African Journal of Environmental Science and Technology Vol. 4(6), pp. 343-351, June 2010
Available online at http://www.academicjournals.org/AJEST
ISSN 1991-637X © 2010 Academic Journals

*Full Length Research Paper*

# Studies on the occurrence and distribution of heavy metals in sediments in Lagos Lagoon and their effects on benthic microbial population

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Accepted 6 April 2010

**An investigation was conducted to assess the concentration of heavy metals in sediments in three selected locations along Lagos lagoon comprising University of Lagos, Ebute Metta and Ijora zones and correlate the effect of metal concentrations on benthic microbial population vis a vis the open water bacterial population. Physiochemical analysis revealed a pH of 8.94, 11.98 and 7.82 of University of Lagos, Ebute Metta and Ijora zones respectively. The concentration of lead was more in Ebute Metta zone (Oko Oba) with a value of 22.75 mg/100 g, while the concentration of iron was more in Ijora zone with a value of 45.31 mg/100 g. The concentration of Cadmium was higher than other zones in Ebute Metta with a value of 14.63 mg/100 g. Mercury was more concentrated in University of Lagos zone with a value of 7.83 mg/100 g, while the value for chromium was more in Ebute Metta sediments with a value of 6.81 mg/100 g. Levene's statistical analysis shows there is no significant difference in the variances for all metals across the three locations understudy. However, ANOVA analysis shows that mean measurements for all metals across the three locations are significantly different at 5% level of significance except for mercury where the mean measurements were not significantly different at 5% level of confidence. The benthic population (bacteria) was less than that of surface water (control). University of Lagos had the highest bacterial mean cfu/ml determined by $\log_{10}$ with a value 6.81 for control and 3.51 for sediments. The cfu value for fungi for control samples for University of Lagos zone, Ebute Metta and Ijora were 1.7, 1.54 and 1.6 respectively. The bacteria isolated and identified were *Bacillus subtilis, Bacillus licheniformis, Arthrobacter* sp and *Achromobacter* sp. Fungi isolated were *Saccharomyces cerevisiae*, *Candida utilissima* and *Sporobolomyces* sp. The values for heavy metals for all zones are of public health significance and pose a threat to the survival of both humans and aquatic life. An immediate attention from concerned authorities is required in order to protect the Lagos lagoon and its dependants from further pollution and diseases.**

**Key words**: Heavy metals, benthic, sediment, *Bacillus, Candida, Achromobacter, Sporobolomyces, Saccharomyces,*

## INTRODUCTION

The occurrence of elevated levels of trace metals especially in sediments can be a good indication of man-induced pollution and high levels of heavy metals can often be attributed to anthropogenic influences, rather than natural enrichment of the sediment by geological weathering (Davies et al., 1991; Lord and Thompson, 1988; Binning and Baird, 2001). There can be significant

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temporal and spatial variability in water column concentrations of heavy metals contaminants, which leads to problems in obtaining representative samples. Sediments, on the other hand, integrate contaminants over time and are in constant flux with the overlying water column. The analysis of heavy metals in the sediments permits detection of pollutants that may be either absent or in low concentrations in the water column (Davies et al., 1991). Their distribution in coastal sediments provides a record of the spatial and temporal history of pollution in a particular region or ecosystem. Heavy metal concentrations in the water column may be relatively low, but concentrations in the sediment may be elevated. It has been estimated that about 90% of particulate matter carried by rivers settles in estuaries and coastal areas (Martin and Whitfield, 1983). Begum et al. (2009) in their study of heavy metal pollution of Cauvery River water observed that the river water, planktons, fish and sediments were contaminated with heavy metals chromium, copper, cobalt, manganese lead and zinc with a greater concentration in sediments. Muhammad and Hooke (2003) in their study described the toxicity of heavy metals (chromium, cadium and lead) on microorganisms isolated from slow sand filter Schmutzdecke. Tumanoz and Krest'yaninov (2004) observed the combined effect of heavy metal ions on bacteria and determined the heavy metals by bioassay. Collins and Stotzky (1992) reported that heavy metals alter the electrokinetic properties of bacteria, yeasts and clay minerals and concluded that the susceptibility of microbes to metal toxicity at higher pH was due to binding of the metal on the microbe, which alter the net charge of the cell. Once heavy metals are discharged into estuarine and coastal waters, they rapidly become associated with particulates and are incorporated in bottom sediments (Hanson et al., 1993). The effect of heavy metal contaminants in the sediments may be either acute or chronic (cumulative) on benthic organisms (Griggs et al., 1977).

