



Heavy Metal Analysis and Histopathological studies of *Bubulcus ibis* (Cattle egrets) in Oko-Oba, Alimosho, Lagos State, Nigeria.

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ABSTRACT

Heavy metal pollution poses a significant threat to ecosystems and organisms, including avian species that serve as bio indicator due to its bioaccumulation and toxic effects on living organisms. This study examined the levels of cadmium (Cd), lead (Pb), copper (Cu), and mercury (Hg) in the feathers, liver, and chest muscles of *Bubulcus ibis* (Cattle Egrets) collected from Oko-Oba, Lagos State, Nigeria. Utilizing feathers, liver, and chest muscles, alongside environmental samples from sediment and water, we performed physicochemical, histopathological, and atomic absorption spectroscopic analyses to determine contamination levels. The highest mean concentrations of heavy metals in feathers were observed for Pb (4.40 ± 0.69 mg/kg) and Cu (4.13 ± 0.85 mg/kg), while Hg showed the highest mean in liver tissues (0.40 ± 0.27 mg/kg). In water samples, Pb recorded a mean concentration of 2.76 ± 0.45 mg/L, and Hg was detected at 0.97 ± 0.14 mg/L. Sediment samples exhibited maximum mean concentrations for Pb (2.37 ± 0.66 mg/kg) and Cd (0.89 ± 0.40 mg/kg). Results revealed substantial bioaccumulation of Pb and Cu, particularly in chest muscles, and elevated Hg concentrations in feathers. Histopathological analyses revealed significant tissue damage, including sloughing and lymphocytic infiltration in intestinal tissues. The results indicate a significant bioaccumulation of Pb and Cu in avian tissues and highlight the role of *Bubulcus ibis* as a bio indicator of heavy metal contamination. These findings underscore the ecological health risks associated with heavy metal contamination, reinforcing the importance of periodic monitoring and conservation strategies to mitigate the effects on local avian populations and ecosystem health.

INTRODUCTION

Toxic metals are metals with specific weights of not more than 5g/cm³, which are neither essential nor has beneficial effect, on the contrary, they display severe toxicological symptoms at low levels. With increasing industrialization, more and more metals are entering into the environment. These metals stay permanently because they cannot be degraded in the environment. They enter into the food material and when ingested, they make their passage into the tissues (Bearshop *et al.*, 2021). Lead, cadmium, mercury and arsenic are among the main toxic metals which accumulate in food chains and have a cumulative effect (Beaker *et al.*, 2018). Bearshop *et al.*, 2021 stated that, Heavy metals often have direct physiological toxic effects and are stored or incorporated in living tissue when their host is exposed to these metals. A study carried out by Gilliespies and Walter (2021) showed that levels of arsenic, cadmium, mercury and lead were detected in several tissues of goats; the results showed that the levels of the above metals were found to be very high and generally above the permissible level. Similarly, the distribution and localization of some heavy metals in the tissues of some calf organs were detected, the most affected organs, which showed higher levels of trace metals, were livers, kidneys and small intestines (Charles *et al.*, 2015). Lead is a metabolic poison and a neurotoxin that binds to essential enzymes and several other cellular components and inactivates them (Allard and Stokes 2019). Toxic effects of lead are seen on haemopoietic, nervous, gastrointestinal and renal systems (Bearshop *et al.*, 2016). Food is one of the principle environmental sources of cadmium (Bearshop *et al.*, 2016). As cadmium moves through the food chain it becomes more and more concentrated as it reaches the carnivores, it increases in concentration by a factor of approximately, 50 to 60 times (Allan *et al.*, 2021, revealed that the Toxic effects of cadmium includes the following: kidney dysfunction, hypertension, hepatic injury and lung damage and that Cadmium chloride at teratogenic dose induced significant alterations in the detoxification enzymes in the liver and the kidney of living organisms. Animals vary in their arsenic accumulation depending upon the type of food they consume (Beaker *et al.*, 2018). Acute arsenic exposure can give symptoms with rapid onset of headache, nausea and severe gastrointestinal irritation (Allan *et al.*, 2021). Similarly, increase in levels of copper causes liver, kidney and brain damage, which may follow haemolytic crisis (Jacklyn, 2016). Because of bio magnification of heavy metals, the higher members of the food chain may contain higher amounts of the metals several times more than the amount found in water or in air. It will consequently endanger the plants and the animals that consume the heavy metal contaminated food (Kreb *et al.*, 2019). Mercury (Hg) is one of the most toxic elements in the environment, considered as the most significant among other heavy metal pollutants. The increase in the

