Sudan University of Science and Technology College of Graduates Studies

Measuring Hazards of Heavy Metals Residues On Fish

قياس مخاطر ترسبات المعادن الثقيلة في الاسماك

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Preface

This work was carried out at the Department of preventive medicine , Faculty of Veterinary Medicine, Sudan University of Science and Technology ,under the supervision of . Prof.Mohamed Abd alsalam the Dean,of Faculty of Veterinary Medicine .

Dedication

To the sole of My Mother and Father….

To My Husband and My Two Lovely Sons Karar and Mohammed with deep love and respect.

Nadia

Acknowledgement

First, thanks to Allah for giving me the health and strength to complete this work. My deepest gratitude to my supervisor Prof. Mohamed Abd ALsalam for his guidance, encouragement and help which made this work possible.

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Abstract

Fish is an important food source for the human body.. Despite its nutritive value consumption fish brings many times a potential hazard concern for the human consumers However, fish are relatively situated at the top of the aquatic food chain; therefore, they normally can accumulate heavy metals from food, water and sediments which can counteract their beneficial effects; several adverse effects of heavy metals to human health have been known for long time.This work had been done in two different states in Sudan by taking 30 tissue samples from the dorsal muscles of two different Spp from two different geographical locations and different lengths and weights, for measuring The concentrations of heavy metals for. (Cd, Cr and Pb) for two types of fish Spp Orechromis niloticus (Bulti) and Labeo niloticus (Dabsa), by taking 10 samples Bulti Spp from white Nile Khartoum State and twenty samples 10 of which is from Bulti Spp and the other 10 is from Dabsa Spp Wadi Halfa Nubian lake North State. the thirty fish species were collected from two main landing areas (Halfa, and White Nile) and were analyzed to measure--- the concentrations of these elements in fish (mg/Kg DW) by using atomic absorption spectrometry. The ranges of the measured concentrations Cd, Cr and Pb (mg/kg) in the total samples were all less than the permissible range . Therefore, the study results revealed that the White Nile river Khartoum state and lake Nubian Northern state might be considered as not polluted with the these heavy

metal . The levels of the concentration of these heavy metals varied among fish species, weight and length . These differences were discussed for the contribution of potential factors that affected metals' uptake, like age, geographical distribution and species'(specific factors). Generally, recorded metal concentrations were within the permissible or below the levels in similar species from global studies. The concentration of metals in the present fish tissue were accepted by the international legislation limits and are safe for human consumption. Three common heavy metals were measured cadmium (Cd) was ranged between 0.011- 0.019, chromium (Cr) ranged between 0022- 0.019 and lead(Pb) between 0.014-0.068 mg/kg(Bulti fish) in White Nile as for lake Nubian were Three common heavy metals were measured cadmium (Cd) was ranged between 0.017-0.066 , chromium (Cr) ranged between 0.035-0.465 and lead(Pb) between 0.130-0.485 mg/kg in (Bulti fish) and that for Dabsa Spp.the cadmium (Cd) was ranged between 0.021-0.285 , chromium (Cr) ranged between 0.065-0.260 and lead(Pb) between 0.075-550 mg/kg .The obtained results showed also the correlation between the heavy metals depending on the weight and length of the fish samples and the geographical location which also showed no significant result.In the conclusion, this results in this study demonstrated that fish species caught in the White Nile River and Nubian were not contaminated with heavy metals. Although the concentrations of heavy metals in the fish were not detected, the potential for metal toxicity danger may appear in the future depending upon the extent of industrial and domestic wastewater influx and human activities in the adjacent areas to Nile and the lake. To develop a healthy freshwater fishing industry and to prevent heavy metal risks to human health in the River, the water standards and concentrations of heavy metals in the water column and fish should be monitored regularly. In addition to types of heavy metals and characteristics of rivers in Sudan should highly considered in selection of different types of fishes including Red Sea fish for heavy metals analysis.

الملخص

تعتبر الاسماك مصدر غذائي هام و بالرغم من هذه القيمة الغذائية استهلاك الاسماك قد يتسبب احيانا في تعرض المستهلكين لبعض المخاطر وعلى كل حال نسبية وجود الاسماك على راس السلسلة الغذائية للاحياء المائية عادة يجعل امكانية تراكم المعادن الثقيلة من الغذاء، الماء او الرواسب يتعارض مع اهميتها الغذائية وتاثيرها العكسي على صحة الانسان وهذا معروفا منذ زمن طويل .

هذا العمل تم انجازه في ولايتين مختلفتن في السودان باخذ 30 عينة من انسجة عضلات الظهر من نوعين مختلفين من الاسماك من مواقع جغرافية مختلفة باطوال واوزان مختلفة لقياس تركيز المعادن الثقيلة لكل (الكادميوم ،الكروميوم والرصاص) لاسماك البلطي والدبسة من كل من ولاية الخرطوم (النيل الابيض وولاية الشمالية(وادي حلفا) باخذ عشرة عينات من البلطي من النيل الابيض ولاية الخرطوم وعشرون عينة من بحيرة النوبة وادي حلفا منها عشرة عينات من البلطي وعشرة عينات من الدبسة هذه العينات تم جمعها بصيدها مباشرة من النيل الابيض وبحيرة النوبة وتم تحليلها لقياس تراكيز المعادن في هذه الاسماك (مل جرام لكل كجم) باستعمال مطياف الامتصاص الذري . نطاق التراكيز التي تم قياسها للكادميوم والكروميوم والرصاص في هذ العينات جميعها اقل من النطاق المسموح به وبهذا نتائج هذه الدراسة اظهرت ان النيل الابيض بولاية الخرطوم وبحيرة النوبة بالولاية الشمالية يمكن اعتبارها غير ملوثة بهذه المعادن . مستوى تركيز هذه المعادن مختلف باختلاف النوع والوزن والطول وهذه الاختلافات نوقشت بمساهمة العوامل المحتملة التي تؤثر على امتصاص المعادن مثل العمر التوزيع الجغرافي والنوع (العوامل المحددة).عامة تراكيز هذه المعادن اقل من المستوى المسموح به لنفس نوعية الاسماك من الدراسات العالمية.تركيز المعادن الثقيلة في انسجة هذه الاسماك مقبولة في حدود التشريعات الدولية وسليمة للاستهلاك البشري. ثلاثة من المعادن الثقيلة تم قياس تراكيزها الكادميوم ، الكروميوم والرصاص وكانت النسب في المدى ما بين 0.011 -0.019 للكادميوم،الكروميوم 0.019- 0.022 - والرصاص ما بين0.014-0.068 مل لكل كجم لاسماك البلطي في النيل الابيض ام بالنسبة لبحيرة

النوبة النتائج: ثلاثة من المعادن الثقيلة تم قياس تراكيزها الكادميوم ، الكروميوم والرصاص وكانت النسب في المدى ما بين 0.021 -0.285 للكادميوم والكروميوم -0.065- 0.260 - والرصاص ما بين0.075-0.485 مل لكل كجم لاسماك البلطي ام اسماك الدبسة وكانت النسب في المدى ما بين 0.066 -0.017 للكادميوم والكروميوم 0.465- 0.034 - والرصاص ما بين0.075-0.550 مل لكل كجم. النتائج المتحصلة اظهرت العلاقة بين المعادن الثقيلة والوزن والطول والمناطق الجغرافية للاسماك والتي اظهرت نتائج غير ذات اهمية، في الختام هذه النتائج من هذه الدراسة التي قدمت فيها انواع الاسماك التي اخذت من كل النيل الابيض وبحيرة النوبة غيرملوثة بالمعادن الثقيلة ، وبالرغم من عدم وجود اكتشاف تراكيز للمعادن الثقيلة في الاسماك الا احتمالية ظهور خطر سميتها في المستقبل يعتمد التوسع في الصناعات ، تدفق المياه المنزلية وانشطة الانسان في المناطق المتاخمة للنيل والبحيرة. ولتحسين صناعة الاسماك صحيا في المياه العذبة و كبح خطورة المعادن الثقيلة لصحة الانسان في الانهارمقاييس المياه وتراكيز المعادن الثقيلة في عمود الماء والاسماك يجب مراقبتها بانتظام دوريا اضافة الى انواع المعادن الثقيلة وخصائص الانهار في السودان تدرس للغاية في اختيار اسماك من الانواعللغاية في اختيار اسماك من الانواع المختلفة وتشمل اسماك البحر الحمر لتحليل المعادن الثقيلة.

