CONCENTRATIONS OF NICKEL (NI) AND VANADIUM (V) ON THE LIVER, MUSCLE, AND GILL OF SNAKEHEAD FISH – (*Channa Obscura*)

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ABSTRACT

Contamination of heavy metals in the aquatic environment can occur from various natural sources. The natural sources of heavy metals are mainly volcanic eruptions and the weathering of metal-bearing rocks, while other sources of heavy metals include agricultural and industrial activities, combustion of fossil fuel and gasoline waste incinerators, mining, etc. The bioaccumulation of nickel (Ni) and vanadium (V) in the tissues of the liver, gill, and muscles has been detected. The findings of Nickel (Ni) and Vanadium (V) in the liver, muscle, and gill of 16 samples of Channa obscura were carried out. The concentrations of nickel (Ni) in the three organs—liver, muscle, and gill—were 0.02–0.20 mg/kg wet wt, 0.06–0.24 mg/kg wet wt, and 0.04–0.20 mg/kg wet wt, respectively. Those of Vanadium (V) in the same organs were 0.18–0.45 mg/kg wet wt, 0.16–0.3 mg/kg wet wt, and 0.28–0.5 mg/kg wet wt, respectively. Nickel concentration varied directly with the body weight in the muscle of the fish to the concentration of 0.24 mg/kg wet wt. The levels of concentrations of nickel (Ni) in the liver and gill were 0.20 mg/kg wet wt, and they varied slightly with the body weight of the fish. The levels of concentrations of (V) in the three organs also varied slightly with an increase in fish body weight. Vanadium concentrations levels showed higher when compared to that of Nickel. The concentration gradient of Vanadium fluctuated slightly in the gill and liver by 0.05 mg/kg wet wt.

Keywords: Nickel, Vanadium, organs, snakehead fish, kwa River.

INTRODUCTION

The significance of the liver, muscle, and gill in the physiology of freshwater can function largely as the regulation of acidic and alkaline contents in the fishes so as to maintain the homeostasis and for the mechanism of the body fluids in order to maintain the body temperature and the blood measures; the liver is the respondent for the functions. Fish have three kinds of muscles. These are smooth (largely the involuntary muscles of the gut), cardiac (heart muscle), and skeletal (striated muscles, the bulk of a fish other than its skeleton). In fishes, as in other vertebrates, the three main types of muscle—smooth, cardiac, and striated—may readily be distinguished histologically.

Uptake of heavy metals by fish from the environment primarily occurs through gills, food, skin, and in freshwater fish, through water taken with food. Taken heavy metals are carried to organs by carrier proteins via blood paths and can reach high concentrations by bonding to metal-binding proteins in these tissues (Sonmez et al., 2016). Biomagnifications mean transfer to a xenobiotic from food sources to an organism, resulting in higher concentration to the organism than the sources (Connell, 1987; 1989; 1990). Gill of fish is responsible in the function of filtration and as a surface for the exchange of gases, ie oxygen and carbon (IV) oxide, in the circulatory system of the fish.

These livers, muscles, and gills of freshwater fishes can be disturbed by containing poisonous elements as trace elements that result in the weakness or malfunctioning of these organs, and suddenly, it can result in the fish's mortality. In the era of the industrial revolution, keeping the environment sustainable and sound is a big concern, and the rapid expansion of industries in the last couple of decades has added extra fuel to the fire, which eventually sank the environment in the threshold limit of tolerance (Kavitha et al., 2010). Out of 70 metals and metalloids present in the environment, 23 are categorised as heavy metals/trace metals, some of which are considered strong biological poisons.

Aquatic environments, especially rivers and seas, are the ultimate receivers of such contaminations/heavy metals, and slight alterations in the quality of the environment, including physiochemical properties, can have a negative impact on the normal physiology of the aquatic organisms, especially fish, which are very sensitive to such changes. All of the elements found in the earth's crust are probably present in deep-sea sediments, although not all of them have yet been detected. The concentrations of a selection of these elements are given in subdivided groups, that is, "clays" and "carbonates, which are quantitatively the two most important types of deep-sea sediment. The deep-sea clays consist predominantly of five-grain and land-derived (lithogenous) particles that have been deposited at a slow rate but may also contain antigenic (hydrogenous) components, such as ferro-manganese phases, which are rich in certain trace elements. In contrast, deep-sea carbonates have a much faster rate of deposition and contain a significant proportion of calcareous debris, which is usually impoverished in trace elements, other than strontium.