global mercury levels in the last few decades is of concern because mercury is a persistent toxic heavy metal that bio-accumulates and biomagnifies in the environment. Its terrible damages to human health and that of other creatures have already been investigated in detailed. Mercury directly or indirectly has the potential to cause many diseases and side effects in human beings. It can also have toxic effects and damage on wild life (Bostan *et al.*, 2017). It has been revealed that birds are quite sensitive to all pollutants and other damaging changes in the environment. To evaluate mercury accumulation, birds are often used as bio indicators of mercury in both the marine and freshwater environments (Finch, 2018 Gill *et al.*, 2020; Joshua *et al.*, 2001; Robin *et al.*, 2016, Gill *et al.*, 2020; and Smith *et al.*, 2005). The position of the carnivorous birds at the top of the food chain and their long lifespan indicate that they are more affected by the pollutants and by the changes in the various parts of the ecosystem with time (Gillispie and Walter, 2021). Among birds, fish eating birds will suffer more damages due to Hg pollution, since the toxic Hg compounds specially methyl mercury is formed in water and taken up into the food chain by planktons. Chad, 2020 revealed that the concentration of Hg in the liver of some wading birds collected from south Florida was so much that it caused some apparent nervous symptoms and some damages to their reproduction system and hence concluded that the reduction of some Ciconiiforms in Florida might be partially due to the Hg pollution of their food resources. In another study it was reported that some of the great white herons which suffered from chronic liver and kidney diseases as a result of Hg pollution were dead and it was concluded that the Hg pollution is harmful for the wading birds' health and reproduction (Smith *et al.*, 2017).

The saw-milling, agricultural and industrial activities at the Oko-oba area in Lagos state, Nigeria. has resulted in discharge of particles and heavy metals to the environments and this has led to the accumulation of pollutants, also this area serves as breeding and feeding sites for the herons. therefore the need to closely monitor the health of this eco-system is paramount as this will help us ensure that heavy metal pollution does not exceed the threshold levels set out by World health organization Increasingly it is becoming very necessary to understand the fate and effect of chemicals to the health of ecosystems and to provide early warning of changes in the environment that might indicate adverse effects, heavy metals, which are especially toxic to humans and wildlife (Gillard and Stokes, 2019) must be appropriately monitored in food chains and in different species To evaluate heavy metal accumulation in ecosystems, birds are often used as a bio-indicator of heavy metals in both marine and freshwater environments. Birds are particularly at risk from mercury poisoning because many species exclusively eat heavy metal laden fish. Birds also have a relatively high tolerance to mercury contamination in comparison to mammals, allowing them to live with much

greater body burdens of mercury. Therefore, predatory birds are useful for representing the contamination of the ecosystem at levels higher than mammalian bio indicators (Chad, 2020). In addition, they are also long-lived animals which accumulate mercury in their bodies over a long period of time (Krebs *et al*, 2019). Therefore this research is aimed to determine the health of the Oko-oba eco-system in Lagos-State, Nigeria, to ascertain the extent of heavy metal pollution in these birds and assess the biological effects in *Bubulcus ibis* as indicators of environmental pollution.

MATERIALS AND METHODS

Study Area

This study was carried out within Oko-oba abattoir area of Lagos state. Oko-oba is located in the south western part of Lagos state, on the geographic grid reference: longitude of 3°10'E and latitude 6°28'N. It has a tropical climate characterized by rainfall in the wet season between April-October and in the dry season in October-May. Water samples and sediment were collected in triplicates at different points of the canal that runs through the abattoir within Oko-oba, Lagos State Nigeria.

