Sudan University of Science and Technology

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Effects of Some Different Water Resources and Their Characteristics on the Body Weight Composition and Meat Values of Nile Tilapia in Sudan

تاثير بعض مصادر المياه المختلفة علي التركيب الوزني و قيمة لحوم أسماك البلطي النيلي في السودان

A Thesis Submitted in Fulfillment of Requirement for the Degree of Ph.D in Fish Science and Technology

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الاستهلال

وهُوَ الَّذِي سَخَّرَ الْبَحْرَ لِتَأْكُلُوا مِنْهُ لَحْمًا طَرِيًّا وَتَسْتَخْرِجُوا مِنْهُ حِلْيَةً تَلْبَسُونَهَا وَتَرَى الْفُلْكَ مَوَاخِرَ فِيهِ وَلِتَبْتَغُوا مِنْ فَضْلِهِ وَلَعَلَّكُمْ تَشْكُرُونَ)

سورة النحل (الاية 14)

DEDICATION

To my Mother, Father,

My Brothers: Al Hadi, Mohamed, and Khalied

To my Sisters: Hadia and Tahra

With great love

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Abstract

The main aim of the present study is to investigate the effect of using the three major different water sources (Jebel Aulia, Sennar and Merowe reservoirs dams) upstream and downstream .Three fish collection sites were designated: as the first site included two collection stations along the White Nile River. The second site included two collection stations that had their water supply along the Blue Nile River. The third site included two collection stations along the River Nile main stream. Water samples were taken randomly from each station regularly every month for one-year (2015) sampling period and testing using water kids aqua zol. Samples of fish were taken also for measuring body weight composition, proximate analysis of fish muscles and carcass, amino acids, fatty acids profiles and heavy metals of water samples and fish meat samples. Statistical analysis were performed using One – way of variance (ANOVA) and Duncan's multiple Range Test, to determine the differences between treatments means at significance rate of $P < 0.05$. The standard deviation of treatment means will be also estimated. All statistics were carried out using Statistical Analysis program (SPSS, 19).The results showed in tables 1.2 and 3 indicate that, there was significant difference at $p \leq 0.5$ level for pH in all conditions both upstream and downstream, while there were a significant different in the three localities between Dissolved Oxygen, ammonia, nitrate, alkalinity and phosphorus both upstream and downstream between the three season. D.O is higher in Sennar dam and lower in Jebel Aullia, while alkalinity is higher in Merowe and lower in Jebel Aullia, on the other hand hardness is higher in Merowe and lower in Sennar dam, phosphorus is higher in Jebel Aullia and lower in Merowe downstream in all seasons.. There were a significant difference between moisture in Jebel Aulia downstream (77.00±0.89) is higher than others areas, Sennar and Merowe both upstream and downstream.

Furthermore, dry matter and Crude protein in upstream Merowe dam is very higher (28.66±1.96 and 32.77±0.37) than others areas meant there were significance difference within groups. While, no significant differences were found between ash and Esther extract in all localities areas and within groups. The mean score for Nitrogen free extract were higher Jebel Aulia upstream (36.81±2.81), downstream for Sennar dam and Merowe dam (36.88±2.07 and 36.40±1.63) respectively. The results, as shown in Tables 10,11 and 12 indicate that, there no significant differences were found between Arginine in upstream for all localities, while there were significant difference between Arginine in downstream. There were significant differences between Isoleucine, Leucine, Lysine and Methionine in Jebel Aulia both upstream and downstream. There were significance difference found between, Phenylalnine, Tyrosine and Valine in Jebel Aulia while, no significance difference for others localities.The results, as shown in Tables 16,17 and 18 and figures 16,17 and 18 indicate that, there were a significant difference between Pb of *O.niloticus*, in Jebel Aulia dam, Sennar dam and Merowe dam, and also within groups upstream and downstream, this mean the result is significant at the p = 0.05 level. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups. The results, as shown in Tables 19, 20 and 21 and figures 19, 20 and 21 indicate that, there were a significant difference between Pb, Cd and Zn in water samples, in Jebel Aulia dam Sennar dam and Merowe dam, but there were no significance difference in Zn upstream and downstream during all seasons. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups.

Key words: ***O.niloticus, Seasons, Dams, Body weight, Water quality, Heavy metals.***

الخلاصة

الهدف الرئيسي من هده الدراسة معرفة تاثير مصادر مياه مختلفة (خزان جبل أولياء ، سنار و مروي) اعلي و أسفل الخزان. تم تحديد ثلاثة مواقع لاخذ عينات الماء و الاسماك كل موقع يحتوي محطتان أعلي و أسفل الخزان ، الموقع الاول خزان جبل أرلياء مصدر المياه النيل الابيض و الموقع الثاني حزان سنار مصدر المياه النيل الازرق اما الموقع الثالث حزان مروي مصدر المياه نهر النيل. تم أخذ عينلت الماء بشكل عشوائي من كل محطة بانتظام كل شهر ولمدة عام واحد (2015) و اختبارها بواسطة أكوا زول. أيضا تم أخذ عينات من أسماك البلطي النيلي بشكل عشوائي و بصورة منتظمة من كل محطة لمدة عام (2015) لتحديد التركيب الوزني و الكيمائي ، الاحماض الامينية و الدهنية للحوم الاسماك و المعادن الثقيلة لعينات الماء ولحوم اسماك البلطي. البيانات المتحصل عليها تم تحليلها احصائيا بواسطة تحليل التباين (ANOVA) و اختبار المدي المتعدد لتخديد الفروقات بين المعاملات عند مستوي معنوية (≤ 0.05) باستخدام برنامج التحليل الاحصائي (SPSS,19).أظهرت نتائج الدراسة وجود فروق معنوية في الاوكسجين الذائب ، الامونيا، النترت و الفسفور في أعلي وأسفل الخزانات الثلاثة في مواسم السنة المختلفة. وجدأعلي تركيز للاوكسجين الذائب في أعلي خزان سنار و التركيو الاقل في أعلي خزان جبل أؤلياء بينما اعلي تركيز للقلوية وجد في خزان مروي و اقل تركير لها في خزان جبل اؤلياء، ومن ناحية اخري اعلي تركيز للعسر الكلي للماء وجد في حزان مروي و اقل تركيز في خزان سنار بينما اعلي تركير للفسفور في خزان حيل أرلياء واقل تركيز في أسفل خزان مروي في مل فصول السنة. كذلك أظهرت النتائج الي وجود فروق معنوية في التركيب الوزني لاسماك البلطي النيلي في أعلي وأسفل الخزانات الثلاثة خلال فصول السنة المختلفة. أيضا أوضحت الدراسة الحالية وحود فرق معنوي في معدل الرطوبة في اعلي خزان جبل أؤلياء (77.00 ± 0.89) وهي الاعلي بين المناطق الاخري علاوة علي ذلك فان المادة الجافة والبروتين الخام اعلي بكثير قي خزان مروي ($32.77\pm0.37, 28.66\pm1.96$) مما يعني وحود فروقات معنوية بين المواقع و المجموعات ، بينما لا توجد فروق معنوية في الرماد و مستخلص الايثؤ في جميع الخزانات حيث كانت اعلي نسبة لمتوسط المستخلص الخالي منالنتروجين في اعلي حزان جبل اؤلياء واسفل خزان سنار و مروي ($36.49\pm1.63, 36.88\pm2.7, 36.81\pm2.81$) علي التوالي. اشارت النتائج كما موضح في جدول 10، 11 و 12 الي عدم وجود فروق معنوية ذات دلالة احصائية بين الارجنين في اعلي الخزانات في كل المحطات بينما يوجد فرق معنوي كبير في اسفل الخزانات في الارجمين و كذلك يوجد فرق معنوي في الليوسين و اللايسين و الميثونيين في خزان اعلي واسفل خزان جبل أولياء و أيضا اظهرت الدراسة وجود فرق معنوي

قي فينلالنين ، تيروزين و فالين قي خزان جبل أولياء بينما لم توجد فروق معنوية في المواقع الاخري. أظهرت النتائج الحالية كما هو موضح في جدول 16، 17 و 18 وجود فروقات معنوية في الرصاص في عينات لحوم البلطي في خزان جبل أولياء و سنار و مروي علاوة علي ذلك لاتوجد فروق معنوية قي الكادميوم والنحاس والزنك في كل المواقع و بين المجموعات.النتائج المتحصل عليها من الدراسة الحالية تبين كما في جدول 19، 20 و 21 وجود فرق معنوي في الرصاص و الكادميوم في عينات الماء في خزان جبل أولياء ، سنار و مروي. لا توجد فروقات معنوية في الزنك في اعلي وأسفل الخزانات في كل فصول السنة و كذلك لا يوجد فرق معنوي في الكادميوم و النحاس في كل الخزانات و بين المجموعات.

الكلمات المفتاحية: البلطي النيلي، المواسم، الخزانات، التركيب الوزني، المعادن الثقيلة.

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CHAPTER ONE

1. INTRODUCTION

Due to the variety of human activities, the aquatic environment is becoming increasingly threatened by xenobiotics. Many of them may have deleterious effects which could be enhanced by bioaccumulation of heavy metals. In addition, these compounds may become concentrated in the organs of aquatic organisms, especially these at the top of the food chain. The nutritional value of fish meat comprises the contents of moisture, dry matter, protein, lipids, vitamins and minerals plus the caloric value of the fish (**Steffens, 2006**).

The physical and chemical properties of water immensely influence its uses, the distribution and richness of the biota (**Unanam and Akpan, 2006**).

Water is the culture environment for fish and other aquatic organisms. It is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (**Bronmark and Hansson, 2005)**, based on this, access to adequate, regular and constant supply of good quality water is vital in any aquaculture project.

According to **Sikoki and Veen (2004),** any water body is a potential medium for the production of aquatic organisms.

Water quality parameters can be divided into three main categories: physical (density, temperature); chemical (pH, conductivity, nutrients) and biological (bacteria, plankton and parasites) (**Moody, 2005**).

All living organisms have tolerable limits of water quality parameters in which they perform optimally. A sharp drop or an increase within these limits has adverse effects on their body functions (**Davenport, 1993**).

Fish has an important role in food security and poverty alleviation in both

rural and urban communities of Sudan, but little is known about the nutritional value of the Nile fishes that are normally utilized either fresh or preserved dried, salted or smoked. Better knowledge of their nutritional value, which could contribute to the understanding of variability in meat quality of different species of the Nile fish. Moreover, the measurement of some proximate profiles such as protein contents, lipids and moisture contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (**Waterman, 2000**).

Recently, there has been much interest in formulating diets on a digestible amino acid basis. Formulating diets in this fashion can result in a decrease of excess nutrients being excreted into the environment. Excess nitrogen excretion can cause detrimental environmental effects. Feed safety margins are commonly used in commercial feed formulations and reducing these safety margins can help to reduce nutrient excretion into the environment. Reducing these feed safety margins can also decrease feed costs, which is an integral input in poultry production. However, there is a lack of information regarding the amino acid content and digestibility of commonly used feedstuffs (**Garcia *et al*., 2007**; **Applegate *et al*., 2009**).

Different water pollutants affect the reproduction of the fish as well. In a study carried out by **Barakat, (2004)** found that most of the dissolved, metals and organic contaminants or their metabolites were monitored in the fish and their eggs. These pollutants were found to affect spawning behavior and duration. The average number of eggs per spawning was higher in the control group than the contaminated ones. Tilapia is the most important fish species in Sudan, and because the quality of aquatic environment is considered the main factors controlling fish quality and subsequentially its growth and production.

Many countries now have comprehensive system of inspection and control of, at least some aspects of fish quality. Thus, from several points of, view, fish quality has become very important in the world. This is because consumers now are more aware of possible food hazards and malpractices which will affect the quality as a result of bad handling and processing. Therefore, consumers individually or collectively, become more demand as in respect of freshness, naturalness, microbial safety, free from pollutants and protection from damage **(Applegate*, et al*, .2009)**.

Water is also a vital resource for agriculture, manufacturing and other human activities. In urban areas, the careless disposal of industrial effluents and other wastes in river and lakes may contribute greatly, to the poor quality of river water and among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccmulate in aquatic ecosystems (**Censi *et al*., 2006**). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, to be toxic to living organisms (**Storelli *et al*., 2005**).

Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to man through fish consumption (**Adeniyi and Yusuf, 2007**).

As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals and thus, causing heavy metal pollution in water bodies Therefore, heavy metals can be bioaccumulated and biomagnified via the food chain and finally assimilated by human consumers resulting in health risks (**Agah *et al*., 2009**).

As a consequence, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high tropic levels and are important food source (**Agah *et al*., 2009**).

Recently, the demand for Tilapia (*O. niloticus*) consumption has increased continuously because *O. niloticus* is of low price with high nutritional value. The whole fish and fillet are admirable for consumers. As a result, it affects the trend of both domestic and export consumption. Moreover, *O.niloticus* has many outstanding advantages such as easy to culture, high growth rate, easy breeding, high fibrillate protein, good taste, white cotton meat like sea bass fish, high nutrition and having more Omega-3than other wild freshwater fishes and wild estuarine fishes.

Objectives

General objective:

The main aim of the present study is to investigate the effect of using the three major different water sources (Jebel Aulia, Sennar and Merowe reservoirs dams) upstream and down stream existing in Sudan in order to determine which one could be most suitable for use in the Sudanese conditions fish culture to yield the best quality of fish for human consumption.

Specific objectives:

1. To determine Water quality in the three sites (Jebel Aulia, Sennar and Merowe reservoirs dams).
2. To determine Body weight composition and chemical composition of *O. niloticus* at three reservoirs dams up and down stream.
3. To determine Amino acids profiles and fatty acids of *O.niloticus* collected from the three sites.
4. To determine Heavy metals concentration in water and meat of *O. niloticus* collected from the three sites.

CHAPTER TWO

2. LITERITURE SURVEY

2.1. Water Quality:

Water is essential for life on earth. Because of the importance of water, the pattern of human settlement throughout history has often been determined by its availability. The fertile river valleys abundant water represents the beginning of civilizations. With growth, demand for water has increased dramatically, and its uses have become much more varied as used in agriculture, industry, recreation, and non-ingested personal consumption. Frequently, each of these uses required a different level of quality in order for the water to be considered adequate.

The physical and chemical properties of water immensely influenced its uses, the distribution and richness of the biota (**Unanam and Akpan, 2006**).

The components of the pollution contribute to greater oxygen demand and nutrient loading of the water bodies, promoting toxic algal blooms and leading to destabilized aquatic ecosystem (**Morrison *et al.*, 2001**).

2.2. Water quality parameters:

2.2.1. Nitrate-Nitrogen (NO_3-N)

Nitrate is formed through nitrification process, i.e. oxidation of NO_2 into NO_3 by the action of aerobic bacteria. Nitrate not taken up directly by aquatic plants is denitrified in anaerobic sediments and micro zones. In tropical systems, de-nitrification will be most intense in the following areas: (a) where detritus accumulates; (b) in water bodies subjected to enhanced nutrient loading from pollution; (c) in water bodies with long residence times; and (d) in wetland ecosystems subject to periodic drying, where oxygen inputs during drying periods

stimulate coupled mineralization-nitrification- de-nitrification within organically rich sediments (**Furnas, 1992**).

Generally, it is stable over a wide range of environmental conditions and is highly soluble in water. Compared with other inorganic nitrogen compounds, it is also the least toxic. However, high levels can affect osmoregulation, oxygen transport, eutrophication and algal bloom (**Lawson, 1995**).

2.2.2. Phosphorous (P)

Phosphorus (P) is found in the form of inorganic and organic phosphates (PO4) in natural waters. Inorganic phosphates include orthophosphate and polyphosphate while organic forms are those organically-bound phosphates. Phosphorous is a limiting nutrient needed for the growth of all plants- aquatic plants and algae alike. However, excess concentrations especially in rivers and lakes can result to algal blooms. A lake with a concentration of below 0.010 mg/L is considered as oligotrophic, while concentrations between 0.010 and 0.020 mg/L are indicative of mesotrophy, and concentrations exceeding 0.020 mg/L are already considered eutrophic (**Muller and Helsel, 1999**).

Phosphates are not toxic to people or animals, unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphates. Among the common sources of phosphorous are wastewater and septic effluents, detergents, fertilizers, soil run-off (as phosphorous bound in the soil will be released), phosphate mining, industrial discharges, and synthetic materials which contain organophosphates, such as insecticides. Aquaculture farms located near these sources can be expected to have higher concentrations of phosphates in the water bodies. Total phosphorus associated with suspended matter in unpolluted tropical rivers normally ranges between 620 – 1860 μg/L (**Furnas, 1992**).

Phosphorous concentration is measured either by using total phosphorus

(TP), which is a measure of all the various forms of phosphorus that are found in a water sample or by Soluble Reactive Phosphorous (SRP), which measures organophosphate, the soluble, and inorganic form of phosphorous which is directly taken up by the plants.

Quality standards on phosphorous levels (in different forms) set by Australia, Malaysia, New Zealand, Norway, Philippines and United States, are between 0.02 and 0.20 mg/L for freshwater and from nil to 0.20 mg/L for marine. This shows that the marine environment is more sensitive to phosphorous level changes, thus is required to have a value lower than freshwater. Algal blooms, red tides, and fish kills occurring show this sensitivity more frequent in marine water and less likely in freshwater environment.

In the Philippines, the standard values are the same as that of the United States. But compared with other countries mentioned, it is more stringent, requiring P levels as low as 0.05 mg/l for freshwater and nil for marine waters.

2.2.3. PH

The term pH was originally derived from a French word, "*pouvoir hydrogen*", which means "hydrogen power" this parameter shows the concentration of hydrogen ions (H+) in the water.

The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. At 25 0C, pH of 7.0 will be considered neutral, i.e. neither acidic nor basic, while values below 7.0 are considered acidic, and above 7.0 are basic. Natural waters range between pH 5.0 and pH 10.0 while seawater is near pH 8.3. A pH meter is an electronic instrument used to measure the pH of a liquid, and typically it consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading.

The pH is interdependent with other water quality parameters, such as

carbon dioxide, alkalinity, and hardness. It can be toxic in itself at a certain level, and also known to influence the toxicity as well as hydrogen sulfide, cyanides, heavy metals, and ammonia (**Klontz, 1993**).

The pH can also affect fish health. For most freshwater species, a pH range between 6.5 - 9.0 is ideal, but most marine animals typically cannot tolerate as wide range pH as freshwater animals, thus the optimum pH is usually between pH 7.5 and 8.5 **Boyd, (1999**). Below pH 6.5, some species experience slow growth (**Lloyd, 1992**). At lower pH, the organism's ability to maintain its salt balance is affected (**Lloyd, 1992**) and reproduction ceases. At approximately pH 4.0 or below and pH 11 or above, most species die (**Lawson, 1995**).

The pH of pond water increases daily as phytoplankton consume carbon dioxide during photosynthesis (reaching a maximum value near 6 PM), and decreases at night as they release carbon dioxide during respiration (reaching a minimum value near 6 AM). Indirectly, changes in pH can also affect aquatic organisms. In fish ponds, the low pH levels can accelerate the release of metals from rocks and sediments. These metals can affect the metabolism of the fish and its ability to take up water through the gills.

Moreover, low pH can reduce the amount of dissolved inorganic phosphorous and carbon dioxide available for phytoplankton during photosynthesis. Ponds with low pH values (< 5) receiving acid rain, many acid drainage or acidic swamp water can be improved by liming. On the other hand, high pH levels can make the toxic form of ammonia become more prevalent, and the phosphate, which is commonly added as a fertilizer, can rapidly precipitate **(Boyd, 1990).**

2.2.4. Total Alkalinity

In aquaculture, 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. Without a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night-time pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and, as a result, drive the pH levels above 10.0. As discussed, fish grow within a narrow range of pH values and either of the above extremes will be lethal to them. Moreover, carbonates and bicarbonates can act as a storage area for surplus carbon dioxide, thus carbon dioxide will not be limited during photosynthesis. This will then ensure that there will be a continuous supply of oxygen in the system (**Boyd, 1990**).

