 8.2mg/l in Oyun Reservoir (Mustapha, 2008), 4.7 – 9.8mg/l in Sabke Reservoir (Bala and Bolorunduro, 2011), 2.24 – 3.46mg/l in Ona River Apata, Ibadan and 0.7 – 1.8mg/l in Awba Reservoir (Anago *et al*., 2013).

The Morpho-Edaphic Index (M.E.I) value of Doma reservoir was low; the lower index value corresponds with low primary productivity. The low Morpho-Edaphic Index values obtained in this reservoir may be due to low total dissolved solids which also result to low electrical conductivity of the reservoir. This finding differs from that of Balogun *et al*. (2000), who recorded high Morpho-Edaphic Index (M.E.I) value for Zaria reservoir. However Ibrahim (2009) made a similar observation in Kontagora reservoir.

5.2 Fish Species Composition and Abundance

The study on fish species diversity of Doma reservoir revealed that eleven (11) species of fish belonging to six (6) families were recorded in the experimental gill net sampling indicating low species diversity when compared with other studies on some of the man-made lakes in Nigeria, for example NARESCON (1992) reported that the fresh water fishery resources in Nigeria comprised of over 200 species from inland waters, with Kainji having about 100 species of fish while Lake Chad had 87 species. Ita (1993) reported 101 species of fish in Lake Kainji and 52 species in Jebba, eighteen (18) species belonging to nine families were recorded in Zaria reservoir (Balogun *et al.*, 2000). Balogun and Auta (2001) recorded nineteen (19) species of fish in Kangimi Lake, similarly Adeosun *et al*. (2011) reported 34 species of fish in Ikere Gorge, 32 species of fish were reported in Umudike water reservoir (Avoaja, 2011), while 19 species was reported in Erinle lake (Komolafe and Arawomo, 2011), 16 species reported in Ikwori lake (Offem *et al.*, 2011) and 27 species in Asejere lake (Ipinmoroti, 2013). Other works with a comparable results to what was obtained in Doma reservoir include, for instance fourteen (14) species of fish were reported in Owena reservoir (Fapohunda and Godstates (2007), eleven (11) species recorded in Gbedikere semi oxbow lake, Oguma, seven (7) species of fish were reported in

Kontagora reservoir (Ibrahim, 2009). Dan-Kishiya *et al*, (2013) reported low diversity of fish species in Lower Usuma Dam, Bwari, Abuja of eleven (11) species of fish belonging to five (5) families, Ayanwale *et al.* (2013) reported seven species of fish in Tagwai lake Minna, while eight (8) species of fish were recorded in Egbe reservoir (Edward, 2013)

The fish family Cichlidae was found to be dominant in all the stations, all habitats, months and seasons during the sampling period in Doma reservoir, followed by Mormyridae and Clariidae in all the stations. The family Cichlidae was most diversified in terms of species diversity with five species representation (*Sarotherodon galilaeus*, *Tilapia zillii*, *Oreochromis niloticus*, *Hemichromis fasciatus* and *Pelmatochromis pulcher*) followed Mormyridae represented by two species (*Hyperopisus bebe* and *Gnathonemus niger*), other families were represented by one species each. *Sarotherodon galilaeus* was the most occurrence species in all the stations, habitats and seasons, followed by *Tilapia zillii*. The dominance of the members of the family Cichlidae in Doma reservoir is comparable to other studies conducted in some of the Nigeria reservoirs. Ita (1979) reported that Cichlidae are the most abundant fish species in Tiga lake, Kano, followed by Bagridae. Balogun and Auta (2001) reported that Cichlidae was found to be the most abundant in terms of number and weight in Kangimi, Kaduna; similar studies revealed the dominancy of Cichlidae in reservoir Ikere gorge reservoir (Adeosun *et al.*, 2011), Erinle Lake (Komolafe and Arawomo, 2011), Egbe reservoir (Edward, 2013). Dan-Kishiya (2013) reported that the family Cichlidae dominated the Lower Usuma reservoir in Bwari, where *Tilapia zillii* and *Sarotherodon galilaeus* were reported to be the most abundant in Tagwai Lake , Minna (Ayanwale *et al*., 2013),. The dominance of the members of the family Cichlidae can be attributed to their ability to thrive on wide variety of food items and the good parental care

of the members of the family which have given them advantage to thrive well in their habitats.

