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ASSESSMENT OF LEAD AND COPPER IN FISH AND SOIL SEDIMENTS IN KIRINYAGA SOUTH DISTRICT, KENYA

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Abstract: This study was conducted to quantify the concentration of copper (Cu) and lead (Pb) in fish and soil sediment, from zones growing horticultural crops in Kirinyaga South District. Fish and soil samples were collected from rivers Thiba, Nyamindi and from the Canal joining the two rivers. The concentrations were determined using Atomic Absorption Spectrophotometry technique. Results showed that the mean concentration of lead was 5.61±1.81mg.kg^{-1} and 5.64±1.79 mg.kg^{-1} in tilapia and catfish respectively while that of copper was 8.28±8.87 mg.kg^{-1} and 3.63±5.20 mg.kg^{-1}, in tilapia and catfish respectively. The mean concentration of Cu and Pb in soil sediment was 18.73±9.59 mg.kg^{-1} and 19.26±5.75 mg.kg^{-1} respectively. The mean concentration of copper was significantly different ($p < 0.05$) between tilapia and cat fish, as observed between the sampling months and sites. The level of copper that was demonstrated in the fish samples was found to be within the FAO (1983) and EC (2001) recommended safe limits. However the levels of lead exceeded the permissible safe limits by the same standards. It is, therefore, recommended that concentration of heavy metals in foodstuff and environment be regularly determined.

Keywords: Heavy metals, tilapia, catfish, foodstuff, environment

INTRODUCTION

Metallic chemical elements have a relatively high density and are toxic or poisonous at low concentrations [1] and generally do not break down further into less harmful constituent. They accumulate in areas where they are released [2]. Sediments are natural collectors of pollutants where persistent contaminants are stored and partially buried, but can be potentially re-suspended, thus re-entering the food web [3]. Marine organisms can accumulate heavy metals through respiration, adsorption and ingestion of water or contaminated food [4]. Metal accumulation in tissues of aquatic animals is dependent upon exposure concentration and period; other factors such as salinity, temperature, interacting agents and metabolic activity of the tissue also influence the accumulation [5].

Extensive use of petrol powered water pumps, washing of motor vehicles and pesticide application apparatus along the rivers and canals may have contributed to contamination of soil sediment, waters and fish by lead and copper and this may result to exposure of famers to the metals. This study was therefore conducted to determine the levels of copper and lead in fish and soil sediments in rivers Thiba and Nyamindi and the canals in Kirinyaga South District where horticultural farming is carried out via irrigation. The concentration of lead as a toxic element and that of copper as an essential element were determined.

Heavy metals that may be found in fish include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb) which have a tendency to bioaccumulate in the food chain and can be highly toxic to human even at low concentrations [6]. These toxic elements are transferred to human through consumption of contaminated fish resulting to a negative effect on human health [7]. On absorption, pollutants are transported in the blood stream to either the bone or liver for transformation and storage [8]. Lead (Pb) exists in several stable oxidation states that are absorbed and accumulated by aquatic organism [5]. Environmental contamination by lead occur in many ways such as deposition from the atmosphere [9], erosion of rocks containing lead [10], mines and other effluents [11] as well as from lead and copper containing gasoline or pesticides used in the past [12].

MATERIALS AND METHODS

Study Area

The study was conducted in Kirinyaga South district, of Kirinyaga County in Central Kenya during the period July 2009 to May 2010. Kirinyaga South district is located between latitude 0°35'-0°45'S and longitude 37°15'-37°30'E on the base of Mt. Kenya at an altitude of approximate1200 meters above the sea level. Rivers Thiba and Nyamindi are the main water sources joined for consumption and irrigation. The two rivers are joined by a canal which is almost 12 kilometers long from where most of the water for irrigation is drawn using gravity or petrol powered water pumps.

Sampling location and Cleanup procedure

Fish and soil sediments were collected from Thiba River, Nyamindi River, Canal and the irrigation furrows. Sampling was carried out early in the morning between 6.00 a.m. and 8.00 a.m. before disturbance of the water by famers and other users. Forty four (44) fish were sampled from fishing points where twenty three tilapia and twenty one catfish were sampled. Each fish sample was washed with clean water at the point of collection, wrapped separately, put in polythene bags, labeled and packed in a cool box for transportation to the laboratory. The fish species were selected based on availability and the ones commonly fished for sale and consumption by the inhabitants of the study area.