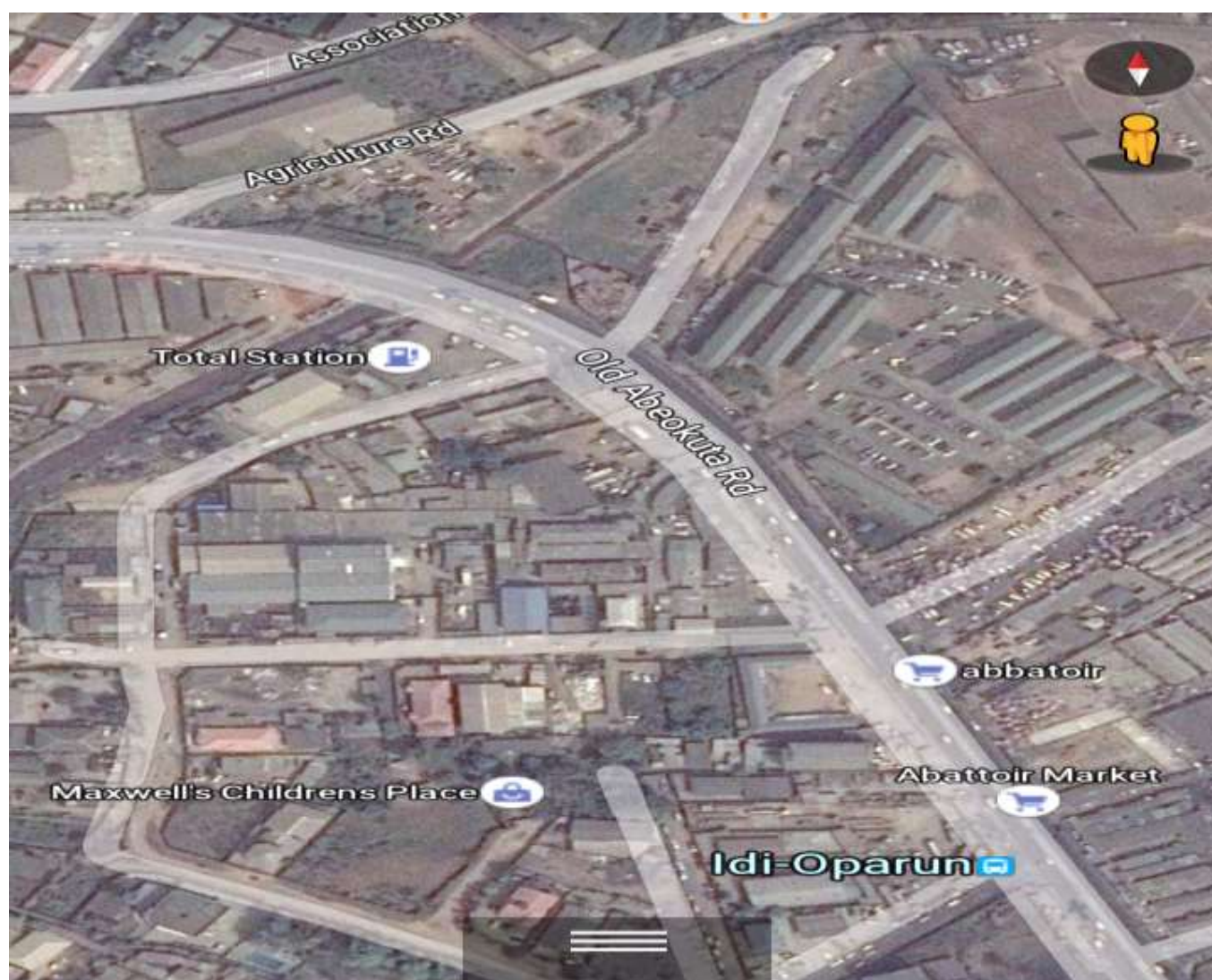


Figure 1: Map of oko oba abattoir Area (Google Earth, 2016)

Test Organism

Cattle egrets (*Bubulcus ibis*) was trapped with the aid of baits and gums, from three locations in Oko-Oba (Slaughter, farm and dump-site) and was transported to the Zoological Garden Laboratory, University of Lagos in a cage for dissection. The feathers were collected, and

birds euthanized in Chloroform and dissected for the collection of liver, chest muscle and intestine.