2.2.5. Dissolved Oxygen (D.O)

In a water body, oxygen is available in a dissolved state. It is found in microscopic bubbles mixed in between water molecules. It can enter into the system through direct diffusion and as a by-product of photosynthesis. This means that the level of dissolved oxygen in the water can be increased through mechanical aeration, e.g. paddle wheels, agitators, vertical sprayers, impellers, airlift pumps, air diffusers, liquid oxygen injection, etc., considerable wind and wave action, and presence of aquatic plants and algae. However, caution should be considered on the latter since it can also cause oxygen depletion when the plant population becomes too dense. On the other hand, it is removed through respiration and decomposition (**Lawson, 1995**).

The oxygen concentration is measured in terms of parts per million (ppm) or mg/L; both units of measure are the same. Dissolved oxygen is considered as one of the most important aspect of aquaculture. It is needed by fish to respire and perform metabolic activities. Thus low levels of dissolved oxygen are often linked

to fish mortality incidents. On the other hand, optimum levels can result in good growth, thus result to high production yield. In general, a saturation level of at least 5 mg/L is required. Values lower than this can put undue stress on the fish, and levels reaching less than 2 mg/L may result to death (but 3 mg/L to some species) **Lawson (1995).**

Physical condition such as temperature, altitude and salinity can also affect oxygen level. It is for this reason that aeration can be used as an option during summer months especially in areas where the aquaculture activity is intense to avoid fish mortality (**Lawson, 1995**).

Other organisms such as bacteria, phytoplankton, and zooplankton also need oxygen, thus compete for dissolved oxygen with fishes. Decomposition of organic materials is the greatest consumer of oxygen in the system. Therefore food wastage and feed quality should be monitored as both significantly affect the levels of dissolved oxygen in the system Oxygen is also needed by other organisms such as bacteria, phytoplankton, and zooplankton (**Lawson, 1995**).

They consume large amounts of dissolved oxygen as well. Decomposition of organic materials is the greatest consumer of oxygen in the system. Therefore food wastage and feed quality should be monitored as both significantly affect the levels of dissolved oxygen in the system (**Lawson, 1995**).

Setting the guidelines for dissolved oxygen for aquaculture can be difficult, because as mentioned above, this is affected by many factors. However, most of the countries listed below had set >5.0 mg/L as the ideal concentration both for marine and freshwater. The Philippines, together with Australia, India, New Zealand, United Kingdom and Asian are among these countries.

2.2 Nile Tilapia (*O.niloticus*)

Among the numerous species of fish for culture, tilapia is widely recognized

as one of the popular species for a wide range of aquaculture systems worldwide. It is an ideal candidate for warm water aquaculture (**Tahoun *et al*., 2008**).

Tilapia generally differs greatly in size and taxonomic group (**Olojo *et al*., 2005**). Worldwide, Nile tilapia (*O.niloticus*) culture increased during the year, 2001 to 2006 from 1,113,737 to 1,988,726 MT representing a growth of 79% thus making it one of the fastest growing freshwater aquaculture species.

Tilapia spawn easily in captivity, use a wide range of natural foods as well as formulated diets, tolerate poor water quality and grows well at warm temperatures. These attributes, along with relatively low input costs, have made tilapia the most widely cultured freshwater fish in tropical and subtropical countries (**Borgeson *et al*., 2006**).

Although the potential for tilapia culture is high, the production in Africa and more importantly, Nigeria is very low; the draw-back being the early maturity, uncontrolled reproduction in ponds leading to increased competition for food, reduction in growth rate which results in a phenomenon referred to as stunting (**Fashina-Bombata *et al*., 2006**).

There are generally low productions of fry of *O. niloticus* which is attributable to low fecundity, inadequate sex ratio, spawning techniques, brood stock nutrition and high fry mortality (**Tahoun *et al*., 2008**).

Although *O. niloticus* is the leading species of tilapia culture globally, there exists an unidentified cichlid „Wesafu", in Epe lagoon, Lagos, Nigeria where it is highly priced. This unidentified cichlid grows to 1,500 g, 414 mm in the wild. At present, there is paucity of information on the origin of the species of fish.

A number of studies have been conducted on the morphometric and meristic characteristics, age and growth, food and feeding habit, nutritional requirement, amino acid profile and biochemical characterization of the fish (**Hammed *et al*,**

2011).

Fish and shell fish are important animal protein and have been widely accepted as a good source of protein and other elements for the maintenance of healthy body (**Adeniyi *et al*., 2012**). Fin and shell fishes have significant role in nutrient, income generation, employment and foreign exchange earnings of the country (**FAO, 2009, 2010**).

O.niloticus typically feeds during daytime hours. Due to their fast reproductive rate, however, overpopulation often results within groups of Nile tilapia. To obtain the necessary nutrients, night feeding may also occur due to competition for food during the daylight hours. A recent study found evidence that, contrary to popular belief, size dimorphism between the sex's results from differential food conversion efficiency rather than differential amounts of food consumed. Hence, although males and females eat equal amounts of food, males tend to grow larger due to a higher efficiency of converting food to energy **(Ogibona *et al*., 2009)**.

Lupatsch *et al.* (2001) reported that Fish Fillets is one of such products according to flesh cut from a whole fish parallel to the line of backbone, it could be block or single fillet of which it is in high demand in developed world, intensive, yet can be a means of providing livelihood support to a large number of people living in the coastal areas and many commercial culture systems in many developing countries, and many types of the tilapia products are available in the world markets. Today, fresh or frozen Tilapia fillets are available in different sizes and packages, as skin-on, skin-off, deep skinned, individually quick frozen, smoked and sashimi grade, and are treated by carbon monoxide or ozone dipped.

Many fish species are filleted to satisfy consumer demand and adds value to product, although this depends very much on the type of market. In general,

filleting is primarily a means of food presentation intended to facilitate culinary preparation (**Andrew, 2001**).

2.3 Fish Body weight composition

As with many animal products, fish and fishery products contain water, proteins and other nitrogenous compounds, lipids, carbohydrates, minerals and vitamins. However, chemical composition of fish varies greatly from one species and one individual fish to another depending on age, sex, environment and season (**Huss, 1995**).

The fish has a skeletal or cartilaginous structure which provides support for the body. The muscles which form the edible part account for most of the weight of the fish. The skin forms a cover, often with an outer layer of scales, and secretes slimy mucus, which lubricates the fish and seals the surface. The gills are the main part of the breathing mechanism and take up oxygen from the water. The organs in the abdominal cavity, including the stomach, intestine and liver are known as the guts. Removal of the guts is normally the first step in handling and preservation (**Huss, 1995**).

The lipid content of fillets from lean fish is low and stable whereas that from fatty species varies considerably. However the variation in the percentage of fat is reflected in the percentage of water, since fat and water normally constitute around 80 percent of the fillet. As a rule of thumb, the amount of fat can be estimated from an analysis of the water content in the fillet (**Huss, 1995**).

Obanu and Ikeme (1988) carried out studies on processing characteristics and yield of some fishes of the river Niger. They mentioned that the fillets, head, viscera and bones were in the range 33.5- 68%, 11- 31%, 3.89- 9.8% and 1.32- 15.3% respectively.

Ali *et al*, (1996) studied body characteristics; yield assessment and

proximate chemical composition of commercial fish species namely *Lates niloticus*, *O.niloticus*, *Sarotheradeom galilaeous*, *Labeo oniloticus* and *Labeo horie*. The results of body characteristics and yield indices revealed clearly percentage decrease in the order of fillets, heads, skeletons, viscera and skin for *tilapia spp.* Compared to order of fillets, skeletons, viscera, head and skin for *Labeo spp.*

The nutritional value of fish meat comprises the contents of moisture, dry matter, protein, lipids, vitamins and minerals plus the caloric value of the fish (**Steffens, 2006**). There are, therefore, a number of variables that can affect the overall chemical composition of fish meat. Nonetheless, there is little information on the effects of sex and size (age) on the individual chemical components of Nile Tilapia meat. thus the human body usually contains small amount of these minerals and the deficiency in these principal nutritional elements induces a lot of malfunctioning; as it reduces productivity and causes diseases (**Mills, 1980)**.

It was also found to influence post-harvest processing and affect the shelf-life of the fish (**Clement and Lovelli, 1994**). Changes in fatty acid and amino acid concentrations were found to be useful as an index of freshness and decomposition of marinated fish in storage (**Özkan, 2005**). Likewise, different cooking methods affect the quality of fish meat (**Prapasri, 1999**).

The study of chemical composition of fish from different environment is an important aspect of fish flesh quality since it influences both keeping quality and the technological characteristics of the fish (**Huss, 1988**).

2.4 Chemical composition

Fish fillet consists of several components, such as moisture, protein, lipids, vitamins and minerals, all of which contribute to the overall meat composition. Fish body composition is affected by both exogenous and endogenous factors

(**Huss, 1995**). Exogenous factors that affect fish body composition include the diet of the fish (composition, frequency) and the environment in which it is found (salinity, temperature). The main exogenous factor affecting proximate composition is diet. Various studies have examined the effects of temperature, light, salinity, pH and oxygen concentration on the proximate composition of fish but these factors would seem to have very limited effects. On the other hand, endogenous factors are genetic and linked to the life stage, age, size, sex and anatomical position in the fish (**Huss, 1995**).

Nile Tilapia exhibits sexual dimorphic growth where males grow significantly faster, larger and more uniform in size than females. Males and females had significantly different final weights owing to supplementations of three different oils (**Biro *et al*., 2009**). There are, therefore, a number of variables that can affect the overall chemical composition of fish meat. Nonetheless, there is little information on the effects of sex and size (age) on the individual chemical components of Nile Tilapia meat.

Fish received increased attention as a potential source of animal protein and essential nutrients for human diets (**Arts *et al.* 2001**). Fish meat contains significantly low lipids and higher water than beef or chicken and is favored over other white or red meats (**Nestel, 2000)**. The nutritional value of fish meat comprises the contents of moisture, dry matter, protein, lipids, vitamins and minerals plus the caloric value of the fish **(Steffens, 2006**). Minerals are essential nutrients, they are components of many enzymes and metabolism, and contribute also to the growth of the fish (**Glover and Hogstrand, 2002**).

The nutritional component of the freshwater fish was found to differ between species, sexes, sizes, seasons, and geographical localities **(Zenebe *et al*., 1998b**). It was also found to influence post-harvest processing and affect the shelf-

life of the fish (**Clement and Lovelli, 1994).** Changes in fatty acid and amino acid concentrations were found to be useful as an index of freshness and decomposition of marinated fish in storage (**Özkan, 2005**). Likewise, different cooking methods affect the quality of fish meat (**Prapasri, 1999**).

Chemical composition of fresh fish greatly differs from one fish species and from one individual to another depending on age, sex, season and environmental condition (**F A O, 1986**).

Stansby,(1954) reported that the chemical composition of fish varies widely from species to species and season to season. There is also individual variation in the same species. Knowledge of chemical composition is essential in order to compare its value as food with other protein foods has elaborated on the importance of chemical analysis.

2.4.1 Moisture Content

Moisture content of fish body does not seem to be constant in view of the inter relationship with many biological and physiological factors. Early instability the juvenile stage and subsequent stability was mentioned by **Ali et al (1996)**

Ahmed (2006) carried out comparison of nutritive value of *Fassiekh* using *Hydrocynus spp.* and *schilbe spp*. She mentioned that the moisture content of the fresh fish was in the range of (72.9 – 81.92 %).

Clucas and Ward (1996) reported that flesh from healthy fish contained (70-80 % water).

Ali *et al* (1996) stated that the moisture content in deep frozen fish of *labeo spp.* was 76.7%.

2.4.2 Crude protein

Although the protein fraction is rather constant in most species variation had been observed such as protein reduction occurring in salmon during long spawning migration and Baltic code during spawning season. For this particular species it

extends from January to June, July (**Borreson, 1992**).

Ahmed (2006) reported that the protein content was in the range (18.9 – 20.5 %).

Clucas and Ward (1996) reported that flesh from healthy fish contained (15-24%) protein.

Remijo (1992) reported that the protein content in fresh *labeo spp* fish was 20-21%.

2.4.3 Fat Content

The lipids present teleost fish species may be divided in two major groups; the phospholipids and the triglycerides. The phospholipids make up the integral structure of the unit membranes in the cells; thus they are often called structural lipids. The triglycerides are lipids used for storage of energy in fat depots, usually within special fat cells surrounded by a phospholipids membrane and a rather week collagen network (**Ackman, 1980**).

Some tropical fish also showed a marked seasonal variation in chemical composition. West African shad (*Ethmalo sadorsalis)* showed fat range of 2.7%(wet weight)over the year with maximum in July (Watts,1957).It has also been observed that oil content of these species varies with size, large fish containing about 10%more oil than smaller one (**Watanabe, 1999**).

Clucas and Ward (1996) reported that flesh from healthy fish contained 1-22% fat. Ahmed (2006) found that fat content ranged between 1.4 – 2.2 %. **Remijo (1992)** reported that the fat content in fresh *labeo spp* fish is 3.5-5.4%. **Johnston (1994)** found that fresh fish fat content varied widely from species to species and from season to another. It was 5.6% in lean fish.

2.4.4 Ash content

Most of the known inorganic elements or minerals can be detected in the human and fish body, but only fifteen of those known to be essential to man need

to be derived from food **(Clucas and Ward,1996).** According to **Ahmed (2006);** the ash content of the fresh fish ranged between 1.1 – 1.7%.

2.5 Amino acid profiles

Zenebe *et al.* (1998b) reported that amino acids (AAs) were the major elements that had been used in assessing the nutritional value of the study fishes. AAs results varied between the study fishes though they were caught from the same source: The White Nile River. This variation in the AAs contents may be due to the different environments from which, they were caught and to body structure of fish families to which, they belong to.

Moses et al (2018) concluded that the habitat influences the nutritional quality and quantity of tilapia. The essential amino acid and protein composition of the fish were better in the dams than in the rivers. The amino acid profile of the fish sample revealed that glutamic acid and aspartic acid are the most concentrated amino acids present in the fish.

Amino acid composition of muscle proteins shows very important differences among fish species. Proteins accounting for 65-70% of total dry body weight in fishes have high nutritional value due to their essential amino acid contents (**Wilson. 1989**).

It is very useful to know amino acid compositions for many reasons. In addition to determination of nutritional value, aromatic properties of fish meat are partly depended on the amino acid distribution (**Hall, Ahmad . 1992).**

Amino acid content in muscle tissues of aquatic organisms is reported to range between 0.5–2.5 % of total muscle weight (**Metusalach and Shahidi, 2000**). Amino acid levels were found higher in cultivated fishes compared to wild fishes in some studies.

Fish meat proteins contain all the essential amino acids. Although essential amino acids (leucine, isoleucine, lysine, valine, methionine, phenylalanine, threonine and tryptophane) have many important functions in human body, food sources with these amino acids increase the essential protein quality of diet because these molecules cannot be synthesized in body (**Brown . 2000**).

Changes in fatty acid and amino acid concentrations were found to be useful as an index of freshness and decomposition of marinated fish in storage (**Özkan, 2005**).

Results of some selected Nile fishes showed that the Nile fishes are of high nutritional value and good source of proteins, minerals as well as essential amino acids; where, Nile Perch (*Lates niloticus,* L.) has high EAA 46%; while, Gargur (*S. shall*) has 38% (**Elagba et al., 2010**).

(**Elagba *et al* ., 2010**) stated that Dabis contained the highest percentages of amino acids, which ranged between 0.02 and 19.36%, followed by those in Garmout, which ranged between 0.86 and 12.63%; those in Gargur, which ranged between 1.03 and 10.05% and those in Himeila, which ranged between 0.01 and 9.99%. The highest AA in Dabis was glutamic (19.36%); in Garmout was glycine (12.63%); in Gargur was glutamic (10.05%) and that in Himeila was cysteine (9.99%); while, the lowest AA in Dabis was cysteine (0.02%); in Garmout was methionine (0.34%); in Gargur was methionine (1.03%) and in Himeila was lysine (0.01%), Methionine had nearly the same percentages among the study fishes as 0.34% in Garmout; 0.74% in Himeila; 1.03% in Gargur and 1.54% in Dabis; whereas, tryptophan was absent in all the study fish samples.

2.6 Fatty acid profiles

The lipid fraction of fish are rich source is long chain n-3PUFA especially, α-linoleic acid (C18:3, ALA), eicosapentaenoic (C20; 5, EPA) and

docosahexaenoic acid (C22:6w3, DHA) (**DeFilippis *et al.*, 2010).**

Glogowski and Ciereszko (2001) revealed the effect of these fatty acids on blood pressure, arrhythmia (abnormal heartbeats), and hypotriglyceridemia. Arachidonic (C20:4n-6) acid and its parent fatty acid, linoleic acid (C18:2n-6) also drew consideration and due to inability of human body to synthesize **EPA** and **DHA**, its constant supply through food is a prerequisite (**Lecerf, 2007**).

There is an inter and intra specific variability in the composition of fatty acids of fish lipids (and of the specific polyunsaturated fatty acids in particular). This could be explained by the existence of a large number of external and internal factors. The external factors are environment, culturing method, and tropic effects. The internal factors include fish species, feeding regime and digestion, life cycle stage, quantitative and qualitative characteristics of lipids- triacylglycerol's, phospholipids and their topographical origin- dorsal and ventral part of muscle tissue (**Buchtova *et al*., 2007**).

In recent years, there have been a large number of experimental studies into some of the above factors causing changes in the composition of fatty acids in various fish species

Detailed information about lipid components and their fatty acids constituents is needed to understand how to diminish oxidative or hydrolytic factors which affect quality of fish. The nature, proportion, and degree of un saturation of the fatty acids in the lipids are all closely related to the oxidation of the oils. However, the fatty acids composition of the muscle cell membranes are especially important factors in determining the stability because oxidative changes are initiated from the membrane components of muscle (**Buckley *et al*, 1989**). Rancidity development is a vital concern to the food industry because It may result in sensory changes (flavour and aroma), loss of nutritional value (Essential fatty

acids, fat-soluble vitamins: A, D, E, K), production of primary and secondary oxidation products (hydro peroxides, free radicals, epoxides, etc). It can also be used for indexing, assisting in technology development.

Fatty acids profile analysis also provide information about the essential fatty acids requirements of fish which would aid the compounding of adequate protein-to-fat ratios feed that would balance energy requirements with caloric intake.

. In addition, fatty acid composition data are needed by food scientists and nutritionists to aid them in dietary formulation, processing and product development (**Ackman, 1989**).

Lipids in marine foods consist mainly of long-chain polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3) (**Kinsella *et al.*, 1990**) which belongs to the physiologically important group of n-3 fatty acids.

The increase of unsaturated fatty acids, along with the reduction of saturated fats, supports the lowering of blood cholesterol in humans (**Kinsella 2005**) and causes a positive impact on human nutrition. Specifically, the increase of unsaturated fatty acids contributes to the prevention of chronic diseases.

Polyunsaturated fatty acids ω-3 (PUSFA ω-3) play a role in preventing heart disease and has anti-inflammatory and anti-thrombosis effects (**Connor 2000**). Also, ω-3 and ω-6 polyunsaturated fatty acids are considered essential cannot be synthesized in the human body; they must be obtained through diet (**Mahan *et al.*, 2005**).

These nutritional benefits of fish consumption were mainly attributed to the effect of ω-3 polyunsaturated fatty acids, which are thought to have several potential cardio protective actions (**Din *et al.*, 2008**).

Chauke *et al* (2008), tilapia is one of the richest fish in the concentration of many fatty acids, especially those essential for human nutrition, in South Africa. **Memon et al (2010)** compared the proximate composition and fatty acid profile among Indus river fish species and the study revealed that the fish are good sources of n-3 fatty acids, particularly EPA and DHA, and should be recommended for dietary inclusion to reduce risks of cardiovascular diseases.

