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COMPARATIVE STUDIES OF TRACE METALS IN LAGOON SNAIL, BLACK-CHIN TILAPIA AND WATER IN THE BRENU LAGOON OF GHANA.

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ABSTRACT

Concentrations of copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb) and mercury (Hg) in tilapia, lagoon snail (tissue and shell) and water from Brenu Lagoon in the Central Region of the Republic of Ghana have been measured in this study. The results of the study are as follows: for tilapia, the concentrations of Zn, Cu, Cd, Pb and Hg are: 1038.8 µg/kg, 667.0µg/kg, 0.200µg/kg, 0.500 µg/kg and 2.113 µg/kg respectively, whereas the concentration of Zn, Cu, Cd, Pb and Hg in the tissues of the lagoon snail are: 805.3 µg/kg, 870.5 µg/kg, 2.500 µg/kg, 19.50 µg/kg and 4.142 µg/kg respectively. Similarly, Zn, Cu, Cd, Pb and Hg concentrations in the shells of the snail obtained from the Brenu Lagoon are: 576.8 µg/kg, 449.3 µg/kg, 5.500 µg/kg, 0.500 µg/kg and 4.990µg/kg, respectively. The concentrations of Zn, Cu, Cd, Pb and Hg in the water from the lagoon are; 144.9 µg/L, 111.7 µg/L, 0.750 µg/L, 4.50 µg/L and 2.761 µg/L respectively. Comparing the result with that of the World Bank Health Safety Guidelines of 300µg/kg, 1000µg/kg, 600µg/g, 100µg/kg and 2.0µg/kg for Cu, Zn, Pb, Cd and Hg respectively, all the samples except water had values above the limit for Cu and Hg. However the black-chin tilapia had higher Zn content than the acceptable levels. The level of mercury pollution is alarming and therefore effort should be made to stop further additions.

KEY WORDS: Esuaku, Obuahu, Asenche, Asosi, Burabin, Brenu Lagoon, *Sarotherodon melanotheron*, *Tympanotonus fuscatus*, Bakatue

INTRODUCTION

Along the West Africa coast, like any other coast, effluents from all sources finally find their way into the sea (Binney, 1985). In recent times, pollution of marine environment has become a significant problem facing countries which lie along the coast. This situation has risen as a result of the rapid growth in population, increased urbanization and expansion of industrial activities, exploration and mining of minerals like gold, aluminium, and so on. Pesticides, weedicides and herbicides may be washed into rivers/streams which eventually end up into the sea.

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Some of the chemicals such as organo-chlorine and heavy metals get into the tissue of different life forms such as fish, mollusc and become bio accumulated (not biodegradable) and may accumulate in human tissue and can cause cancer, tumour, physical and mental handicaps in human beings who consume them.

The extent of pollution in a marine environment can be determined by the use of biological organism living in the marine environment. Bivalves are widely used as bio-indicators of heavy metals pollution in coastal areas because they are known to concentrate these elements, providing a time – integrated indication of environmental contamination (Philips, 1976). In comparison to fish and crustaceans, bivalves have a very low level of activity of enzymes systems capable of metabolizing persistent organic pollutant (POP's) such as a polycyclic aromatic hydrocarbons and biphenyls.

Concentrations of heavy metals and non-metals in aquatic organisms such as mollusc at the same location differ between different species and individuals due to species – specific ability or the capacity of the organism to regulate or accumulate trace metals and other toxic chemicals. Therefore contaminants concentrations in tissue of bivalves more accurately reflect the magnitude of environmental contamination (Philips, 1990). Different animals in the same community at the same trophic level could accumulate pollutants differently due to differences in habitat/niche's physical and chemical properties. The choice of biological indicator for the study of trace metals must possess some special properties. The properties are that; the organisms should be able to accumulate metals to some appreciable levels and considerably higher than in the water column, sediments and in some cases to indicate fluctuations in levels.

Tilapia and lagoon snail were chosen for this study because they are able to bio-accumulate heavy metals from marine environment and they help to make concrete observation and conclusion on pollution levels for a particular locality (Pillar, 1985) The other reason for the choice of the lagoon snail is the relatively low movement nature of the organism so that the levels of pollutants in the body can be used as a fair representation of pollution taking place at the locality.

The main thrust of this study is to:

- Determine the concentrations of Cu, Zn, Pb, Cd and Hg in black-chin, lagoon snail (tissue and shell) and water from the Brenu Lagoon in the Central Region of the Republic of Ghana.
- Determine the extent of marine pollution using the concentrations of Cu, Zn, Pb, Cd and Hg in black-chin tilapia, lagoon snail (tissue and shell) and water from Brenu Lagoon as bio-indicators for the extent of marine pollution in Ghana.