1-Introduction

1.1Fish:

Today, fish has become the main supply of protein besides meat and poultry products and contributed to a large percentage of dietary protein globally.

In most Asian countries, especially in Southeast Asia like Thailand, Indonesia and Malaysia fish is taken as the main dish of their diet.

Importance of fish:

1.1.2 Importance of fish:

fish is a vital source of food for people. It is man's most important single source of high-quality protein, providing 16% of the animal protein consumed by the world's population, according to the FAO (1997). FAO estimates that about one billion people world-wide rely on fish as their primary source of animal protein (FAO, 2000).

Fish is an important food source for the human body. Fish provide essential fatty acids like omega 3, proteins, vitamins and minerals. Despite its nutritive value consumption of fish brings many times a potential hazard concern for the human consumers. Gado MS, Midany SA (2003) . In the recent years, world consumption of fish has increased simultaneously with the growing concern of their nutritional and therapeutic benefits. In addition to its importance as a source of protein, fish typically have rich contents of essential minerals, vitamins and unsaturated fatty acids R.J.Medeiros,(212). The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of omega-3 fatty acids P. Kris-Etherton, (2002).

1.1.3 Nutritional value of fish:

. "Fish provides a good source of high quality protein and contains many vitamins and minerals. It may be classed as either whitefish, oily or shellfish. Whitefish, such as haddock and seer, contain very little fat (usually less than 1%) whereas oily fish, such as sardines, contain between 10-25%. The latter, as a result of its high fat content, contain a range of fat-soluble vitamins (A, D, E and K) and essential fatty acids, all of which are vital for the healthy functioning of the body. Fellows P and Hampton A (Eds.) (1992).

It is particularly valuable for providing food with nutritional value in the form of protein, and minerals such as calcium, phosphorus, iron and copper. . Besides protein, fish is also high in essential fatty acids (EFAs), known as eicosapentaenoic acid (EPA) and Docosa Hexaenoic Acid (DHA) that are important to the diet. In addition, consumption of fatty fish is recommended by nutritionist as a means to prevent cardiovascular diseases (Siscovick *et al*., (1995); j Daviglus *et al*., (1997) ;Domingo *et. al*.,(2007). The aim of this study to detect the contamination of heavy metals on the fish in the White Nile River at Khartoum state and Nubian lake in North state. After decades of rapid urbanization, population growth and industrialization

1.2 General objectives:

Assessment of the heavy metals in according to WHO standards.

1.3 Specific objective:

Hazardous heavy metals contaminant in fisheries in Sudan.

2. Literature Review

2.1. Heavy Metals:

Heavy metals are individual metals and it can impact human health. Eight common heavy metals are discussed in this brief: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. These are all naturally occurring substances which are often present in the environment at low levels. In larger amounts, they can be dangerous. These Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity and accumulation by marine organisms (Malik, 2014). The concentration of heavy metals in the fish from the Rivers water has shown that the metal concentration found in the fish samples were higher than the range of maximum acceptable limits as per WHO. The various industrial outlets which drain into the river is a probable source of the heavy metals in the rivers, leading to severe deleterious effect in humans, fish and plants (Sen *et al.,* 2011). Various national and international agencies have determined the recommended range of heavy metals permissible to human health (Singh *et al*., 2014). Early studies have identified the rise in the pollution of particular heavy metals in freshwater systems around the world, particularly in rivers. The pollution has mainly been caused by industrial processes and industrial waste, typically from rubber and oil palm mills (Tariq *et al*., 1996).Heavy metals are intrinsic, natural constituents of our environment and the term "heavy metals" refers to any metallic element that has relatively high density and are toxic or poisonous even at low concentration (lenntech, 2004). Moreover they are also known as trace elements because they occur in minute concentrations in biological systems. Sediments may become contaminated by the accumulation of heavy metals through various sources such as disposal of high metal wastes, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation (Khan, 2008; Zhang *et al*., 2010). Lead in water may come from industrial and smelter discharges; from the dissolution of old lead plumbing, lead containing pesticides, through precipitation, fallout of lead dust, street runoff, and municipal wastewater [Sorensen, 1991; Sepe *et al*., 2003]. The concentration and bioavailability of Pb is mainly dependent on the absorption into the sediments and the natural organic matter content of the water as well as the pH, alkalinity and hardness (Mager ,2011: Sepe *et al*., 2003). The agricultural drainage water containing pesticides and fertilizers and effluents of industrial activities and runoff in addition to sewage effluents enter into the water bodies and sediment with huge quantities of inorganic anions and heavy metals (EDCG, 2002). The heavy metal contamination of aquatic ecosystems above the natural background load has drawn the attention of many researchers. Heavy metals may accumulate in aquatic species, enter the food chain and cause serious harm to human health when the contamination content and exposure are significant (Goyer, 1997; Papagiannis *et al*., 2004; Türkmen *et al*., 2005; Fernandes *et al*., 2007). . The accumulation of heavy metals in fish is an important issue because many fish species are consumed as a source of protein by a large section of the population, especially those who live near rivers. The low saturated fat and sufficient omega fatty acids in fish are also important in supporting good human health. Fish, in comparison with invertebrates, are more sensitive to many toxicants and are a convenient test subject for indication of ecosystem health (Adams and Ryon, 1994; Zaki, *et al*., 2010) . Heavy metals are produced from a variety of natural and anthropogenic sources (Bauvais *et al.*, 2015). In aquatic environments, heavy metal pollution results from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products, also via wastewater treatment plants (WWTPs) (Demirak *et al.*, 2006; Maier *et.al.*, 2014; Dhanakumar *et al*., 2015). Essential metals include Fe, Cu, Zn and manganese (Mn), whereas non-essential metals are Hg, Pb, nickel (Ni) and Cd (Türkmen *et al*., 2005). High concentrations of heavy metals affected the growth and development of fish during early life stages such as hatching, larval development and juvenile growth because they were more sensitive during these stages than during mature stages. Evidently, fish form the link for the transfer of toxic heavy metals from water to humans (Ashraf *et al.*, 2010). The harmful effect of trace elements when consumed above the recommended limit can be toxic (acute, chronic or sub-chronic), and heavy metals can be neurotoxic, carcinogenic, mutagenic or teratogenic. Fishes are considered to be most significant biomonitors in aquatic systems for the estimation of metal pollution level (Rashed, 2001). (Authman 2008) offered several specific advantages in describing the natural characteristics of aquatic systems and in assessing changes to habitats. In addition, fish are located at the end of the aquatic food chain and may accumulate metals (Rashed, 2001)., developing countries are now home to many of the world's most critical air, water and solid waste problems. Early studies have identified the rise in the pollution of particular heavy metals in freshwater systems around the world, particularly in rivers. The accumulation of heavy metals in fish is an important issue because many fish species are consumed as a source of protein by a large section of the population, especially those who live near rivers. The low saturated fat and sufficient omega fatty acids in fish are also important in supporting good human health. The levels of heavy metal accumulation in fish depend on the growth rate, metabolism, feeding pattern and ecological requirements of a given fish species (Yilmaz *et al.* 2005, 2010). Another factor is the differences in life history patterns among species (including trophic levels and geographical distribution of life stages), which influence their exposure to heavy metals (Allen-Gil & Martynov 1995). Due to feeding and living in the aquatic environments fish are particularly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants(Yarsan E, Yipel M 2013). (Mahboob S, Al-Balawi HFA, Al-Misned F, Al-Quraishy S, Ahmad Z 2014) (Saleh, YS, Marie M-A.S. 2014) Essential metals are important for the normal metabolism of fish, and non-essential metals may accumulate in their organs (Canli & Atli 2003). The general symptoms of humans related to metal [e.g., Cd, Pb, As, Hg, Zn, Cu and aluminum (Al)] poisoning include vomiting, convulsions, paralysis, ataxia, haemoglobinuria, gastrointestinal disorder, diarrhoea, stomatitis, tremor, depression and pneumonia (Mc Cluggage 1991). (Garcia JC,et al. 2015). Coal combustion is one of the most important anthropogenic emission sources of trace elements and an important source of a number of metals (Wagner, A. and Boman, J. 2003). The contamination of heavy metals and metalloids in water and sediment, when occurring in higher concentrations, is a serious threat because of their toxicity, long persistence, and bioaccumulation and bio magnification in the food chain.(Eisler R 1993),(Has-Schön E, Bogut I, Strelec I 2006). In addition, fish are located at the end of the aquatic food chain and may accumulate metals (Lamas S, Fernández JA,et al 2007) and pass them to human beings through food causing chronic or acute diseases (Al-Yousuf MH, El-Shahawi MS, Al-Ghais SM 2000) .