Simopoulos (2001) indicated that, the high ratio of ω-6 to ω-3fatty acids in Western diets may contributes to a higher risk of chronic disease. The international society for the study of Fatty Acids and Lipids also recommends at least 0.5 g per day of EPA plus DHA for cardio protective benefits in healthy adults .

Unfortunately, polyunsaturated fatty acids (PUFAs) are susceptible to oxidation and to thermal damage due to excessive heat. Modifications of fatty acids during cooking could be related to three mechanisms: oxidation, loss of fatty acids by diffusion (in roasting) or fatty acid exchange between fish and oil (in frying). The nutritive value of fish can be affected by processing or cooking methods. The effects of different processing and cooking methods on nutritive values of different fish species have been previously studied (**Garcia-Arias *et al.,* 2003a**).

Polyunsaturated fatty acids are known to be highly susceptible to oxidative breakdown (**Sant'ana and Mancini-Filho 2000**) and heat catalysts strongly for the initiation of lipid peroxidation (**Kingston *et al.,* 1998**).The oxidation and changes in lipid profile of the fish lipid resulting during cooking can lead to certain medical disorders such as higher risk of atherosclerosis (**Modugo *et al.,* 2011**), oxidative stress, and exacerbate atherogensis by incorporating into lipoproteins (**Penumetcha 2000**).

It has been recognized that lipid oxidation product exert toxic carcinogenic

and mutagenic effects (**Yang *et al.,* 1998**) and causing a decrease of fatty acid digestibility and adsorption as a result of cross-linking reactions of secondary lipid oxidation with protein (**Kirk 1984**).

Several studies have shown that cooking methods effect on fatty acid compositions and the lipid class composition of fish (**Garcia-Arias *et al.,* 2003**). The effect of cooking methods on the fatty acid profile has been studied however, there were moisture and lipid losses during cooking amongst the different methods. The fatty acid profile showed only minor differences between the methods apart from an increase in PUFAs in the deep fried salmon due to linoleic acid uptake from the frying oil (**Danae *et al.,* 2010**).

Most of the cooking methods such as poach, steam, microwave and oven baked showed good preservation of ω-3 fatty acids, and this is attributed to internal protection of ω-3 fatty acids in king salmon. It also was the effect of heating on fish lipid sprat, herring and bream. Furthermore, the increasing of peroxide value was proportional to heating temperature. DHA increased by 20% after 1 h heating at 100°C ; a 45% decrease after 15 min heating at 160°C and a 70% loss after 1 hr at the same temperature. EPA under the same conditions reported losses of less than 20% (**Kolakowska *et al.,* 2010**).

2.7 Heavy metals in aquatic environment

Recently the aquatic organisms are used as indicators of trace metals pollution. Heavy metals concentrations are extremely variable in various marine and fresh water organisms depending on the geochemical background , the level of the pollution in a given area, and fish activity(**Yilmaz *et al* ., 2007**).

Bioaccumulation of heavy metals in the fish may critically influence the growth rate, physiological and biochemical status and consequently the meat quality of fish (**Haggag *et al*., 1999**) moreover, it has been observed that through

biological amplification, some aquatic organisms may concentrate metals present in the low concentration in the environment of levels that exceed standards and harmful to organisms.

It is recommended that the developed histopathological change in the fish can be used as bio indicators for environmental pollution and differential toxicity of heavy metals can be attributed to several factors such as type of heavy metals tested, solubility of compounds, predominated ion and physic-chemical characteristics of the test medium and the mechanism of action (**Marzouk *et al*., 1994**).

Metals can accumulate in the fish body depending upon the concentration and period of the exposure, higher uptake of metals beyond permissible limits can induce remarkable changes in the fish physiology (**Vinodhini and Narayanan, 2008**).

The available literature on the effect of metals on aquatic organisms is concerned largely about the individual metals while the studies on metal mixtures on fish are limited (**Dondero *et al* 2011**) interaction among metals may be different and the effects of various mixtures on fish growth and survival may also vary depending upon their concentration, specific composition and duration of fish exposure.

The results of many field studies of metal accumulation in fish living in polluted waters show that considerable amounts of various metals may be deposited in fish tissues without causing mortality. Various metals are accumulated in fish body in different amounts. These differences result from different affinity of metals to fish tissues, different uptake, and deposition and excretion rates. Metal levels in live fish usually follow the ranking: Fe > Zn > Pb > Cu > Cd > Hg. The levels of Zn may be very high, up to over 300 µg/g d. W. The maximum

concentrations of lead and copper are lower and usually do not exceed 10 µg/g d. W. Cadmium and mercury are accumulated by the fish in very low amounts, below 1 µg/g d.w. Metal accumulation in fish depends on pollution, and may differ for various fish species living in the same water body **(Jezierska and Witeska, 2000**).

Generally, the higher metal concentration in the environment, the more may be taken up and accumulated by fish. Relationship between metal concentrations in fish and in the water was observed in both, field and laboratory studies (**Zhou *et al*., 1998**). It should be, however, it should be emphasized that body metal level is related to its waterborne concentration only if a metal is taken up by the fish from water. If food is the main source of metal, such a relationship does not necessarily occur. Metals in natural waters occur in particulate or soluble form. Soluble species include labile and non-labile fractions. The labile metal compounds are the most dangerous to fish. They include various ionic forms of different availability to fish. Many data show that the amounts of metals in the labile fraction, and the share of various metal ions strongly depend on environmental conditions.

Heavy metals from natural sources and anthropogenic activities are continually released into aquatic systems, causing serious threat because of their toxicity, bioaccumulation, long persistence and bio-magnification in the food chain (**Eisler1988**).

Fish are considered as one of the most indicative factors, in freshwater ecosystems, for the estimation of trace metals pollution (**Rashed, 2001**). Fish are at the high trophic level of the food web and may accumulate large amounts of some metals from the water and often in concentrations several times higher than in the ambient water. Heavy metals are taken up through different organs of the fish because of the affinity between them. In this process, many of these heavy metals are concentrated at different levels in different organs of the fish body (**Bervoets *et***

***al*., 2001**).

Heavy metals like copper, iron and zinc are essential for fish metabolism, while some others such as mercury, cadmium and lead have no known role in biological systems. For normal metabolism the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects (**Yousafzai, 2004**).

Studies from the field and the laboratory experiments reveal that accumulation of heavy metals in fish is mainly dependent upon metals concentration in ambient water and exposure period, although some other factors such as water salinity, pH, hardness and temperature, ecological needs, size and age, lifecycle, capture season and feeding habits of fish also play significant role in metal accumulation (**Gupta, 2009**).

The contamination of aquatic resources with a wide range of pollutants has become a matter of concern over the past few decades (**Narayanan and Vinodhini, 2008**).

Natural aquatic systems are extensively contaminated with heavy metals released from domestic, industrial and other anthropogenic activities (**Velez and Montoro, 1998**).

Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (**Farombi *et al*., 2007**).

Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effects and death in the aquatic systems (**Farkas *et al*., 2002**).

Studies carried out on various fishes have shown that heavy metals alter the physiological activities and biochemical parameters both in tissues and in blood

(**Basa and Usha Rani, 2003**).

The toxic effects of heavy metals have been reviewed, including bioaccumulation (**Waqar, 2006**).

River Kabul is a source of livelihood for thousands of poor fishermen living on the banks of the main river or its tributaries. It originates in Afghanistan and passes through Khyber Pukhtoonkhwa province of Pakistan before flowing into River Indus. In Pakistan it flows through densely populated towns and agricultural fields where all the sewages and agricultural run offs finally drains into Kabul River. A wide data regarding aquatic pollution in River Kabul is available (**Yousafzai, 2004**).

The World Health Organization as well as the Food and Agriculture Organization of the United Nations state that monitoring eight elements in fish (Hg, Cd, and Pb, As, Cu, Zn, Fe, and Sn) is obligatory and monitoring of others is suggested Increases in agricultural and industrial activities in an area directly influences the quality of water, in other words, water reservoirs are collectors of all materials spread by human industrial and agricultural activities. Heavy metals penetrate into water reservoirs via atmosphere, drainage, soil waters and soil erosion. as the concentration of heavy metals in the environment increases, the metals inevitably enter the bio geochemical cycle (**WHO,1985**) Having contaminated water, heavy metals accumulate in organisms, which are consumed by fish or penetrate into fish directly through skin and gill later (**Surec B.2003**) hMs cause the mutation of fish inner organs, disturb immune reactions, change blood parameters, reduce an organism's adaptation qualities, vitality, resistance to disease of fish are observed as a result of heavy metals pollution (**Blasco .and Arias Saenz 1999**) usually, many toxic compounds affect organisms in nature at the same time, each of them having a specific effect on physical and chemical

processes that influence an organism's condition and reactions.

The contamination of aquatic systems with a wide range of pollutants has become a matter of concern since the last few decades (**Gupta *et al*., 2009**).

The natural water bodies may extensively be contaminated with various heavy metals released from domestic, industrial effluents, idol immersion, draining of sewage, dumping of hospital, other wastes and anthropogenic activities, etc. (**Laxmi *et al*., 2011**).

Fish occupies a higher level in the food chain and is an important source of protein food for human beings; the heavy metals in aquatic ecosystem are transferred through food web into human beings, some of heavy metals can cause health problems to fish consumers (**Taweel *et al*., 2011**).

Diverse industrial wastes have aggravated the problem of water pollution, this problem becomes complex because of the non-degradability of inorganic pollutants like heavy metals **(M.H. Depledge, 1994)**Metals have received particular attention among other non-degradable toxic chemicals because of their adverse effects on aquatic life forms(**Furness,1990**).

To control water pollution, the immediate problems have to be solved by adopting alternative technologies to chemical specific tools which suit low capital availability and minimum manpower. There has been a considerable interest in using aquatic plants for removal of various pollutants, including heavy metals, from water bodies because of their fast growth rate and simple growth requirements, which are favorably compared to those of fish (**Lewis1995**). Moreover, aquatic plants are particularly important in heavy metal pollution studies, since the analysis of these plants can give an indication of the state of water environment to which they have been exposed (**Hellawell1986**).

The pollution of the aquatic environment with heavy metals has become a

worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms (**MacFarlane, 2000**). Among the environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems (**Ottonello, D., 2006**).

The accumulation of heavy metals in freshwater ecosystem has been a major concern, heavy metals generally enter the aquatic environment through natural atmospheric deposition, erosion of geological matrix or anthropogenic activities caused by industrial effluent, domestic sewage, mining and agriculture wastes**, (Vautukuru. 2005**).

Fish being one of the main aquatic organisms in the food chain may often accumulate large amounts of certain metal above the levels in the aquatic environment **(Deb. Sandtra, 1997**).

Essentially fishes have been reported to assimilate these heavy metals through ingestion of suspended particulates, food materials and or by constant ion exchange process of dissolved metals across the lipophilic membranes such as the gills, absorption of dissolved metals on tissue and membrane surfaces (**Marzouk. 1994**). As a result metal bioaccumulation is a major route, thought which increased levels of the pollutants are transferred across food chain web creating public health problems wherever man is involved in the food chain therefore, it is important to always determine the bio accumulation capacity for heavy metals by organisms especially the edible ones, in order to assess the potential risk to human health (**Stroreli *et al*., 2005**).

Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, to be toxic to living organisms (**Storelli *et al.,* 2005**). Bioaccumulation and magnification is capable of leading to toxic level

of these metals in fish even when the exposure is low. The presence of metal pollutant in freshwater is known to disturb the delicate balance of the aquatic systems. Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play an important role in human nutrition, they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to man through fish consumption (**Adeniyi and Yusuf, 2007**). Anthropogenic activities continuously increase the amount of heavy metals in the environment, especially in aquatic ecosystem. Pollution of heavy metals in aquatic system is growing at an alarming rate and has become an important worldwide problem (**Malik *et al*., 2010**). Increase in population, urbanization, industrialization and agriculture Practices have further aggravated the situation (**Gupta *et al*., 2009**). As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals **(Linnik and Zubenko, 2000**) and thus, causing heavy metal pollution in water bodies (**Malik *et al*., 2010**).

Heavy metals from natural sources and anthropogenic activities are continually released into aquatic systems, causing serious threat because of their toxicity, bioaccumulation, long persistence and bio-magnification in the food chain **(Eisler, 1988).** Fish are considered as one of the most indicative factors, in freshwater ecosystems, for the estimation of trace metals pollution **(Rashed, 2001).**

Freshwater ecosystems support human life in numerous ways; on top of being a source of drinking water, rivers provide water for irrigation, industry, transport and many other aspects of food production and processing. Pollution of the aquatic environment by inorganic chemicals and heavy metals is a major threat to human health and to aquatic organisms (**Samir and Ibrahim 2008**). Heavy metals pollution in aquatic ecosystem is growing at an alarming rate and has

become an important worldwide problem (**Malik *et al.*, 2010**). According to the World Health Organization reports, about 5 million people die every year from drinking polluted water (**WHO, 2009**). Anthropogenic activities represent the major contributor to the contamination of aquatic environments. Drainage water containing pesticides and fertilizers, effluents of industrial activities, and sewage effluents contaminate water bodies and sediments with huge quantities of heavy metals. Heavy metal contamination is particularly significant in ecotoxicology since these metals are highly persistent and can bioaccumulate and biomagnify in the food chain, thus becoming toxic to living organisms at higher trophic levels (**Storelli *et al.* 2005**).

On the other hand, heavy metals are natural elements that occur in the earth crust. Some of these metals are necessary for human health and metabolic activities in trace amounts (**Smith, 2007**).While, others, such as mercury, cadmium, lead and chromium, are toxic even in low concentrations. Trace metals derived from natural inputs and anthropogenic emissions are ubiquitous in the global environment (**Milenkovic *et al.*, 2005**). Since heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals (**Linnik and Zubenko 2000**) and thus, causing heavy metal pollution in water bodies (**Malik *et al.*, 2010**). Therefore, metals that are deposited in aquatic environment accumulate in the food chain and pose a threat to human health due to biomagnifications over time (**Agah *et al.*, 2009**).

Aquatic organisms have been widely used in biological monitoring and assessment of safety levels of heavy metals in the environment (**Tiina *et al.*, 2006**). They have been reported to accumulate heavy metals in their tissues several times above ambient levels (**Canli and Atli, 2003**). Fish are often used as indicators of

heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are an important food source (**Agah *et al.*, 2009**).

Environmental pollution has become a major problem in all developed and developing countries in especially recent years. Pollutants in aquatic environments may dramatically reduce the water quality and adversely affect the aquatic organisms. Heavy metals which remain for a long time in the contaminated areas, give rise to toxic effects in aquatic organisms and accumulate in the food chain are of great importance because of their threat to human health. Concentrations of certain heavy metals in aquatic environments are in equilibrium for normal conditions. But waste discharges from industrial, urban and agricultural activities containing heavy metals may cause extreme increasing of toxic element accumulations in the aquatic habitats (**Tokatlı *et al.*, 2012a).**

River Nile and its tributaries White Nile and Blue Nile water quality is expected to be deteriorated gradually since a lot of human activities near the rivers banks and few kilometers from them have increased dramatically. Large amount of sewage due to increased population, excessive use of pesticides and fertilizers in agriculture, chemical and petrochemical industries and formal and informal gold mining are among the main activities expected to add chemical pollutants and negatively affect the chemical quality of the River Nile and its tributaries.

Khartoum state's main sources of water supply are the River Nile system and the ground water. Khartoum state is currently supplied about 52% by ground water and 48% by water extracted from the Nile River (**Haga and Glynn, 2013**).

Bastawy conduct a thesis to assess the water quality of the River Nile around Khartoum city, and investigates eventual influences of the city on the River Nile by analysis of temperature, pH, conductivity, adsorb- able organic halogen (AOX), cadmium (Cd), lead (Pb), chromium (Cr), total organic carbon (TOC) and nitrate

(NO-3). The analysis was carried out in 2006. It was concluded that the city Khartoum added small but legible concentrations of cadmium, lead, chromium and TOC to the River Nile. However, the resulting concentrations were all within acceptable levels. Also the observed results showed that the Blue and White Niles, which merge together upstream on the outskirts of Khartoum, had concentration of AOX and chromium which were not suitable for drinking water (**Bastawy.2007**)

(**Saeed 2000)** who found that heavy metals concentration showed seasonal variations, being greater in summer and lowest in winter and autumn. This may be attributed to the high temperature which is result in increasing water evaporation from the Nile. Or may be back to phytoplankton growth which was higher in autumn season that can absorb large quantities of heavy metals from water.

Cd is used in Nickel- Cadmium rechargeable batteries and for planting, also used in some paints, Plastic and ceramic **(WHO, 1993).** All these activities are found in Khartoum city Industrial areas nearest Soba and Alamab station and discharged in White Nile through sewage ponds or access the Nile throw the rain folds.

The reports for Zn and Cu were found to be 23.3–38.9 mg/kg and 3.7–8.2 l mg/kg respectively **(Aucoin *et al*, 1999).**

Elements from water are taken by fish through gills and the gastrointestinal tract, where they can be accumulated in inner organs, leading to pathological changes **(Cengiz *et al,* 2006)**

(**Haram.2016**) reported that concentrations of trace metals in fish muscles in White and Blue Nile rivers from different stations. Showed that, the maximum concentration of Cu, Cr, Pb and Zn, were observed in summer. While the minimum values were detected in autumn. While Cd and Fe showed no significance different in all seasons. Moreover, the highest concentrations of Cu were found in Jabal

Awlia station and the lowest value was found in Alamab in the White Nile while Cr represents the opposite. But Cd concentration was high in Adubaseen and lower in Alamab. In the Blue Nile all heavy metals were detected as the highest concentration from Soba station.

Oreochromis niloticus feeds mainly on phytoplanktons which accumulate large amounts of heavy metals while *Clarias gariepinus* feeds mainly on, insects and crustaceans. Moreover, *Clarias gariepinus* lives mainly in muddy or semimuddy bottom and *Oreochromis niloticus* wanders in water from surface to bottom, being frequently in contact with soil particles **(Saeed, 2000).**

CHAPTER THREE

3. MATERIAL AND METHODS

3.1 Description of the Study Area

Three fish collection sites, were designated as the first site w included two collection stations along White Nile River. The second site included two collection stations that had their water supply along the Blue Nile River. The third site included two collection stations along the Nile River main stream.

The first site was Jebel Aulia Dam which is a dam on the White Nile near the capital of Sudan, Khartoum.

The third site was Merowe Dam is a large dam near Merowe Town in northern Sudan, about 350 km (220 mi) north of the capital Khartoum. Its dimensions make it the largest contemporary hydropower project in Africa. It is situated on the river Nile, close to the 4thCataract where the river divides into multiple smaller branches with large islands in between. Merowe is a city about 40 km (25 mi) downstream from the construction site at Hamdab. The main purpose for building the dam was the generation of electricity.

3.2 Sampling Procedures

Water samples were taken randomly from each station regularly every month for one year (2015) sampling period. The samples were mixed together in a plastic container and analyzed for chemical and physical parameters. Samples of fish were taken also for measuring body weight composition, proximate analysis of fish muscles and carcass, heavy metals and fatty acids profiles.

3.3 Analytical Methods

Physio-chemical water quality parameters were measured using water kids aqua zool as follows;

3.3.1. PH:

- A Clean test tube was filled with 5 ml of water to be tested (to the line on the tube).
- Five drops of High Range pH Test solution were added, holding dropper bottle upside down in a completely vertical position to assure uniformity of drops.
- The test tube was caped and was inverted several times to mix solution.
- The test results were read by comparing the color of the solution to the appropriate High Range pH Color Card (choose either freshwater or Saltwater).

The tube was viewed in a well- lit area against the white area of the card. The closest match indicates the pH of water sample. The test tube was rained with clean water after use.