Riley (1975) experimented and found out that Vanadium (V) has 20 un ppm of deep-sea (carbonate) and 120 un ppm of deep-sea (clay), while Nickel (Ni) has 30 un ppm of deep-sea (carbonate) and 225 un ppm of deep-sea (clay). Nickel (Ni) and Vanadium (V) are found in the periodic table with atomic numbers of 28 and 23, respectively. Being transition elements, they are found in period four (4) in the periodic table. They are called trace metals, of which they are important but needed in mild quantities. These elements are toxicants that negatively affect aquatic life when found in water. Nickel occurs in the +2 valency state. It is generally considered that Ni^{2+} is the form of nickel primarily responsible for eliciting a toxic response in aquatic organisms.

Possible effects of runoff from road deicing salt, particularly on the release of mercury from contaminated sediment. In laboratory studies of sandy and highly organic sediments, it was found that the addition of calcium and sodium chloride increased the relative amount of mercury released from the sediment into water by several orders of magnitude. The effect was probably due to the complexation of the mercury for the exchange site on the sediment.

Specific industrial processes are known to contain trace elements in their waste of effluents. For example, a report compiled by an association of dye manufacturers considered the sources and likely concentrations of eight metals in dyehouse streams from a variety of textile dyeing and related operations. These heavy metals mainly enter the fish body through gills, body surface, and digestive tract during ingestion of metal-accumulated food materials. Nickel, Vanadium. Mercury, lead, chromium, etc., are the most common heavy metal pollutants that cause severe toxicity in fishes.

The first heavy rain after a dry period may flush high concentrations of heavy metals, such as lead, from geological formations to the lakes, streams, ponds, and rivers. In addition to discharges by man, mining processing also contributes more inorganic chemicals into water bodies. The chemical concerns are heavy metals such as mercury. Tin and Cadmium.

Trace element sources that are considered which contribute to the atmosphere over take to be:

(i) Coal burnt for electrical and heating uses
(ii) Emission from coke ovens in the manufacture of metallurgical coke
(iii) Fuel oil burned for electrical and heating needs.
(iv) Outermotive fuel burned for transportation
(v) Emission from iron and steel manufacturing, facilities and
(vi) Emission from cement manufacturing plant.

Trace elements are defined as those that generally occur at concentrations in natural freshwater below 1 mg/L. Also, trace elements are simple substances that are essential to plants and animals, and they are needed in small or lesser quantities. It is important to stress that just because an element exhibits a typical recycled profile, it does not mean that the element cannot be scavenged from solution as well (e.g., Ni, V, Cu, Zn, Fe); conversely, a scavenged profile does not preclude involvement in the metabolism of organisms (e.g., Mn, Co, and Al). Concentration depth profiles merely indicate which of the two patterns of behaviour is dominant.

Another interesting regularity concerns what is sometimes called uptake by analogy; indeed, the trace elements may be toxic. Such pairs are As and P, Ag and Cu, Pb and Ni, and Cd and Zn. The last is particularly interesting because cadmium is closely correlated with phosphorus in freshwater. Although cadmium has no known metabolic role, it may find its way into organics. Via the pathway used for Zn, it is then "trapped" there, which will account for its involvement in the cycling of biogenic particulate matter.

Of course a deficiency in any trace element (Mo, Mn, Si) can limit productivity. However, in a lake, the total supply usually exceeds by far the need for trace constituents for a potential maximum production; thus, temporary and localised limitations of productivity seem possible. The adverse effects of the excess of these metals on fish are that it weakens the immune system, causes tissue and organ damage, causes growth defects, and reduces reproductive ability.

The rich source of high-quality protein filled with vitamins and omega-3 fatty acids encourages the human beings to uptake fish as a major food source. So accumulated heavy metals in the fish tissues directly transfer to the human body and cause toxic effects to expedite various diseases. But the eating of the contaminated fish or shellfish with synthetic organic compounds or heavy metals depends on their concentrations in the seafood and on how much seafood is consumed. Obviously, those most affected would be fishermen and coastal dwellers whose main source of protein is restricted to fish from polluted waters. In tropical developing countries, 60% of the people depend on fish for 40% or more of their protein. Unfortunately, few of these fish are tested for concentration of elements in human health records that are poorly kept, and little is known about the human health effects of long-term low-concentration exposures. In some parts of the United States, women of childbearing age are warned not to eat trouts or salmons because they contain levels of synthetic organic compounds that could cause birth defects.