STUDY AREA

Brenu lagoon where the study was conducted is located about 13km west of Cape Coast (1°26´W and 5°04´N) in the Central Region of Ghana. It is a classical lagoon (Yankson and

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Obodai. 1999) fed by five small streams namely Esuaku, Obuahu, Asenche, Asosi and Burabin (Figure 1). Most of the streams dry out during the dry season. The consolidated sand

bar between the lagoon and the sea is breached by the local inhabitants during the rainy season if the lagoon threatens to flood the nearby villages.
At spring tides, sea water enters the lagoon and during an annual festival (Bakatue) of the area the inhabitants remove the sand bar manually to connect the lagoon to the sea.

The Brenu lagoon has fringing mangrove vegetation, which is heavily exploited for fuel wood a d cut to create space for construction of salt ponds. The samples taken from the lagoon were snails, black-chin tilapia and water.

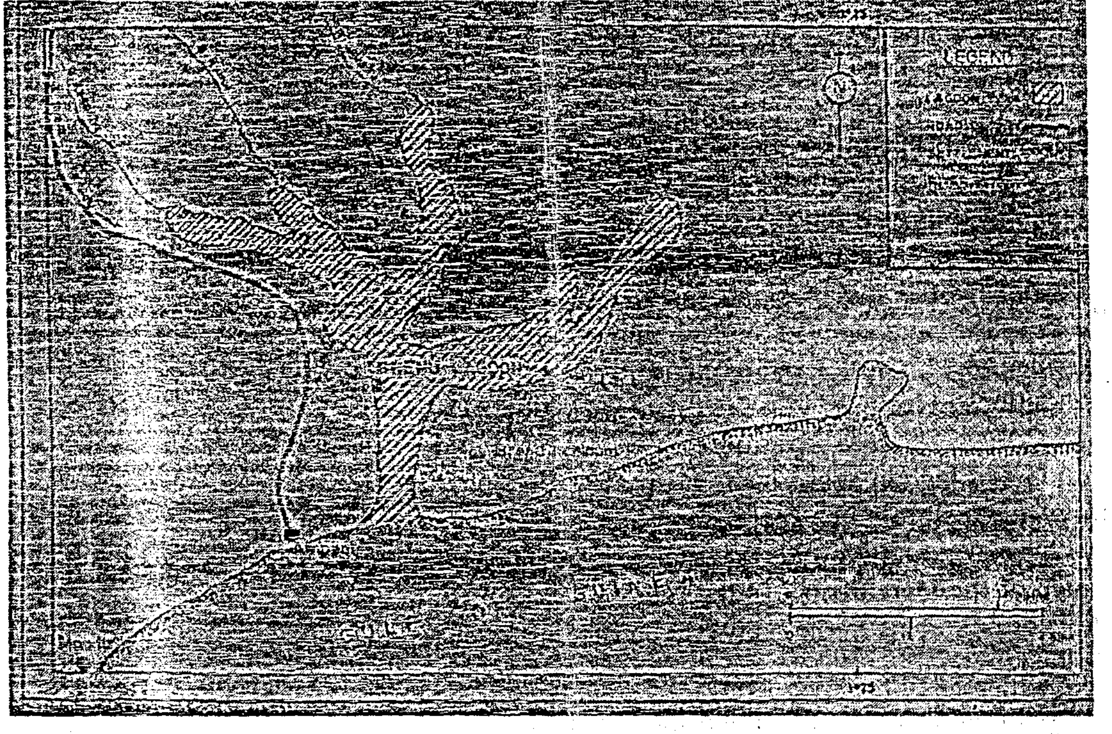

Figure 1 Location of Brenu Lagoon

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MATERIALS AND METHODS

Field sampling

The samples were collected randomly from Brenu lagoon. The lagoon does not flow directly into the sea except when there is a heavy flood. The black-chin tilapia *Sarotherodon melanotheron* samples were obtained from the landings of the local fishermen that fished in the lagoon, the same day and time that the other samples were taken. The snails *Tympanotonus fuscatus* were collected from various parts (sampling sites labeled station 1-4

in Fig. 1 above) of the lagoon for the analysis of trace metals. The water samples were taken randomly at four different sites (sites labeled station 1-4 in Fig. 1 above) by means of small clean bottles. Sampling was done on monthly basis for four months from February to May 2005.

Sample preparations

Snail shell and tissue

The snails were thoroughly rinsed with distilled water and the shells of 40 equally sized snails were cracked by means of mortar and pestle and the tissues gently removed with cleaned forceps. The shells were again rinsed to remove any tissue attached to them. The shells were then ground into smaller particles by means of mortar and pestle and sample taken for trace metal analysis. The tissues were rinsed with distilled water several times to remove shell particles attached to them and the samples taken for trace metal analysis.