Physicochemical Analysis

In-situ physicochemical analysis was carried out in three different locations (Abattoir market, Agriculture road and dump sitec) of Agege local government area using

Horiba U-52G. The horiba was dipped in the sea water to get the physicochemical properties of the water. The physicochemical tests included the determination of temperature (°C), turbidity (NTU), total dissolved solids (g/L), pH, electrical conductivity (mS/cm), dissolved oxygen (mg/L), salinity (ppt) and specific gravity (σt).

Histological Analysis

Intestines samples were carefully collected from the birds using dissecting kit. The samples were immersed in buoins' fluid till histopathological analysis was carried out. These tissues were processed for histopathological examination using the routine paraffin-wax embedding method. Sections, 5 µm thick, were stained with Haematoxylin and Eosin, and observed under the light microscope for histopathological changes. Histopathological assessment and photomicrography of the prepared slides was done using an Olympus light Microscope with attached Kodak digital camera.

Heavy Metal Analysis

Air drying of sample

Tissue and sediment samples were air-dried in the open laboratory free from contamination for 72 hours, by being spread on labelled aluminum foil. Water sample collected does not require air drying so this procedure was omitted for water.

Digestion Sample

The air-dried samples were broken into small size aggregate (powdery form). 5g of sample was carefully weighed into a clean dry 100ml beaker. Water sample collected does not require air drying so this procedure was omitted for water. 1 g of the sample was taken in a 100 ml digestion flask. 10 ml of nitric acid (HNO₃) was added to it and the flask was placed in dark overnight. On next day, 5 ml per chloric acid (HClO₄) was added

to it. The mixture was then placed on a hot plate at 50 °C for 15 minutes and then the temperature was raised slowly up to 200 °C. Heating was continued till the white dense fumes of per chloric acid were disappeared. After digestion, the contents were cooled and filtered through Wattman filter paper. Then it was transferred to a 50 ml volumetric flask and diluted with deionized water up to the mark. The volume of the solution in the standard flask was then made up to 100ccm³ mark and shaken.

Analysis:

The resulting solution was then aspirated into the flame of Beck-mann Atomic Absorption Spectrophotometer model 1233 equipped with hollow cathode lamp. The instrumental parameters were adjusted according to manufacturer's instructions, the hollow cathode lamps for selected minerals were used as a light source and the lamp currents were set. The gas used was acetylene with 20 Pa pressure and air 45 Pa Pressure. The instrument was calibrated with standard solutions and the samples were introduced to it by means of capillary tube. The concentration reading appeared on the display unit was noted.

Table 1: Metals and Their Respective Wavelengths

Metal	Wavelength
Cd	228.8
Cu	324.8
Hg	359.4
Pb	217.0

The following tables were obtained in different monitoring units of *Bubulcus ibis* showing different ranges of heavy metals bio concentration in the liver, chest muscle and feathers of *Bubulcus ibis*.

Table 2: Heavy metals concentration in the feather, chest muscles, and liver of *Bubulcus ibis*