AIM AND OBJECTIVE

The aim of this work is to determine the level of concentrations of trace metals in the organs of fishes in water, mostly freshwater, and to check the causes and sources of these contaminants, thereby reducing the rate of water pollution. The toxicity of these metals, Nickel (Ni) and Vanadium (V), comes from chemical industries, and sometimes human beings or heavy rainfall bring about the pollution of waters. Through this research, contaminated fish are not advisable for consumption.

LITERATURE REVIEW:

Heavy metal concentrations in fish muscle were quite variable with and among lakes. Fish muscle typically contains less than dry weight of nickel (Ni) and four others. Relatively little work has been carried out on the influence of chemicals or contaminant exposures on the differential blood cell ratios in this lake trout (Spannhof et. al.; 1979; Niimi, 1984). The contaminants in erythrocytes are consistent with the previous report of anaemia effect in fish (Sjobeck et al., 1984).

Nickel (Ni) can enter the environment naturally through weathering of minerals and rocks and through anthropogenic sources. More than 90% of Nickel (Ni) in the aquatic environment is associated with particulate matter of sediments. Nickel is found at low background concentrations in most natural waters. Bioavailability and the uptake of heavy metals depend on many factors, such as the concentration of heavy metals, their exposure period, interaction with other metals, age and size of the fish, detoxifying mechanisms, metabolic processes of the fish, feeding behaviour, and physio-chemical parameters of the environment, etc. (Delahaut et al.; 2020: Vincent, 2014)

Artic Lake showed that the site rank order of concentrations of metal (Cu, Cd, Ni, and Zn) in sediment and freshwater fish tissue among lakes was non-consistent. They suggested that a number of physical, physiological, and chemical parameters mediate metal broad bioavailability and uptake in this system (Allen-Gill et al., 1995).

The study of Akueshi (1980) indicated the presence of Pb, Ni, Hg, V, and Zn in effluents discharged into the Dilimi River (Jos) from local mines affecting the physiological state of fishes. Metal concentrations in sediment and two species of freshwater fish, lake trout (Salvelinus namaycush) and grayling (Thymallus arcticus), were examined from Arctic lakes in Alaska. Concentration of several metals was naturally high in the sediment relative to contaminated lakes in other regions and more temperate locations. For example, concentrations of mercury (Hg) and nickel (Ni) were 175 ng/g and 250 ng/g dry weight, respectively, in Feniak Lake surface sediment.

Heavy metals can enter into the fish body through feed, water uptake for respiration, or ion exchange through a semi-permeable membrane, followed by accumulating in various tissues within this body (Ahmed et al., 2010; Islam et al., 2015). The heavy metals can bind with the biological particles containing N2, S, O_2, etc., thus affecting/altering the structure and function of proteins, enzymes, chromosomes, etc., which ultimately damage different organs of fish (Banday et al., 2019). Nickel shows concentration in the liver of lake trout in different lakes. Lake Elusive, Schrader, Feniak, and Desperation, Nickel Concentrations are 0.17 mg/g wet wt, respectively. In grayling of Lake Elusive, Schrader, Feniak, and Desperation Nickel (Ni) concentrations in the liver are 0.20 mg/g wet wt, 0.76 mg/g wet wt, 0.59 mg/g wet wt, and 1.07 mg/g wet wt, respectively.

The concentration of several metals in muscle has been investigated by Vinogradov (1953) and Brooks and Rumsby (1965). Segar, Collins, and Riley (1971). Some of this analysis, particularly that of Nickel (Ni) and Vanadium (V), are represented. In the South Coast, England, the nickel concentrations are 2.1 mg/g wet wt and 3.7 mg/g wet wt. In New Zealand, the concentration was 7.0 mg/g wet wt. In the East Coast of England, the vanadium concentration is 5.0 mg/g wet weight, and the soft part of the mussels was mostly affected by these elements. The toxic element concentration in fish depends on the sex and age of the fish, season, and place. Pollution of water sources by anthropogenic activities leads to aquatic loss and therefore disrupts the balance of the food chain.

Fish are frequently employed as bioindicators of pollutants on the environment and health of humans (Luczynski et al., 2022). Both ingested trace elements from water and food and non-dietary mechanisms like muscle and gills contribute to accumulating these contaminants in aquatic food webs. However, environmental and dietary element concentrations likely affected the observed variations in trace element accumulation (Luczynska et al., 2019; Huang et al., 2022). Consuming fish with a high concentration of trace elements can potentially have severe consequences for human health (Ali and Khan, 2020).

SITE LOCATION

The geographical study (fig 1) shows the area of great kwa River located in cross River State where the samples of *Channa obscura* were caught for this course.