The higher fish species and abundance in the dry season than comforms with the findings of earlier workers but contradicts with the report of other authors. Iorchor *et al*. (2007) recorded higher fish abundance in the wet season than dry season in the main channel of the Lower Benue River, Higher abundance of Paraillia pelucida during rainy season than dry season in the fresh water reaches of Num River, Niger Delta was reported by Allison *et al*. (2007), Yakub reported higher fish total abundance, species number and diversity level in rainy than the dry season. On the other hand higher fish abundance was recorded in dry season than rainy season in Lower Bonny Estuary by Chindah and Osuamkpe (1994), Mangrove habitat of Lagos lagoon by Nwadukwe (1995) and Urie creek, Niger Delta by Meye and Ikomi (2008). Ayoola and Kuton (2009) reported that fish species were more evenly distributed in the dry season than wet season, Adeyemi observed that the fish landing in a semi oxbow lake of Gbedikere, North central, Nigeria were highest in January, February and December. Offem *et al*. (2011) reported higher values for the fish species, richness and diversity in the dry season than rainy season in Ikwori Lake while Falaye *et al*. (2015) observed that the overall fish abundance was significantly higher in the dry season than the wet season.

The highest catch per unit effort (CPUE) in the three water habitats indicated that most of the fish caught in the experimental sampling were from the shore habitat followed by the surface and the least from the bottom habitat. The shore habitat was also dominated by the fish caught by gill net of small mesh sizes, this agreed with the fact that shoreline served as

a breeding ground for some species of fish, and the occurrence of most fish in the shore habitat could also be attributed to the presence of abundant food items.

In the frame survey two fishing villages are located around Doma reservoir (Kwararafa and Yelwa) with a total number of 54 fishermen of which 47 were full time fishermen and seven (7) part time fishermen. A total of 44 canoes were counted without engine and the most commonly used fishing gears included gill net, cast net, Malian trap and hook and line. The common transport system was the wooden canoes. Dan-kishiya *et al*. (2012) in a similar study on Lower Usuma reservoir recorded only one fishing village with a total of 47 migrant Hausa fishermen, the common gears were gill net, trap, drag net, cast net and hook and line, the transport system was the use of unmotorized wooden dugout canoes. Ibrahim *et al.* (2009a) recorded two fishing villages around Kontogora reservoir with a total number of 34 fishermen with the following fishing gears, gill net, cast net, Malian trap and hook and line and the transport system was wooden canoes without engine. Balogun *et al* (2000) recorded eight fishing villages around Zaria reservoir with a total of 49 fishermen with the following fishing gears cast net, gill net and traps and the transport system included canoes without engine and gourds. Balogun and Auta (2001), in another study recorded three fishing villages located around Lake Kangimi with a total of 50 fishermen and the fishing gears used included cast net, long lines, gill net and traps and transport system included dugout canoes and gourds. Abiodun (2007) also recorded four fishing villages around Lake Yamama, with a total of 107 fishermen of which 66 were on full time fishing and 41 were part time, the fishing crafts used included 34 canoes and 46 gourds and the fishing gears included the gill nets, cast nets, long lines and fishing traps.

The actual count and weight of fish caught by the local fishermen in the catch assessment survey were carried out at the Kurarafa fishing village for the period between July 2012 and June 2014. The actual counts and weights by 20 local fishermen showed a total mean catch of 32.32kg/canoe or 439fishes/canoe with a total of twelve (12) different fish species belonging to seven (7) families. Ten (10) of these fish species also features in the experimental gill net sampling. Thus a total of thirteen (13) species of fish belonging to eight (8) families were recorded in Doma reservoir from both the experimental gill net sampling and artisanal fishery survey. Dan-kishiya *et al*. (2012) in a similar study recorded 14.07kg of fish per canoe from 19 local fishermen, Ibrahim *et al.* (2009a), recorded 4.24kg of fish per canoe or 159 fishes per canoe from 19 local fishermen with a total of seven species of fish belonging to five families. Balogun *et al*. (2000) on Zaria reservoir recorded 4.84kg of fish per canoe or 77 fishes per canoe from 10 local fishermen with a total of 19 different species from artisanal fisheries and a total of 25 different fish species belonging to 9 different families were recorded from both experimental and artisanal fisheries. Balogun and Auta (2001) also recorded a mean catch of 7.03kg per canoe or 62 fishes per canoe from artisanal fisheries in Kangimi Lake from 14 fishermen and 19 different fish species belonging to 9 fish families were recorded from both experimental and artisanal fisheries.