S/N of Birds	Cadmium			Lead			Copper			Mercury		
	Feather	Chest	Liver	Feather	Chest	Liver	Feather	Chest	Liver	Feather	Chest	Liver
Control	ND	:	ND	:	ND	:	ND	:	ND	:	ND	:
1	0.36	0.07	0.58	3.73	0.02	4.97	0.65	5.18	2.06	4.51	ND	ND
2	0.50	0.04	0.72	3.94	1.32	6.90	3.71	6.40	1.76	ND	ND	ND
3	0.92	ND	0.41	2.40	0.03	1.47	7.32	6.83	3.47	ND	ND	ND
4	0.07	0.85	0.42	4.21	4.32	1.47	6.84	4.26	14.93	ND	ND	0.82
5	0.28	ND	0.03	3.72	2.24	9.70	3.08	4.08	ND	1.8	ND	ND
6	ND	ND	ND	9.80	7.94	5.29	5.59	1.37	6.67	ND	1.93	1.70
7	0.14	0.25	ND	3.01	ND	2.55	5.24	7.34	5.55	ND	ND	1.52
8	ND	ND	4.53	2.26	2.19	3.58	4.29	6.52	6.94	4.99	1.70	4.62

ND= No Deposit

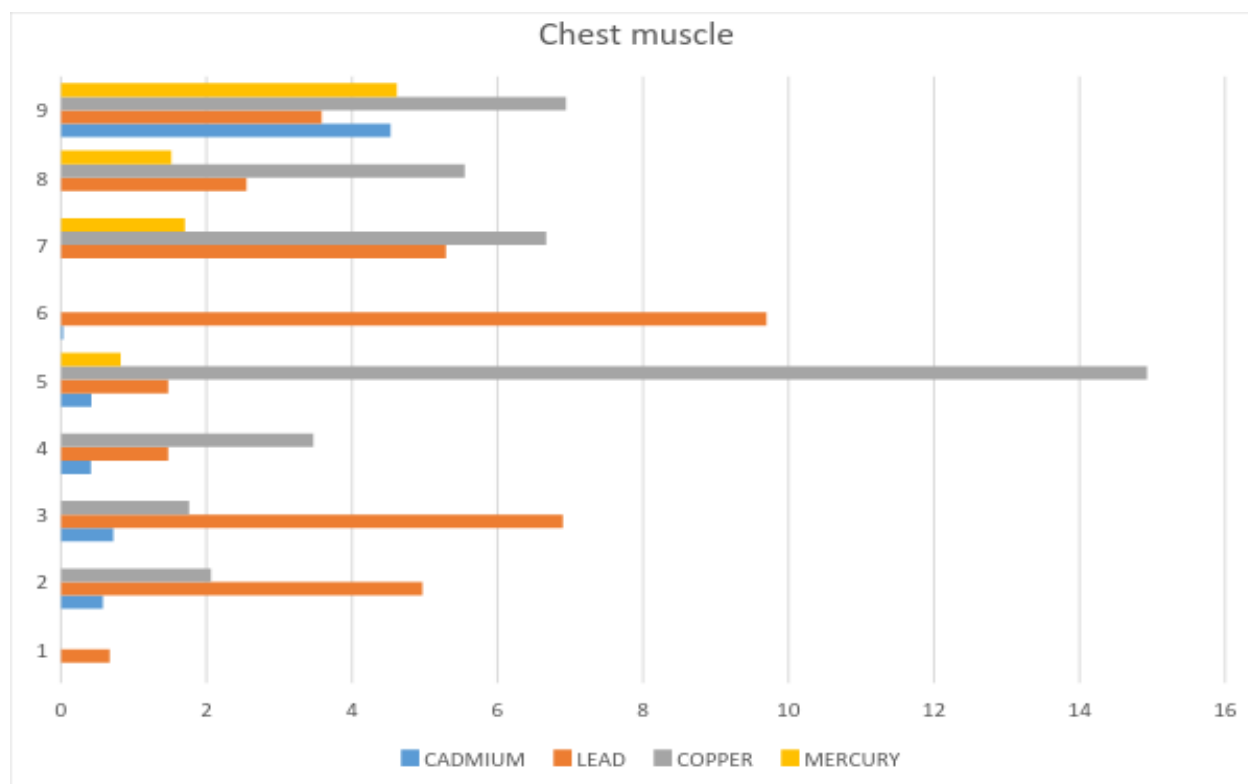


Figure 1: Chart showing heavy metal concentration in the chest muscle of *Bubulcus ibis*