This was in the mouth of January 2024 where there was no great volume of water thereby the benthic was with less volume of water thereby the benthic was examined and found to be somehow muddy or sandy with the aid of hands.

METHOD OF SAMPLING

The traps made by petioles of raffia palm used for the sampling of the fish. These local traps were set at four different places along a small area of flowing water for possible migration of the fish into the trap. Inside the traps, palm fruit (ripe) were used as baits.

The traps were inspected at evening and 16 sample of *Channa obscura* of different sizes were studied. The caught samples were brought to the laboratory and weighed with the aid of mettler balance and stared at -4°C, for further treatment and analysis.

EXPERIMENTAL STUDIES

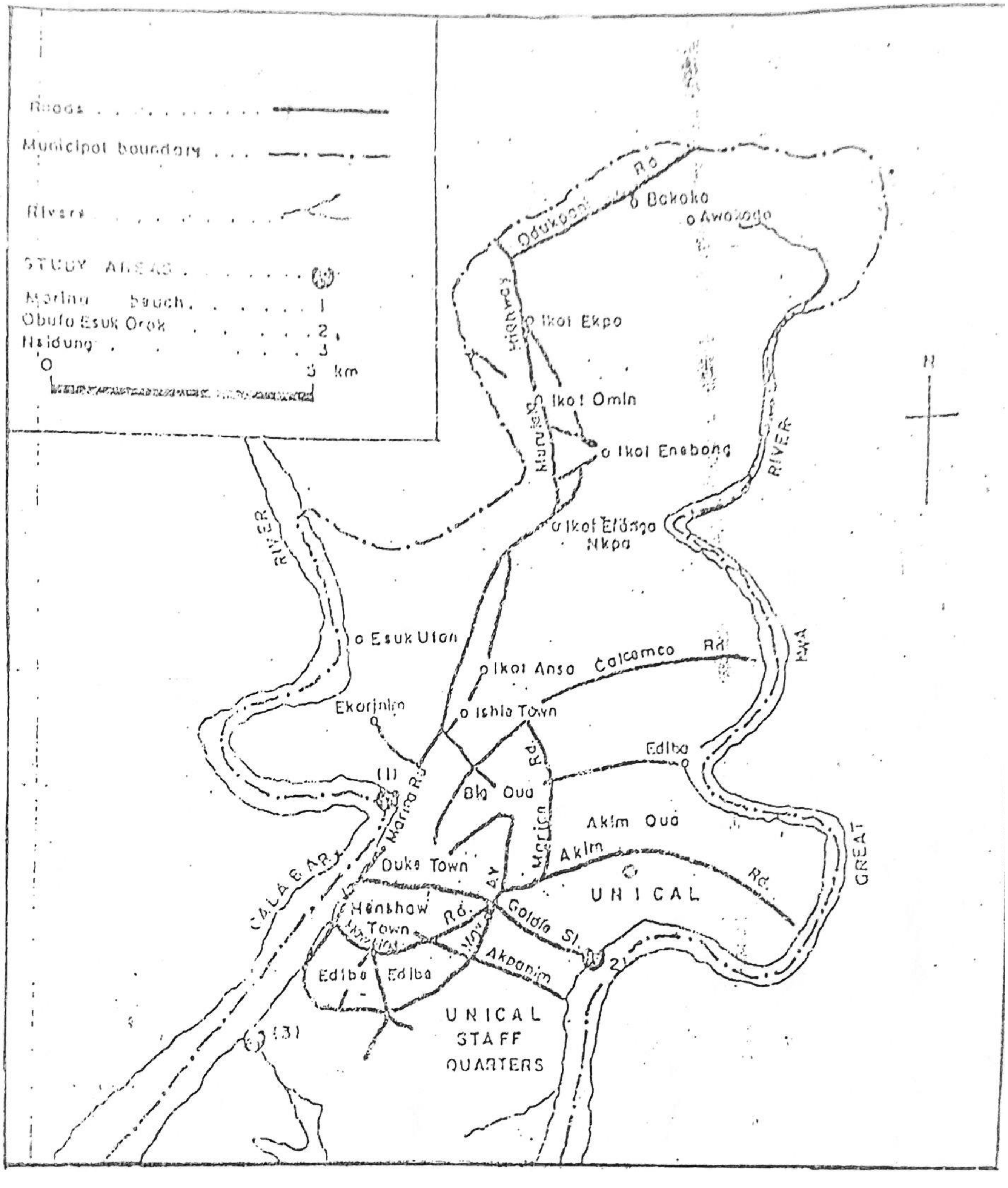
In the laboratory, the body weights were taken with the aid of mettle balance and the total length, and standard length were measured after preservation with the aid of meter rule.