3.3.2. Alkalinity:

- Ten ml of water sample were taken in the test jar. 2 drops of **Ak1** were added. Mix well. If a pink color does not appears, this indicators P Alkalinity is nil. Then proceed to step No.4.
- If a pink color appears, this indicates presence P Alkalinity
- Then **Ak5** is added. Counting the number of drops while mixing until the pink color disappears (N drops).
- To this solution one spoonful of (provided herewith) **AK4 is** added. The sample will turn green.
- Then **AK5**$^{\#}$ is added counting the number of drops while mixing. Until the pink color change from green to reddish violet (N 1 drops).

  # if the expected Alkalinity is more than 100 ppm, then **AK6** will be used instead of **AK5**.

Calculations:

P Alkalinity ppm as $CaCo_3$ = 5 × (N. of drops of **AK5**)

M or Total Alkalinity ppm as $CaCo_3$ = 5 × (N+N1 drops of **AK5**)

P Alkalinity ppm as $CaCo_3$ = 25 × (N drops of **Ak6**)

M or Total Alkalinity ppm as $CaCo_3$ = 25× (N+N1 drops of **AK6**)

3.3.3. Dissolved Oxygen:

Range: 0.65 – 7.8 ppm

I.D.O. Fixing: the dissolved Oxygen requires to be fixed before testing.

- The **D.O**. test bottle was rinsed 2-3 times with sample water. Filled till it overflows with the sample water and then stoppered the bottle and ensure that no air bubbles are trapped inside.
- 10 drops of **D.O.1** was added followed by 10 drops of **D.O.2**. Mixed well. Wait for a minute. A brown precipitate was formed and start setting. Firmly stopper the bottle and shake the contents thoroughly. Then put bottle in a safe place for a minimum of 20 minutes.
- 10-12 drops of **D.O.3** were added. The stopper is replaced and bottle was shaken till the precipitate dissolves. Add more drops if required to dissolve the precipitate.

Now this sample is used for testing.

II. D.O. determination:

1. 10 ml. of sample (from step 3 of **D.O**. fixing) were taken in the test jar.

2. 4 drops of D.O.4.were added mixed well.

3. **D.O.5**, were added counting the number of drops while mixing, until the blue color disappears.

Calculation:

Dissolved Oxygen ppm = 0.65 × [No. of drops of **D.O.5**]

Where 0.65 ≡ constant

3.3.4. Total hardness:

- A clean test tube was rinsed with water to be tested.
- The test tube was filled with 5ml of water to be tested (to the line on the tube).
- Holding the bottle vertically, add general hardness Test Solution, one drop at a time. Be sure to count the number of drops being added.
- The test tube was capped invert several times after each drop.
- The test is completed when the water in the test tube, after having been shaken, turns from orange to green. If have difficulty discerning the color after the first drop of test solution is added, remove the cape from the test tube and, while holding it over a white background, look down though the tube.
- The general hardness value is determined by the number of drops of reagent that must be added to turn the water in the test tube green.

Use the table below to create the ideal water hardness level for your aquarium fish. When keeping a community with a variety of tropical fish, adjust general hardness and water hardness to 3- 6˚(50 – 100 ppm).

3.3.5. Total ammonia (NH_3/NH_4)

- A clean tube was filled with 5 ml of water to be tested (to the line tube).
- 8 drops from Ammonia Test Solution Bottle #1 were added, holding the dropper bottle upside down in a completely vertical position to assure uniform drops.
- Add eight drops from Ammonia Test Solution Bottle #2, holding the bottle upside down in a completely vertical position to assure uniform drops.
- The test tube capped and shakes vigorously for 5 seconds.
- Wait 5 minutes for the color to develop.
- The test results were read by comparing the color of the solution to the appropriate Ammonia Color Card (use the fresh water color card). The tube

should be viewed in a well – lit area against the white area of card. The closest match indicates the ppm (mg/l) of ammonia in the water sample. the test tube was rinsed with clean water after use.

3.3.6. Nitrate (NO_3^-):

1. A clean tube with was filled with 5 ml of water to be tested (to the line tube).

- 10 drops from Nitrate Test Solution Bottle #1 was added, holding the dropper bottle upside down in a completely vertical position to assure uniform drops.
- The test tube was capped and inverts tube several times to mix solution.
- Vigorously shake the Nitrate Test Solution Bottle #2, for at least 30 seconds. This step is extremely important to ensure accuracy of test results.
- Now add 10 drops from Nitrate Test Solution Bottle #2, holding the dropper bottle upside down in a completely vertical position to assure uniform drops.
- Cap the test tube and shake vigorously for 1 minute. This step is extremely important to ensure accuracy of test results.
- Wait five minutes for the color to develop.
- The test results were read by comparing the color of the solution to the appropriate Nitrate Color Card (use the fresh water color card). The tube should be viewed in a well – lit area against the white area of card. The closest match indicates the ppm (mg/l) of Nitrate in the water sample. Rinse the test tube with clean water after use.

3.3.7. Phosphate (PO_4^{3-}):

1. A clean test tube was rinsed with water being tested.
2. A clean tube was filled with 5 ml of water to be tested (to the line tube).
3. Holding the bottle vertically, 6 drops Phosphate Test Solution Bottle #1were added. Cap the test tube and shake vigorously for 5 seconds.
4. The bottle vertically was then holds, add 6 drops from Phosphate Test Solution

Bottle #2. Contains a very thick solution and may require increased pressure to release drops.

5. The test tube was capped and shaken vigorously for 5 seconds.

- Wait 3 minutes for the color to develop.
- The test results were read by comparing the color of the solution to the appropriate Phosphate Color Card (use the fresh water color card). The tube should be viewed in a well – lit area against the white area of card. The closest match indicates the ppm (mg/l) of total Phosphate (PO_4^{3-}) in the water sample. The test tube was rinsed with clean water after use.

3. 4.Proximate Composition Analysis

Monthly samples were collected from each station representing the three different locations; twelve fish from each water source were sacrificed for the proximate analysis. Analysis of fish flesh and carcass for moisture, crude protein, fat, ash and amino acids were determined by standard methods according to AOAC (2005; NRC, 2011),the fatty acid profiles of experiment were analyzed by using Gas liquid Chromatography (GLC).The nitrogen free extract was calculated by difference N.F.E = 100 - (moisture + protein + lipid + fiber +ash), the gross energy (kcal/kg diet) were calculated using factor 5.64, 9.44 and 4.11 for crude protein and fat, respectively according to **NRC 2011)**.

Moisture content, crude protein, fat and ash were determined for wet sample according to standard methods of Association of Official Analytical Chemists **(AOAC) (2005**) as follows:

3.4.1 Moisture Content Determination:

The samples were first weighed (Initial weight) then dried in an electric oven at 1050C for 24-30 hours to obtain a constant weight. The moisture content was calculated as follows:-

Moisture content (%) = $\frac{\text{Initial weight – Dry weight}}{\text{Initial weight}} \times 100$

3.4.2 Crude Protein Determination:

The Kjeldal method for estimation of nitrogen was applied. Nitrogen content was converted to protein percentage by multiplying by 6.25 as follows:

Protein % = $\frac{(Va - Vb) \times N \times 14 \times 6.25}{1000 \times Wt} \times 100$

Where Va = volume of HCL used in titration

Vb = volume of sodium hydroxide of known normality used in back titration

14 = conversion factor of ammonium sulfate to nitrogen

Z\|z6.25= conversion factor of nitrogen to protein

Wt= weight of sample

N= normality of NaoH

3.4.3 Crude Fat Determination:

Fat content of each sample was determined according to Soxhlet method by ether extract using two gm of fish samples. Extraction continued for 5 hours at 100 0C before finding the weight of the extract fat. Fat percentage was then calculated as follows:

Fat % = $\frac{\text{Extracted fat weight} \times 100}{\text{Sample weight}}$

3.4.4 Ash Content Determination:

Ash was determined by heating one gm at 5500C in muffle furnace until a constant weight was obtained. Ash content percentage was given by the following formula:

Ash % = $\frac{\text{Ash weight} \times 100}{\text{Sample weight}}$

3.6 Detection of Heavy Metals

3.6.1 Preparation and analysis of fish

Twelve fresh samples of *O. niloticus* were taken randomly from each station regularly every month for year sampling period. The samples stored in ice container and transferred to the Soba Laboratory Center in Khartoum State for preparation and processing for measuring heavy metals.

Each fish sample was collected from each locality up and down stream dissected for its muscle tissues. The flesh samples were dried using electric oven at 105c for at least 9 hours till constant weight was achieved. Dry sample was grinded using manual porcelain mortar.

About five (g) from wet organ (muscle) were dried, ignited and digested with concentrated HNo_3 and HCl. The heavy metals Cu, Zn, Cd and Pb in water and flesh were measured using atomic absorption spectrophotometer (Thermo 6600, thermo electron corporation, Cambridge, UK).

3.6.2 Determination of heavy metals

Two (g) of powder sample were weighed into a silica evaporating (crucible of known weight), place then transfer to the crucible on a hot plate and allow smoking until completely charred then transfer to muffle furnace at 470c and ashed at this temperature for three hours. When ashing was complete, then cooled and extracted, with minimum amount of hydrochloric acid. Evaporated to dryness, extracted again with 10ml of 25% HCL, boiled and filtered into 100ml calibrated flask, the filter washed through with warm 1%HCL, and solution made up to 100ml with water and mix. This solution was used for the determination of heavy metals. The procedure used was followed according to **(Olaifa *et al*,(2004)).** The instrument which was adopted for the readings the two trace elements was the atomic

Absorption Spectrometer (AAS) A Analyst 700. All tools were made of stainless steel to avoid contamination with metal residues.

3.7 Statistical Analysis

Statistical analysis were performed using one way (ANOVA) Analysis of variance and Duncan's multiple Range Test, to determine differences between treatments means at significance rate of $P < 0.05$. The standard deviation of treatment means were be also estimated. All statistics were carried out using Statistical Analysis program (SPSS, 19).

CHAPTER FOUR
4. RESULTS

4.1 Water characteristics

The physical and chemical water characteristics were studied in the three localities Jebel Aulia, Sennar and Merowe dams both upstream and downstream showing tables 1 to 3 and Figures 1 to 3 illustrate the comparison of the parameters in three localities during the three seasons winter, autumn and summer.

Table 1 Means values and SD of water quality characteristics of the three sites in summer season from March to June

	Jebel Aulia Dam		**Sennar Dam**		**Merowe Dam**	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
pH	8.2±0.07[a]	8.2±0.07[a]	8.2±0.28[a]	7.8±0.21[a]	8.3±0.21[a]	7.4±0.00[a]
D.O (mg/l)	3.5±0.46[a]	4.1±0.21[a]	6.8±0.35[b]	9.5±0.42[c]	3.8±0.21[a]	5.4±0.71[b]
NH_4(ppm)	0.1±0.07[a]	0.8±0.35[b]	0±0.00[a]	0±0.00[a]	0.1±0.07[a]	0±0.00[a]
No_2(ppm)	0±0.00[a]	0±0.00[a]	0±0.00[a]	0.1±0.07[a]	0±0.00[a]	2.8±3.18[b]
Alkalinity(ppm)	136.6±2.12[a]	139±1.41[a]	151±1.41	153±4.24	149±1.41[b]	167.5±10.61
Hardness(ppm)	122.5±3.54[b]	138±2.83[c]	141±1.41[c]	115±7.07[a]	146±8.49[d]	175±35.36[e]
Phosphorus(ppm)	0.4±0.14[a]	5.5±6.36[c]	0.3±0.07[a]	4±1.41[c]	1.1±0.14[b]	0.3±0.28[a]

[a,b,c,d] Means ±SEM in the same raw bearing the same superscripts are significantly different ($p<0.05$).

The results, as shown in table 1and figure1, indicated that, there were a significant difference at ($p \leq 0.5$) level for pH in all conditions both upstream and downstream. While there were a significant difference in the three localities between D.O, ammonia, nitrate, alkalinity and phosphorus both upstream and downstream during summer season. D.O is higher in Sennar dam and lower in Jebel Aullia, while alkalinity is higher in Merowe and lower in Jebel Aullia, on other hand hardness is higher in Merowe and lower in Sennar dam, phosphorus is

higher in Jebel Aullia and lower Merowe downstream in summer season.

Table 2 Means values (+SD) of water quality characteristics (ml/l) for each site in the autumn season from Jully to October

Parameters	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
	Upstream	Downstream	Upstream	Downstream	Upstream	downstream
pH	7.9±0.07[a]	8.2±0.21[a]	7.8±0.35[a]	7.9±0.14[a]	8.1±0.14[a]	7.3±0.28[a]
D.O(mg/l)	3.6±0.07[a]	4.1±0.14[a]	6.3±0.35[b]	9.3±1.56[c]	4.1±0.49[a]	4.5±0.49[a]
NH_4(ppm)	0±0.00[a]	1.2±0.07[b]	0±0.00[a]	0±0.00[a]	0.1±0.07[a]	0±0.00[a]
No_2(ppm)	0.1±0.07[a]	0.1±0.07[a]	0.1±0.07[a]	0±0.00[a]	0.1±0.14[a]	1.5±0.07[a]
Alkalinity(ppm)	139.5±0.71[b]	141±1.41[b]	100±0.00[a]	162.5±3.54[d]	151±1.41[c]	173±4.24[e]
Hardness(ppm)	126.5±2.12[a]	140±1.41[b]	185±7.07[c]	192.5±3.54[d]	141±1.41[b]	195±7.07[d]
Phosphorus(ppm)	0.2±0.14[a]	0.1±0.07[a]	0.1±0.07[a]	0.1±0.07[a]	0.6±0.57[a]	0.5±0.14[a]

[a,b,c,d,e]Means ±SDin the same raw bearing the same superscripts are significantly different ($p<0.05$).

The results, as shown in table 2, indicated that, There was no significance differences between pH upstream while, there were a significant different in pH downstream, further analysis were showed that there were significant difference between D.O both upstream and downstream ,while, there were significant different between ammonia, nitrate and phosphorus in three conditions both upstream and downstream during autumn season, The pH is higher in Jebel Aullia while lower in Merowe dam, D.O is higher in Sennar dam while lower in Merowe dam, nitrate was higher in Merowe dam while lower Jebel Aullia dam, alkalinity is higher in Merowe dam while lower in Jebel Aullia and hardness is higher in Merowe dam while was lower in Jebel Aullia dam downstream autumn season. Alkalinity is higher in Merowe and lower in Sennar dam, on other hand hardness was higher in Sennar dam and lower in Jebel Aullia dam.

Table 3 Means values (+SD) of water quality characteristics from each site in the winter season in from November to Februrary.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
pH	8.1±0.42[a]	7.9±0.14[a]	7,9±0.28[a]	7.6±0.28[a]	7.8±0.35[a]	7.9±0.07[a]
D.O(mg/l)	5.6±0.49[b]	6.7±0.28[b]	3.8±0.67[a]	3.6±0.46[a]	6.2±0.49[b]	7.4±0.21[b]
NH_4(ppm)	0.3±0.03[a]	0.3±0.08[a]	0.2±0.04[a]	0.2±0.03[a]	0.3±0.04[a]	0±0.00[a]
No_2(ppm)	0±0.00[a]	0±0.00[a]	0±0.00[a]	0±0.00[a]	0.1±0.07[a]	0±0.00[a]
Alkalinity(ppm)	105±7.07[a]	129±12.73[c]	173.5±2.12[d]	110±14.14[b]	125±0.00[c]	110±14.14[b]
Hardness(ppm)	110±14.14[a]	149±1.41[c]	155±7.07[d]	149±1.41[c]	135.5±0.71[b]	153±4.24[d]
Phosphorus(ppm)	0.4±0.14[a]	0.4±0.21[a]	0.2±0.04[a]	1.9±1.56[b]	0.2±0.07[a]	0.2±0.21[a]

[a,b,c,d]Means ±SEM in the same raw bearing the same superscripts are significantly different ($p<0.05$).

There were no significant differences between pH in the three localities upstream, while, there were significant differences between pH in the three localities down stream during winter season , the mean score for D.O were significant different in the three conditions both upstream and downstream during winter season which is higher in Merowe dam and lower in Saner dam , on other hand ammonia and nitrate showed no significant difference, while there were significant differences in the three conditions upstream and downstream in alkalinity which is higher in Sennar dam and lower in Jebel Aullia dam upstream also, alkalinity is higher in Merowe dam and lower in Sennar dam downstream ,and hardness which higher in Sennar dam and lower in Jebel Aullia dam upstream while hardness was high in Merowe and low in Sennar , on other hand ammonia, nitrate and phosphorus was not statistically differences from areas upstream during winter season. Phosphorus was higher in Sennar than the two conditions downstream during winter season.

4.2 Body weight characteristics

The body weight characteristics of *O. niloticus* in summer; autumn and winter seasons was compared in the fish collected from different sites (Table 4-6).

Table 4 Means values ±SD and yields percentages of *O. niloticus* in the summer season in different habitats.

Habitats (Dam)		Body weight characteristics %			
		HW	VW	SF	F
Jebel Aulia	Upstream	22.2±2.0[a]	4.9±1.75[c]	19.05±1.69[a]	45.9±5.60[b]
	Downstream	24.2±3.4[a]	7.5±2.80[a]	20.2±4.10[a]	44.5±6.50[a]
Sennar	Upstream	21.8±1.87[a]	15.6±6.54[a]	19.7±0.46[a]	45.5±0.79[b]
	Downstream	23.8±2.05[a]	6.7±2.05[b]	19.8±1.18[a]	45.0±2.82[a]
Merowe	Upstream	21.4±4.01[a]	8.7±4.19[b]	16.67±2.91[b]	47.10±4.51[a]
	Downstream	19.4±3.50[b]	8.0±1.80a	18.66±3.46[b]	43.09±9.2[b]

From table (4 to 6),[a,b,c]: Mean in the same colum with superscript are significant different at ($p \leq 0.05$), whereas: HW= Head weight, VW= Viscera weight, SF = skeleton and fins, F=Fillet

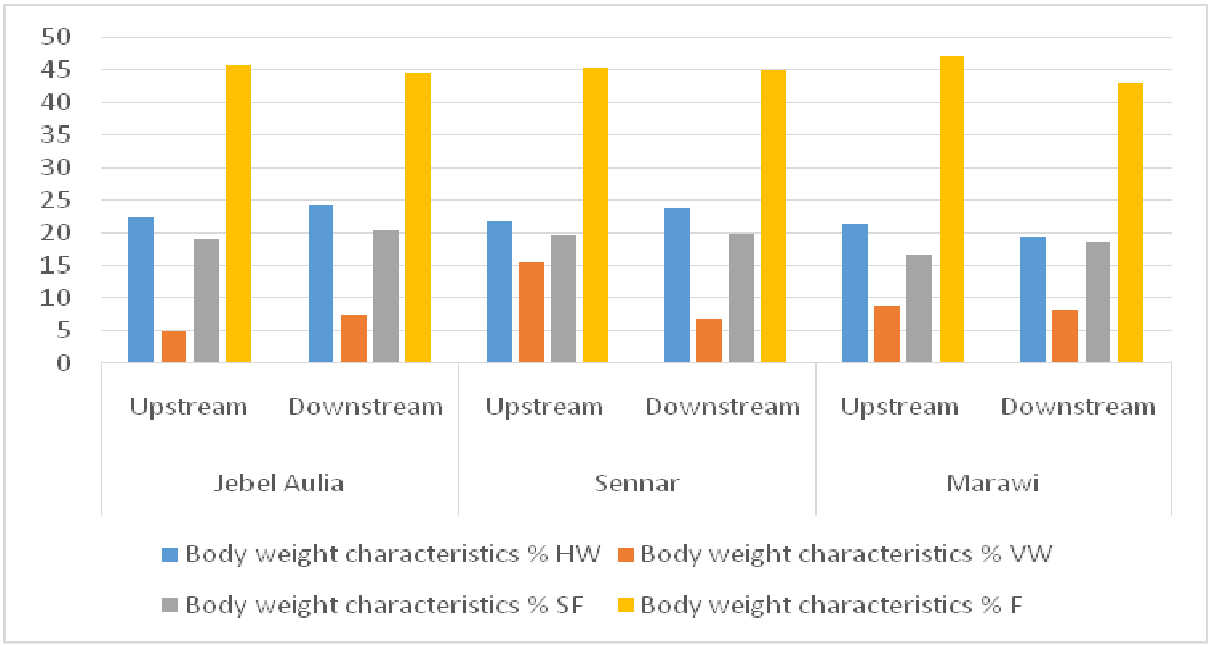

Figure 1 Means values ±SD and the yields percentages of *O.niloticus* in the summer season in different habitats.