5.3 Length-Weight Relationship, Condition Factor and Productivity

The study of length-weight relationship of common occurring fish species of Doma Reservoir revealed allometric pattern of growth. The b values for *S. gariepinus* and *T. zilli* were less than 3.0 indicting negative allometric growth; this implied that the weight of fish increases at a lesser rate than the cube of the body length. This agrees with the study of Kumolu-Johnson and Ndimele (2011) who reported similar growth for *S. gariepinus* and *T.*

zillii in Ologe Lagoon, Lagos. Fish weight is considered to be a function of length (Wheatherley and Gill, 1987; Zafar *et al.*, 2003; Odedeyi *et al*., 2007). Normally an ideal fish, which maintains dimensional equality the isometric value of b, would be 3.0. This value has been observed only occasionally. A b value greater or less than 3.0 indicates allometric pattern of growth. A value less than 3.0 shows that the fish become lighter (negative allometric) or greater than 3.0 the fish become heavier (positive allometric) for a particular length (Zafar *et al.*, 2003; Odedeyi *et al*., 2007). Negative allometric growth was also reported for *T. zillii* (Imam *et al*., 2010, Dan-Kishiya, 2013 and Atama *et al*., 2013). The b value for *O. niloticus*, *H. fasciatus*, *H. bebe* and *C. gariepinus* were higher than 3.0 indicating positive allometric growth, which imply faster increase in body weight than the cube of the body length. This result for *O. niloticus* and *H. fasciatus* disagree with study of Kumolu-Johnson and Ndimele (2011) where they exhibit negative allometric growth, the studies of Imam *et al*. (2010), Obasohan *et al*. (2012), Dan-Kishiya (2013) and Atama *et al*. (2013) revealed negative allometric growth in *O. niloticus*. Negative allometric growth was reported for the *C. gariepinus* (Imam *et al*., 2013). The values of corelation coefficient (r) for the fishes were higher than 0.900 and were positively and highly correlated, showing positive relationship between fish total length and body weight.

The result of this study shows that the value of condition factor (K) for *S. galilaeus*, *T. zillii*, *O. niloticus* and *H. fasciatus* were greater than 1.0 which implied that they were in good condition while those of *H. bebe* and *C. gariepinus* were less than 1.0 implied that they were not in good condition. The condition factor (K) reflects the well-being of the fish (Kumolu-Johnson and Ndimele, 2010; Abowei, 2010). It gives information on the physiological stage of the fish in relation to its welfare. It is influenced by both