Sarotherodon melanotheron

Black-chin tilapia caught from the lagoon were washed and dried in the oven at a temperature of 75°C. The dried fish were then ground gently into powder using mortar and pestle for the trace metal analysis. This was done carefully to avoid any contamination by the mortar and pestle.

Water

Standard methods were used to take samples of brackish water from the lagoon for the trace metal analysis.

Digestion procedure for samples

Sample digestion for Mercury

Small amount (1.0g) of dried powdered fish was weighed into a clean beaker. 4mL concentrated H_2SO_4 and 1mL HNO_3 acid was added to the sample. The mixture was then placed on a water bath 80°C for 30 minutes after which it was removed and then cooled to 4°C in an ice bath. 15mL $KMNO_4$ and 8mL concentrated Potassium persulphate, $(K_2S_2O_3)$ were added to oxidize all alkyl mercury in the fish to the +2 state. The mixture was again heated on water bath for another 30 minutes and then removed and cooled. 6ml of Hydroxylamine Hydrogen chloride was added to remove excess $KMNO_4$. The solution was then filtered into 50mL volumetric flask and diluted to the mark with distilled water. This

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procedure was repeated for the snail shell and the tissue. All reagents used in the analysis were of the analytical grade supplied by BDH UK (AWWA, 1998).

Sample digestion for Cu, Cd, Pb, and Zn

The shells of 40 equally sized snails were cracked gently (The use of mortar requires additional control of analytical quality as it is a well known source of samples contamination so it was done gently) by means of mortar and pestle and the tissues gently removed with cleaned forceps. The tissues were rinsed with distilled water to remove shell particles attached to them. 10g of the sample was weighed into a thoroughly cleaned 100mL beaker. The wet ashing method was employed in the digestion. A solution made up of 1:1 v/v concentrated perchloric acid and nitric acid (20mL each) were added to the content of the beaker.

This was then covered with watch glass and allowed to stand overnight in a fume chamber to ensure complete digestion. This was then placed on a hot plate and allowed to boil gently until the volume reduced to 7-10mL.

The resulting solution was then allowed to cool and then filtered into a 25mL volumetric flask and diluted to the mark with distilled water. The same sample procedure was used to digest 25mL of the water sample, 10g of dried fish, snail and shells (USEPA (2003 Method 7061), USEPA (2003 Method 3050B).

Digestion of water samples for the analysis of mercury

100mL of water samples were transferred into different 250mL conical flask and labeled. 5mL concentrated sulphuric acid were added to each flask. Additional 2.5mL of concentrated Nitric acid were added to each flask and thoroughly mixed after each addition. 15mL of Potassium permanganate were added to each flask and allowed for the purple colour to persist for at least 15 minutes. 8mL of Potassium persulphate was added to each flask and then heated on a water bath for 2 hours at a temperature of 95°C. The samples were cool and 6ml of 12% w/w Hydroxylamine hydrochloride added to each of the samples to reduce the excess permanganate. Quantities of the samples were poured into small bottles for analysis.

The concentration of the heavy metals under study was determined at Water Research Institute (Environmental chemistry laboratory) using Atomic Absorption Spectrometry (AAS-Flame) (I. U. P. A. C, 1988).

RESULTS AND DISCUSSION

Validation of the method used

Reproducibility and recovery studies were done to validate the various methods used in the analysis. The recovery studies for 2μg/L in double distilled water for ten readings of Copper, Zinc, Lead, Cadmium and Mercury gave the following results: Mean = between 1.860 and 1.960, percentage recovery, between 95 and 98%, standard deviation between 0.020 and 0.035, standard error between 0.005 and 0.01 and Coefficient of Variation 1.602% and 1.687%

The reproducibility studies for 2µg/L solutions of Copper, Zinc, Lead, Cadmium and Mercury in double distilled water for ten readings gave the following results: Mean = between 1.901 and 1.994, percentage recovery, between 96 and 98%, standard deviation between 0.019 and 0.032, standard error between 0.005 and 0.01 and Coefficient of Variation 1.662% and 1.702%.

From the above results it is clear that the method employed for the chemical analysis was reliable

The results of this study have been presented in table 1 below.. The mean concentration of Cu, Zn, Pb, Cd and Hg in water samples from the lagoon is: 111.7µg/L, 144.9µg/L, 4.500µg/L, 0.750µg/L, and 2.761µg/L, respectively (Table 1).

The concentration of Cu, Zn, Pb, Cd and Hg in tilapia from the lagoon is: 66.7µg/kg 1,038.8µg/kg, 0.500µg/ kg, 0.200µg/kg, and 2.113µg/kg respectively.