The results, as showed in table 4 figure4, indicated that there were significant difference in all body weight characteristics of the studied fish between the three sites upstream and downstream in summer season,

Table 5 Means values+ SD and yields percentages of *O. niloticus* in the autumn season in different habitats.

Habitats (Dam)		Body weight characteristics %			
		HW	VW	SF	F
Jebel Aulia	Upstream	28.41±3.13[a]	7.41±1.15a	23.10±2.62[a]	35.68±2.27[c]
	Downstream	30.04±3.10[a]	9.60±2.62[a]	21.58±1.50[b]	31.78±3.05[c]
Sennar	Upstream	27.88±5.19[a]	8.28±3.91[a]	21.25±2.56[b]	39.20±0.93[b]
	Downstream	29.99±2.73[a]	8.57±0.69[a]	23.05±3.73[a]	36.65±3.97[c]
Merowe	Upstream	28.90±3.02[a]	6.86±2.00[b]	19.53±1.15[b]	42.79±1.92[a]
	Downstream	28.82±0.68[a]	6.42±1.55[b]	19.53±1.35[b]	42.55±6.69[a]

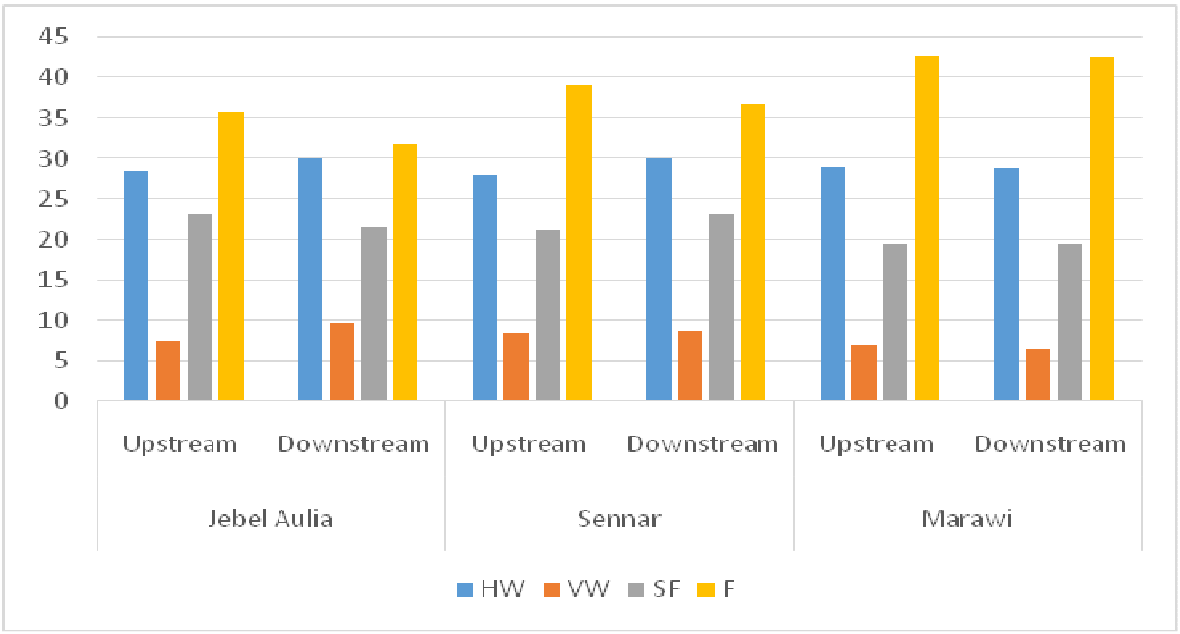

Figure 2 Means ±SD values and the yields percentages of O. niloticus in the autumn season in different habitats.

The mean score of the body weight characteristics of the studied fish table 5 figure 5, reveled that, there were statistical significant difference in all parameters between the three sites in summer season up and downstream

Table 6 Means values+ SD and yields percentages of *O. niloticus* in the winter season in different habitats.

Habitats (Dam)		Body weight characteristics %			
		HW	VW	SF	F
Jebel Aulia	Upstream	30.25±0.48^{a}	10.61±3.59^{a}	19.16±1.60^{b}	40.71±2,66^{a}
	Downstream	30.36±2.20^{a}	6.22±1.48^{b}	19.83±1.50^{b}	39.53±1.63^{a}
Sennar	Upstream	30.81±3.03^{a}	4.77±0.68^{b}	24.99±5.12^{a}	37.02±1.69^{b}
	Downstream	30.11±1.67^{a}	5.20±1.14^{c}	22.72±1.24^{a}	36.51±0.14^{b}
Merowe	Upstream	25.68±12.91^{b}	9.60±0.51^{a}	19.29±2.11^{b}	41.84±7.59^{a}
	Downstream	29.35±12.13^{a}	9.36±3.27^{a}	18.70±1.35^{b}	39.80±6.75^{a}

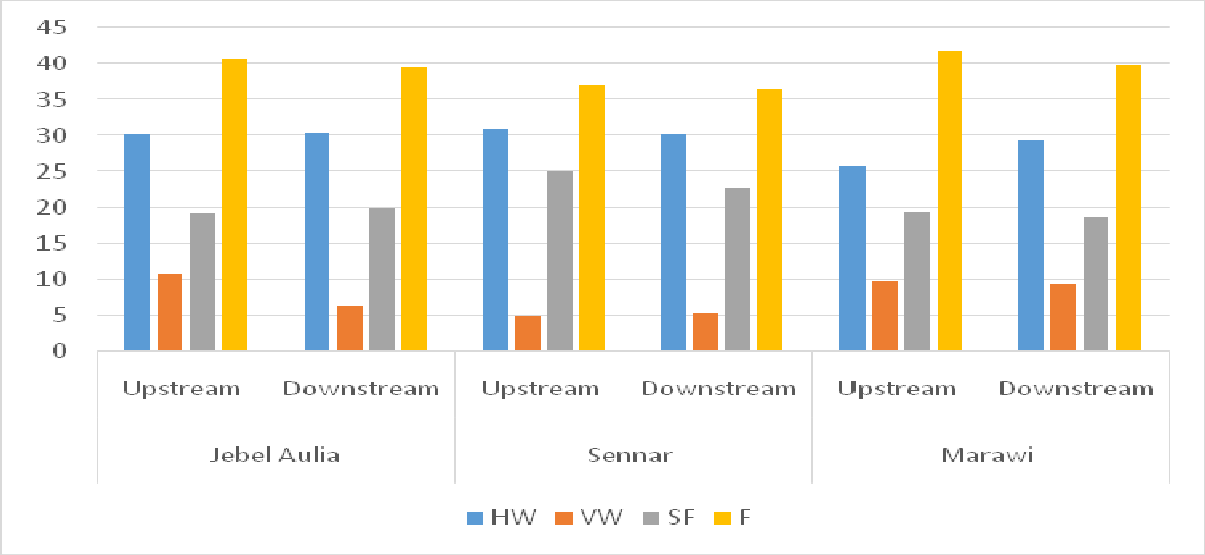

Figure 3 Means values ± SD and the yields percentages of *O. niloticus* in the winter season in different habitats.

There were significant differences between body weight characteristics of the studied fish in the three sites in winter season both upstream and downstream table 6, figure 6.

4.3 Chemical composition

Chemical composition of *O.niloticus* in summer, autumn and winter seasons was compared in these fish from different sites (Tables 7- 9 and figures 7-9) showed different variations in the chemical composition (M, DM, CP, Ash, E.E and NFE).

Table 7 Means values ± SD illustrate approximate chemical composition (%) of *O.niloticus* in summer season.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
Moisture	75.50 ± 3.08^{b}	77.00 ± 0.89^{c}	75.00 ± 2.6^{b}	76.50 ± 1.51^{a}	71.33 ± 1.96^{a}	76.50 ± 1.04^{b}
DM	24.50 ± 3.08^{b}	23.00 ± 0.89^{a}	25.50 ± 1.5^{b}	23.50 ± 1.51^{a}	28.66 ± 1.96^{c}	23.50 ± 1.04^{a}
CP	30.33 ± 0.55^{a}	31.05 ± 0.57^{b}	32.00 ± 0.7^{c}	31.02 ± 0.56^{b}	32.77 ± 0.37^{c}	31.25 ± 0.38^{b}
Ash	1.28 ± 0.14^{a}	1.20 ± 0.15^{a}	1.48 ± 0.3^{a}	1.53 ± 0.32^{a}	1.06 ± 0.08^{a}	1.21 ± 0.07^{a}
EE	7.05 ± 0.18^{a}	7.00 ± 0.23^{a}	7.53 ± 0.1^{a}	7.21 ± 0.23^{a}	7.46 ± 0.16^{a}	7.05 ± 0.12^{a}
NFE	36.81 ± 2.81^{c}	37.75 ± 1.43^{c}	33.98 ± 3.3^{b}	36.88 ± 2.07^{c}	30.03 ± 1.85^{a}	36.40 ± 1.63^{c}

From table (7 to 9),^{a,b,c}: Mean in the same raw with superscript are significant different at ($p\leq0.05$), DM = Dry matter, CP = Crude protein, EE = Esther extract, NFE = Nitrogen free extract.

There was significant difference between moisture in Jebel Aulia downstream (77.00±0.89) higher than others areas, Sennar and Merowe both upstream and downstream. Furthermore, dry matter and crude protein in upstream Merowe dam was very higher (28.66±1.96 and 32.77±0.37) than others areas means there were significance difference within groups. While, no significant differences were found between ash and esther extract in all sites areas and within groups. The mean values for nitrogen free extract were higher Jebel Aulia

upstream (36.81±2.81), downstream for Sennar dam and Merowe dam (36.88±2.07 and 36.40±1.63) respectively.

Table 8 Means values ± SD illustrate approximate chemical composition (%) of O. niloticus in autumn season.

Parameters	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
	Upstream	Downstream	Upstream	Downstream	Upstream	downstream
Moisture	74.44+1.46^{b}	77.64+1.06^{c}	71.46+3.36^{a}	73.23+2.18^{b}	73.00+2.19^{b}	76.33+1.36^{c}
DM	25.55+1.46^{b}	23.69+2.60^{a}	28.36+3.31^{c}	30.10+4.61^{d}	27.00+2.19^{b}	23.66+1.36^{a}
CP	31.62+0.54^{b}	30.88+0.59^{a}	31.49+0.53^{b}	30.80+0.33^{a}	32.95+0.30^{b}	31.03+0.49^{b}
Ash	1.11±0.11^{a}	1.26±0.05^{a}	1.13±0.12^{a}	1.21±0.11^{a}	1.15±0.10^{a}	1.15±0.10^{a}
EE	7.20±0.23a	7.35±0.18^{a}	7.03±0.18^{a}	7.26±0.18^{a}	7.51±0.14^{a}	7.15±0.18^{a}
NFE	34.50±1.58^{b}	38.21±1.20^{c}	31.71±4.08^{a}	30.61±4.58^{a}	31.25±2.24^{a}	37.13±1.62^{c}

^{a,b,c}: Mean in the same raw with superscript are significant different at ($p \leq 0.05$), DM = Dry matter, CP = Crude protein, EE = Esther extract, NFE = Nitrogen free extract.

The results, as shown (Table 8), indicated that, there was significant difference between moisture, dry matter, nitrogen free extract and crude protein of *O. niloticus*, in Jebel Aulia, Sennar dam and Merowe dam, and also within groups upstream and downstream, this result was significant at the p = 0.05 level. While, no significant differences were found between ash and esther extract in all sites areas and within groups.

Table 9 Means +SD illustrate approximate chemical composition (%) of *O.niloticus* in winter season.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
Moisture	74.83±3.37[b]	76.00±1.41[b]	69.50±1.3[a]	69.70±1.70[a]	85.16±1.72[c]	85.66±2.06[c]
DM	25.00±3.16[b]	24.00±1.41[b]	30.56±1.3[c]	30.28±1.71[c]	14.83.±1.7[a]	14.33±2.06[a]
CP	27.96±0.63[a]	27.85±0.62[a]	30.03±0.7[b]	29.43±0.96[b]	31.53±0.97[b]	30.73±0.32[b]
Ash	3.33±0.81[a]	2.50±0.54[a]	2.16±0.1[b]	2.18±0.14[a]	2.91±0.73[a]	2.86±0.35[a]
EE	6.35±0.81[a]	6.36±0.54[a]	6.10±0.08[a]	5.88±0.14[a]	6.75±0.18[a]	6.88±0.14[a]
NFE	37.35±4.22[b]	39.28±1.09[b]	31.20±1.4[a]	32.21±1.42[a]	43.96±1.50[c]	44.35±2.18[c]

[a,b,c]: Mean in the same raw with superscript are significant different at ($p \leq 0.05$), DM = Dry matter, CP = Crude protein, EE = Esther extract, NFE = Nitrogen free extract.

There was significant difference between moisture, dry matter and nitrogen free extract of *O. niloticus*, in Jebel Aulia, Sennar dam and Merowe dam but no significance difference within group that to say in upstream and downstream. Mean of crude protein is very high in Sennar and Merowe dam, this result is significant at the $p \leq 0.05$ level. While, no significant differences were found between ash and Esther extract in all localities areas and within groups.

4.4Amino acids

Amino acids percentage of *O.niloticus* in summer, autumn and winter seasons were compared in these fish from different sites are shown in (Tables 10-12).

Table 10 Means +SD illustrate amino acids (%) of *O.niloticus* in summer seasoncalculated according to (Furuya et al., 2010; NRC, 2011) reported for Nile Tilapia.

	Localities					
	Jebel Aullia		**Sennar**		**Merowe**	
	Up stream	**Down stream**	**Up stream**	**Down stream**	**Up stream**	**Down stream**
Arginine, %	0.6±0.01[c]	0.4±0.28[b]	0.6±0.01[c]	0.06±0.01[a]	0.63±0.01[c]	0.62±0.01[c]
Histidine, %	0.04±0.0[a]	0.01±0.0[a]	0.01±0.0[a]	0.02±0.01[a]	0.0±0.0[a]	0.02±0.00[a]
Isoleucine %	0.08±0.0 [b]	0.02±0.01[a]	0.0±0.0 [a]	0.04±0.0 [a]	0.01±0.0 [a]	0.03±0.00 [a]
Leucine %	0.04±0.0 [b]	0.04±0.0 [b]	0.0±0.0 [a]	0.07±0.0 [c]	0.02±0.0 [a]	0.05±0.00 [b]
Lysine %	0.15±0.0 [c]	0.03±0.02 [a]	0.0±0.0 [a]	0.06±0.0 [b]	0.01±0.0 [a]	0.03±0.00 [a]
Methionine %	0.06±0.0 [b]	0.00±0.0 [a]	0.0±0.0 [a]	0.01±0.0 [a]	0.0±0.0 [a]	0.01±0.00 [a]
Cystine %	0.0±0.0 [a]	0.00±0.00 [a]	0.0±0.0 [a]	0.01±0.0 [a]	0.0±0.0 [a]	0.01±0.00 [a]
Phenylalnine %	0.08±1.39[b]	0.02±0.01[a]	0.0±0.0[a]	0.01±0.0[a]	0.01±0.0[a]	0.04±0.00[a]
Tyrosine %	0.07±0.0 [b]	0.01±0.01[a]	0.02±0.01[a]	0.03±0.0[a]	0.0±0.0[a]	0.02±0.00[a]
Threonine %	0.00±0.0[a]	0.02±0.01[a]	0.0±0.0[a]	0.3±0.0 [c]	0.01±0.0[a]	0.03±0.00 [b]
Tryptophan %	0.00±0.0[a]	0.00±0.00[a]	0.0±0.0[a]	0.01±0.0[a]	0.0±0.0[a]	0.01±0.00[a]
Valine %	0.10±0.0 [b]	0.03±0.02[a]	0.0±0.0[a]	0.4±0.0 [c]	0.0±0.0[a]	0.04±0.00 [a]

[a,b,c,] Means±SEM in the same column bearing the same superscripts are significantly different ($p<0.05$).

The results, as shown in Table 10, indicate that, there no significant differences were found between Arginine in upstream for all localities, while there were significant difference between Arginine in downstream. There were significant differences between Isoleucine, Leucine, Lysine and Methionine in Jebel Aulia both upstream and downstream. There were significance difference found between, Phenylalnine, Tyrosine and Valine in Jebel Aulia while, no significance difference for others localities. In addition, no significant differences were found between Cystine, Threonine, and Histidinein all localities areas.

Table 11 Means +SD illustrate amino acids (g) of O.niloticus in autumn season.Calculated according to (Furuya et al., 2010; NRC, 2011) reported for Nile Tilapia.

	Localities					
	Jebel Aullia		Sennar		Merowe	
	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream
Arginine, %	0.6±0.02[a]	0.60±0.01[a]	0.60±0.02[a]	0.60±0.02[a]	0.60±0.01[a]	0.62±0.01[a]
Histidine, %	0.05±0.0[c]	0.02±0.0[a]	0.02±0.0[a]	0.02±0.00[a]	0.01±0.0[b]	0.02±0.00[a]
Isoleucine %	0.08±0.0[b]	0.01±0.01[a]	0.01±0.0[a]	0.03±0.0[a]	0.02±0.0[a]	0.02±0.00[a]
Leucine %	0.14±0.0[d]	0.02±0.01[a]	0.02±0.0[a]	0.06±0.0[b]	0.03±0.0[c]	0.04±0.00[c]
Lysine %	0.14±0.0[c]	0.04±0.03[b]	0.02±0.0[a]	0.05±0.0[b]	0.02±0.0[a]	0.03±0.00[a]
Methionine %	0.06±0.0[b]	0.03±0.02	0.00±0.0[a]	0.01±0.0[a]	0.00±0.0[a]	0.01±0.00[a]
Cystine %	0.0±0.0[a]	0.00±0.00[a]	0.00±0.0[a]	0.01±0.0[a]	0.00±0.0[a]	0.01±0.00[a]
Phenylalnine %	0.08±0.0[c]	0.00±0.00[a]	0.01±0.0[a]	0.04±0.0[b]	0.02±0.0[a]	0.04±0.00[b]
Tyrosine %	0.07±0.0[c]	0.02±0.01[a]	0.03±0.0[b]	0.03±0.0[b]	0.3±0.0[b]	0.01±0.00[a]
Threonine %	0.08±0.0[c]	0.02±0.00[a]	0.01±0.0[a]	0.3±0.0[b]	0.01±0.0[a]	0.02±0.00[a]
Tryptophan %	0.00±0.0[a]	0.02±0.00[b]	0.00±0.0[a]	0.01±0.0[a]	0.00±0.0[a]	0.1±0.00[a]
Valine %	0.10±0.0[c]	0.03±0.02[b]	0.02±0.0[a]	0.04±0.0[b]	0.02±0.0[a]	0.03±0.00[b]

[a,b,c,d]Means±SEMin the same column bearing the same superscripts are significantly different ($p<0.05$).

There were no significant differences between Arginine in three localities whether upstream or downstream. While, there were a significant difference between the two conditions upstream in Jebel Aullia and upstream in Merowe in Histidine. On other hand, Isoleucine is difference from areas. The mean score for Leucine were significance different for upstream and downstream from three different areas. Further analysis showed that there were significance different for

Lysine, Methionine, Cystine, Cystine, Phenylalnine, Tyrosine, Threonine, Tryptophan and Valine respectively in three localities areas both upstream and downstream. (As shown in Table 11 above).