The bioaccumulation of metals in various fish and shellfish organisms is well studied (Canli and Furness, 1993; Wolfe et al., 1996), whilst the bioavailability of trace metal concentrations is controlled by many chemical, physical and biological factors (Morse et al., 1993; Morse and Rowe, 1999). Guedu-Ababio et al. (1999) have also demonstrated that the density and diversity of nematode communities in the Swarkops River estuary are influenced by the degree of heavy metal contamination in the sediments. Many of these metals serve no known biological function in the marine environment, but can act synergistically with other chemical species to increase toxicity (Binning and Baird, 2001). Increased heavy metal concentrations and organic carbon will tend to be associated with finer-grained sediments because of their high surface to volume ratios and absorption abilities (Binning and Baird, 2001). The effect of metal pollutant on macrobiota and microbiota has been stressed by several workers: loss of species (Hickerman et al., 2002); invisible extinction of species (Odiete, 1999); elimination of shellfish, molluscan, fish and crustaceans in coastal and estuarine zone (UNEP, 1982). About 2000 medium and large-scale industries in Lagos State discharge untreated effluents directly or indirectly into the lagoon. The Ogun River carries wastes from hinterland and discharge into the lagoon. The effluent from Agbara Industrial Estate also ends via Lagos lagoon through discharge into Ologo lagoon, which is linked to Lagos lagoon through Badagry creek. Odiete (1999) reported the occurrence of heavy metals and their compounds as well as bacterial pathogens and sawdust in Lagos lagoon. Ajao (1990) reported that a visible effect of these heavy metals is presented in fish caught, which are falling drastically from one million kilograms in 1990, due largely to the combination of pollution and over fishing.

Other workers have explained that heavy metals constitute a significant threat to the aquatic environment: hindrance to fishing (Edgardo, 1993); impairment of water quality and injury to living organisms (UNEP, 1982, 1984); contamination of benthic fauna via bioaccumulation and biomagnification and changes in benthic communities (Odiete, 1999); indirect effect on man through consumption of sea foods (Odiete, 1999). Such changes have ecological and commercial importance on trophic levels. Quinton and Catt (2007) observed that water erosion on agricultural soils, which has received only agrochemicals, has enriched sediment metal concentrations to toxic levels which breached many accepted standards for soils and sediments. When lead is released into the environment, it has a long residue time compared with most other pollutants (Jacob, 1997). As a result lead and its compounds tend to accumulate in soils and sediments where due to their low solubility and relative freedom from microbial degradation, they will remain accessible to the food chain and to human metabolism for the future. The purpose of this study was therefore to ascertain the presence and concentration of heavy metals in sediments in selected sections along Lagos lagoon and speculate the significance of these heavy metals vis-à-vis their toxic effects on benthic and surface microbial distribution along the lagoon stretch, and alert inhabitants of Lagos and its environs on the danger these heavy metals pose to their health and the consequences of the consumption of benthic macrobiota obtained from the Lagoon.

## MATERIALS AND METHOD

### Collection of samples

The sediments for this study were collected from three locations- University of Lagos lagoon front, Ijora and Ebute Metta zones of Lagos lagoon within Lagos metropolis of Lagos State, Nigeria. The samples were transferred to the laboratory in plastic container prior to analysis in iced coolers at 4°C. Three sampling point was chosen from each location (about 20 m apart) and three replicate samples were collected from each point. The samples collected were representative of which location from where they were taken. The mean value of each metal from the representative samples was

**Table 1.** The concentration of heavy metals in University of Lagos sediments and their upper limits.

| Element | Standard conc. (ppm) | Standard absorbance | Sample absorbance | Sample conc. (mg/100 g) | Upper permissible limit (mg/L) |
|---|---|---|---|---|---|
| Lead | 2.00 | 0.098 | 0.090 | | 0.05 |
| | | | 0.084 | 17.75 | 0. |
| Iron | 3.00 | 0.048 | 0.072 | | |
| | | | 0.071 | 44.68 | 20.00 |
| Cadmium | 2.00 | 0.179 | 0.121 | | |
| | | | 0.119 | 13.40 | 0.10 |
| Mercury | 2.00 | 0.162 | 0.064 | | |
| | | | 0.063 | 7.83 | 0.01 |
| Chromium | 2.00 | 0.182 | 0.053 | | |
| | | | 0.050 | 5.65 | 0.05 |

determined.