2.2.History Of Heavy Metals:

The toxic effects of arsenic, mercury and lead were known to the ancients but methodical studies of the overall toxicity of heavy metals appear to date from only 1868. In that year, Wanklyn and Chapman speculated on the adverse effects of the heavy metals "arsenic, lead, copper, zinc, iron and manganese" in drinking water. They noted an "absence of investigation" and were reduced to "the necessity of pleading for the collection of data." (Wanklyn & Chapman 1868) .

2.2.1. Cadmium:

Cadmium exposure is a phenomenon of the early twenty century, and onwards. In Japan in 1910, the Mitsui Mining and Smelting Company began discharging cadmium into the Jinzugawa river, as a byproduct of mining operations. Residents in the surrounding area subsequently consumed rice grown in cadmium-contaminated irrigation water. They experienced softening of the bones and kidney failure. The origin of these symptoms was not clear; possibilities raised at the time included "a regional or bacterial disease or lead poisoning."*(* Pritchard J 19 May 2010). "Wal-Mart Pulls Miley Cyrus Jewelry After Cadmium Tests". USA Today.*In 1955, cadmium was i*dentified as the likely cause and in 1961 the source was directly linked to mining operations in the area.(Mulvihill G, Pritchard J 4 June 2010)."McDonald's Recall: 'Shrek' Glasses Contain Toxic Metal Cadmium". Huffington Post.Aggrawal, A. Textbook of Forensic Medicine and Toxicology. New Dehli: Avichal Publishing Company. ISBN 978-81-7739-419-1.*}*

2.2.2. Chromium:

Potassium chromate, a carcinogen, is used in the dyeing of fabrics, and as a tanning agent to produce leather.Chromium(III) compounds and chromiummetal are not considered a health hazard, while the toxicity and carcinogenic properties of chromium(VI) have been known since at least the late 19th century.](Haines, AT; Nieboer, E 1988*).* *"* ISBN 0471856436 In 1890, Newman described the elevated cancer risk of workers in a chromate dye company.National Research Council 1974, p. 68 Chromate-induced dermatitis was reported in aircraft workers during World War II.(Tovey J 17 December 2011). "Patches of Carcinogen Seen After Orica Leak".The Sydney Morning Herald. In 1963, an outbreak of dermatitis, ranging from erythema to exudative eczema, occurred amongst 60 automobile factory workers in England. The workers had been wet-sanding chromate-based primer paint that had been applied to car bodies.*(* Vallero, DA; Letcher, TM 2013). In Australia, chromium was released from the NewcastleOrica explosives plant on August 8, 2011. Up to 20 workers at the plant were exposed as were 70 nearby homes in Stockton. The town was only notified three days after the release and the accident sparked a major public controversy, with Orica criticized for playing down the extent and possible risks of the leak, and the state Government attacked for their slow response to the incident.*(* Vallero, DA; Letcher, TM 2013).

2.2.3. Lead:

The adverse effects of lead were known to the ancients. In the 2nd century BC the Greek botanist Nicander described the colic and paralysis seen in lead-poisoned people. (Pearce 2007*);(* Pearce JM 2007) (Needleman 2004) Lead was used extensively in Roman aqueducts from about 500 BC to 300 AD. (Gilbert SG, Weiss B 2006)Julius Caesar's engineer, Vitruvius, reported, "water is much more wholesome from earthenware pipes than from lead pipes. For it seems to be made injurious by lead, because white lead is produced by it, and this is said to be harmful to the human body."(Prioreschi, P 1998). During the Mongol period in China (1271−1368 AD), lead pollution due to silver smelting in the Yunnan region exceeded contamination levels from modern mining activities by nearly four times. (Hillman et al. 2015). ″. In the 17th and 18th centuries, people in Devon were affected by a condition referred to as Devon colic; this was discovered to be due to the imbibing of lead-contaminatedcider. In 2013, the World Health Organization estimated that lead poisoning resulted in 143,000 deaths, and "contributed to 600,000 new cases of children with intellectual disabilities", each year. World Health Organization(2013) In north-east America, in the city of Flint, Michigan, lead contamination in drinking water has been an issue since 2014. The source of the contamination has been attributed to "corrosion in the lead and iron pipes that distribute water to city residents".(Torrice 2016).

2.3.Factors Affecting Accumulation of Heavy Metals in Fish Tissue:

Studies from the field and laboratory works showed that accumulation of heavy metals in a tissue is mainly dependent on water concentrations of metals and exposure period; although some other environmental factors such as water temperature, oxygen concentration, pH, hardness, salinity, alkalinity and dissolved organic carbon may affect and play significant roles in metal's accumulation and toxicity to fish .(Benaduce APS,et al 2008) . Ecological needs, size and age of individuals, their life cycle, feeding habits, and the season of capture were also found to affect experimental results from the tissues (Yarsan E, Yipel M 2013), (Benaduce APS, Kochhann D, Flores ÉMM, Dressler VL, Baldisserotto B 2008). Fish have the ability to uptake and concentrate metals directly from the surrounding water or indirectly from other organisms such as small fish, invertebrates, and aquatic vegetation (Yarsan E, Yipel M 2013). . Heavy metals enter the aquatic environment mainly by anthropogenic sources. Fish is at the top of the aquatic food chain, and during its life can accumulate large amounts of toxic elements. Heavy metals are defined by their weight. To be classified as a heavy metal, it must have a specific gravity of 2.7 example lead (Mahdy AA, Trok TY, Arel MA 1993) . One category of toxic contaminations accumulated by fishes are heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd) chromium (Cr) and arsenic (As). Any of these heavy metals can destroy life when they concentrate in the body above acceptable levels. Heavy metals have the tendency to accumulate in various organs and muscle tissue of fish. Contaminated fish enter the human body through consumption and it causes health hazards. Most of these chemicals are released in nearby water bodies and lead to water pollution. Surface runoffs of soil and rock debris although non-toxic can be harmful for aquatic lives surrounding the areas. Release of toxic chemicals into the water is obviously harmful for the flora and fauna of the water bodies. Besides pollution, mining processes use water from nearby water sources (Nadal MM, Schuhmacher M, Domingo JL 2004). Sometimes, abandoned quarry pits turn into stagnant lakes which create breeding ground for mosquitoes and black flies which spread disease within the locality. These wastes have been reported to contain toxic and hazardous substances including heavy metals, which eventually settle in bottom sediments (Ademoroti CMA 1996) (Forstner U, WittmannGTW 1981). stated that microbial and redox processes may change the properties of sediments and affect the composition of interstitial water, while reworking of the sediments by organisms will also bring sediments to the surface, where a significant fraction of heavy metals will be released. A good knowledge of the distribution of heavy metals in water and sediments plays a key role in detecting the sources of pollution in aquatic systems

(Forstner U, WittmannGTW 1981). There are numerous heavy metals, some of which are highly toxic, like mercury, lead, arsenic, and cadmium. Fish accumulate toxic materials at various levels, depending on species, age, season, feeding habits, and so on. None of the metals are biodegradable, and though they can change forms from solid, to liquid, to dust and gas, they never completely disappear. The ones that are toxic in even the same minute amounts create instant cellular destruction in any of their forms. Marine animals such as fish are able to readily absorb metals and their bodies regulate to accommodate their presence. They are easily stored in fatty tissue and will bioaccumulate if the fish is exposed to further contamination (. Sindayigaya E, Cauwnbergh RV, Robberecht H, Deelstra H 1994).

Heavy metals are commonly found in natural waters and some are essential to living organisms, they may become highly toxic when present in certain concentrations. These metals also gain access into ecosystem through anthropogenic and get distributed in the water body, tended solids and sediments during the course of their mobility. The rate of bioaccumulation of heavy metals in aquatic organisms depends on ability of the organisms to digest the metals in the river; it has to do with the concentration of the heavy metal in the surrounding soil sediments, and as well the feeding habits of the organism. Aquatic animals (including fish) bio-accumulates trace metals in considerable amounts and stay over a long period. Fishes have been recognized as a good accumulator of organic and inorganic pollutants (Gado MS, Midany SA 2003) . Age of fish, lipid content in the tissue and mode of feeding are significant factors that affect the accumulation of heavy metals in fishes. Some heavy metals such as Zn and Fe are essential nutrients for animals and plants but are dangerous at high leve whereas Pb have no well defined physiological function but are detrimentalat (Ochieng EZ, Lalah JO

, Wandiga SO 2007) .(Kar D, Sur P, Mandal SK, Saha T, Kole RK 2008) . At such concentration, it may cause neurological impairment and central nervous system malfunctioning. When fish bio-accumulates these pollutants, it becomes a threat to human health since consumers depend heavily on the fish for their dietary needs. In addition, the streams also which serves as both drinking and domestic water become undrinkable since it endangers human health directly or indirectly.