Table 12 Means +SD illustrate amino acids (g) of O.niloticus in winter season. Calculated according to (Furuya et al., 2010; NRC, 2011) reported for Nile Tilapia.

	Localities					
	Jebel Aullia		**Sennar**		**Merowe**	
	Up stream	**Down stream**	**Up stream**	**Down stream**	**Up stream**	**Down stream**
Arginine, %	0.56±0.02^{b}	0.58±0.02^{c}	0.54±0.02^{b}	0.06±0.01^{a}	0.58±0.01^{c}	0.06±0.01^{a}
Histidine, %	0.05±0.0^{b}	0.01±0.0^{a}	0.01±0.0^{a}	0.01±0.00^{a}	0.02±0.0^{a}	0.00±0.00^{a}
Isoleucine %	0.08±0.0^{c}	0.02±0.0^{a}	0.02±0.0^{a}	0.00±0.0^{a}	0.03±0.0^{a}	0.02±0.00^{a}
Leucine %	0.14±0.0^{d}	0.02±0.01^{a}	0.02±0.0^{a}	0.00±0.0^{a}	0.06±0.0^{c}	0.00±0.00^{a}
Lysine %	0.15±0.0^{c}	0.04±0.03^{b}	0.05±0.0^{b}	0.00±0.0^{a}	0.05±0.0^{b}	0.00±0.00^{a}
Methionine %	0.06±0.0^{c}	0.04±0.02^{b}	0.01±0.0^{a}	0.00±0.0^{a}	0.01±0.0^{a}	0.00±0.00^{a}
Cystine %	0.0±0.0^{a}	0.01±0.00^{a}	0.01±0.0^{a}	0.00±0.0^{a}	0.04±0.0^{b}	0.00±0.00^{a}
Phenylalnine %	0.09±0.04^{c}	0.01±0.00^{a}	0.03±0.0^{b}	0.00±0.0^{a}	0.03±0.0^{b}	0.01±0.00^{a}
Tyrosine %	0.07±0.00^{c}	0.02±0.00^{b}	0.02±0.0^{b}	0.00±0.0^{a}	0.3±0.00^{b}	0.00±0.00^{a}
Threonine %	0.08±0.0^{c}	0.00±0.00^{a}	0.03±0.0^{b}	0.0±0.0^{a}	0.02±0.0^{a}	0.01±0.00^{a}
Tryptophan %	0.00±0.0^{a}	0.00±0.00^{a}	0.04±0.0^{b}	0.00±0.0^{a}	0.01±0.0^{a}	0.0±0.00^{a}
Valine %	0.10±0.0^{c}	0.03±0.02^{b}	0.04±0.0^{b}	0.0±0.0^{a}	0.04±0.0^{b}	0.02±0.00^{b}

^{a,b,c,d}Means±SEM in the same column bearing the same superscripts are significantly different ($p<0.05$).

The results, as shown in Table 2, indicate that, there were significance different at the $p<0.05$ level for Arginine within upstream and downstream for three localities areas. While, No significant differences were found betweenHistidine, Isoleucine, and Leucine in upstream and downstream for two areas and there is significance difference within Jebel Aulia, upstream and

downstream all mentioned above. The mean score for Lysine were significant difference within groups. There were no significant differences betweenMethionine for *O.niloticus* in Sennar and Merowe, while there is increase in Methionine was detected in Jebel Aulia (upstream and downstream). There was no increase of Cystine associated with*O.niloticus* in Jebel Aulia, Sennar and Merowe. Further analysis showed that, there were significance differences for Phenylalnine , Tyrosine, Threonine, Tryptophan and Valine respectively.

4.5 Fatty acids

Fatty acids of *O.niloticus* in summer, autumn and winter seasons was compared in these fish from different habitats (Tables 13- 15) showed different variations in the fatty acids profiles.

Table 13 Means +SD illustrate fatty acids profiles (g) of *O.niloticus* in summer season.

		Localities					
		Jebel Aulia		Sennar		Merowe	
Fatty acid Profile		**up**	**Down**	**up**	**Down**	**up**	**Down**
Sat							
Myristic	14:0	0.00^{a}	0.10^{a}	0.00^{a}	0.00^{a}	0.02^{a}	0.00^{a}
Palmitic acid	16:0	0.19^{b}	0.28^{c}	0.21^{b}	0.01^{a}	0.45^{d}	0.00^{a}
Stearic acid	18:0	0.04^{b}	0.08^{c}	0.08^{c}	0.00^{a}	0.05^{b}	0.00^{a}
Mon							
Palmitoleic acid	16:1 n-7	0.00^{a}	0.14^{b}	0.00^{a}	0.00^{a}	0.02^{a}	0.01^{a}
Oleic acid	18:1 n-9	0.89^{d}	0.43^{c}	0.46^{c}	0.02^{a}	0.34^{b}	0.00^{a}
Gadoleic acid	20:1 n-11	0.03^{a}	0.14^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
n-3 LC-PUFA							
Linoleic acid (LA)	18:2 n-6	0.64^{c}	0.12^{b}	1.02^{d}	0.02^{a}	1.03^{d}	0.02^{a}
Gamma-Linolenic acid (GLA)	18:3 n-6	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Arachidonic acid	20:4 n-6	0.00^{a}	0.01^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Alpha-Linolenic acid (ALA)	18:3 n-3	0.00^{a}	0.03^{a}	0.14^{b}	0.00^{a}	0.00^{a}	0.00^{a}
Stearidonic acid	18:4 n-3	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Eicosapentaenoic acid (EPA)	20:5 n-3	0.00^{a}	0.15^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosapentaenoic acid (DPA)	22:5 n-3	0.00^{a}	0.06^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosahexaenoic acid (DHA)	22:6 n-3	0.00^{a}	0.20^{b}	0.00^{a}	0.02^{a}	0.00^{a}	0.00^{a}

^{a,b,c,d}Means ±SEM in the same column bearing the same superscripts are significantly different ($p<0.05$).

There were no significant difference between Myristic, Gamma-Linolenic acid (GLA), Arachidonic acid, Alpha-Linolenic acid (ALA), Stearidonic acid in all localities both upstream and downstream, while. On average Palmitic acid, Stearic acid, Palmitoleic acid, Oleic acid and Gadoleic acidwere shown to have significant differences Jebel Aulia, Sennar, and Merowe. No significant differences were found between Gamma-Linolenic acid (GLA), and Arachidonic acid in all localities. Further analysis showed that there were significant difference between Alpha-Linolenic acid (ALA) in Jebel Aulia and Sennar. There were a significant difference between Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA), and Docosahexaenoic acid (DHA)in Jebel Aulia both upstream and downstream, while, there were no significant difference for others areas.

Table 14 Means +SD illustrate fatty acids profiles (g) of O.niloticus in autumn season.

		Localities					
		Jebel Aulia		Sennar		Merowe	
Fatty acid Profile		**up**	**Down**	**up**	**Down**	**up**	**Down**
Sat							
Myristic	14:0	0.04^{a}	0.20^{b}	0.00^{a}	0.00^{a}	0.03^{a}	0.00^{a}
Palmitic acid	16:0	0.38^{d}	0.56^{c}	0.41^{c}	0.02^{a}	0.91^{b}	0.00^{a}
Stearic acid	18:0	0.08^{b}	0.15^{c}	0.15^{c}	0.01^{a}	0.09^{b}	0.00^{a}
Mon							
Palmitoleic acid	16:1 n-7	0.04^{a}	0.28^{b}	0.01^{a}	0.00^{a}	0.03^{a}	0.01^{a}
Oleic acid	18:1 n-9	1.79^{e}	0.86^{d}	0.91^{c}	0.04^{a}	0.68^{b}	0.01^{a}
Gadoleic acid	20:1 n-11	0.05	0.29	0.01	0.00	0.00	0.00
n-3 LC-PUFA							
Linoleic acid (LA)	18:2 n-6	1.28^{c}	0.24^{b}	0.24^{b}	0.03^{a}	0.06^{a}	0.04^{a}
Gamma-Linolenic acid (GLA)	18:3 n-6	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Arachidonic acid	20:4 n-6	0.00^{a}	0.03^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Alpha-Linolenic acid (ALA)	18:3 n-3	0.00^{a}	0.06^{b}	0.27^{c}	0.00^{a}	0.01^{a}	0.00^{a}
Stearidonic acid	18:4 n-3	0.00^{a}	0.07^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.01^{a}
Eicosapentaenoic acid (EPA)	20:5 n-3	0.00^{a}	0.31^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosapentaenoic acid (DPA)	22:5 n-3	0.00^{a}	0.13^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosahexaenoic acid (DHA)	22:6 n-3	0.00^{a}	0.39^{b}	0.00^{a}	0.03^{a}	0.00^{a}	0.00^{a}

^{a,b,c,d,e}Means±SEM in the same column bearing the same superscripts are significantly different ($p<0.05$).

The results, as shown in Table14, indicated that, there were a significance different at the $p<0.05$ level for Myristic Downstream in Jebel Aulia, on other hand No significant differences were found between Myristic in Sennar and Merowe whether upstream or downstream. Further statistical tests revealed there were significance difference for Palmitic acid in upstream in differences localities, while no significance difference for Senar and Merowe in downstream. The mean score for Stearic acid were significance differences for all areas. There were no significant differences were found betweenPalmitoletic acid in Senar and Merowe and Upstream in Jebel Aulia while there difference in downstream in Jebel Aulia. None of these differences were statistically significant with Gamma-Linolenic acid (GLA), Stearidonic acid, Alpha-Linolenic acid (ALA) and Arachidonic acid for all areas. The mean score for Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA) and Docosahexaenoic acid (DHA) respectively were significance difference in downstream for Jebel Aulia only, on other hand, No increase in Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA) and Docosahexaenoic acid (DHA) respectively were detected for others areas.

Table 15 Means +SD illustrate fatty acids profiles (g) of *O.niloticus* in winter season.

		Localities					
		Jebel Aulia		Sennar		Merowe	
Fatty acid Profile		**up**	**Down**	**up**	**Down**	**up**	**Down**
Sat							
Myristic	14:0	0.03^{a}	0.15^{b}	0.00^{a}	0.00^{a}	0.02^{a}	0.00^{a}
Palmitic acid	16:0	0.02^{a}	0.29^{b}	0.31^{b}	0.02^{a}	0.68^{c}	0.00^{a}
Stearic acid	18:0	0.07^{b}	0.11^{c}	0.11^{c}	0.01^{a}	0.07^{b}	0.00^{a}
Mon							
Palmitoleic acid	16:1 n-7	0.03^{a}	0.21^{b}	0.01^{a}	0.00^{a}	0.02^{a}	0.01^{a}
Oleic acid	18:1 n-9	1.34^{d}	0.65^{c}	0.68^{c}	0.03^{a}	0.51^{b}	0.01^{a}
Gadoleic acid	20:1 n-11	0.04^{a}	0.22^{b}	0.01^{a}	0.00^{a}	0.00^{a}	0.00^{a}
n-3 LC-PUFA							
Linoleic acid (LA)	18:2 n-6	0.96^{c}	0.18^{b}	1.53^{d}	0.02^{a}	1.55^{d}	0.03^{a}
Gamma-Linolenic acid (GLA)	18:3 n-6	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Arachidonic acid	20:4 n-6	0.00^{a}	0.02^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Alpha-Linolenic acid (ALA)	18:3 n-3	0.00^{a}	0.05^{b}	0.20^{c}	0.00^{a}	0.01^{a}	0.00^{a}
Stearidonic acid	18:4 n-3	0.00^{a}	0.05^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.01^{a}
Eicosapentaenoic acid (EPA)	20:5 n-3	0.00^{a}	$0,23^{b}$	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosapentaenoic acid (DPA)	22:5 n-3	0.00^{a}	0.10^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Docosahexaenoic acid (DHA)	22:6 n-3	0.00^{a}	0.29^{b}	0.00^{a}	0.02^{a}	0.00^{a}	0.00^{a}

^{a,b,c,d,}Means±SEM in the same column bearing the same superscripts are significantly different ($p<0.05$).

There were a significant difference between Myristic, Palmitoleic acid, Gadoleic acid, Stearidonic acid, Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA), and Docosahexaenoic acid (DHA) in Jebel Aulia both upstream and downstream, while, there was no increase of Myristic, Palmitoleic acid, Gadoleic acid, Stearidonic acid, Eicosapentaenoic acid (EPA), Docosapentaenoic acid

(DPA), and Docosahexaenoic acid (DHA) associated withSennar and Merowe. On averagePalmitic acid, Stearic acid, Oleic acid and Linoleic acid (LA) were shown to have significant differences in all localities and within groups itself. No significant differences were found between Gamma-Linolenic acid (GLA), and Arachidonic acid in all localities. Further analysis showed that there were significant difference between Alpha-Linolenic acid (ALA) in Jebel Aulia and Sennar.

4.6 Heavy metals from studied fish

Heavy metals from fish species *O.niloticus* in summer, autumn and winter seasons is compared in these fish from different habitats (Tables 16- 18 and figure 10-13) showed different variations in the heavy metals (Pb, Cd, Cu, and Zn).

Table 16 Means+SD illustrate heavy metal of *O.niloticus* in summer season collected form different localities

Habitats (Dam)		Heavy metals (mg/L)			
		Pb	**Cd**	**Cu**	**Zn**
Jebel Aulia	Upstream	0.215 ± 0.156^{b}	0.217 ± 0.003^{a}	0.127 ± 0.003^{a}	0.105 ± 0.004^{b}
	Downstream	0.295 ± 0.054^{b}	0.032 ± 0.003^{a}	0.133 ± 0.005^{a}	0.105 ± 0.005^{b}
Sennar	Upstream	0.184 ± 0.008^{a}	0.021 ± 0.002^{a}	0.115 ± 0.006^{a}	0.102 ± 0.005^{b}
	Downstream	0.216 ± 0.010^{b}	0.028 ± 0.003^{a}	0.128 ± 0.004^{a}	0.106 ± 0.004^{b}
Merowe	Upstream	0.184 ± 0.013^{a}	0.080 ± 0.001^{a}	0.120 ± 0.003^{a}	0.101 ± 0.004^{b}
	Downstream	0.227 ± 0.019^{b}	0.020 ± 0.002^{a}	0.128 ± 0.002^{a}	0.079 ± 0.054^{a}

^{a,b} Mean in the same column with superscript are significant different at ($p\leq0.05$).

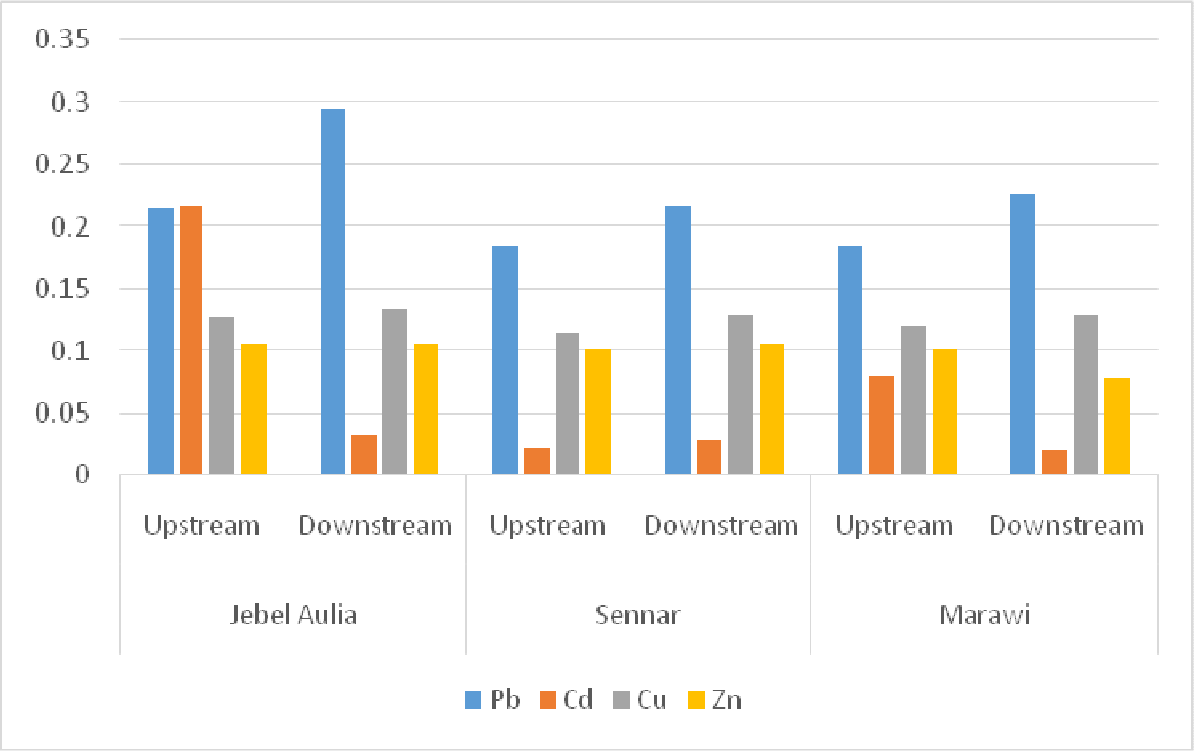

Figure 4 Means+SD illustrate heavy metal of *O.niloticus* in summer season collected form different localities

The results, as shown in Table 16 indicate that, there were a significant difference between Pb of *O.niloticus*, in Jebel Aulia dam, Sennar dam and Merowe dam, and also within groups upstream and downstream, this mean the result is significant at the p = 0.05 level. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups.

Table 17 Means+SD illustrate heavy metal of *O.niloticus* in autumn season collected form different localities.

Habitats		Heavy metals (mg/L)			
		Pb	**Cd**	**Cu**	**Zn**
Jebel Aulia	Upstream	0.174±0.006[a]	0.014±0.001[a]	0.118±0.003[a]	0.096±0.005[a]
	Downstream	0.209±0.011[b]	0.021±0.001[a]	0.124±0.004[b]	0.103±0.003[a]
Sennar	Upstream	0.182±0.106[a]	0.019±0.001[a]	0.123±0.004[a]	0.095±0.006[a]
	Downstream	0.208±0.007[b]	0.023±0.002[a]	0.128±0.003[a]	0.108±0.008[a]
Merowe	Upstream	0.172±0.007[a]	0.015±0.002[a]	0.121±0.004[a]	0.096±0.006[a]
	Downstream	0.215±0.023[b]	0.018±0.002[a]	0.126±0.006[a]	0.110±0.004[a]

[a,b] Mean in the same column with superscript are significant different at (p≤0.05).