Three replicate of *Channa obscura* were chosen, 1.0g wet muscle obtained from each sample by filleting on both sides of the fish. The second of 1.0g of the gill from each sample, and lastly 1.0g of the liver from each sample. These organs were ground differently and later digested with a mixture of 2.1 analar grade nitric acid and sulphuric acid in a slicia beaker. The resultant solutions were heated to dryness using a hot plate while the residue was dissolved in 20% nitric acid and (10.0ml) and the solution diluted with water freed from ion (30.0ml) before analysis. By using flame Atomic Absorption spectrophotometer, the analysis of the trace metal in the fish samples were studied and the data presented in table 1. (Beetsch et al., 1982)

STATISTICAL ANALYSIS

Data for the three organs were analysed by plotting of graph to determined if concentration differed with the body weight and because weight were determined prior to evisceration.

Since the influence of caudal fin (tail) was controlled both the standard and total length were taken from the tip of the upper jaw to the end of the caudal peduncle and from the mouth end of the fish to the caudal end respectively.


Roads
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Nsukara
o Ikot Enebong
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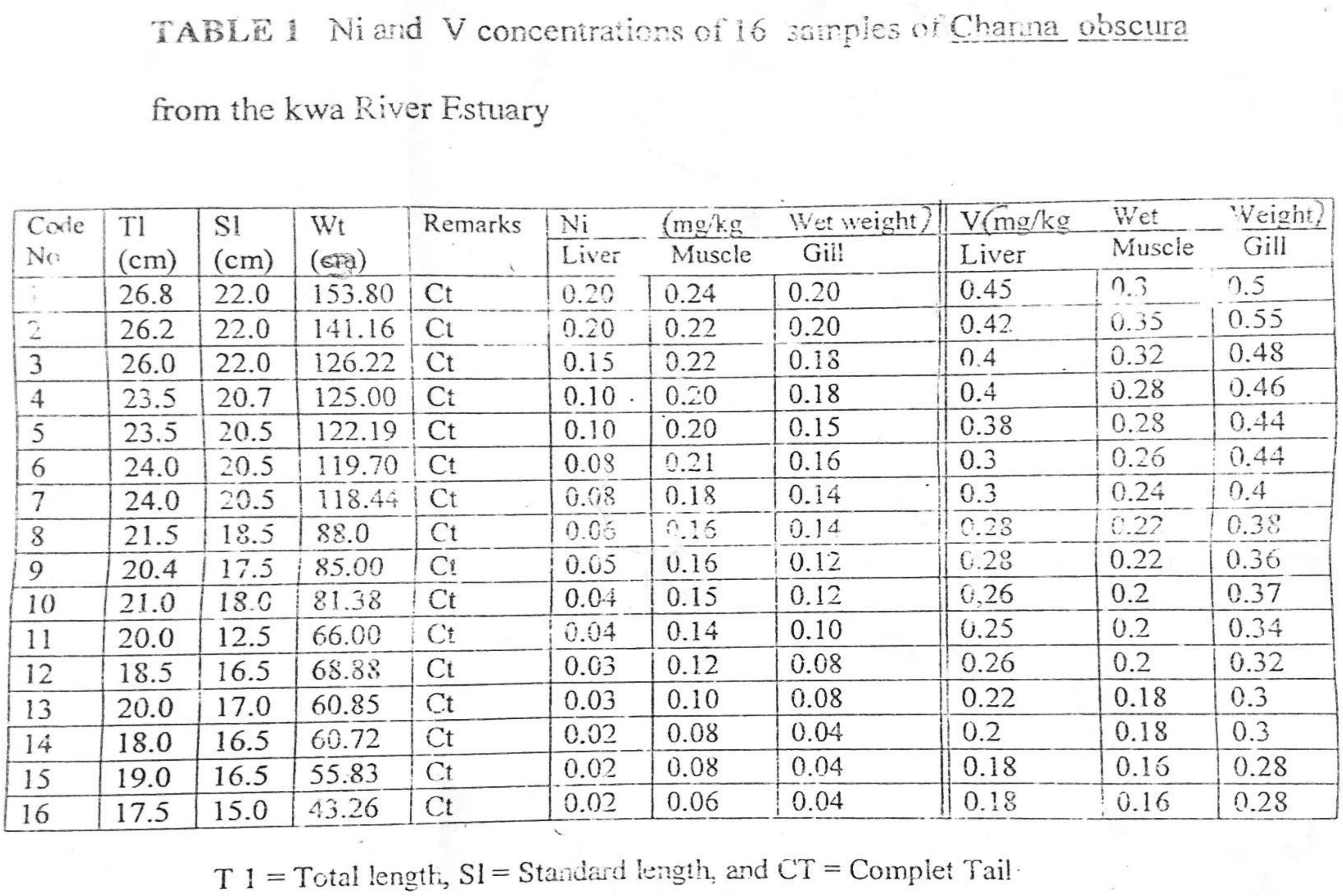