2.4.Toxic Heavy Metal :

Heavy metals are found naturally in the earth. They become concentrated as a result of human caused activities and can enter plant, animal, and human tissues via inhalation, diet, and manual handling. Then, they can bind to and interfere with the functioning of vital cellular components. The toxic effects of arsenic, mercury, and lead were known to the ancients, but methodical studies of the toxicity of some heavy metals appear to date from only 1868. In humans, heavy metal poisoning is generally treated by the administration of chelating agents. Some elements otherwise regarded as toxic heavy metals are essential, in small quantities, for human health.Heavy metals are intrinsic, natural constituents of our environment and the term “heavy metals” refers to any metallic elements that have relatively high density and are toxic or poisonous even at low concentration (Lenntech 2004).

Heavy metals include Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and the platinum group elements. Moreover they are also known as trace elements because they occur in minute concentrations in biological systems. Sediments may become contaminated by the accumulation of heavy metals through various sources such as disposal of high metal wastes, land application of fertilizers, animal manures, sewage sludge, pesticides, and wastewater irrigation (. Khan S, Cao Q,et al 2010). The agricultural drainage water containing pesticides and fertilizers and effluents of industrial activities and runoff in addition to sewage effluents enter into the water bodies and sediment with huge quantities of inorganic anions and heavy metals (ECDG 2002) . Some animal wastes like livestock, poultry and pig manures created in agriculture and it is also used as food in aquaculture pond and usually supplied to fish either in the form of solids or semi solids. The manures that are created from animals as a result of these diets possess greater amounts of Cu, As and Zn and if continually supplied as fish feed in pond, can result in reasonable accumulation of these metals in the longer period of time in these sediment (Basta NT, Ryan JA, Chaney RL 2005).

2.5. Entry Routes of Heavy Metals:

Heavy metals entre in fish bodies by three possible ways: by gills, bydigestive track, and body surface. The gills are considered as the significant site for direct uptake of metals from the water (Romeo M, Siau Y, Sidoumou ZÌn, 1999).(Beijer K, Jernelov A, 1986).Through the body surface is normally estimated to take minor part in uptake of heavy metals in fish. (Selda OT, Nurşah A, 2012). Heavy metals enter plant, animal and human tissues via air inhalation, diet and manual handling. Motor vehicle emissions are a major source of airborne contaminants including arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhobdium. (Balasubramanian, He & Wang 2009), Water sources (groundwater, lakes, streams and rivers) can be polluted by heavy metals leaching from industrial and consumer waste; acid rain can exacerbate this process by releasing heavy metals trapped in soils.(Worsztynowicz & Mill, 1995) Heavy metals can be taken up into fish either from i:ngestion of contaminated food via the alimentary tract or through the gills and skin (Linbo TL,et al 2009).

The heavy metal concentration in fish tissues reflects past exposure via water and/or food and it can demonstrate the current situation of the animals before toxicity affects the ecological balance of populations in the aquatic environment. (Birungi Z,et al 2007).Active biomonitoring of trace heavy metals using fish (Oreochromis niloticus) as bio-indicator species. The case of Nakivubo wetland along Lake Toxic heavy metals can bioaccumulate in organisms as they are hard to metabolize. (Pezzarossa, Gorini & Petruzelli (2011).

2.6. Sediment Heavy Metal Content in Inland Aquatic Ecosystem:

The common heavy metals that can be found in fish and shellfish are potassium, copper, calcium, iron, iodine, mercury, lead and cadmium (Connel, 1984). The concentrations of heavy metals in receiving environments have both natural causes, such as sea-bed volcanic activity, atmospheric convection, rivers or erosion, and man-made causes, such as mining, the rapid increase of treatment and refining systems, the excessive use of fossil fuels, and the use of metallic products in agriculture (like arsenic pesticides). Of the heavy metals that are transported into the water, one portion is diffused in the water and the other portion forms solid compounds with carbonate, sulfate and sulfur, sinks to the bottom, and is accumulated in the sediment.(Topçuoğlu, S.,2005) Accordingly, the sediment forms a trap for heavy metals, and thus, concentrations of heavy metals in the sediment can be several orders of magnitude greater than in the overlying water. Metals found in the sediment directly threaten detrital and deposit-feeding benthic organisms, and could possibly be a long-term source of contamination higher up the food chain. (Boyd, C.E. and Tucker, C.S.

1990).Fish can take in heavy metals through respiration (through the gills or the skin), adsorption to body surfaces or feeding. The intake of heavy metals and their accumulation in the organisms in aquatic ecosystems are affected by several factors, such as differences in the amount of metals entering the environment, the condition of the organism and the physical and chemical properties (temperature, salinity, pH and dissolved oxygen) of the aquatic environment in which the organisms are found. Quantitative sediment quality guidelines (SQG) exist for freshwater ecosystems, and these provide a reliable benchmark for assessing sediment quality in freshwater ecosystems. The threshold effect level (TEL) and the probable effect concentrations (PEC) for different sediment contaminants in freshwater ecosystems were determined by(MacDonald, D.D., Ingersoll, C.G. and Berger, T.A. ,2000). These metals accumulate in fish from water, food, sediment and some suspended particulate materials (Agusa et al, 2005). In many, countries, industrial wastes geochemical structure and mining of metals create a potential source of heavy metals pollution in the aquatic environment dueto their toxicity and accumulation behaviour. Under certain environmental conditions, these heavy metals might accumulate up to a toxic concentration and cause ecological damage (Sivaperumal *et al*., 2007). On the other hand, industrial and agricultural activities also were reported to be the largest contributor to the accumulation of pollutants in the aquatics including seawater (Jordao *et al*., 2002). Although heavy metal contamination exist at high concentrations in water or sediment, however, it does not involve direct toxicological risk to fish, especially in the absence of significant bioaccumulation (Fernandes *et al*., 2007).

2.7. Effect of different Heavy Metals on Fish:

The toxic effects of heavy metals can affect the individual growth rates, physiological functions, mortality and reproduction in fish (Amundsen PA,et al 1997).. Heavy metal accumulation can also be caused by the food source, possibly leading to bio-magnification, the augmentation of toxins up the food chain .(Per-Arne,SJ,et al 1997). As a human food, Fish are considered as an excellent source of polyunsaturated fatty acids (predominantly omega-3 fatty acids, protein, Zn, iron and calcium. (Toth J.F, Brown RB1997). Seafood will be an even more important and safe source of food in future for protein and fatty acids for human intake and products made from aquaculture (WHO, 1999). Different factors that are considered to be critical are size, developmental stage and salinity in heavy metal toxicity to marine and estuarine organisms. (Grosell M, Blanchard J, Brix K, Gerdes R 2007). Affected organisms show response to heavy metals by accumulating in their bodies or by shifting to the next trophic level of the food chain (Shah SL, Altindag A 2005).

2.7.1. Effects of cadmium on fish:

Cadmium is the non-essential and most toxic heavy metal which is widely distributed in the aquatic environment and earth's crust. Burning of fossil fuels and municipal waste are known to be largest sources of cadmium release to the environment (such as coal or oil) Nriagu JO, Pacyna JM 1988). Reproduction rate of aquatic organisms may also be affected due to Exposure to heavy metals and can lead to a gradual extinction of their generations in polluted waters. (Sridhara CN,et al 2008). For example Cd and mercury(Hg) damage the kidney and produced signs of chronic toxicity, including impaired reproductive capacity and kidney function,tumors, hypertension and hepatic dysfunction .(Mansour SA, Sidky MM, 2002).