**Determination of pH of samples**

The pH of each sample was determined using the pH meter (Unicam 9450 model). Samples were shaken with the vibratory shaker and 100g dispensed into a clean beaker and their pH were read by dipping the pH electrodes into it. The meter was standardized using standard buffers of pH 4.0 and 7.0.

**Preparation of samples for metal analysis**

The samples were prepared by drying separately in clean glass container in an oven at 65°C for 3 - 5 days. Previously, portions were removed from samples to determine their microbial content (fungi and bacteria) (benthic microbial population).

**Determination of heavy metal in samples**

The concentrations of the heavy metals (lead, mercury, iron, cadmiums, and chromium) in sediment samples were determined using the method describe by A.O.A.C (1990). Briefly, about 10 g of each dried sample was incinerated into white ash at 550°C in a muffle furnace for 4 h, cooled and the ash was washed into 250 $cm^3$ beaker with 100 $cm^3$ of concentrated trioxonitrate (V) acid and evaporated to dryness on steam water bath. The residue was further heated for 30 min, and thereafter dissolved in 40 $cm^3$ of hydrochloric acid (HCl) at ratio 1:1 and digested for 2 h on a hot plate with magnetic stirrer. About 1 $cm^3$ of dilute hydrochloric acid was further added to the sample and boiled for about an hour, filtered while hot with Whatman No. 4 filter paper, washed with HCl and the volume made up to 100 $cm^3$ with distilled water. The metal constituents of the sediment samples (Pb, Hg, Fe Cd and Cr) were determined spectrophotometerically using atomic absorptions spectrophotometer (AAS) (Philip model. PU 9100x) with a hallow cathode lamp and fuel rich flame (air acetylene). Samples were aspirated and the mean signal response was recorded for each of the element respective wavelength. The concentration of each metal element in each sample was calculated as follows:

$$Concentration(mg/100g) = \frac{Standard\ concentration\ x\ sample\ absorbance\ x\ 100}{Standard\ absorbance\ x\ weight\ of\ sample}$$

**Microbiological analysis of samples**

About 1 gm of the sediment sample from each zone was serially diluted in 9ml portion of sterile water in test tube to a dilution of $10^{-4}$ and thereafter 0.1 ml aliquot of the $10^{-3}$ and $10^{-2}$ dilution were plated on nutrient agar and potato dextrose agar respectively and pure cultures of the resulting bacterial and fungal species were identified. The bacterial and fungal species were identified according to the identification scheme of Buchanan and Gibbon (1974) and Smith (1969) (Barnett et al., 1990) respectively. The procedure was repeated for water samples collected from each of the zones. The bacterial and fungal species were isolated and identified accordingly using the same identification scheme above.

## RESULTS

Tables 1, 2, 3 show the concentration of heavy metals in the three zones along Lagos and their permissible upper limits. Figure 1 represents the pH of all sediment samples obtained from the three locations. Sediment samples from Ebute Metta has a pH value of 11.94, which is higher than samples from University of Lagos and Ijora zones with values of 8.94 and 7.82 respectively. A noticeable phenomenon among the sediment samples from the three zones is the alkaline nature of the sediment samples. Results from sediments from University of Lagos showed that lead, iron, cadmium, mercury and chromium were all present at concentrations of 11.75, 44.8, 13.4, 7.83 and 5.63 mg (Figure 2). The high concentration of these metals in the sediments has serious environmental significance. The concentration of the heavy metals were in the order iron >Lead > Cadmium > Mercury > Chromium. Sediments from Ebute metta zone had the following concentrations for each metal; Lead (22.5) (Figure 3), Iron (38.75) (Figure 2), Cadmium (14.63) (Figure 3), Mercury (6.91) (Figure 2) and Chromium (6.81) (Figure 4). The order of concentration of metals in this zone was iron > lead > cadmium > mercury > chromium. In Ijora zone, the concentrations of heavy metal were Lead (20.5), iron