environmental conditions and can be affected by factors like sex, season, age and maturity stages of fish (Kamelan *et al*., 2014). Condition factor can also be used as an index to acess the status of the aquatic ecosystem (Edah *et al*., 2010). When the value of K is less than 1.0 the fish is considered not to be in good physiological condition and when value is greater than 1.0 the fish is considered to be in good physiological condition. The condition factors (K) of the species of fish in this study were similar to what was obtained in other tropical water bodies. For example Iman *et al*. (2010) reported a ranged of K values of 0.93 and 3.40 in Wasai Reservoir in Kano, Nigeria, Adeyemi (2011b) recorded a K value between 2.32 and 2.36 in Idah Area of River Niger, kogi state. Kumolu-Johnson and Ndimele (2011) also reported a ranged of between 0.91 and 8.46 from Ologe Lagoon, Lagos, while a ranged of K value of between 0.50 and 3.26 was reported from Ibiekuma stream, Ekpoma, Edo state (Obasohan *et al*., 2012), Atama *et al*. (2013) obtained a ranged of K value of six Cichlids species of fish between 1.73 and 2.69 for male, 1.71 and 2.67 for female and between 1.75 and 2.68 for combined sex in Anambra River, Nigeria and Dan-Kishiya (2013) reported a ranged of K value of between 1.06 and 2.02 from Lower Usuma Reservoir in Bwari, Abuja.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Study on physico-chemical parameters of Doma reservoir shows that mean values of the physico-chemical parameters obtained were within the acceptable ranges for safe drinking water and aquatic life; though there were monthly and seasonal variations in some physico-chemical parameters of water there were no variations in physico-chemial parameters between the sampling stations. The mean dry season values for water temperature, transparency, salinity, total dissolved substances, conductivity, hardness and dissolved oxygen were significantly higher ($P<0.05$) than those of the rainy season while the mean rainy season values for depth, ammonia-nitrogen, alkalinity, carbon dioxide and chloride were higher than those of dry season. The correlation analysis between the physico-chemical parameters studied in Doma Reservoir shows that there were significant relationships ($P<0.001$) between some physico-chemical parameters. The result on the study of fish diversity and physico-chemical parameters of Doma reservoir revealed the presence of six families of fish represented by eleven species of fish in the experimental gill net sampling and seven families of fish represented by twelve species of fish in artisanal fishery survey. Thus, eight families of fish represented by thirteen species of fish were recorded in the Doma reservoir. The most diversified family in both experimental sampling and artisanal survey was Cihlidae with five species of fish richness followed by Mormyridae with two species of fish richness, other families were represented by one species of fish each. The most abundant species of fish both in number and weight in

experimental and artisanal survey was *Sarotherodon galilaeus* followed by *Tilapia zillii*. There was a significant different ($P<0.05$) in the mean distribution of fish families and fish species in the major habitats of the reservoir. *Hemichromis fasciatus*, *Pelmatochromis pulcher*, *Gnathonemus niger* and *Labeo senegalensis* were restricted to the shore habitat, *Hepsetus odoe* was recorded in the shore and the surface habitats while the other species of fish were recorded in the three major habitats (shore, surface and bottom). In the artisanal fishery survey two fishing villages were located around the Doma reservoir with an average of 45 full time fishermen and an average of seven part time fishermen. The fishing gears included the gill net, cast net, Malian trap and hook and line. Wooden canoes without engines are major means of transport. The mean fish catch for the twenty fishermen selected for artisanal fisheries survey was 32.32kg/canoe or 439 fish/canoe.

The length-weight relationship of the species of fish in study shows that they exhibit allometric pattern of growth in Doma Reservoir, while the values of condition factor (K) of between 0.54 and 1.96 were comparable with other studies and indicate that the family Cichlidae were in good condition.

6.2 Conclusions

The mean values of the physico-chemical parameters of water obtained from Doma reservoir showed that they were within the acceptable ranges safe for drinking water and for fish culture. There were monthly and seasonal variation in some physico-chemical parameters in Doma Reservoir, this observation may be due to the changes in climatic conditions and human activities around the reservoir area such as changes in weather, flood from catchments areas and agricultural activities.

Thirteen species of fish belonging eight families which are of economical values are present in Doma reservoir. The family Cichlidae formed the dominant family both in number and weight in the reservoir and also dominated the three major habitats (shore, surface and bottom) of the reservoir. *Sarotherodon galilaeus* was the most abundant fish species recorded in the experimental gillnet sampling of Doma Reservoir. There were few fish species in the reservoir which indicate that the reservoir may be over-exploited; as fishing was throughout the year in the reservoir, different types of fishing gears employed by the local fishermen were gillnets, cast nets of different mesh sizes, traps, hook and line were used without proper monitoring by the appropriate authorities.

There were monthly and seasonal variations in the fish species composition of Doma Reservoir; the family Cichlidae dominated the catches.

The Length-weight relationships of the fish species indicated allometric growth pattern and the values of correlation coefficient (r) were higher than 0.900, indicating positive relationships between fish total length and the body weight. The physiological well-being of fish species expressed by the condition factor (K) shows that most of the fish species in the Reservoir were in good condition.