TABLE 1 Ni and V concentrations of 16 samples of Channa obscura from the kwa River Estuary

Code No	Tl (cm)	Sl (cm)	Wt (gm)	Remarks	Ni (mg/kg Wet weight) Liver	Muscle	Gill	V (mg/kg Wet Weight) Liver	Muscle	Gill
1	26.8	22.0	153.80	Ct	0.20	0.24	0.20	0.45	0.3	0.5
2	26.2	22.0	141.16	Ct	0.20	0.22	0.20	0.42	0.35	0.55
3	26.0	22.0	126.22	Ct	0.15	0.22	0.18	0.4	0.32	0.48
4	23.5	20.7	125.00	Ct	0.10	0.20	0.18	0.4	0.28	0.46
5	23.5	20.5	122.19	Ct	0.10	0.20	0.15	0.38	0.28	0.44
6	24.0	20.5	119.70	Ct	0.08	0.21	0.16	0.3	0.26	0.44
7	24.0	20.5	118.44	Ct	0.08	0.18	0.14	0.3	0.24	0.4
8	21.5	18.5	88.0	Ct	0.06	0.16	0.14	0.28	0.22	0.38
9	20.4	17.5	85.00	Ct	0.05	0.16	0.12	0.28	0.22	0.36
10	21.0	18.0	81.38	Ct	0.04	0.15	0.12	0,26	0.2	0.37
11	20.0	12.5	66.00	Ct	0.04	0.14	0.10	0.25	0.2	0.34
12	18.5	16.5	68.88	Ct	0.03	0.12	0.08	0.26	0.2	0.32
13	20.0	17.0	60.85	Ct	0.03	0.10	0.08	0.22	0.18	0.3
14	18.0	16.5	60.72	Ct	0.02	0.08	0.04	0.2	0.18	0.3
15	19.0	16.5	55.83	Ct	0.02	0.08	0.04	0.18	0.16	0.28
16	17.5	15.0	43.26	Ct	0.02	0.06	0.04	0.18	0.16	0.28