**Table 2.** The concentration of heavy metals in Ebute Metta sediments and their upper permissible limits.

| Element | Standard conc. (ppm) | Standard absorbance | Sample absorbance | Sample conc. (mg/100 g) | Upper permissible limit (mg/L) |
|---|---|---|---|---|---|
| Lead | 2.00 | 0.098 | 0.113 | | |
| | | | 0.110 | 22.25 | 0.05 |
| Iron | 3.00 | 0.048 | 0.064 | | |
| | | | 0.060 | 38.75 | 20.00 |
| Cadmium | 2.00 | 0.179 | 0.132 | | |
| | | | 0.130 | 14.63 | 0.10 |
| Mercury | 2.00 | 0.162 | 0.054 | | |
| | | | 0.058 | 6.91 | 0.001 |
| Chromium | 2.00 | 0.182 | 0.061 | | |
| | | | 0.063 | 6.81 | 0.05 |

**Table 3.** The concentration of heavy metal in Ijora sediments and their upper limits.

| Element | Standard Conc. (ppm) | Standard Absorbance | Sample bsorbance | Sample Conc. (mg/100g) | Upper permissible limit (mg/L) |
|---|---|---|---|---|---|
| Lead | 2.00 | 0.098 | 0.101 | | |
| | | | 0.100 | 20.50 | 0.05 |
| Iron | 3.00 | 0.048 | 0.073 | | |
| | | | 0.072 | 45.31 | 20.00 |
| Cadmium | 2.00 | 0.179 | 0.114 | | |
| | | | 0.112 | 12.62 | 0.10 |
| Mercury | 2.00 | 0.162 | 0.060 | | |
| | | | 0.060 | 7.49 | 0.001 |
| Chromium | 2.00 | 0.182 | 0.083 | | |
| | | | 0.082 | 9.06 | 0.05 |

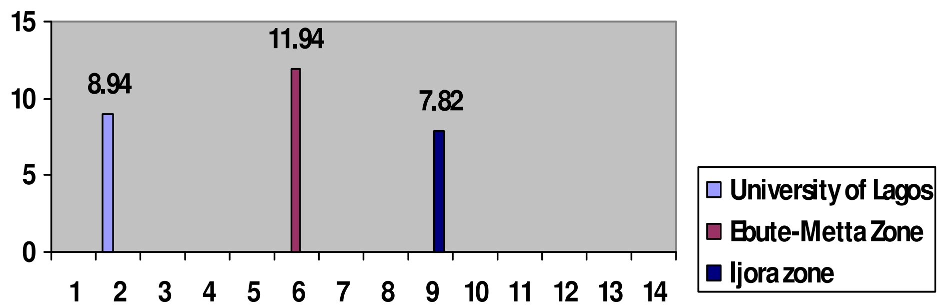


**Figure 1.** pH values of sediment samples from different Zones along Lagos Lagoon.

(45.31), cadmium (12.62), mercury (7.49) and chromium (9.06). The concentrations of these metals were in the order iron > lead > cadmium > chromium > mercury (Figure 4). Lead, iron and chromium were more concentrated in Ebute Metta sediments than the other two zones, while mercury was more concentrated in University of Lagos sediments than the other zones.

The values obtained for all heavy metals are above National and International Standards (FEPA, WHO). WHO has place the level at which risk begins at 50 ppm of mercury in hair for most people after which the organization then applied a safety factor of ten (10), estimating that a level of 5 or less is safe even for the most vulnerable population. This is the recommended range set for the general public. The bacteria population in each zone was as shown in Figure 5. The bacterial