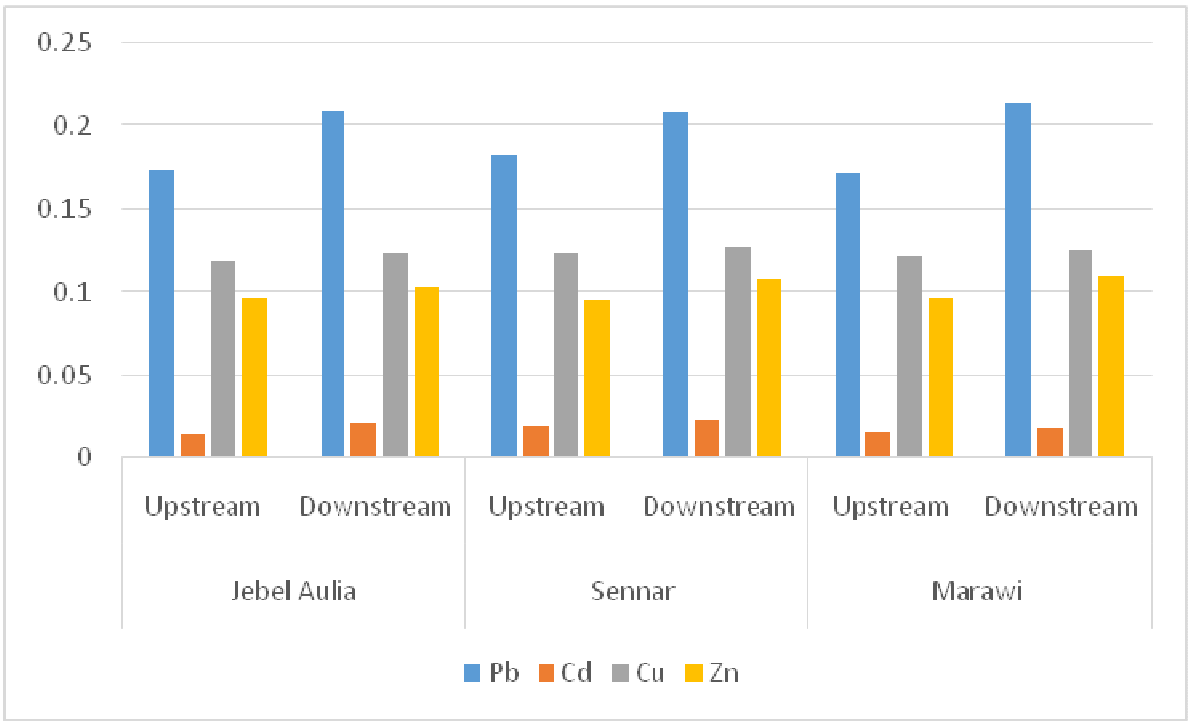

Figure 5 Means+SD illustrate heavy metal of O.niloticus in autumn season collected form different localities.

The results, as shown in Table 17 and figure 5, indicate that, there were a significant difference between Pb of *O.niloticus,* in Jebel Aulia dam, Sennar dam and Merowe dam, and also within groups upstream and downstream, this mean the result is significant at the p = 0.05 level. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups.

Table 18 Means+SD illustrate heavy metal of *O.niloticus* in winter season collected from different localities.

Habitats (Dam)		**Heavy metals (mg/L)**			
		Pb	**Cd**	**Cu**	**Zn**
Jebel Aulia	Upstream	0.253±0.008[b]	0.037±0.005[a]	0.127±0.007[a]	0.109±0.011[a]
	Downstream	0.257±0.012[b]	0.050±0.010[a]	0.137±0.009[a]	0.115±0.005[a]
Sennar	Upstream	0.283±0.009[b]	0.032±0.003[a]	0.119±0.004[a]	0.101±0.004[a]
	Downstream	0.314±0.017[b]	0.360±0.001[a]	0.123±0.003[a]	0.124±0.003[a]
Merowe	Upstream	0.219±0.004[a]	0.032±0.005[a]	0.130±0.004[a]	0.107±0.005[a]
	Downstream	0.229±0.003[a]	0.049±0.008[a]	0.145±0.004[a]	0.123±0.005[a]

[a,b] Mean in the same column with superscript are significant different at ($p \leq 0.05$).

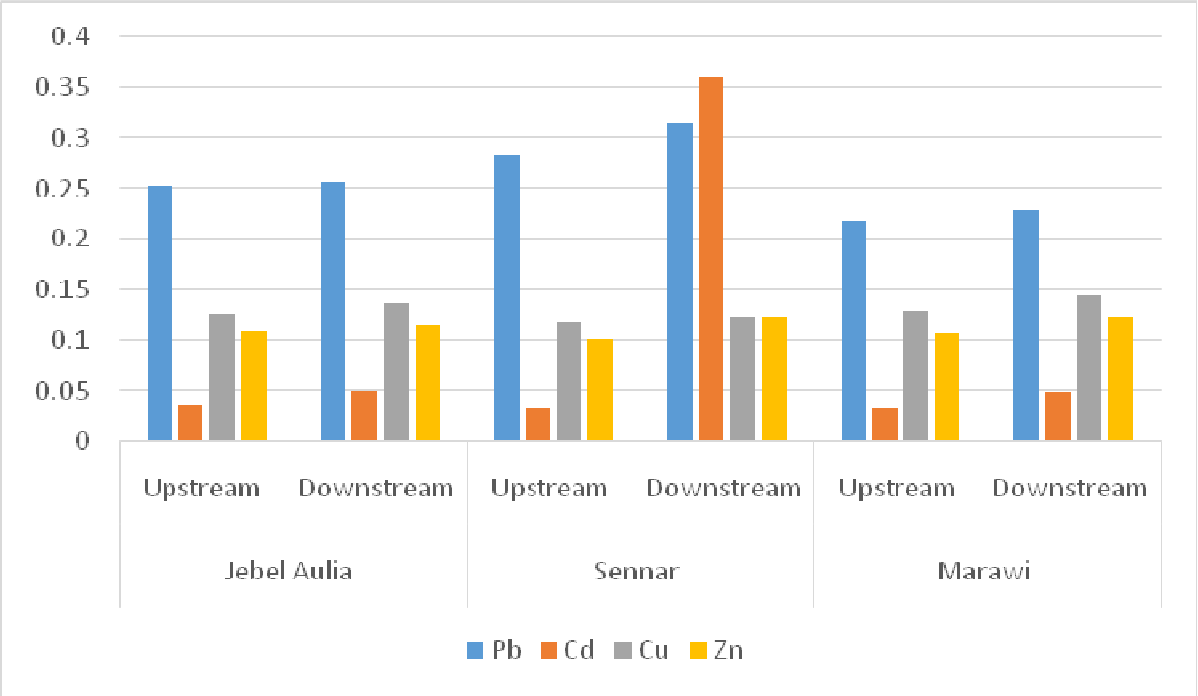

Figure 6 Means ±SD illustrate heavy metal of *O.niloticus* in winter season collected from different localities.

The results, as shown in Table 18 and figure 18, indicate that, there were a significant difference between Pb of *O.niloticus*, in Jebel Aulia dam, Sennar dam and Merowe dam, but there were no significance difference within groups upstream and downstream. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups.

4.7 Heavy metals from water samples

Heavy metals from water samples in summer, autumn and winter seasons is compared in these water from different habitats (Tables 19- 21 and figure 14-16) showed different variations in the heavy metals (Pb, Cd, Cu, and Zn).

Table 19 Means+ SD illustrate heavy metal of water samples in summer collected from different areas.

Habitats (Dam)		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.20±0.00[a]	0.05±0.04[a]	0.12±0.00[a]	0.10±0.00[a]
	Downstream	0.21±0.00[a]	0.02±0.00[a]	0.12±0.00[a]	0.10±0.00[a]
Sennar	Upstream	0.22±0.01[a]	0.34±0.43[b]	0.07±0.06[a]	0.13±0.00
	Downstream	0.24±0.00[b]	0.03±0.00[a]	0.14±0.00[a]	0.10±0.00[a]
Merowe	Upstream	0.24±0.01[b]	0.02±0.01[a]	0.10±0.01[a]	0.12±0.00[b]
	Downstream	0.27±0.10[c]	0.03±0.01[a]	0.13±0.00[a]	0.15±0.00[c]

[a,b,c]: Means in the same column with superscript are significant different at ($p \leq 0.05$).

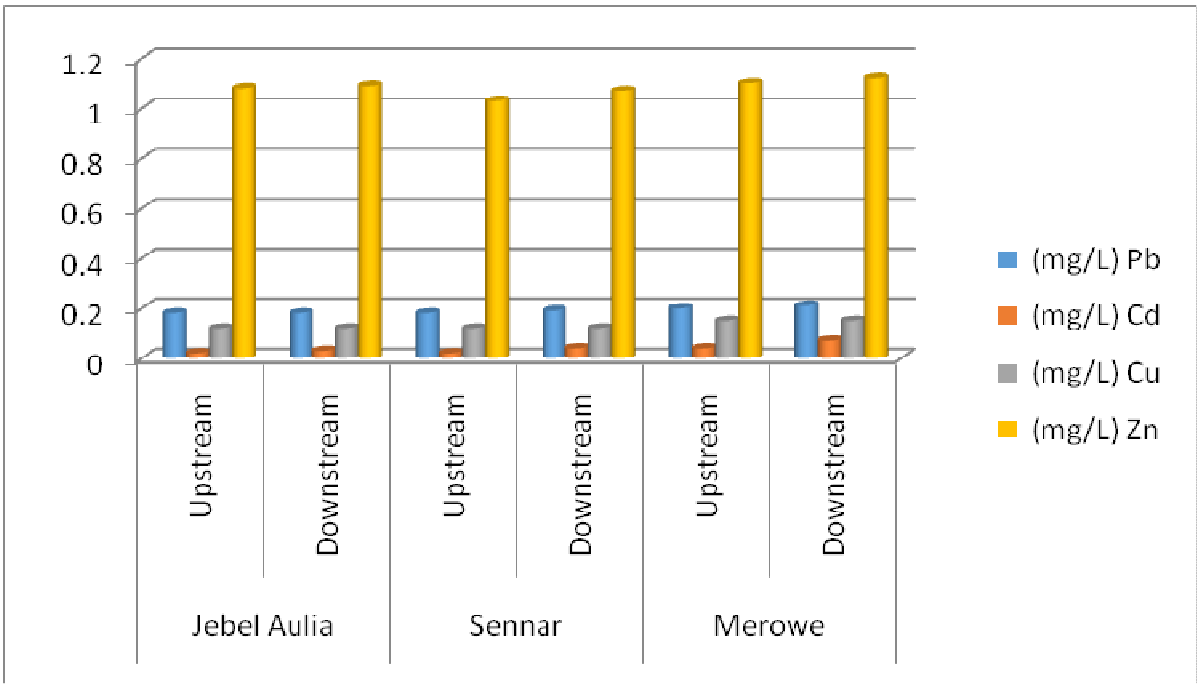

Figure 7 Means+ SD illustrate heavy metal of water samples in summer collected from different areas.

The results, as shown in Table 19 and figure 19, indicate that, there were a significant difference between Pb, Cd and Zn of water samples, in Jebel Aulia dam Sennar dam and Merowe dam, but there were no significance difference in Zn upstream and downstream during summer season. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups.

Table 20 Means+ SD illustrate heavy metal of water samples in autumn collected from different areas.

Habitats		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.11±0.00[a]	0.01±0.00[a]	0.03±0.00[a]	0.07±0.00[a]
	Downstream	0.12±0.00[a]	0.01±0.00[a]	0.05±0.00[a]	0.09±0.00[b]
Sennar	Upstream	0.11±0.00[a]	0.01±0.00[a]	0.09±0.00[b]	0.08±0.00[b]
	Downstream	0.13±0.00[b]	0.02±0.00[a]	0.10±0.00[b]	0.10±0.00[b]
Merowe	Upstream	0.12±0.00[a]	0.04±0.00[b]	0.10±0.00[b]	0.06±0.00[a]
	Downstream	0.14±0.00[b]	0.06±0.00[c]	0.11±0.00[b]	0.08±0.00[b]

[a,b,c]: Means in the same column with superscript are significant different at ($p \leq 0.05$).

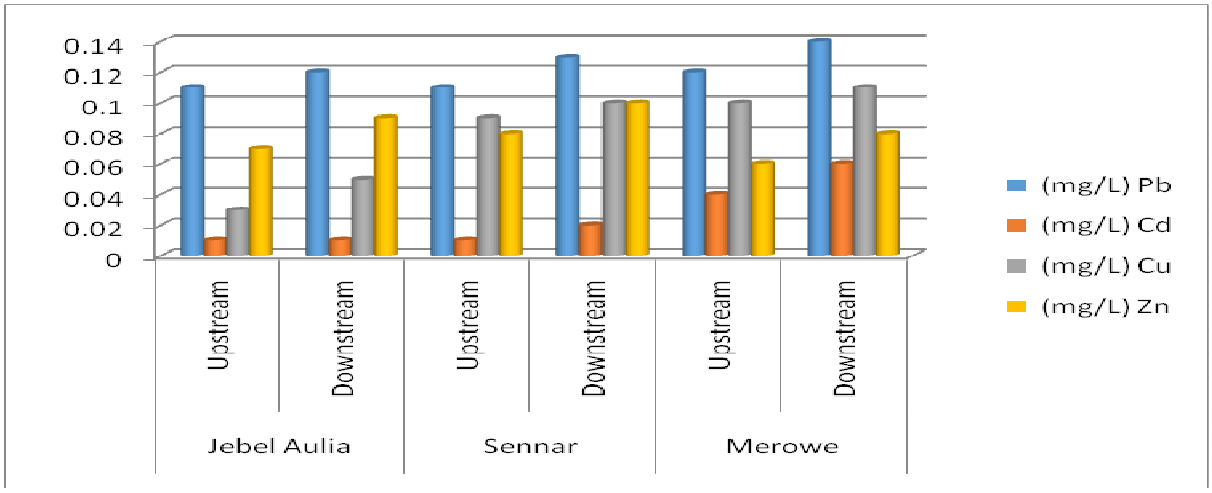

Figure 8 Means+ SD illustrate heavy metal of water samples in autumn collected from different areas.

The results, as shown in Table 20 and figure 20, indicate that, there were significant difference between Pb, Cd. Cu and Zn of water samples, in Jebel Aulia dam Sennar dam and Merowe dam during autumn season. Furthermore, no significant differences were found between Pb, Cd, Cu and Zn in all localities dams and within groups.

Table 21 Means + SD illustrate heavy metal of water samples in winter collected from different areas.

Habitats (Dam)		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.18±0.01[a]	0.02±0.00[a]	0.12±0.00[a]	1.08±0.04[a]
	Downstream	0.18±0.01[a]	0.03±0.00[a]	0.12±0.00[a]	1.09±0.04[a]
Sennar	Upstream	0.18±0.00[a]	0.02±0.00[a]	0.12±0.00[a]	1.03±0.04[a]
	Downstream	0.19±0.00[a]	0.04±0.00[a]	0.12±0.00[a]	1.07±0.04[a]
Merowe	Upstream	0.20±0.01[a]	0.04±0.00[a]	0.15±0.00[b]	1.10±0.05[a]
	Downstream	0.21±0.01[b]	0.07±0.00[b]	0.15±0.00[b]	1.12±0.05[a]

[a,b,c]: Means in the same column with superscript are significant different at ($p \leq 0.05$).

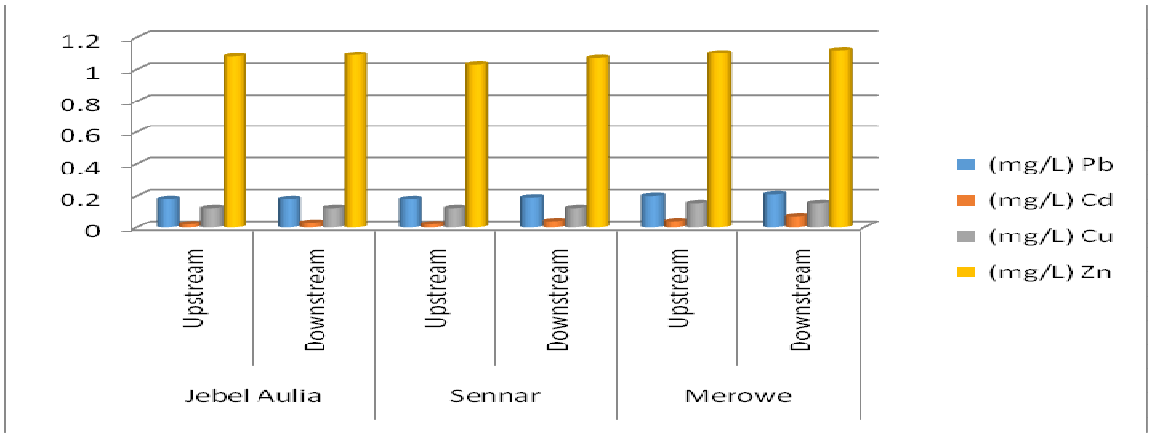

Figure 9 Means + SD illustrate heavy metal of water samples in winter collected from different areas.

The results, as shown in Table 21 and figure 21, indicate that, there were a significant difference between Pb, Cd and Cu of water samples, in Merowe dam upstream and downstream, but there were no significance difference in Zn upstream and downstream during winter season. Furthermore, significant differences were found between Pb Cd, and Cu in all localities dams and within groups.

CHAPTER FIVE
5. DISSCUSION

During summer season, however pH was 8.3±0.21 which was higher in Merowe upstream and lower in Merowe downstream 7.4±0.00, while, in Autumn the pH was8.2±0.21 which was higher in Jebel Aulia downstream and lower in Merowe dam downstream 7.3±0.28, and in winter season the pH was 8.1±0.42 which was higher in Jebel Aulia dam upstream and lower in Sennar dam upstream7.6±0.28.This results were in line with **Boyd(1992**) who reported pH range of 6.09 - 8.45 as being ideal for supporting aquatic life including fish. Thus, the pH range obtained in this study is within the permissible level of 6.0 to 8.5 for culturing tropical fish species **(Kolo and Oladimeji.2004),** since federal Environmental protection Agency (FEPA) recommended 6.0-9.0 for aquatic life.

Relatively, D.O was 9.5±0.42 which was higher in sennar dam and lower in Jebel Aulia3.5±0.46 during summer season, while during Autumn season D.O was9.3±1.56 which was higher in sennar dam downstream and lower in Jebel Aulia dam upstream 3.6±0.07, nitrate was 1.2±0.07 which was higher in Jebel Aulia downstream and lower in Jebel Aulia upstream 0±0.0, and was found to be 7.4±0.21 which was higher in Merowe dam downstream and lower in Sennar dam downstream 3.6±0.46 during winter season. indeed said results matched and in agreement with **(Ibe PA, 1993)** who reported that the dissolved oxygen in the reservoir was higher during the dry season**.** The high oxygen value for the dry season coincides with periods of lowest turbidity and temperature.

The nitrate-nitrogen ($N0_3$-N) revealed from this study was found to be Nitrate was 2.8±3.18 which was higher in downstream Merowe and lower in Jebel Aulia dam 0±0.0 during summer season, while Nitrate was 1.5±0.07 which was higher in downstream Merowe and lower in Sennar dam0±0.o during Autumn

season and Nitrate was 0.1±0.07 which was higher in upstream Merowe and lower in Sennar dam during winter season in the three dams respectively and there is no significant difference ($p<0.05$) between up and downstream in three dams in nitrate levels. This result is in agreement of the finding of **(Furnas.1992)** who reported that generally, nitrate - nitrogen it is stable over a wide range of environmental conditions and is highly soluble in water. Compared with other inorganic nitrogen compounds, it is also the least toxic. **(Coming *et al*, 1983)**, stated that a high nitrate concentration in river and lake is related to inputs from agricultural lands.(Organic load form sewage and rainfall from watershed)

Alkalinity was167.5±10.61which was higher in Merowe and lower in Jebel Aulia139±1.41, on other hand hardness was higher in Merowe 175±35.36 and lower in Sennar dam 115±7.07 phosphorus was 5.5±6.36 which was higher in Jebel Aullia and lower in Merowe 0.3±0.28 downstream in summer season, while alkalinity was 173±4.24 which was higher in Merowe dam downstream and lower in Sennar upstream 100±0.00 on other hand hardness was 195±7.07 which higher in Merowe dam downstream and lower in Jebel Aulia dam upstream 126.5±2.12during Autumn season and alkalinity was 173.5±2.12 which was higher in Sennar dam upstream and lower in Jebel Aulia upstream 105±7.07 during Winter season. The negative correlation values obtained indicate that alkalinity of water increase with decreasing water level. Similar observations have been reported by **Talling (1967)** on Rivers Sokoto and Nile in Egypt respectively. The alkalinity was higher in the dry season and lower in the rainy season, when the dam had high water level. This could be due to low water levels with its attendant concentration of salts and the lower value in the rainy season could be due to dilution **(Ufodike, 2001).**

Water hardness in the present study was found to be higher in Merowe

175±35.36 and lower in sennar dam 115±7.07 phosphorus was 5.5±6.36 which is higher in Jebel Aullia and lower in Merowe 0.3±0.28 downstream in summer season, while during Autumn season hardness was 195±7.07 which higher in Merowe dam downstream and lower in Jebel Aulia dam upstream 126.5±2.12 and hardness was 155±7.07 which was higher in Sennar dam upstream and lower in Jebel Aullia dam upstream 110±14.14 during winter season. The mean hardness agreed with the range value documented by **Boyd** (1981) for natural water. Also this result agrees with the result of **(Kolo, Oladimeji, 2004)** who reported that water hardness was higher during the dry season than the rainy season. This could be as a result of low water levels and the concentration of ions, and the lower rainy season value could be due to dilution.