The soil sediments were collected by scooping two handfuls of sediment from the water bed then put in a polythene bag, labeled and packed in a cool box separately. A total of thirty six (36) soil sediment samples were collected. The samples were transported the same day for analysis. The fish and soil sediment samples were stored in separate freezers at -20°C until analyzed.

For each whole dry fish sample, 1 gram was weighed and digested with 10 mls of concentrated nitric acid. Full digestion was attained with hydrogen peroxide and the mixture filtered. Aliquots of the filtrates were used to determine the concentration of the metal by Atomic Absorption Spectrophotometry model Specter AA-10 Varian.

Two and half grams of the soil sample were weighed and complete digestion was achieved using Hydrochloric acid / Nitric acid, at 1:3 and a aliquots of final filtrate used to determine the concentration of copper and lead in samples using AAS model –Specter AA-10 Varian on their respective cathode lamps.

Statistical analysis

Data obtained was analyzed using Statistical Package for Social Scientists Statistic 17.0 version. Descriptive statistics, the mean and standard deviation, and two-way ANOVA was used to determine the significance difference ($p<0.05$) of statistical means of the heavy metal in the fishes and soil sediments.

RESULTS AND DISCUSSION

The mean weight of tilapia and catfish were 18.97±5.42 grams and 33.84±25.8 grams respectively while tilapia had a mean length of 10.5±1.44 cm and catfish 15.7±3.29 cm. Analysis of variance (ANOVA) for the heavy metals revealed that the mean concentration of copper was significantly varied ($p<0.05$) between the fish species with tilapia having the highest levels. This observation agrees with that of Rahmawati [13] that concentration of heavy metal in smaller fish is always higher than in bigger fish. Fish absorb and accumulate metals through ingestion of water or contaminated food. Heavy metals undergo bioaccumulation in tissue of aquatic organisms, on consumption of fish; these metals become transferred to man [2]. Comparing the mean concentration of Cu in fish obtained from the study area with European Commission (EU) [14] and Food and Agriculture Organization (FAO) [15] permissible standards limits indicate that the copper levels of 18.28 $mg.kg^{-1}$ and 3.63 $mg.kg^{-1}$ in tilapia and catfish respectively are within the permissible limits safe for human consumption. However the mean Lead concentrations of 5.61 $mg.kg^{-1}$ and 5.64 $mg.kg^{-1}$ in tilapia and catfish respectively were above the acceptable maximum levels set by EC and FAO for human consumption. The levels of lead are almost ten times the accepted standards suggesting possible adverse health effect to the people consuming tilapia and catfish in the study area. Possible adverse effects include chronic damage to the central nervous system and gastrointestinal tract as reported by Duriebe [16] (Table1).

Table 1: Mean (±standard deviation) concentration and range of lead and copper in fish sampled from Thiba and Nyamindi rivers and the canal joining the two rivers of Kirinyaga South District

	Metal Concentration in Tilapia and Catfish ($mg.kg^{-1}$)			
	Lead		Copper*	
	Mean(±SD)	Range	Mean(±SD)	Range
Tilapia(n=23)	5.61±1.81	2.50-9.66	18.28±8.87	0.50-33.33
Cat fish(n=21)	5.64±1.79	2.00-9.00	3.63±5.20	0.50-25.66
Cumulative Mean	5.63±1.77	2.00-9.66	6.06±7.64	0.50-33.33

Key: * Mean significantly different ($p<0.05$) between species for copper, SD= Standard Deviations: FAO (1983) and EC (2001) permissible limits for lead 0.5; copper 30.

Concentrations of Lead and Copper in Tilapia by month of sampling

An Analysis of variance (ANOVA) comparing the mean concentration of the metal revealed that copper was significantly different ($p<0.05$) between the sampling months of December and

May, such that December had significantly high levels of copper. The levels of copper in tilapia fish varied significantly ($p<0.05$) between the sampling months such that, the month of December had a mean level of 16.35±7.92 mg.kg^{-1} which was eight times more than the mean level of 2.08±1.08 mg.kg^{-1} during the month of May. During the month of December 2009, ambient temperatures were generally high; water levels in the rivers were relatively shallow and flowing slowly suggesting increased contact time of the tilapia with the surrounding medium which may explain the high concentration of copper during this month (Table 2).

Table 2: Mean (±Standard Deviation) concentrations and range of Lead and Copper in Tilapia sampled during the month of December 2009 and May 2010 from combined sources of Thimba river, Nyamira river and the Canal.