6.3 Recommendations

Doma reservoir desired a systematic approach towards management and development of the reservoir for the sustainability of the fishery resources. For this reason the following measures are recommended:

i. To avoid pollution of the Reservoir which may have devastating effect in future it is recommended that the authorities in charge of the reservoir should put in place mechanisms to monitor and control physico-chemical parameters of the reservoir.

ii. There is a need to monitor human activities and fishing intensity on the reservoir, in order not to destroy the fish diversity.

iii. The fishermen should be advised to use approved gill net and cast net of mesh size 7.6cm or 3" recommended by government for all inland gill net fishing to prevent the over exploitation.

iv. The potential fishermen should be educated on the importance of the sustainability of fisheries resources of the reservoir and the number of fishermen operating on the reservoir should also be regulated (if possible registered) by the authorities concern.

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APPENDIX I

Pearson's Correlation Coefficient Showing Correlation of the Physico-Chemical Parameters, of Doma Reservoi (July 2013 June 2014)

Parameters	Air temp (^{0}c)	Water temp (^{0}c)	Transparency (cm)	Depth (m)	pH	Salinity (ppm)	TDS (ppm)	Conductity (µs)	NH_3-N (ppm)	Alkalinity (ppm)	CO_2 (ppm)	Chloride (ppm)	Hardness (ppm)	Dissolved oxygen (ppm)	M.E.I
Air temp(^{0}c)	1														
Water temp(^{0}c)	.582**	1													
Transparency(cm)	.813**	.518**	1												
Depth(m)	-.116	.016	-.202	1											
PH	.723**	.576**	.697**	-.119	1										
Salinity (ppm)	.233	-.136	.187	-.058	.136	1									
TDS(ppm)	.168	-.065	.114	.028	.097	.951**	1								
Conductivity(µs)	.163	.112	.046	.186	.103	.691**	.826**	1							
Amm-N(ppm)	-.417*	-.705**	-.384*	.025	-.380*	.178	.189	.191	1						
Alkalinity(ppm)	.340*	.070	.347*	-.249	.381*	.268	.171	.222	.159	1					
CO2(ppm)	-.256	-.420*	-.493**	.178	-.361*	-.082	-.097	-.037	.520**	.022	1				
Chloride(ppm)	.167	.075	.195	-.116	.166	.109	.071	.041	.060	-.022	-.097	1			
Hardness(ppm)	.110	-.170	-.073	-.016	.117	.139	.124	.253	.423*	.501**	.581**	.173	1		
Dissolved oxygen(ppm)	-.147	-.025	.196	-.119	.005	-.153	-.098	-.113	-.125	-.329*	-.597**	.085	-.611**	1	
M.E.I	.224	.016	.264	-.905**	.198	.373*	.330*	.216	.053	.356*	-.166	.163	.142	.035	1

** Correlation highly significant (P<0.01)

* Correlation significant (P<0.05)

* temp = temperature

APPENDIX II

T-test analysis showing any significant variations in the seasonal Physico-chemical parameters