Fish creates major sources of human beings food which as protein. Fishes are major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish. (Andersen JL, Depledge MH 1997). (Prudente M, et al 1997).(ErdoÄŸrul Ãz, AteÅŸ DA 2006).. The nutritive need of different tissues of fish depends on their biochemical configuration like mineral contents, amino acids, protein and vitamins, *etc*. The sub lethal concentration of Cd has showed deviations on the electrophoresis arrangements of protein segments in gills and muscle (*O.mossambicus*.Afshan *et al* RJCES Vol 2 February 2014) .

metals such as cadmium, mercury, arsenic and lead are non-essential and therefore have toxic effects on living organisms . .(Amiard J,et al 1987).(Barka S,et al 2001)..(Hanna LA, et al CL 1997). These heavy metals accumulate in tissues and body of aquatic organisms in higher concentration than concentrations in water and biomagnified in food chain that cause physiological damages at higher atrophic levels and in human consumers. Human being takes Cd mainly through food. Food materials contains higher Cd can significantly increase the Cd concentration in human bodies. The food materials that contain higher Cd are; fish liver, shellfish, mushrooms, dried seaweed etc. In start Cd transported to liver through the blood where it binds to proteins to form complexes that are transported to kidneys where it harms the purifying mechanisms. In results, this causes the excretion of sugars and essential proteins from the body and further damage kidneys. It takes time before Cd that accumulated in kidneys and excreted from human body.

Other related health effects caused by cadmium are:

- Diarrhea

- Vomiting
- Stomach problems
- Fractures in bone
- Damage to DNA
- Failure in reproduction and fertility
- Cause damage to nervous system
- Damage to immune system
- Cause cancer

2.7.2. Effects of Chromium on Fish:

Heavy metals accumulated in fish either from the surrounding water or by ingestion of food in environment (D Said S,et al ,1992). to anthropogenic activities natural water is being contaminated by this metal. The chromium concentration in rivers and lakes stated to range between 1 to 10 ug/L and EPA recommendation for permissible level are 50 to 100 ug Cr/L for protection of human health and aquatic life respectively. Some species of fishes have poisonous effect of chromium as echoed in the blood changes such as anemia, eosinophilia and lymphocytosis, bronchial and renal lesions. Chromium known for its lesser accumulation in fish bodies while the higher concentrations of Cr damages the gills of fish swimming near point of Cr disposal .Effect of chromium on humans by fish intake Fish being at the higher level of the food chain accumulate large quantities of metals and the accumulation depends upon the intake and elimination from the body. (Karadede Hl, Oymak SA, ÃoenlÃ E 2004). Cr (VI) is harmful to human health, mainly for those who work in textile and steel industry. The tobacco smokers also have higher possibility of disclosure to Cr. Chromium (VI) can cause many health effects. Chromium in leather products can cause skin rash like allergic reactions. After breathing it can cause nose irritations and nose bleeds. . (Karadede Hl, Oymak SA, ÃoenlÃ E 2004).Other health problems caused by Cr (VI) are:

- Faded immune system
- .Skin diseases
- Cause ulcer and upset stomach
- Respiratory tract problem
- Alteration in genetic material
- Lung cancer
- liver and kidney damage
- Death

2.7.3. Effects of Lead on Fish:

When accumulation reaches a substantially high level, accumulated heavy metals in the tissues of aquatic animals and may become toxic (Aq Y, Gonulalan Z, Narin I, Soylak M 2009).

2.8. Bioaccumulation:

is the accumulation of substances or chemicals in an organism. There are a small number of plants that easily absorb high levels of metals from the surrounding soil. These are called hyper accumulators. If these plants are harvested for human use, exposure to harmful levels of metals can happen. Normally, this is a concern only if plants are collected from areas with high concentrations of metals in the soil. Metals uptake by plants is dependent on soil acidity (pH). The higher the acidity, the more soluble and mobile the metals become, and the more likely they are to be taken up and accumulated in plants. In general, humans are more likely to be exposed to metal contamination from soil that sticks to plants than from bioaccumulation. This is because it is very difficult to wash all soil particles off of plant materials before preparing and ingesting them. Root crops (like potatoes and carrots), leafy vegetables (like spinach and lettuce), and parts of plants that grow near the soil (like strawberries) are a higher risk for exposure to metal contamination than the higher portions of plants, like fruits or berries. Stressed plants may be a sign of metal contamination. Look for unusual changes in the coloring or growth pattern of plants as an indicator of a stressful growth environment (like drought) combined with high metals concentrations in the soil. These kinds of conditions make it more likely that the plants are bioaccumulations (or up taking) metals. Deficiencies in the plant (like a low level of zinc) can also influence a plant's likelihood to accumulate metals. Animals can accumulate metals as well by eating plants, fish, or drinking water with elevated metal concentrations. These metals are not excreted by the animals; rather, they accumulate mostly in the organs as well as the skin, hair, and bones. Fish accumulate metals from the water they live in as well as from organisms they eat. Bottom feeders are particularly susceptible to metals bioaccumulation as they can ingest sediments laced with metals for fish consumption advisories, (website, http://www.epa.gov/waterscience/fish/Seaweed accumulates metals from the surrounding water as well as the sediments it grows in).In addition to ingesting metals via food, there are a number of ways to be exposed to metal contamination through plant use. They include, inhaling contaminants from burning plant materials (like smudging), inhaling contaminants from smoking plant materials (like tobacco or jimson weed), volatilization (turning into a gas) of contaminants in plant materials in enclosed areas (like sweat lodges or work areas), ingestion, inhalation, or skin contact from handcrafts using plants, and daily use of plant materials as tonics to promote health (like ginseng or sage).Environmental Science and Technology Briefs for Citizens.

2.8.1 Bioaccumulation of Cadmium:

Fish, plants and animals bio-accumulate.Examples: liver, kidney, meat, mushrooms, shellfish, mussels, cocoa powder and dried seaweed. Fish consumption advisories: http://www.epa.gov/waterscience/fish/ Be primarily concerned with roots or contamination from soil on lower portion of plant (dust). Under certain conditions (high soil levels plus plant stress) can accumulate to levels harmful to humans. Rice plants are particularly vulnerable.

2.8.2. Bioaccumulation of Chromium:

High potential for uptake by aquatic life, especially bottom-feeders. Fish consumption advisories: http://www.epa.gov/waterscience/fish/Possible uptake by plants. Be primarily concerned with roots.

2.8.3. Bioaccumulation of Lead:

Generally not absorbed or limited to roots. Be primarily concerned with roots and contaminated soil adhering to lower portion of plant. Without phosphates, lead can move from roots to plant tissues.

Table(1).Type of fishes and its local name in Sudan (AbuGiderri,Y.B 1976).

Species	Local name
Hydrocynus forskali	KASS
Hydrocynus linatus	KASS
Hydrocynus brevis	KASS
Chrysicthys auratus	Abureyala
Chrysicthys ruepelli	Abureyala
Labeo horiae	Tutkum
Alestes baremose	Kawara

Eutropius niloticus	Schibaya arabi
Oreochromic nilotica	Bulti
Tilapia gallilea	Bulti
Tilapia nilotica	Bulti
Tilapia zilli	Bulti
Sarothredon galiaeus	Bulti
Syndontis schall	Gargour
Syndontis olarias	Gargour
Syndontis serratus	Gargour
Syndontis filamentus	Gargour
Syndontis nigrita	Gargour
Syndontis khartomensis	Gargour
Morymyrus caschive	Barrat
Morymyrus kannume	Umshifa
Ganthonemus cyprinoids	Umshifa
Petrocephalus bane	Ras Elhajar
Marcusenius isidori	Ras Elhajar
Marcusenius isidori	Ggadfdana
Mormyrops anguilloides	Tarza
Syndontis batensoda	Glaby
Syndontis embranacens	Glaby
Syndontis khartomensis	Umsisi
Bagrus bayad	Bayad
Bagrus docmac	Kabaros
Chrysichthys auratus	Abu Riala-Kabaros
Clarotes latoceps	Bamseika

Auchenoglanis bisctatus	Homar Elhot
Alestesa dentex	Kawara baladi
Alestesa nurse	Kawara hemel
Distechodus niloticus	Kharish
Distechodus brevipinnis	Kharish Omer
Schilbe uranoscopus	Umdankis
Schilbe mystus	Shilba
Shilbe uranoscopus	Shilbaya
Labeo niloticus	Dabeis
Labeo kalii	Dabeis
Labeo horie	Kadan
Labeo coubie	Kadan
Barbus bynnr	Binni
Barbus werneri	Binni
Polypterus senegalus	Abshir
Polypterus bichir	Dabib Elhot
Polypterus senegalus	Dabib Elhot
Heterotic niloticus	Nok
Clarias anguillaris	Garmout
Clarias lazera	Garmout
Lates niloticus	Igil
Tetradon fahaca	Tambeira
Malapterurus electicus	Barada
Alestes nurse	Himella
Alestes macrolepidotus	Safsaf
Chelaethieo psbibie	Alhagaar