Table 1: **Mean Concentrations of Cu, Zn, Pb, Cd and Hg in the samples from Brenu Lagoon and Aquatic Biota Standards**

Samples	Mean Concentrations ± S.E				
	Cu	**Zn**	**Pb**	**Cd**	**Hg**
Water (µg/L,)	1.117	1.446	0.045	0.008	0.003
Black-chin tilapia (µg/kg)	667.0	1038.8	0.500	0.200	2.113
Lagoon Snail Tissue(µg/kg)	870.5	805.3	19.50	2.500	4.142
Lagoon Snail Shell (µg/kg)	449.3	576.8	0.500	5.500	4.990
Aquatic Biota Standards (µg/kg)	300	1000	600	100	2

Source of Aquatic Biota Standards: The World Bank policies and guidelines, supplemented with information from OECD sources and the proposed revisions to the World Bank guidelines. (converted to mg/kg) (The World Bank policies and guidelines) L:\wpeu\guidelns\current\word6\min_pit.doc

Again from table 1, it can been seen that the concentration of Cu, Zn, Pb, Cd and Hg in th tissue of Lagoon snail was 870.5µg/kg, 805.3µg/kg, 19.50µg/kg, 2.500µg/kg and 4.142µg/k respectively, whilst the concentrations of Cu, Zn, Pb, Cd and Hg in the shells of lagoon sna were; 449.3µg/kg, 576.8µg/kg, 0.500µg/kg, 5.500µg/kg and 4.990µg/kg respectively.

The result of concentration of copper in the tissues of lagoon snail was 870.5µg/kg, a 449.3µg/kg in the shells were found in the Brenu Lagoon. The tissue of the snail contains tl highest concentration of copper. This can be attributed to mode of feeding and also lack digestive mechanism to digest the ingested copper, which also bioaccumulate over a period time in the tissues of the snail. The copper concentration in the shells of the mollusc was

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about half the concentration in the mollusc tissue indicating some level of correlation in terms of accumulated copper. The concentration of copper in the tissues of lagoon snail was 7.79 times higher than the concentration of copper in water from the lagoon, which suggests that mollusc accumulate a significant amount of copper from its environment. The water samples from the Brenu Lagoon showed smaller concentrations of copper as compared to the snail tissue and tilapia as shown in Table 1 above. Comparing the concentration of copper in the tissue of the mollusc and tilapia species with the World Bank Environment, Health and Safety guideline (The World Bank policies and guidelines), value of 300μg/kg, it can be said that the lagoon is polluted with copper and that residents around the lagoon who feed on the snail and tilapia from the lagoon are at risk.

The concentration of zinc in tilapia was the highest (1,038.8μg/kg). The concentration of zinc in the tissues of lagoon snail was 805.3μg/kg whilst zinc concentration in the shells of mollusc was also 576.8μg/kg. Comparing the concentrations of zinc in the mollusc obtained in this study to the World Bank Environment, Health and Safety value of 1000μg/kg shows that the value obtained in this study falls within the acceptable range.

However, zinc concentration in tilapia was found to be above the World Bank Environment, Health Safety value. The concentration of zinc in water from the Brenu lagoon was 1.449μg/L. This would have accumulative effect on humans as they take in these species as food and suggests some level of zinc pollution of the lagoon.

The mollusc tissue has the highest concentration of lead (19.50μg/kg) and lowest concentration in snail shell (0.500μg/kg). These values fall within the World Bank Environment, Health Safety value of 600μg/kg. The primary source of lead in the lagoon night be from the previous use of leaded fuel by vehicles which ply along roads around the agoon. Most of the vehicles that ply the road to the villages surrounding the lagoon are over ged vehicles and therefore their exhausts release a lot of pollutants into the atmosphere. The tmospheric lead is deposited on leaves, soils, rivers and streams including lagoons. From the esults of the study, it is clear that lead pollution is not a significant health problem, residents vho feed on tilapia and mollusc in the lagoon run the risk of accumulated lead in their body ssues and this could pose significant health problems over a long period of time.

rom the results of the study, the highest concentration of cadmium was found in the shell of tollusc (5.500μg/kg), the least concentration of cadmium were found in the water samples om the lagoon and tilapia species in the lagoon. Sources of cadmium include air pollution om incineration and exposures from anthropogenic sources and disposal of cadmium itteries into the lagoon. The concentration of cadmium in the shell of the mollusc is about vice that in the tissue of the mollusc by comparism. The highest concentration of mercury as found in the shell of the mollusc (4.990μg/kg) in the lagoon. This is attributed to the oaccumulation of mercury in the shell and tissue of mollusc due to its feeding pattern.

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Finally, it can be said that the levels of trace metals in fishes (e.g. shell fishes) and mollusc in contaminated rivers, streams and lagoons can be used as bio-indicators to monitor the levels of pollution. Shell fish and other benthic feeders; in particular mollusc contain excessive concentration of cadmium, copper, mercury, lead and zinc in the study area.

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