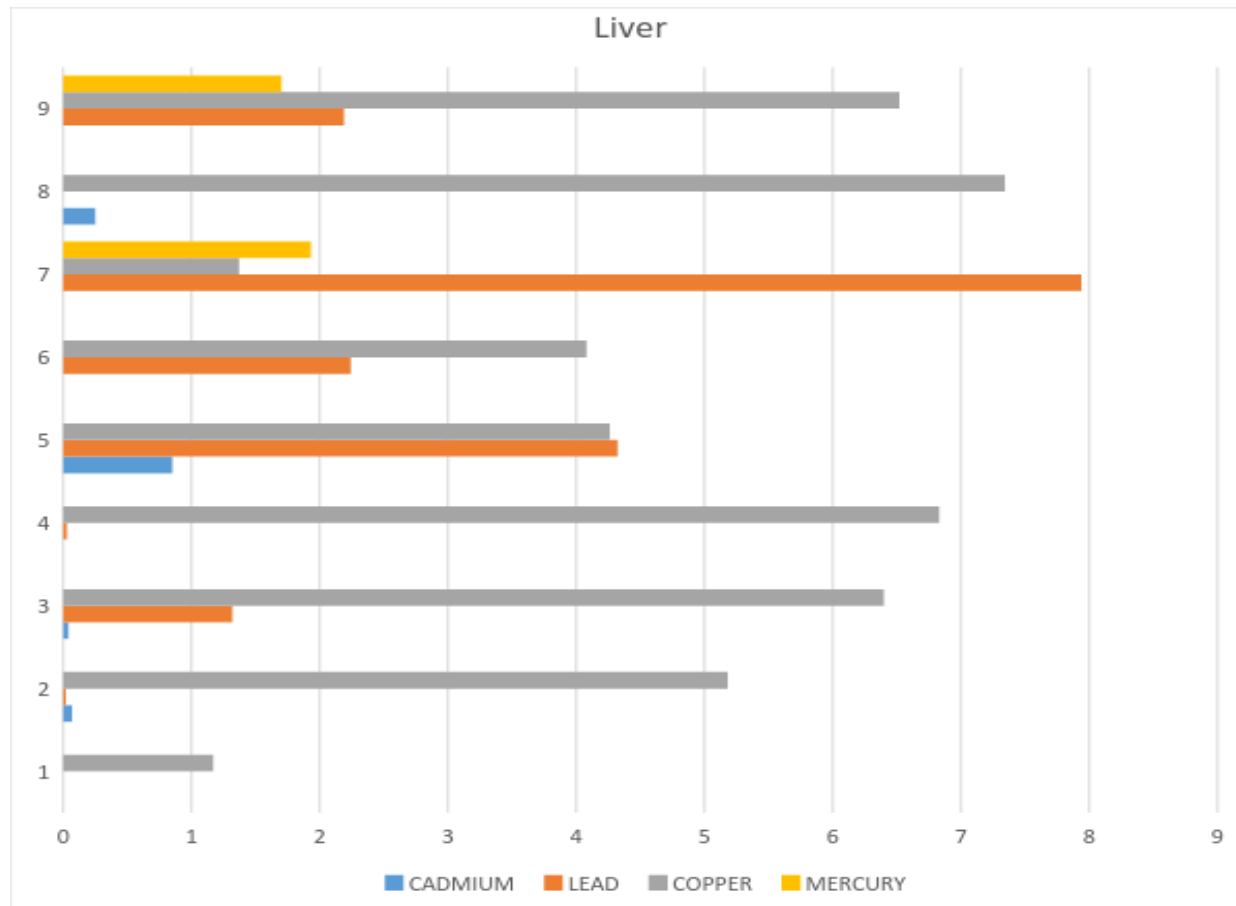


Figure 2: Chart showing heavy metal concentration in the liver of *Bubulcus ibis*