Silurandon ouritus	Shilbaya
Mormyrus cashive	Kashm Elbanat
Mormyruskannume	Kashm Elbanat
Hyperopisus bebe	Sawiya
Heterobrachus bidorsalis	Sourtta
Distichodus engecrphalus	Kharsh
Citharinus citharws	Bitkoya

3. Material and methods

3.1.Site Description (1) White Nile Khartoum State:

Sudan is located in the northeastern part of Africa. The White Nile River flows past several important states, White Nile and Khartoum state. The White Nile river is flowing from its source Victoria Lake in Uganda through South Sudan country in which it joints other tributaries up to Khartoum before joining the Blue Nile River to form River Nile basin which flows up passing through Wadi Halfa in north Sudan up to the Mediterranean sea. The River has been used by the local people for domestic use, transportation, agriculture, plantation irrigation, small scale field and fishing.Site Description (2) Nubian Lake Wadi Halfa North State

3.2. Sample Collection and Fish Tissue Preparation:

Ten fishes of Bulti fish were collected from the White Nile River in August 2016 (rainy season in Sudan) and Bulti Spp and Dabsa Spp were collected from Wadi Halfa in winter season in December 2016 in plastic bags and were taken to Suba Central veterinary research laboratory. Muscle tissue of fish (dorsal muscle) was used in this study because it is the major target tissue for metal storage and is the most edible part of the fish. Fish tissues were cut and oven dried at 110°C to a constant weight (Tüzen, 2003).

3.3. Typical Analytical Procedure:

3.3.1.Sample Preparation:

Twenty five grams of wet tissue were weighed (5 g dry weight) into crucible; samples were dried at 135 °C for 2 hr and obtained a dry weight. Then it was transferred to a cool muffle furnace and slowly temperature was raised to 450 °C-500 °C overnight ash samples were removed, let cool to room temperature, cautiously 2 ml HNO3were added and swirled. Evaporated carefully just to dryness on warm hot plate or steam bath. Then transferred to cold furnace, temp was raised slowly to 450 °C- 500 °C and held at this temperature for 1 hour. Crucible was removed and cooled. HNO_3 treatment was repeated, to obtain clean, practically carbon-free ash (Somers, 1968; Childs and Gaffke, 1974; Meranger ; Capar, 1977). Ten ml of 1N HCl was added and ash was dissolved by heating cautiously on a hot plate. Then was transferred to a 25-mL volumetric flask and HCl was the mixture added as necessary. It was cooled and diluted to volume .(AAS,1994;Umit and Mustafa, 2008; Najim, 2013).

2.3.2. Statistical Analysis:

All analysis was determined at significance levels of $p<0.05$. When necessary, data were $\log_{10}(x+1)$ transformed to normalize the distributions. All statistical analyses were computed using Statistical Package for Social Sciences (SPSS) version 16.0.

4. Results

Three common heavy metals were measured cadmium (Cd) was ranged between 0.011- 0.019, chromium (Cr) ranged between 0022- 0.019 and lead(Pb) between 0.014-0.068 mg/kg(Bulti fish) in White Nile Table (1) .

Table (2) Heavy Metal (mg/kg) in *Orechromis niloticus* from White Nile in Khartoum State .

White Nile Bulti	Cd	Cr	Pb
1	0.016	0.036	0.140
2	0.014	0.026	0.120
3	0.015	0.034	0.014
4	0.019	0.042	0.026
5	0.018	0.046	0.035
6	0.011	0.022	0.068
7	0.012	0.035	0.050
8	0.018	0.040	0.041
9	0.013	0.035	0.052
10	0.017	0.031	0.044
Range rate	0.011-0.019	0.022-0.046	0.014-0.068

The length of fish was ranged between 8 – 11.7 cm and this have no any significant statistic difference ($P > 0.05$) in accumulation of three tested heavy metal in fish. Whereas the weight of fish which was ranged between 175 – 245 grams showed no significant statistic difference also ($P>0.05$) among three tested heavy metal in fish .

Table (3).Length in cm and Weight in gram of *Orechromis niloticus* (Bulti fish) from White Nilein Khartoum, State.

No	Length cm	Weight gm
1-	8	120
2-	10.2	265
3-	11.4	240
4-	9.5	195
5-	11.7	320
6-	9.4	215
7-	9.7	235
8-	9.4	175
9-	10.9	315
10	10.4	245

Table (4) Heavy Metal (mg/kg) in *Orechromis niloticus (Bulti Spp) and Labeo niloticusb (Dabsa Spp)* from Nubian lake Wadi Halfa in North State.

Bolti	Cd	Cr	Pb	Dabsa	Cd	Cr	Pb
1-	0.065	0.115	0.315	1-	0.021	0.260	0.205
2-	0.057	0.085	0.130	2-	0.055	0.075	0.105
3-	0.035	0,050	0.175	3-	0.285	0.080	0.185
4-	0.034	0,055	0.165	4-	0.058	0.095	0.550
5-	0.017	0.075	0.160	5-	0.076	0.065	0.290
6-	0.056	0.035	0.150	6-	0.054	0.095	0.210
7-	0.021	0.175	0.375	7-	0.046	0.220	0.205
8-	0.045	0.465	0.485	8-	0.049	0.072	0.75
9-	0.062	0.072	0.195	9-	0.067	0.090	0.245
10-	0.066	0.055	0.235	10-	0.056	0.070	0.160
Range	0.017-0.066	0.035-0.465	0.130-0.485		0.021-0.285	0.065-0.260	0.075-550
Mean	0.0456	0.1152	0.2385		0.0767	0.1122	0.2230

***Halfa :Orechromis niloticus* (Bulti Spp) .**

Table (5) Weight in gm and length in cm of *Orechromis niloticus* (Bulti Spp).

No	Length cm	Weight gm
1-	11.0	430
2-	11.0	330
3-	10.8	325
4-	11.0	428
5-	10.9	410
6-	10.8	498
7-	11.0	319
8-	10.3	400
9-	8.8	230
10-	7.2	160

Halfa

***Labeo niloticus* (Dabsa Spp).**

Table(6) Weight gm and Length in cm *Labeo niloticus* Spp (Dabsa).

No	Length cm	Weight gm
1-	12.0	448
2-	11.5	396
3-	12.0	335
4	12.0	325
5-	11.5	253
6-	13.2	440
7-	13.4	478
8-	11.5	312
9-	10.9	310
10-	11.0	300

3.1. Results Analysis:

Table (7) Relation between the conc. Cr, Cd and Pb of Bolti Spp in White Nile and Halfa.

Bolti	Cr	Cd	Pb
Halfa	0.118	0.046	0.239
Khrtoum	0.o35	0.015	0.059
Pvalue	0.066	0.001	0.001

Figure(1)

Correlation between Bulti Spp in White Nile Halfa.

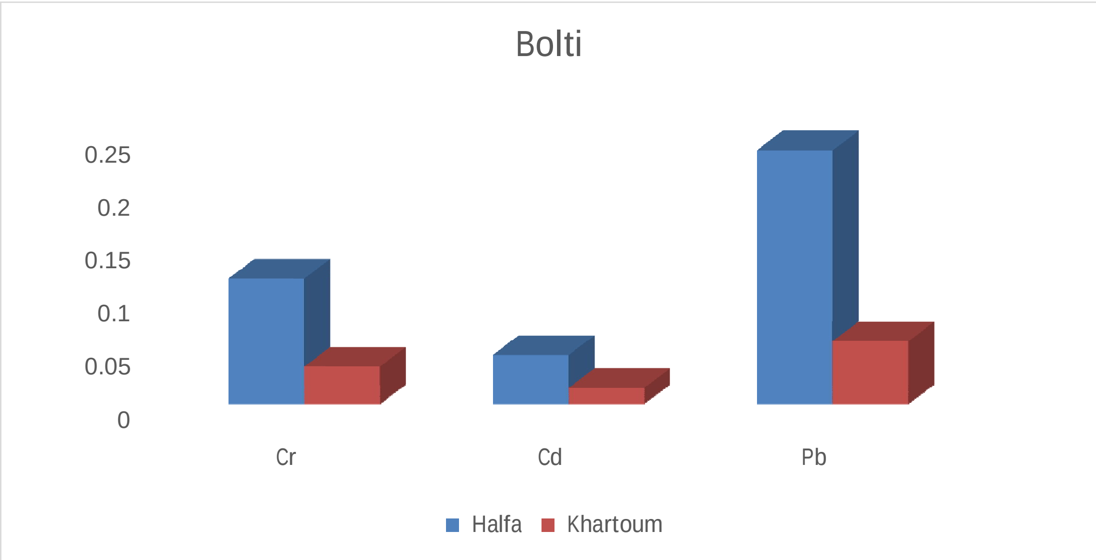

Table (8) Relation between the conc. Cr, Cd and Pb of Bulti Spp and Dabsa in Halfa.