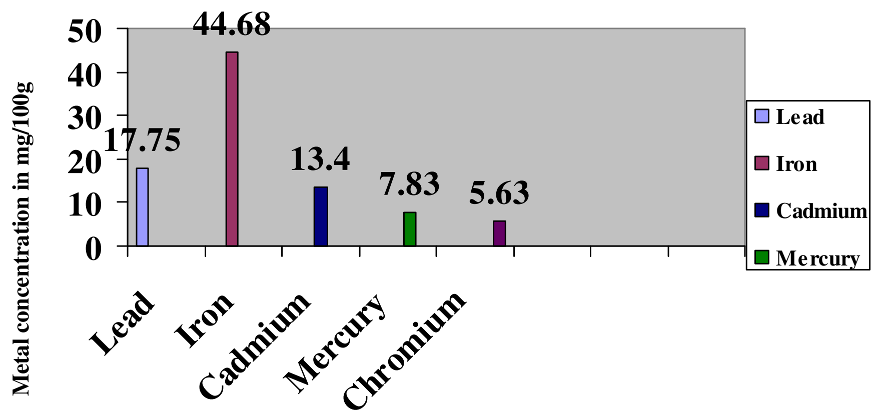


**Figure 2.** Concentration of heavy metals in University of Lagos sediments.

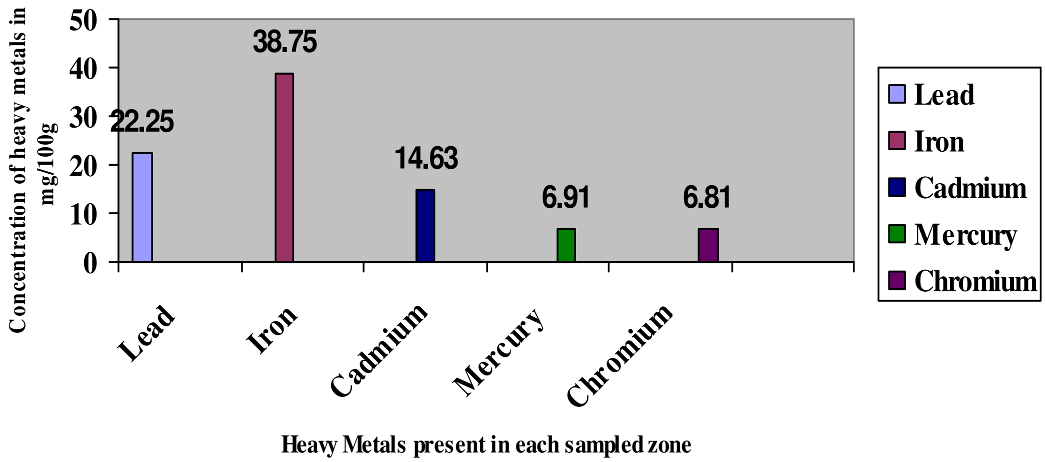


**Figure 3.** Concentration of heavy metals in Ebute-Mette sediments.

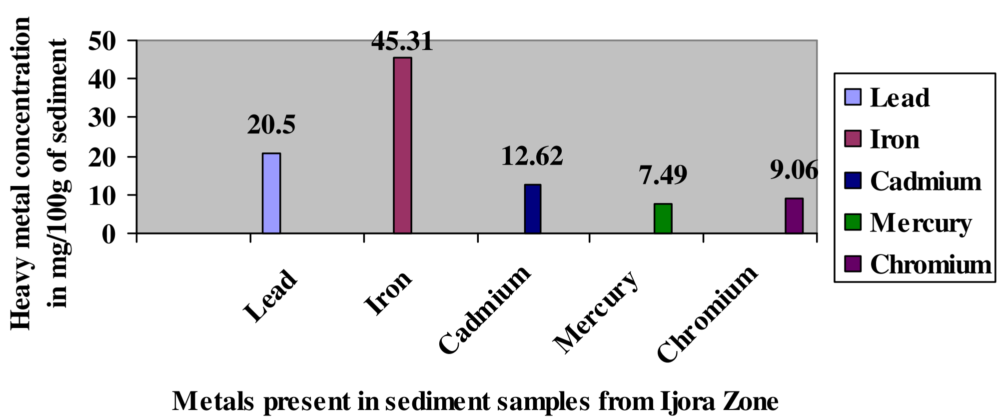


**Figure 4.** Concentration of heavy metals in Ijora sediments.

population determine as $\log_{10}$ values were for control(water), and sediment for all zones as follows; University of Lagos (control 6.83; sediment 3.05), Ebute metta (control 6.54; sediment 3.79), Ijora (control 6.79; sediments 3.93). There was a preponderance of bacteria in Ijora (3.93) than Ebute metta (3.79) and University of