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Temp(air)	Equal variances assumed	.049	.826	6.650	70	.000	2.53333	.38093	1.77359	3.29307
	Equal variances not assumed			6.650	68.219	.000	2.53333	.38093	1.77324	3.29342
Temp(water)	Equal variances assumed	.505	.480	4.551	70	.000	1.73056	.38024	.97219	2.48892
	Equal variances not assumed			4.551	70.000	.000	1.73056	.38024	.97219	2.48892
Trans(cm)	Equal variances assumed	.147	.703	3.890	70	.000	26.03611	6.69250	12.68834	39.38388
	Equal variances not assumed			3.890	69.178	.000	26.03611	6.69250	12.68555	39.38667
Depth(m)	Equal variances assumed	.048	.827	-1.448	70	.152	-.97500	.67351	-2.31827	.36827
	Equal variances not assumed			-1.448	69.982	.152	-.97500	.67351	-2.31828	.36828
PH	Equal variances assumed	4.521	.037	4.982	70	.000	.52778	.10594	.31649	.73907
	Equal variances not assumed			4.982	61.502	.000	.52778	.10594	.31597	.73958
Sal (pps)	Equal variances assumed	11.872	.001	2.302	70	.024	2.50000	1.08603	.33399	4.66601
	Equal variances not assumed			2.302	68.431	.024	2.50000	1.08603	.33312	4.66688
TDS(ppm)	Equal variances assumed	2.287	.135	1.103	70	.274	1.38889	1.25901	-1.12212	3.89990
	Equal variances not assumed			1.103	69.593	.274	1.38889	1.25901	-1.12238	3.90016
Cond(µs)	Equal variances assumed	.184	.670	1.070	70	.288	1.21944	1.13950	-1.05321	3.49210
	Equal variances not assumed			1.070	69.684	.288	1.21944	1.13950	-1.05339	3.49228
Amm-N(ppm)	Equal variances assumed	2.040	.158	-1.963	70	.054	-.08333	.04245	-.16799	.00132
	Equal variances not assumed			-1.963	64.391	.054	-.08333	.04245	-.16812	.00145
Alkalinity(ppm)	Equal variances assumed	.061	.805	-.295	70	.769	-.33333	1.12828	-2.58362	1.91695
	Equal variances not assumed			-.295	67.385	.769	-.33333	1.12828	-2.58515	1.91849
CO2(ppm)	Equal variances assumed	.052	.820	-3.167	70	.002	-1.72222	.54376	-2.80672	-.63772
	Equal variances not assumed			-3.167	69.847	.002	-1.72222	.54376	-2.80677	-.63768
Chloride(ppm)	Equal variances assumed	.882	.351	-.943	70	.349	-.50000	.53013	-1.55732	.55732
	Equal variances not assumed			-.943	69.595	.349	-.50000	.53013	-1.55742	.55742
Hardness(ppm)	Equal variances assumed	.147	.703	3.164	70	.002	2.94444	.93071	1.08820	4.80069
	Equal variances not assumed			3.164	62.515	.002	2.94444	.93071	1.08428	4.80461
DO (ppm)	Equal variances assumed	.163	.688	.095	70	.924	.01667	.17512	-.33259	.36593
	Equal variances not assumed			.095	69.560	.924	.01667	.17512	-.33263	.36597
M.E.I	Equal variances assumed	1.419	.238	1.898	70	.062	.44231	.23299	-.02239	.90700
	Equal variances not assumed			1.898	68.644	.062	.44231	.23299	-.02255	.90716

APPENDIX III

Analysis of variance (ANOVA) showing any significant variations in the Physico-chemical parameters between the sampling stations

Physico-chemical parameters		Sum of Squares	df	Mean Square	F	Sig.
Temp(air)	Between Groups	.531	2	.265	.061	.940
	Within Groups	297.824	69	4.316		
	Total	298.355	71			
Temp(water)	Between Groups	.956	2	.478	.140	.869
	Within Groups	235.123	69	3.408		
	Total	236.079	71			
Trans(cm)	Between Groups	58.662	2	29.331	.030	.971
	Within Groups	68578.011	69	993.884		
	Total	68636.673	71			
Depth(m)	Between Groups	504.305	2	252.153	206.238	.000
	Within Groups	84.361	69	1.223		
	Total	588.667	71			
PH	Between Groups	.010	2	.005	.018	.982
	Within Groups	19.145	69	.277		
	Total	19.155	71			
Sal (pps)	Between Groups	19.444	2	9.722	.425	.656
	Within Groups	1579.167	69	22.886		
	Total	1598.611	71			
TDS(ppm)	Between Groups	11.111	2	5.556	.190	.828
	Within Groups	2020.833	69	29.287		
	Total	2031.944	71			
Cond(µs)	Between Groups	21.748	2	10.874	.457	.635
	Within Groups	1641.072	69	23.784		
	Total	1662.820	71			
Amm-N(ppm)	Between Groups	.003	2	.002	.048	.953
	Within Groups	2.392	69	.035		
	Total	2.395	71			
Alkalinity(ppm)	Between Groups	52.000	2	26.000	1.154	.321
	Within Groups	1554.000	69	22.522		
	Total	1606.000	71			
CO2(ppm)	Between Groups	7.694	2	3.847	.635	.533
	Within Groups	418.250	69	6.062		
	Total	425.944	71			
Chloride(ppm)	Between Groups	13.444	2	6.722	1.344	.268
	Within Groups	345.167	69	5.002		
	Total	358.611	71			
Hardness(ppm)	Between Groups	2.333	2	1.167	.065	.937
	Within Groups	1245.167	69	18.046		
	Total	1247.500	71			
Disol-oxygen(ppm)	Between Groups	.881	2	.441	.805	.451
	Within Groups	37.763	69	.547		
	Total	38.644	71			
M.E.I	Between Groups	42.433	2	21.217	49.644	.000
	Within Groups	29.489	69	.427		