Halfa	Cr	Cd	Pb
Dabsa	0.112	0.077	0.223
Bolti	0.118	0.046	0.239
P value	0.897	0.258	0.818

Figure (2)

Corelation between Bulti Spp and Dabsa in Halfa.

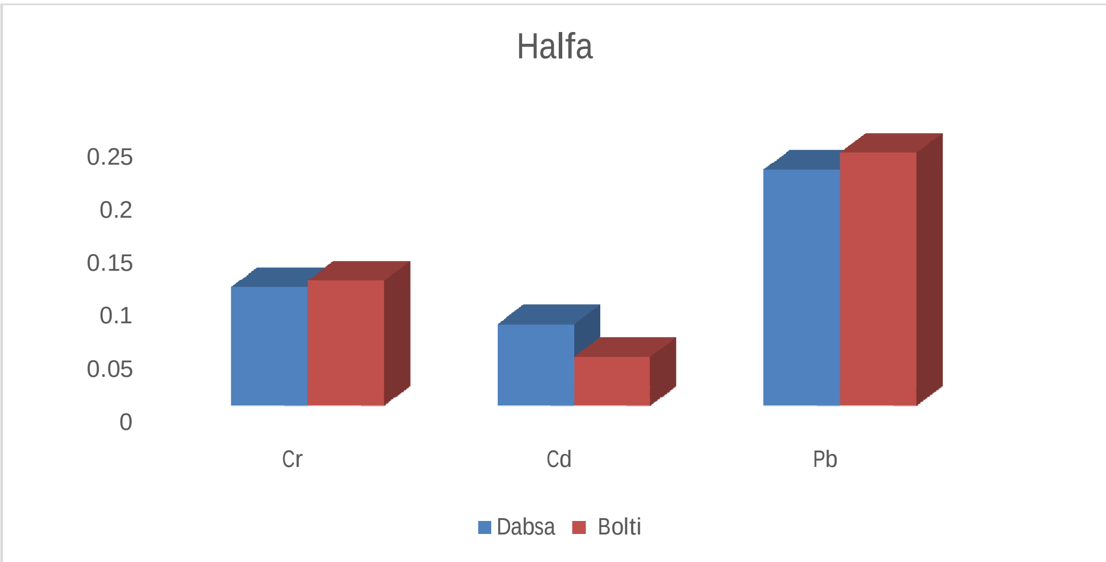

Table (9) Relation between length in cm and weight in gm in both Bulti Spp and Dabsa in Halfa.

Halfa	Length (cm)	Weight (g)
Dabsa	11.9	359.7
Bolti	10.28	353.0
Pvalue	0.001	0.847

Figure (3)

Correlation between Bulti Spp and Dabsa with according to weight and length.

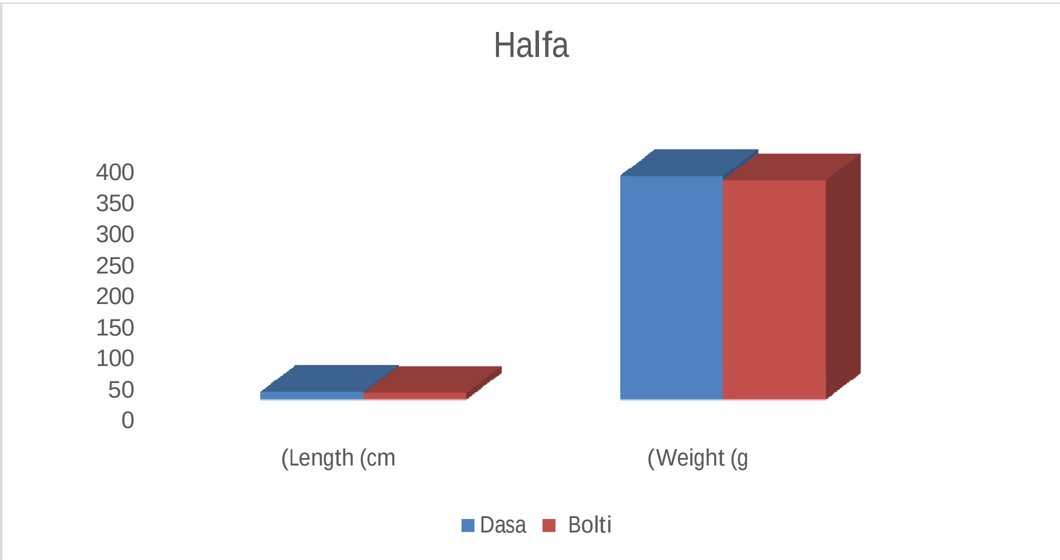

Table (10)) Relation between length in cm and weight in gm in Bulti Spp in Khartoum Halfa.

Bolti	Length (cm)	Weight (g)
Khartoum	10.06	232.5
Halfa	10.28	353.0
P value	0.719	0.024

P value less than 0.05 is significant

Figure (4)

Correlation between Bulti Spp and Dabsa Spp according to length and weight.

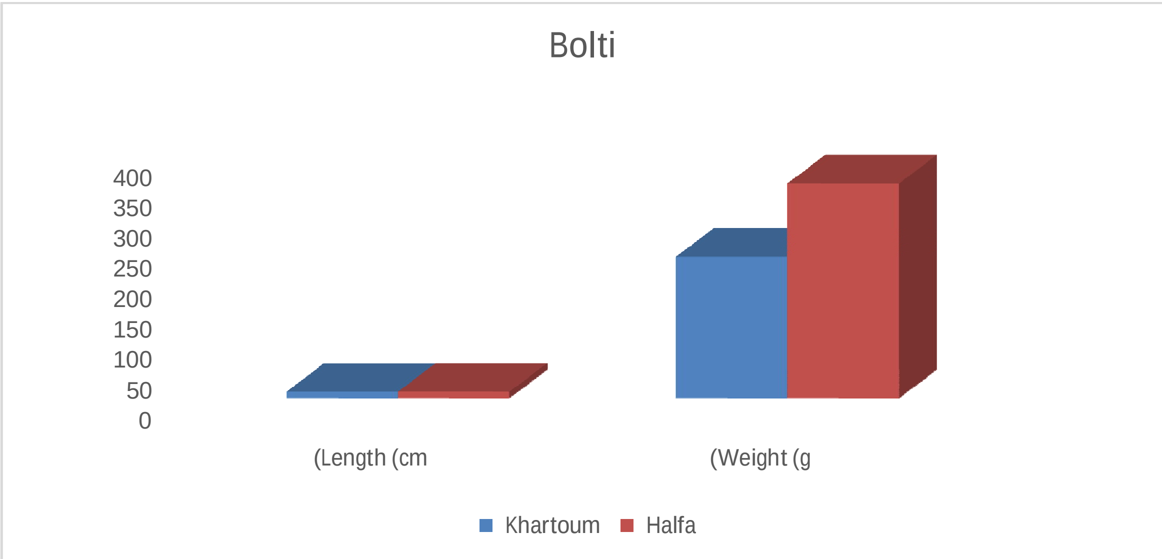

Table (11) Relation between the conc. Of Cr ,Cd and Pb and length in cm and weight in gm in Bulti in Halfa.

	Cr	Cd	Pb	Length
Cd	-0.101			
Pb	0.881**	-0.054		
Length	0.091	-0.524	-0.019	
Weight	0.131	0.284	0.003	0.807**

*correlation is significant at 0.05

**correlation is significant at 0.01

Table (12) Relation between the conc. Of Cr,Cd and Pb and length in cm and weight in gm in Bulti and Dabsa in Halfa.