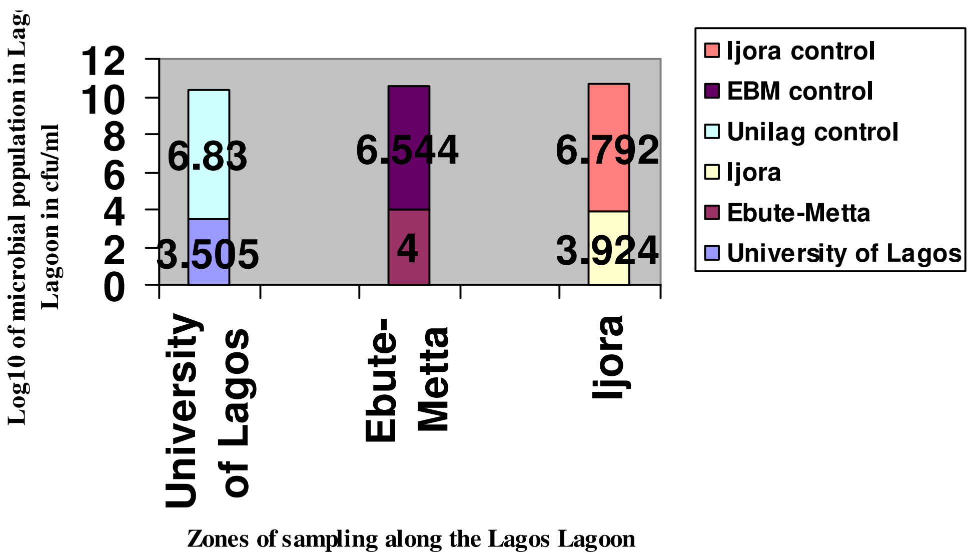


**Figure 5.** $Log_{10}$ of average values of bacterial population in sediments and water samples (control) from three sample locations along Lagos Lagoon prior to ashing. Key: EBM = Ebute-Metta Unilag = University of Lagos.

**Table 4.** Microbes identified for all zones

| Bacterial Isolates | Fungal Isolates |
|---|---|
| *Bacillus subtilis* | *Sacharomyces cerivisae* |
| *Bacillus listeniformis* | *Candida utilisima* |
| *Arthrobacter* species | *Sporobomyces* sp |
| *Achromobacterium* sp. | |
| *Clostridium perfringens* | |

Lagos (3.05) sediments. The cfu/ml of yeast population in sediments and control from all zones were as shown in Figure 6. University of Lagos zone has a larger population of $Log_{10}2.699$. This was closely followed by Ijora with a population of $Log_{10}2.60$ and Ebute metta zone with a population $log_{10}$ value of 2.54. Sediments from University of Lagos had the highest yeast population with a $Log_{10}$ value of 2.699. The trend in the reduction of yeast population along the Lagoon length is also in accordance with the findings of Collins and Stotzky (1992). The concentration of iron was highest among all the metals sampled in all zones. This was followed by lead, cadmium, mercury and chromium in that order for all zones except in Ijora zone where the value of chromium (9.06 mg/100 g) was higher than mercury (7.49 mg/100 g). Concentrations of all metals were relatively higher in Ebute metta zone than in all the zones. This observation further explains why there was a drastic reduction in CFU value of microbes assessed for Ebute Metta zone compared with other zones for all microbes. The concentration of these metals in sediments in the lagoon poses environmental worries not only to humans but also to bottom dwellers (Table 4).

## DISCUSSION

The pollution status of the Lagos Lagoon resulting fromorganic and metal deposition has for long been subject of debate amongst researches and public health watchers (Ajao, 1990; Okoye, 1991; Akpata et al., 1993; Otitoloju, 2002). The concentration of heavy metals in sediments of university of Lagos zone of the Lagos lagoon is shown in Figure 1. Most of the heavy metals detected may have originated from run offs from battery chargers workshops as well as electroplating works. Similar observation was reported by Abdulrahman (2001) in his studies on heavy metal pollution in Sokoto environment by commercial and municipal activities. Binning and Baird (2001) in their survey of heavy metal concentration of Swarkops River estuary, Port Elizabeth South Africa, also reported high concentration of heavy metal in the estuary. Okoye (1991) reported the presence of heavy metals in Lagos lagoon but the concentration values he obtained are different from those reported in this study. Davies et al. (1991) also reported the presence of heavy metals in the Rive tees estuary sediments. Figure 2 shows the concentration of heavy