APPENDIX IV

Analysis of variance (ANOVA) showing any significant variations in the monthly Physico-chemical parameters

Physico-chemical parameters		Sum of Squares	df	Mean Square	F	Sig.
Temp(air)	Between Groups	180.375	11	16.398	8.339	.000
	Within Groups	117.980	60	1.966		
	Total	298.355	71			
Temp(water)	Between Groups	163.590	11	14.872	12.310	.000
	Within Groups	72.488	60	1.208		
	Total	236.079	71			
Trans(cm)	Between Groups	43910.108	11	3991.828	9.686	.000
	Within Groups	24726.565	60	412.109		
	Total	68636.673	71			
Depth(m)	Between Groups	33.382	11	3.035	.328	.976
	Within Groups	555.285	60	9.255		
	Total	588.667	71			
PH	Between Groups	12.752	11	1.159	10.862	.000
	Within Groups	6.403	60	.107		
	Total	19.155	71			
Sal (pps)	Between Groups	615.278	11	55.934	3.413	.001
	Within Groups	983.333	60	16.389		
	Total	1598.611	71			
TDS(ppm)	Between Groups	548.611	11	49.874	2.017	.042
	Within Groups	1483.333	60	24.722		
	Total	2031.944	71			
Cond(µs)	Between Groups	344.812	11	31.347	1.427	.185
	Within Groups	1318.008	60	21.967		
	Total	1662.820	71			
Amm-N(ppm)	Between Groups	1.428	11	.130	8.060	.000
	Within Groups	.967	60	.016		
	Total	2.395	71			
Alkalinity(ppm)	Between Groups	340.667	11	30.970	1.469	.168
	Within Groups	1265.333	60	21.089		
	Total	1606.000	71			
CO2(ppm)	Between Groups	180.611	11	16.419	4.016	.000
	Within Groups	245.333	60	4.089		
	Total	425.944	71			
Chloride(ppm)	Between Groups	43.278	11	3.934	.749	.688
	Within Groups	315.333	60	5.256		
	Total	358.611	71			
Hardness(ppm)	Between Groups	489.500	11	44.500	3.522	.001
	Within Groups	758.000	60	12.633		
	Total	1247.500	71			
Disol-oxygen(ppm)	Between Groups	10.541	11	.958	2.046	.039
	Within Groups	28.103	60	.468		
	Total	38.644	71			
M.E.I	Between Groups	10.206	11	.928	.902	.544
	Within Groups	61.716	60	1.029		
	Total	71.922	71			

APPENDIX V

Analysis of Variance (ANOVA) to show any significant difference in fish species composition in three major habitats, monthly composition and T-test analysis to show any variation seasonal fish composition of Doma Reservoir

ANOVA for variation in the Habitats

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1929.573	2	964.787	9.079	.000
Within Groups	38573.784	363	106.264		
Total	40503.358	365			

ANOVA for Monthly variations

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3679.903	11	334.537	3.216	.000
Within Groups	36823.454	354	104.021		
Total	40503.358	365			

Student T-test for seasonal variation

Seasons	N	Mean	Std. Deviation	Std. Error Mean
Dry season	172	8.9709	13.76598	1.04965
Rainy season	194	6.0515	6.15915	.44220

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	24.840	.000	2.668	364	.008	2.91938	1.09412	.76780	5.07097
Equal variances not assumed			2.563	230.648	.011	2.91938	1.13899	.67523	5.16354