T 1 = Total length, SI = Standard length, and CT = Complet Tail

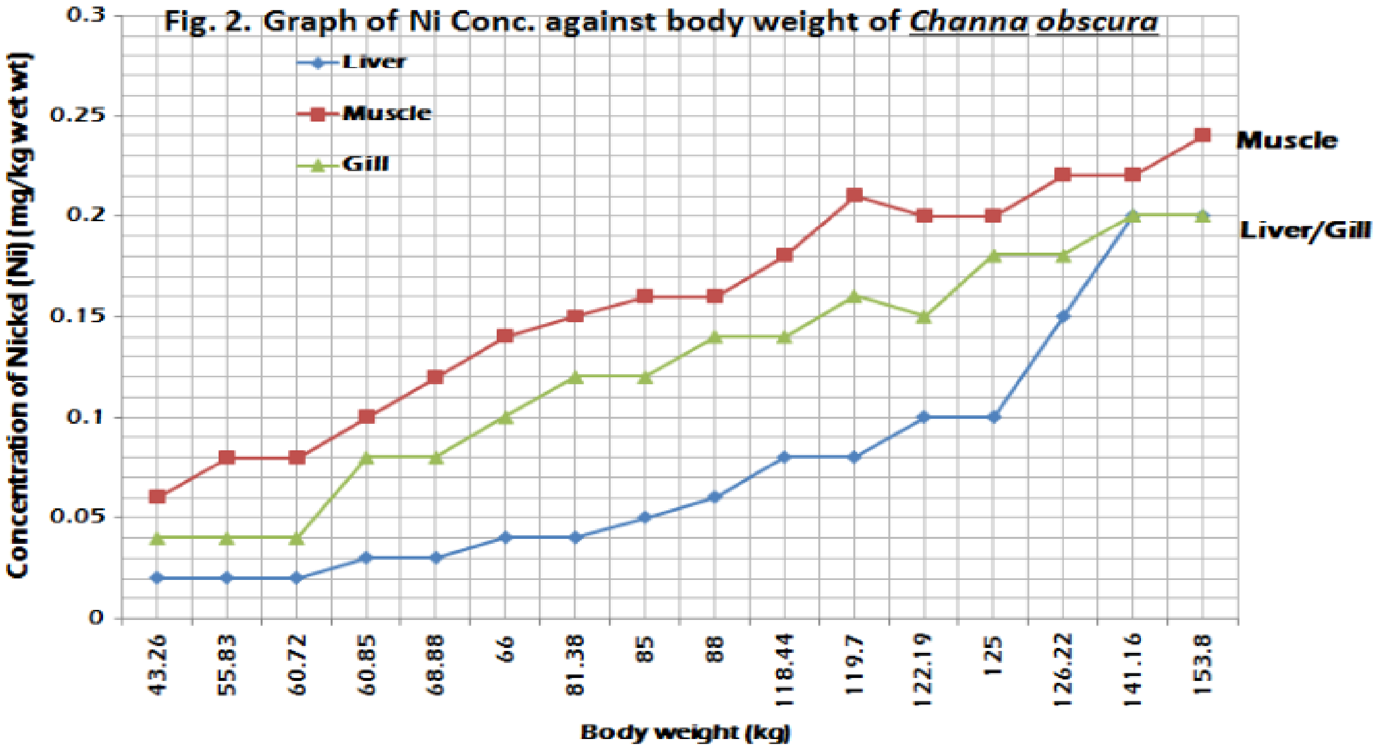
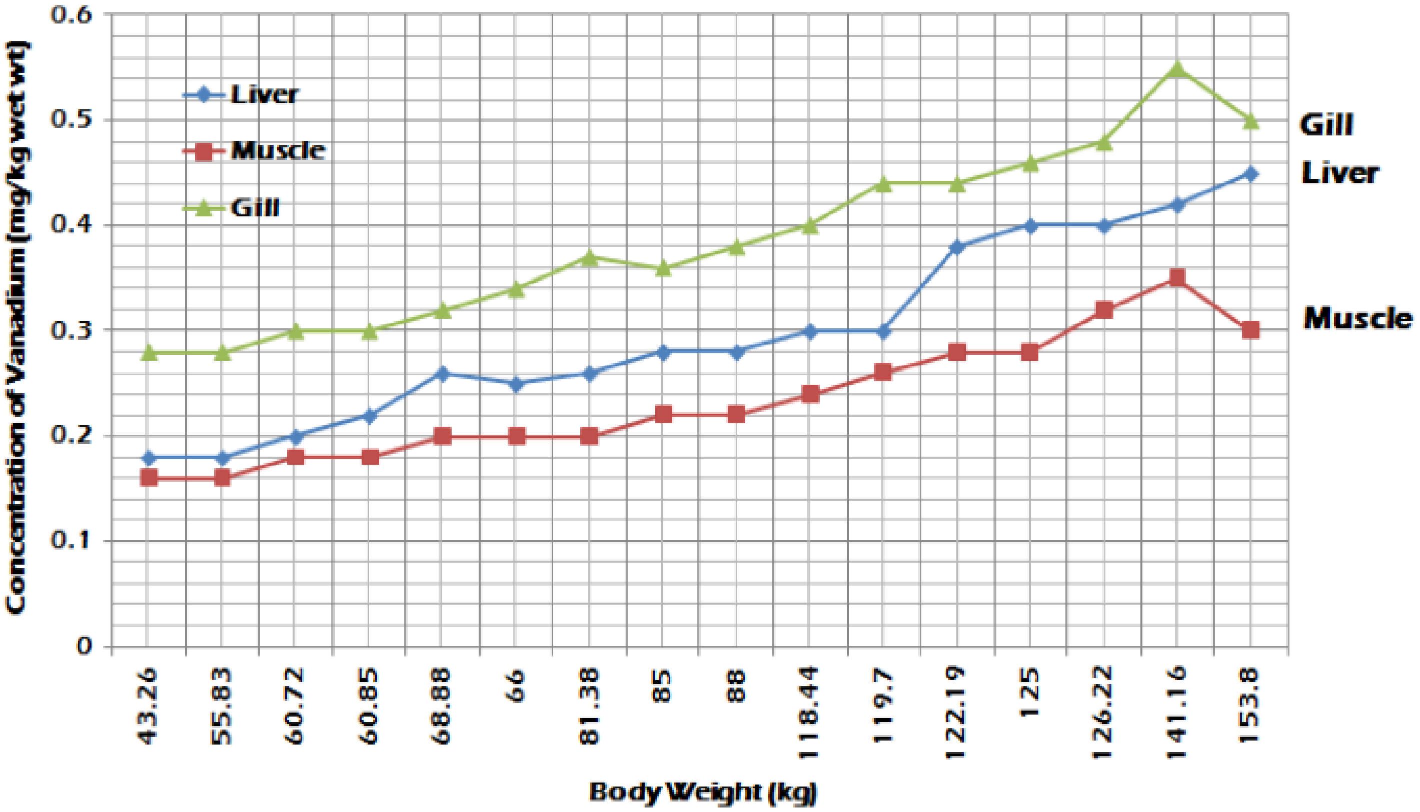