Phosphorus was 5.5±6.36 which is higher in Jebel Aullia and lower in Merowe 0.3±0.28 downstream in summer season, while, phosphorus was 0.6±0.57 which was higher in Merowe dam upstream and lower in sennar dam upstream 0.1±0.07 during Autumn season and Phosphorus was 1.9±1.56 which was higher in Sennar downstream and lower in Merowe dam downstream 0.2±0.07 during winter season. The high dry season mean value of phosphate phosphorus (PO4-P) could be due to concentration effect because of reduced water volume. It could also be due to lower water hardness, thus less co-precipitation of phosphate with calcium carbonate, a phenomenon that has often been reported to occur in many fresh water rivers **(Heleen *et al*, 1995).**

further more the SF was 20.2±4.10 which was higher in Jebel Aulia downstream and low in upstream Merowe 16.67±2.91, SF was 23.10±2.62 which was higher in Jebel Aulia upstream and lower in Merowe downstream 19.53±1.35 and SF was 24.99±5.12 which was higher in upstream Sennar and was lower in downstream Merowe 18.70±1.35 during three season . on other hand the means

score for F was 47.10±4.51 which was higher in upstream Merowe and lower in Merowe downstream 43.09±9.25 in summer season,also means percentage for F was 42.79±1.92 which was higher in Merowe upstream and was lower in Jebel Aulia downstream in Autumn season and F was 41.84±7.59 which was higher in upstream Merowe and was lower in downstream Sennar 36.51±0.14 during winter season**.**The fish fillet of the studied fish collected from Jabel Aulia, Sennar and Marawi Dams upstream and downstream disagreed with the findings mentioned that the edible parts ranged between 45 and 50% and percentage levels differ according to the shape and body size of fish **(Fawole *et al*, 2007)** and yet **(Obanu and Ikeme.1988)** in line with the results revealed from this study. **Mac(1994)** who carried out studies on meat yield and nutrition value determination of Nile Tilapia *Oreochromis niloticus* found that the physical characteristics of the species has a decreasing order of fillet, head, fins and skeleton, viscera and skin for Tilapia as well as weight of whole fish and weight of fillets were significantly differed from each other. These findings matched the low fillet yield which might also be attributed to large head, lower viscera and method and techniques of filleting from this study. Further, the results showed a decreasing order of fillet, head, fins and skeleton, viscera for *O. niloticus* respectively. The results of the fish body weight characteristics has clearly revealed that the percentage of fillet, head, fins and skeleton, viscera and skin between the studied species differ significantly this variability might to attributable to differences of food intake, diet, size, age, sex, season of capture and environmental conditions.

Chemical composition of *O.niloticus* in summer, autumn and winter seasons is compared in these fish from different habitats (Tables 7- 9 and figures 7-9). This showed different variations in the chemical composition (M, DM, CP, Ash, E.E and NFE).

The present study revealed that there is a significant difference ($P<0.05$) in the Ash content. The finding of the present study regarding the chemical composition showed some fact on the manifesto of the most popular consumed fish of tilapia *O. niloticus* collected from three different water resources which serves as the principle basis in evaluating the nutritional value of the fish. The proximate chemical composition analysis clearly revealed that, a distinct variation on the chemical composition of the studied fish. The levels of moisture content percentage of *O. niloticus* collected from upstream and downstream sites showed that there were a significant difference between moisture in Jebel Aulia downstream (77.00±0.89) was higher than others areas, Sennar and Merowe both upstream and downstream in summer season, further more there were a significant difference between moisture of *O.niloticus* in Jebel Aulia downstream (77.64±1.6) was higher than other conditions in Autumn season and there were a significant difference between moisture of *O. niloticus* (85.66±2.06)which was higher in downstream Merowe dam, upstream Sennar dam and downstream Merowe in winter season. This result agree with (**Parker and Vanstone, 1966**) who mentioned Moisture content of fish body does not seem to be constant in view of the inter relationship with many biological and physiological factors.

Further, the results obtained showed dry matter and Crude protein in upstream Merowe dam was higher (28.66±1.96 and 32.77±0.37) than others areas this means there were significance difference within groups in summer season, while, dry matter, nitrogen and crude protein of *Oreochromis niloticus* was higher (30.10±4.61 and 32.95±0.30)in Sennar downstream and Merowe upstream, and also within groups upstream and downstream in Autumn season and no significance difference within group that to say in upstream and downstream. Mean of crude protein was 31.53±0.97 which was higher in downstream Merowe

and lower Jebel Aulia dam 27.85±0.62, this result was significant at the $p \leq 0.05$ level.This result disagrees with who **Ahmed (2006)** reported that the protein content was in the range (18.9 – 20.5 %).

The ether extract showed a slight variation between the flash of *O. niloticus* collected from upstream at three different localities and there was a significant difference in ether extract at downstream as well as the nitrogen and Ash. However, at the downstream ash content showed a higher significant difference among collection sites. In respect to nitrogen free extract content, yet showed significant difference at upstream but in downstream no significant differences were observed. This observation were agree with (**Ogata & Shearer, 2000**) who noted that the fish´s chemical composition can be affected by many factors, including species, environmental conditions, fish size, level of protein in the diet, and feeding rate.

The results, as shown in Tables 10, 11 and 12 indicate that, no significant differences were found between Arginine in upstream for all localities, while there were significant difference between Arginine in downstream in summer season, There were no significant differences between Arginine in three localities whether upstream or downstream in Autumn season and there were significance different at the $p<0.05$ level for Arginine within upstream and downstream for three localities areas in winter season,While, there was a significant difference between the two conditions upstream in Jebel Aulia and upstream in Merowe in Histidine in Autumn, further more no significant differences were found betweenHistidine in winter. There were significance difference found between, Phenylalnine, Tyrosine and Valine in Jebel Aulia while, no significance difference for others localities. In addition, no significant differences were found betweenCystine, Threonine, andHistidinein all localities areas in summer. Further analysis showed that there

were significant difference for Lysine, Methionine, Cystine, Cystine, Phenylalnine, Tyrosine, Threonine, Tryptophan and Valine respectively in the three localities both upstream and downstream in Autumn and there were significance differences for Phenylalnine , Tyrosine, Threonine, Tryptophan and Valine in winterrespectively. This finding were in line with (**Brown. 2000**) who mentioned that Fish meat proteins contain all the essential amino acids. Although essential amino acids (leucine, isoleucine, lysine, valine, methionine, phenylalanine, threonine and tryptophane) have many important functions in human body, food sources with these amino acids increase the essential protein quality of diet because these molecules cannot be synthesized in body

There were no significant difference between Myristic, Gamma-Linolenic acid (GLA), Arachidonic acid, Alpha-Linolenic acid (ALA), Stearidonic acid in all localities both upstream and downstream in summer, while there were a significance different at the $p<0.05$ level for Myristic Downstream in Jebel Aulia, on other hand No significant differences were found betweenMyristic in Sennar and Merowe whether upstream or downstream. Further statistical tests revealed there were significance difference for Palmitic acid in upstream in differences localities, while no significance difference for Sennar and Merowe in downstream in Autumn and There was a significant difference between Myristic, Palmitoleicacid, Gadoleic acid, Stearidonic acid, Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA), and Docosahexaenoic acid (DHA) in Jebel Aulia both upstream and downstream, while, there was no increase of Myristic, Palmitoleic acid, Gadoleic acid, Stearidonic acid, Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA), and Docosahexaenoic acid (DHA) associated withSennar and Merowe in winter. This finding with in line with **(Satoh *et al*, 1989)** who stated that the variation in the concentration of fatty acids in the species

may be attributed to the feed among other factors. Also agreement with **(Satio and Yamashira, 1997)** who reported that diet had a major effect on the fatty acid composition of lipid. Other factors that may influence their fatty acid composition include size or age, reproductive status, geographic location and season .Further analysis showed that there were significant difference between Alpha-Linolenic acid (ALA) in Jebel Aulia and Sennar. There were a significant difference between Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA), and Docosahexaenoic acid (DHA)in Jebel Aulia both upstream and downstream, while, there were no significant difference for the other areas in summer, while no increase in Eicosapentaenoic acid (EPA), Docosapentaenoic acid (DPA) and Docosahexaenoic acid (DHA) respectively was detected for the other areas and there were significant difference between Alpha-Linolenic acid (ALA) in Jebel Aulia and Sennar in winter. This result was similar to **(Osibona ,2011)**who reported report from other authors on similar studies also indicated the dominance of these fatty acids in fish species .

The amounts of Pb, Cd, Zn and Cu in *O.niloticus* muscle are summarized in Tables 16,17 and 19 figures 16, 17 and 18, indicate that, there was a significant difference between Pb concentration of *O.niloticus,*in Jebel Aulia dam, Sennar dam and Merowe dam, and also within groups upstream and downstream, this mean the result is significant $p \leq 0.05$ level. Furthermore Pb was 0.295±0.156 which was higher in Jebel Aulia downstream and lower in Sennar upstream 0.184±0.008, while Cd was 0.217±0.003 which was higher in Jebel Aulia upstream and lower in Merowe downstream, further more Cu and Zn (0.133±0.005 and 0.106±0.004) which was higher in Jebel Aulia down stream and Sennar downstream in summer respectively, while there were a significant difference between Pb in *O.niloticus,*in Jebel Aulia dam which was higher in Merowe downstream 0.215±0.023 and lower

in Merowe upstream 0.172±0.007, Furthermore, no significant differences were found between Cd, Cu and Zn in all localities dams and within groups. on other hand Cd was 0.023±0.002 which was higher in Sennar dam downstream and lower in Jebel Aulia upstream 0.014±0.004, also Cu was 0.128±0.004 which was higher in Sennar downstream in Autumn and Pb was 0.314±0.017 which was higher in Sennar downstream and was lower in Merowe upstream 0.219±0.004, but there was no significance difference within groups upstream and downstream. Furthermore, no significant differences were found between Cd, Cu and Zn in all localities and within groups. Cd and Cu were (0.360±0.001 and 0.145±0.004) which was higher in Sennar downstream and Merowe downstream in winter respectively. This finding was in line with (**Haram H.A.2016**) who reported that concentrations of trace metals in fish muscles in White and Blue Nile rivers from different stations. Showed that the maximum concentration of (Cu, Cr, Pb and Zn) was observed in summer, while the minimum values were detected in autumn. While Cd and Fe showed no significance difference in all seasons. Moreover, the highest concentrations of Cu were found in Jabal Aulia station and the lowest value was found in Alamab in the White Nile while Cr represents the opposite. But Cd concentration was high in Adubaseen and lower in Alamab. In the Blue Nile all heavy metals were detected as the highest concentration from Soba station. The results of the present study reveal that there were significant difference between the three areas in Zn (0.133±0.005 and 0.106±0.004) which was higher in Jebel Aulia down stream and Sennar downstream in summer, while the means score for Zn was 0.110±0.004 which was higher in Merowe downstream and lower in Jebel Aulia upstream in Autumn and further analysis showed that Zn was 0.124±0.004 which was higher in Sennar downstream and was lower in Sennar upstream 0.101±0.004 in winter season. This result agree with(**Saeed 2000)** who found that

heavy metals concentration showed seasonal variations, being greater in summer and lowest in winter and autumn.

CHAPTER SIX
6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The present study concluded that there was significant in the chemical composition in the studied fish collected from the three localities in all parameters. There are some marked variations in the water quality parameters observed form the sampling stations in the months of summer season at upstream and downstream in the three dam's reservoirs in the present study. The levels of the parameters determined were within the acceptable ranges for domestic water purposes and fish production. Moreover, the samples of the studied fish collected from upstream from three localities showed significant variations in the total weight, head weight, viscera weight, fin and skeleton weight and fillet weight.

The results suggest that *O.niloticus*is good sources of nutrients especially with the presence of Omega -3 and Omega-6 series of polyunsaturated fatty acids (PUFA). Levels of protein and lipids are also quite appreciable. This study is likely to serve as additional information on the proximate and fatty acid content of commercially important fish species from Sudanese reservoir dams.

Heavy metal analysis of the *O. niloticus* muscle and water samples collected from Jebel Aulia, Sennar and Marawi dams showed that there was significant concentration of Pb, Cd, Zn and Cu in *O. niloticus* muscle from the three localities

6.2 Recommendations

Based on the findings during this study, the following recommendations are suggested:

Future study will be needed for:

1. Dams and their effect on water quality parameters and fishes.
2. To determine the planktons (phytoplankton and Zooplankton) at the three areas.
3. To assess of physical properties of *O. niloticus* meat at the three habitats.
4. To determine the bacterial loads and parasites prevalence at the three dams.
5. The genetics characterization of the studies fish at the three locations.
6. To detect the heavy metals concentration from sediments and plant at the three reservoir dams.

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Appendix

Appendix 1 Means+SD illustrate the body weight characteristics (g) of *Oreochromis niloticu*, in the summer season in different habitats.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
TL	23.08±3.9^{a}	22.08±2.8^{b}	21.4±1.9^{b}	21.7±2.1^{a}	24.5±4.9^{a}	21.7±3.0^{a}
SL	19.75±4.5^{b}	19.33±2.8^{a}	17.9±1.6^{c}	18.1±1.7^{a}	21.0±4.4^{a}	18.3±2.7^{a}
TBW	153.3±27.6	180.8±74.5^{b}	179.9±45.6	183.0±44.4^{b}	358.6±240.3	245.0±99.7
HW	34.16±7.3^{c}	43.3±18.6^{b}	40.0±11.4^{b}	44.2±14.0^{b}	70.8±37.7^{a}	49.1±26.9^{a}
VW	7.5±2.7^{c}	14.16±10.6^{c}	16.2±7.0^{b}	12.3±3.0^{b}	38.3±40.1^{a}	19.5±7.4^{a}
SF	29.16±5.8^{c}	36.6±18.0^{b}	35.5±8.8^{b}	36.4±9.5^{b}	61.6±36.6^{a}	45.7±21.9^{a}
FW	70.0±13.0^{c}	77.5±36.1^{c}	81.9±20.7^{b}	81.7±16.8^{b}	166.6±111.5	103.9±46.3^{a}

From table (1 to 3),^{a,b,c}: Mean in the same raw with superscript are significantly different at ($p \leq 0.05$), TL= Total length, SL= Standard length, TBW= Total body weight, HW= Head weight, VW= Viscera weight, SF = skeleton and fins, FW= Fillet weight

Appendix 2 Means+SD illustrate the body weight characteristics (g) of Oreochromis niloticus in the winter season in different habitats.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
TL	21.3±0.5^{a}	21.3±4.0^{a}	22.3±2.5^{a}	21.6±1.1^{a}	22.3±2.3^{a}	21.6±2.5^{a}
SL	18.3±0.5^{a}	18.0±3.4^{a}	19.0±2.0^{a}	19.0±0.0^{a}	18.3±2.3^{a}	18.1±1.7^{a}
TBW	171.0±21.6^{b}	189.6±119.8	172.0±45.5	164.6±32.3^{b}	200.0±40.7	191.0±38.8^{a}
HW	51.6±5.6^{b}	57.6±36.7^{a}	53.0±14.2^{a}	49.3±7.7^{b}	52.0±15.5^{a}	56.3±13.4^{a}
VW	18.6±8.6^{a}	10.6±3.7^{b}	8.0±1.0^{b}	8.3±0.5^{c}	19.3±4.9^{a}	17.3±5.0^{a}
SF	33.0±7.0^{c}	38.6±27.1^{a}	43.6±18.4^{a}	37.3±6.8^{a}	39.0±11.5^{b}	36.0±9.6^{b}
FW	69.3±5.8^{b}	74.0±44.1^{b}	64.0±18.5^{c}	59.3±11.8^{c}	81.6±2.5^{a}	77.0±24.2^{a}

Appendix (3): Means±SD illustrate the body weight characteristics (g) of *Oreochromis niloticus* in the autumn season in different habitats.

	Jebel Aulia Dam		Sennar Dam		Merowe Dam	
Parameters	**Upstream**	**Downstream**	**Upstream**	**Downstream**	**Upstream**	**downstream**
TL	22.6±1.1[a]	23.3±2.0[a]	20.3±1.1[b]	21.3±1.5[b]	22.0±1.0[a]	24.3±0.5[a]
SL	19.3±0.5[a]	19.6±1.0[a]	18.0±1.0[a]	18.0±1.0[b]	19.0±1.0[a]	20.3±0.5[a]
TBW	208.6±18.5[a]	218.0±62.2[b]	157.0±45.4	151.3±26.1[c]	186.0±11.3	242.6±13.5[a]
HW	59.6±11.9[a]	65.6±21.5[b]	45.0±20.8[c]	45.3±8.7[c]	54.0±8.7[b]	70.0±5.2[a]
VW	15.3±1.15[a]	21.0±8.54[a]	12.3±4.0[b]	13.0±2.6[c]	12.6±3.2[b]	15.6±4.1[b]
SF	48.0±4.0[a]	46.6±11.8[a]	33.6±11.5[c]	34.6±7.2[b]	36.3±3.2[b]	47.6±10.0[a]
FW	74.3±6.0[b]	69.3±22.0[b]	61.3±16.4[c]	55.6±12.3[c]	79.6±7.0[a]	102.6±11.01

Appendix (4). Permissible limits of heavy metals in water and fish according to international organization

Metals	**Water (mg/L)**		**Fish (mg/g)**	
FDA	**WHO**	**EPA**	**WHO**	
Pb	0.005	0.01	0.05	1.5
Zn	-	3.0	5.0	150
Cu	1.0	1-2	1.0	-
Fe	-	0.3	0.1	2.5
Cd	0.05	0.03	-	0.2
Cr	-	0.1-0.5	0.05	-

Appendix (5): Permissible limits of heavy metals in fish muscle according to International organization.

Metal	**Permissible**	**Country and reference**
Copper	1.00 ppm 20.0 ppm	WHO (1984) South Africa (Foodstuffs, cosmetics
Lead	0.05 ppm 0.1 mg/kg 0.5 ppm 50 /	WHO (1984) Egypt "E.O.S.Q.C. (1993) FAO/WHO (1992)
Cadmium	0.005 ppm 0.05 ppm 0.1 mg/kg 10 /	WHO (1984) FAO/WHO (1992) Egypt "E.O.S.Q.C. (1993) Si Blti Offiil dl Etd (1991)
Mercury	0.001 ppm 0.5 mg/kg 0.5 ppm	WHO (1984) Egypt "E.O.S.Q.C. (1993) FAO/WHO (1992)

Appendix (6): The heavy metal concentrations in water guidelines (mg/L).

Guidelines/Locality	Cd	Cr	Cu	Fe	Ni	Pb	References
TSE-266	0.005	0.05	2	0.2	0.02	0.01	TSE-266, 2005
WPCL	0.003	0.02	0.02	0.3	0.02	0.01	WPCL, 2004
CIW	0.01	0.1	0.2	5	0.2	5	Anonymous, 1997
WHO	0.01	0.05	2	-	0.02	0.05	WHO, 1993
EPA	0.01	0.05	1.3	0.3	-	0.05	EPA, 2002
EC	5	50	2	0.2	20	10	EC, 1998