	Cr	Cd	Pb	Length
Cd	-0.314			
Pb	0.007	-0.051		
Length	0.502	-0.025	0.099	
Weight	0.751**	-0.248	-0.190	0.77**

*correlation is significant at 0.05

**correlation is significant at 0.01

Correlation Khartoum, bolti

Table (13) Relation between the conc. Of Cr,Cd and Pb and length in cm and weight in gm in Bulti in Khartoum.

	Cr	Cd	Pb	Length
Cd	0.738			
Pb	-0.408	-0.263		
Length	0.189	0.045	-0.603	
Weight	0.045	-0.187	-0.371	0.884**

*correlation is significant at 0.05

**correlation is significant at 0.01

Flame Atomic Absorption Concentration Ranges:

Table(14) Flame Atomic Absorption Concentration Ranges.

Heavy metals	Detect limit mg/L	Linear Range mg g\L
cadmium	0.01	2
chromium	0.04	5
lead	0.08	20

3.2.. Statistical Analysis:

Data was analyzed as complete randomized design. Analysis of variance (ANOVA) was performed According to procedure described by Gomez and Gomez (1984). Means were separated by Using Duncan Multiple Range Test (DMRT). The result were used in the simple linear correlation studies to find out the relationship existing among the concentrations obtained by the different extractants and their respective concentration and uptake by maize and alfalfa.Gomez, K.A. and Gomez, A.A. (1984).Statistical Procedures for Agricultural Research.John – Willey and Sons, New York.

Table(15) The EPA Allowable Limits in Waste: An Overview.

Heavy Metal	Hazardous Waste Code	EPA Allowable Limits
Cadmium	D006	1.0 ppm (mg/L)
Chromium	D007	5.0 ppm (mg/L)
Lead	D008	5.0 ppm (mg/L)
Mercury	D009	0.2 ppm (mg/L)

5. Discussion

The concentration level of Cd, Cr, Pb of 10 Bulti fish in different samples which are shown in table 1 are found less than the permissible concentration levels of Cd Cr and Pb and they were ranging over following intervals: Cd: (0.011-0.019) mg/Kg, Cr: (0.022-0.046) mg/Kg, Pb: (0.014-0.068) mg/Kg.In food, the allowed amounts of heavy metals (HMs) vary from country to country and are based both on the WHO recommendations and local requirements. According to Lithuanian Standards of Hygiene (LSH, 2001, Yarsan and Yipel, 2013) the maximum tolerable limit (MTL) of Pb in fish meat is 0.4 mg/kg which is the same as the value adopted by the European Commission for Pb in marine fish muscle (EC, 2000), while FAO set a limit of 0.5mg/kg (FAO, 1983). The guideline limit set for Cd by(FAO 1983) is 0.05mg/kg for fish, the concentration range from this study is less the recommended one.(WHO 1993) has set a maximum limit of 0.05 mg/l of Cr in drinking water. An estimate of the daily intake was ranging from 0.025 to 0.2 mg/day (Codex, 1995). Since no standard/ guidelines were set for Cr, the stable oxidation state in biological samples, thus Cr found in this study may not be above the recommended daily intake. The muscle concentration of non-essential element Pb in all fish samples was below the detection limit. Turkish Food Codex (Anonymous, 2008) and Commission Regulation (EC) (Anonymous, 2006) indicate that maximum level is 0.30 mg/kg wet wt. for Pb. Cd concentration was, however, well below the proposed maximum in the food safety regulations (MAFF, 1995). Fish tissue used in this study is from one species which is *Orechromis niloticus* (Bolti fish). The obtained results showed also the correlation between the heavy metals depending on the weight and length of the fish samples which were shown in table2 which also showed no significant result. The levels of heavy metal accumulation in fish depend on the growth rate, metabolism, feeding pattern and ecological requirements fish species (Yilmaz *et al*., 2010). Another factors are the differences in life history patterns among species including trophic levels and geographical distribution of life stages, which influence their exposure to heavy metals (Allen-Gil and Martynov, 1995). In conclusion, the total mean heavy metal concentration of all fish species in this study revealed an order of Pb, Cr and Cd. Therefore, the results in this study demonstrated that fish species caught in the White Nile River were not contaminated with heavy metals. Although the concentrations of heavy metals in the fish were not detected, the potential for metal toxicity danger may appear in the future depending upon the extent of industrial and domestic wastewater influx and human activities in the adjacent areas to Nile. To develop a healthy freshwater fishing industry and to prevent heavy metal risks to human health in the River, the water standards and concentrations of heavy metals in the water column and fish should be monitored regularly. Type of heavy metals and characteristics of rivers in Sudan should highly considered in selection of different types of fishes including Red Sea fish for heavy metals analysis.

In Halfa :

On the other hand the concentration level of Cd, Cr, Pb of 10 Bolti fish and Dabsa fish in different samples which are shown in table 1 are found less than the permissible concentration levels of Cd Cr and Pb and they were ranging over following intervals: Cd: (0.011-0.019) mg/Kg, Cr: (0.022-0.046) mg/Kg, Pb: (0.014-0.068) mg/Kg.In food, the allowed amounts of heavy metals (HMs) vary from country to country and are based both on the WHO recommendations and local requirements. According to Lithuanian Standards of Hygiene (LSH, 2001; Yarsan and Yipel, 2013) the maximum tolerable limit (MTL) of Pb in fish meat is 0.4 mg/kg which is the same as the value adopted by the European Commission for Pb in marine fish muscle (EC, 2000), while FAO set a limit of 0.5mg/kg (FAO, 1983). The guideline limit set for Cd by FAO (1983) is 0.05mg/kg for fish, the concentration range from this study is less the recommended one. WHO (1993) has set a maximum limit of 0.05 mg/l of Cr in drinking water. An estimate of the daily intake was ranging from 0.025 to 0.2 mg/day (Codex, 1995). Since no standard/ guidelines were set for Cr, the stable oxidation state in biological samples, thus Cr found in this study may not be above the recommended daily intake. The muscle concentration of non-essential element Pb in all fish samples was below the detection limit. Turkish Food Codex (Anonymous, 2008) and Commission Regulation (EC) (Anonymous, 2006) indicate that maximum level is 0.30 mg/kg wet wt. for Pb. Cd concentration was, however, well below the proposed maximum in the food safety regulations (MAFF, 1995). Fish tissue used in this study is from one species which is *Orechromis niloticus* (Bulti fish). The obtained results showed also the correlation between the heavy metals depending on the weight and length of the fish samples which were shown in table2 which also showed no significant result. The levels of heavy metal accumulation in fish depend on the growth rate, metabolism, feeding pattern and ecological requirements fish species (Yilmaz *et al*., 2010). Another factors are the differences in life history patterns among species including trophic levels and geographical distribution of life stages, which influence their exposure to heavy metals (Allen-Gil and Martynov, 1995). In conclusion, the total mean heavy metal concentration of all fish species in this study revealed an order of Pb, Cr and Cd. Therefore, the results in this study demonstrated that fish species caught in the White Nile River were not contaminated with heavy metals. Although the concentrations of heavy metals in the fish were not detected, the potential for metal toxicity danger may appear in the future depending upon the extent of industrial and domestic wastewater influx and human activities in the adjacent areas to Nile. To develop a healthy freshwater fishing industry and to prevent heavy metal risks to human health in the River, the water standards and concentrations of heavy metals in the water column and fish should be monitored regularly. Type of heavy metals and characteristics of rivers in Sudan should highly considered in selection of different types of fishes including Red Sea fish for heavy metals analysis.

6. Conclusion

Overall, the total mean heavy metal concentration of all fish species in this study revealed an order of Pb>Cr>Cd. Therefore, the results in this study demonstrated that fish species caught in the White Nile River were not contaminated with heavy metals. Although the concentrations of heavy metals in the fish were not detected , the potential for metal toxicity danger may appear in the future depending upon the extent of industrial and domestic wastewater influx and human activities in the adjacent areas to Nile. To develop a healthy freshwater fishing industry and to prevent heavy metal risks to human health in the River, the water standards and concentrations of heavy metals in the water column and fish should be monitored regularly.

7. Recommendations

1- Type of heavy metals and characteristics of rivers in Sudan should highly considered in selection of different types of fishes including Red Sea fish for heavy metals analysis.

2- Further studies should be conducted.

3- Comparative studies on the presence of these heavy metals on different environmental and ecological conditions, is recommended.

4- Further studies should be carried out in aquaculture farms also because Sudan has the potentialities for this new technology

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