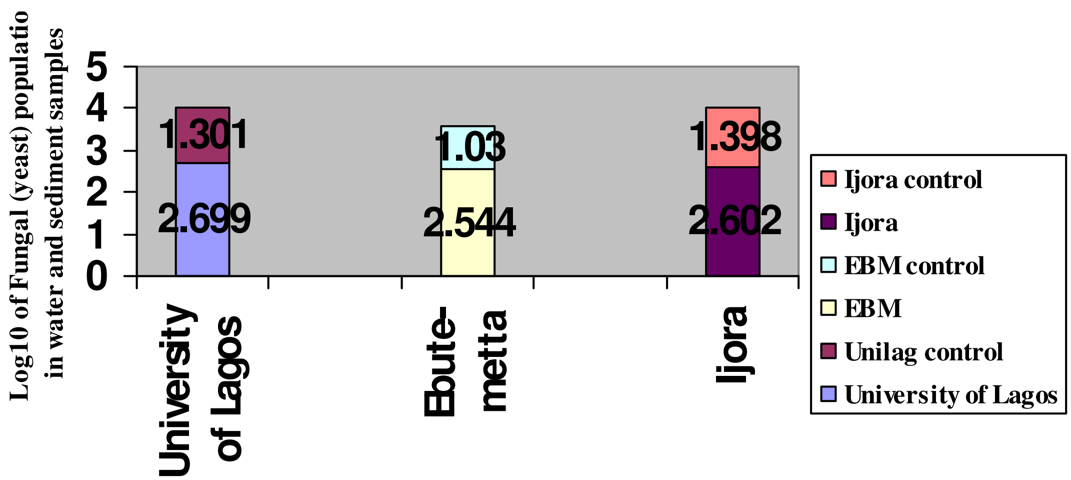


**Figure 6.** $Log_{10}$ of average values of fungal (yeast) population in sediments and water samples (control) obtained from three (3) locations along Lagos Lagoon prior to ashing.

metals in Ebute-Metta sediment samples. After analysis, it was observed that iron had the highest concentration with chromium having the least concentration. Other heavy metals analyzed in this sample were lead, cadmium, and mercury with decreasing concentrations in that order of 22.75 mg/100 g, 14.63 mg/100 g and 6.91 mg/100 g, respectively. Figure 3 shows the concentration of heavy metals in Ijora sediments. All heavy metals assayed were present in these sediments though in varied concentrations. From this table it would be observed that lead, iron, cadmium, mercury and chromium were present as 20.50 mg/100 g, 45.31 mg/100 g, 12.62 mg/100 g, 7.40 mg/100 g and9.06 mg/100 g respectively. However, Iron was noted to have the highest concentration and mercury the least. The differential concentration of metals observed in each zone is a reflection of the commercial and municipal activities in the different areas that supply their run offs to the different sections of the Lagoon. On a comparative basis, it would be observed from Tables 1, 2, 3 that metals analyzed from sediments in Ijora have a higher concentration when compared with those from University of Lagos and Ebute-Metta zone. The results obtained from this analysis reveals that all the heavy metals analyzed were above the upper permissible limits for all metals (FEPA, 2001). The average bacterial population in the control sample (water) was more for all the zones compared with what was obtained for the sediments in all zones. The variation in the population of benthic bacteria Lagoon water column as observed in this study may be ascribed to the concentration of heavy metals in the sediments. For example, University of Lagos zone had a lower colony-forming unit (cfu) of $3.2 \times 10^3$ compared with the control of $6.5 \times 10^6$. This was followed with Ebute Metta with an average benthic population of $6.0 \times 10^3$ compared with an average control value of $3.5 \times 10^6$. Ijora had cfu value of $8.2 \times 10^3$ compared with an average control value of $6.2 \times 10^6$. The same trend was observed for benthic fungal population (Table 4). The differences in average cfu value for each of the zone do not seem to follow the difference in concentration of heavy metals witnessed in this study. However, it is not inconceivable that intrinsic and extrinsic factors not considered in this study may have been responsible. It is either that higher levels of heavy metals above the permissible levels is required to affect microbial activities and hence their population or that a synergistic effect of these metals in sediments have a deleterious effect on microbial growth, metabolism and population. This observation is in line with the findings of Collins and Stotzky (1992) who reported that heavy metals alter the electrokinetic properties of bacteria, yeast and clay minerals in the presence of high pH values, since the hydrolyzed speciation forms of the metals at such high pH values, bind on the surface and alter the net charge of the cell. The pH of the three zones is high with Ebute Metta zone having highest pH value. This may have been responsible for the low bacteria density observed for Ebute Metta zone. Muhammad and Hooke (2003) described the susceptibility of three species of environmental bacteria isolated from the schmutzdecke of biologically active slow sand filters to cadmium, chromium and lead and advised that care must be taken to ensure that these heavy metals are prevented from entering water supplies due to their toxicity. The reduction in microbial population between lagoon sediments and water column may have arisen from the difference between the pH of the open water and the sediments with the sediments having higher pH values. This difference in pH value may have been largely responsible for reduction in cfu/ml for sediment samples compared to the open water samples.