Fig. 2. Graph of Ni Conc. against body weight of *Channa obscura*

Fig. 3 Graph of Vanadium Conc. against body weight of *Channa obscura*



RESULTS

Nickel (Ni) and Vanadium (V) concentrations in the 16 samples of *Channa obscura* are presented in Table 1. The concentration of Nickel (Ni) in the fish ranged from (0.02-0.20)mg/kg wet wt, (0.06-0.24)mg/kg wet wt, and (0.06-0.20)mg/kg wet wt in the liver, muscles and gill respectively.

The Vanadium (V) concentration ranged from (0.18-0.45)mg/kg wet wt, (0.16-0.3)mg/kg wet wt, and (0.28-0.5)mg/kg wet wt in the liver, muscle, and gill respectively.

The concentration of Nickel (Ni) in the organs; liver, muscle, and gill is low compared to that of Vanadium (Table 1).

The concentration of Nickel (Ni) in the muscle is 0.24mg/kg wet wt while in the liver and gill is 0.20mg/kg wet wt (fig 2). The higher concentration of Vanadium in gill, 0.50mg/kg wet wt followed by 0.45mg/kg wet wt of liver and 0.3mg/kg wet wt of the muscle (fg3)

DISCUSSION - Nicke (Ni)

Heavy metal concentration in fish muscle were also quite variable with and among lakes and ponds.

From Arctic lakes, Nickel (Ni) concentration of 0.17ug/g wet wt and 0.36ug/g wet wt ranged with the immediate investigation (table 1) at this concentration of 0.20mg/kg wet wt and at this level it does not cause fish mortality rather some physiological activities hindered. From the work of Vinogradov et al: (1953) if the concentration of Nickel (Ni) is above 7-8 ug/g wet wt there would be fish mortality.

The same level pattern of elevated metal burdens in lake trout from Feniak lake relative to the other Elusive lake that was observed in the liver was also apparent in muscle.

Nickel (Ni) concentration in the liver of *Channa obscura* of great kwa River of Cross River State is not very strange. The low concentration of Nickel in pronounced in the liver and gill than the muscle which in high.

VANADIUM (V)

From table 1, data of Vanadium presented shows high level of concentration mostly in the gill of *Channa obscura*. The capacity of some components of the food chain to accumulate metal is so high, that level of the metal in them may be a thousand times as high as that in the water.

When in high concentrations, Vanadium (V) combines with mucus which covers the gills resulting in interference with respiration and causing immediate death by suffocation. However, fish exposed for a prolonged period of low concentration of Vanadium were affected internally, causing some changes in the blood, liver and spleen. Low concentration of Vanadium (V) in Channa obscura affect the muscle (table 1).

By Segar (1971), the concentration of Vanadium (V) in the East Coat, England was 5ug/g wet wt and it is high in concentration as compared to the values of table 1 of great Kwa River. Also in the New Zealand, the concentration of Vanadium (V) was 7.0ug/g wet wt and as compared to the value of the great kwa River it high in concentration. The Vanadium (V) contents of great Kwa River is mild while those from East Coast, England and New Zealand are high and fish mortality may result.

SUMMARY AND CONCLUSION:

The contaminants, Nickel (Ni) and Vanadium (V) in the 16 samples of snakehead fish, *Channa obscura* are toxic to the liver, muscle and gill.

In view of the ever-increasing importance of fish as a source of protein as our meat production declines, it is time to make an estimate of the hazard posed by these metals to aquatic organisms in general and fish in particular. The objective of this "hazard assessment" will be to provide information from which we can make a valid judgment regarding the safety of these metals to fisheries.

Unless hazard assessments are made and a swift more made by the various State Governments, better still by the National Assembly, to legislate permissible levels of heavy metals in effluents from our industries and receiving bodies of water, most of our fish species may be in danger of extinction.

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