	Metal Concentration in Tilapia (mg.kg^{-1})			
	Lead		Copper*	
Month	Mean(±SD)	Range	Mean(±SD)	Range
December(n=10)	6.36±1.77	4.42-9.66	16.35±7.92	9.13-33.33
May (n=13)	5.04±1.69	2.5-8.0	2.08±1.08	0.5-4.0
Cumulative Mean	5.62±1.81	2.5-9.66	8.28±8.87	0.5-33.33

Key: * Mean significantly different ($p<0.05$) between sampling months for copper, SD= Standard Deviations: FAO (1983) and EC (2001) permissible limits for lead 0.5; copper 30.

Concentration of Lead and Copper in soil sediment samples

Soil sediment sampled from the Canal and the Furrow had the highest copper concentrations of 34.40 mg.kg^{-1} and 24.40 mg.kg^{-1} respectively. An Analysis of variance (ANOVA) of the mean concentration of the metal from the four sampling sites showed that the concentrations of copper in the canal was significantly higher ($p<0.05$) than from other sampling sites during the study period. In a study by Byran and Langston [17], it was observed that the background levels of copper in sediment range from less than 10 mg.kg^{-1} to 75 mg.kg^{-1} while normal soil levels range from <10 to 100 mg.kg^{-1}, with levels above 200 mg.kg^{-1} classified as contaminated. A comparison of these levels with the mean concentration of copper in soil sediments in the area of study shows that the levels of copper are within the normal range implying no contamination. Sources of copper may include chemical discharges, agricultural runoffs and urban sewage effluents draining into the rivers (Table 3).

In this study the mean concentration of lead in soil sediment was 18.73±9.59 mg.kg^{-1} ranging from 6.80 to 66.40 mg.kg^{-1}. Concentrations of lead in uncontaminated sediments range from <10 mg.kg^{-1} to 50 mg.kg^{-1}, while levels of Lead in soil can range from <10 mg.kg^{-1} to 500 mg.kg^{-1}, with levels over 1000 mg.kg^{-1} being classified as contaminated [17]; [18]. Comparing these levels with the mean concentration of lead in soil sediment in the study area indicates insignificant contamination since the metal was within the range of uncontaminated soil sediment (Table 3).

Source of heavy metals contamination

Presence of faulty petrol powered water pumps and disposal of empty pesticide containers next to the water sources may have contributed to the load of heavy metal contamination and especially when leakages from faulty petrol pumps flow into the rivers and canals. Lead is not an environmentally mobile metal and is often heavily bound to suspended particulate and sediment material [19]. However, according to Bryan and Langston [17], tilapias are fast growing and short lived fish that are primarily herbivores and feed on water plants especially duckweed which is known to uptake and concentrates many minerals. In the current study, the presence of copper and lead in the soil sediment may have resulted to accumulation of the two metals to high levels in the water plants and in turn passed on to the fishes. Aquatic organisms including fish are reported to accumulate metals from their surrounding medium or food by ingestion or absorption [20].

Table 3: Mean concentration (± standard deviation) of lead and copper ($mg.kg^{-1}$) in soil sediment sampled from different water sources in Kirinyaga South District during the month of May 2010.

	Metal Concentration($mg.kg^{-1}$)			
	Lead		Copper*	
Sample source	Mean ± (SD)	Range	Mean ± (SD)	Range
Canal(n=12)	16.6±2.91	12.00-22.40	23.4±6.20	16.00-34.40
Farrow(n=3)	15.6±2.80	12.40-17.60	20.67±4.84	15.20-24.40
Nyamindi(n=10)	16.10±7.69	6.80-29.60	14.15±3.30	11.20-20.80
Thiba(n=11)	22.95±15.11	13.20-66.40	18.07±3.29	14.00-23.60
Cumulative mean	18.73± 9.59	6.80-66.40	19.26±5.75	11.20-34.40

Key: *Copper mean significantly different ($p < 0.05$) between sampling sites.SD =Standard Deviation

CONCLUSIONS

Copper and lead residues were detected in both tilapia and catfish from Thiba and Nyamindi Rivers and from the canal. The levels of copper were within the permissible maximum limits while those of lead were above the recommended levels. Although these results do not indicate a clear manifestation of toxic effects, the possibility of harmful effects cannot be ruled out after a long period of consumption of fish caught in the study area. Heavy metals have a tendency of accumulating in various marine organisms especially fish which in turn may enter into human metabolism through consumption of the fish causing serious health hazards [21]. As such potential dietary exposure to lead can occur in the future hence it is highly recommended that regular checks on levels of heavy metals, in fish, soil and foodstuff be carried out. This should be done regularly in order to evaluate the possible risk to human health.

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