The significance and method of entry of these heavy metals into bodies of water cannot be over emphasized. When cadmium enters the top soils and eventually washed into rivers by surface waters it poses dangerous threats not only to human lives but also to aquatic organisms as it accumulates. Clain and Perry (1978) reported that at low-level exposure over prolonged periods, cadmium causes high blood pressures, sterility among males, kidney damage and flu-like disorders. Cadmium is also believed to cause untold and unimagined damage to the body system and can even induce some mutational changes in genes, which can be passed down the generation. The concentrations of lead obtained from all the sediments analyzed were quite high and their origins most essentially are from battery workshops or deterioration of galvanized iron sheet (Abdulrahman, 2001). Lead is a cumulative toxic metal and it poses dangerous threat to the environment, the most severe effect being brain damage caused by lead poisoning. Greenbery et al. (1992) reported that lead has been found to be carcinogenic and a potent enzyme inhibitor as it inhibits utilization of iron in the body interferes with fertility and causes renal damage. The presence of iron in these sediments is of great concern in that a high concentration can be fatal in children (Ibok et al., 1990). The values obtained for all sediment samples are far above upper allowable limits, which are FEPA, 20 mg/dm$^3$. USEPA stipulates that limit of iron in public water supply intake should be within the range of 0.3 - 0.5/dm$^3$ (Jack et al., 1979; FEPA, 2001). Iron is known to cause iron overload chemo-chromatoris, an inherited disorder. The versatility of chromium in terms of its various applications might be responsible for the high values analyzed from the sediment samples. The high concentration observed may not be unconnected with discharge from local aluminum manufacturers. Clain and Perry (1978) reported that chromate poisoning causes skin cancer and liver damage. Abdulrahman (2001) also advanced reasons to support the fact that chromates are carcinogenic. Mercury is a very dangerous metal with high significant hazard. Ewan et al. (1998) observed that chronic exposure to mercury might result in permanent damage to the central nervous system and kidney. Mercury can also cross the placenta horizontally from the mother's body to the foetus and accumulate, resulting in mental retardation, brain damage, cerebral palsy, blindness and inability to speak.

The overall implications of the concentration of these heavy metals in lagoon sediments is that living organisms (that is fishes, shrimps snails, crabs) especially the benthic population can concentrate these metals in their tissues and pass them back to man on consumption. These toxic metals can bioaccumulate in the human tissues, get to threshold concentrations and consequently cause a lot of damage to humans and affect labor tremendously. Heavy metal accumulation in lakes and natural bodies of water especially Lagoon has been on the increase due to industrial, agricultural and domestic activities (Okoye, 1991; Kusemiju et al., 2001). Metals analyzed in this study have also been found associated with bottom sediments and water. They constitute a potential danger to both autotrophic and heterotrophic benthic organisms (Jeng and Hans, 1994). Begum et al. (2009) observed high toxicity of heavy metals in planktons, fish and sediments and reported that the concentration of the heavy metals in the three different samples were far above the upper permissible limits. An immediate attention from concerned authorities is required to protect the Lagos lagoon from further metal pollution. The need arise for government to strictly monitor the source of discharge of these heavy metals, as the concentrations observed in this study are lethal not only to aquatic life but humans who consume seafood. This finding is therefore of public health significance. Recently, fishermen have been complaining bitterly of decrease in catch in Lagos lagoon as a result of fishes running away from the Lagoon. Hence there is the need to revisit the existing laws and apply them appropriately or amend them to make them more effective in order to save man from a catastrophic situation. Morgan et al., (1992) observed that bioaccumulation and bio-concentration of various heavy metals in aquatic organisms also need effective monitoring as they have been found associated with several species of living organisms. Another area of concern is biotransformation of organic deposits in sediments. With reduction in benthic population matter recycling will be affected drastically in the Lagoon, which will in turn affect availability of nutrients for both microbiota and macrobiota in the water body. It is therefore, essential that regulatory authority see and ensure that existing laws are strictly obeyed and if need be place heavy fines on defaulters who fail to obey the laws governing the discharge of industrial effluents.

## ACKNOWLEDGEMENT

We thank the staff of environmental section of Federal Institute of Industrial Research Oshodi (FIIRO) for providing their gas chromatographic equipment and the Department of Food Technology, Yaba College of Technology for making available their Muffle furnace for this study.

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