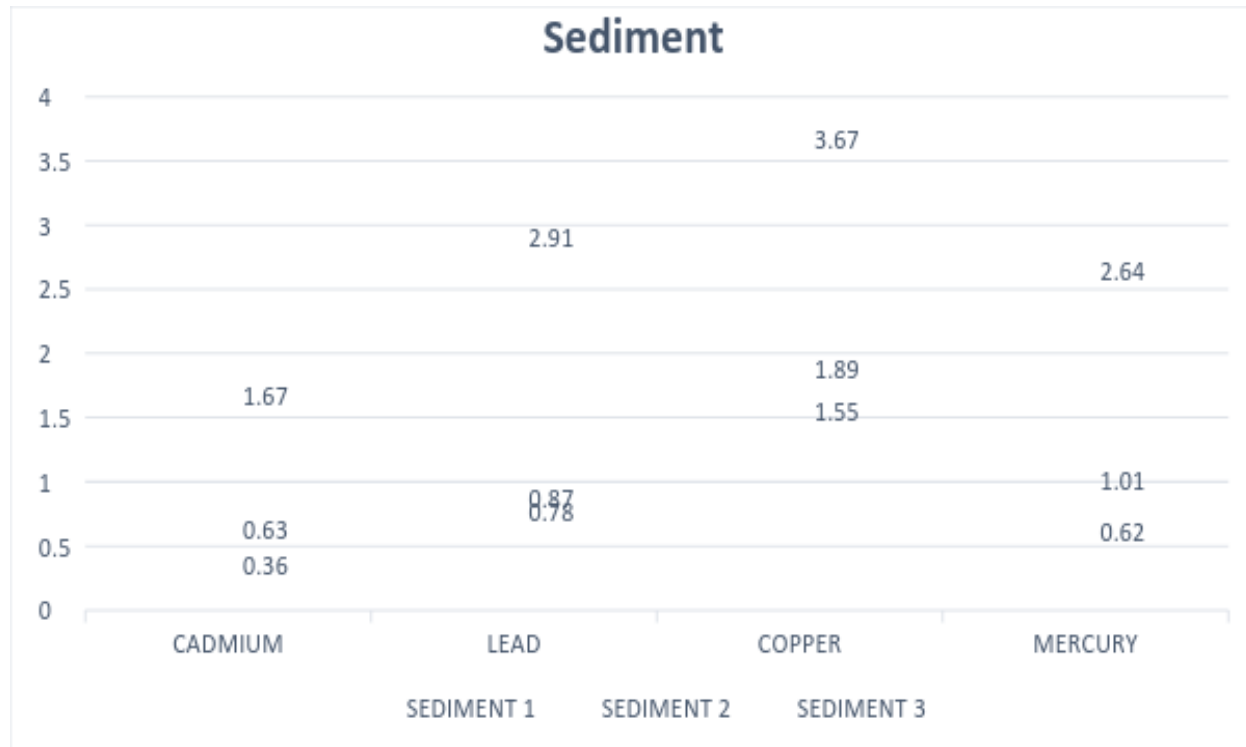


Figure 3: Chart showing heavy metal concentration in sediment samples at different locations in Oko-oba.



Figure 4: Chart showing heavy metal concentration in water samples at different locations in Oko-oba.

Table 3: Varying heavy metals toxicity in the different monitoring units and in sediment and water.

Heavy Metal	Feather	Chest	Liver	Sediment	Water
CADMIUM					
Mean ± S.E	0.38 ± 0.13	0.74 ± 0.48	0.13 ± 0.09	0.89 ± 0.40	0.36 ± 0.63
Minimum	0.07	0.00	0.00	0.36	0.75
Maximum	0.92	4.53	0.85	1.67	1.92
COPPER					
Mean ± S.E	4.13 ± 0.85	4.07 ± 0.98	2.09 ± 0.81	1.52 ± 0.70	1.20 ± 0.36
Minimum	2.26	0.67	0.00	0.78	1.67
Maximum	2.80	9.70	7.94	2.91	1.87
LEAD					
Mean ± S.E	4.40 ± 0.69	4.60 ± 1.96	4.79 ± 0.76	2.37 ± 0.66	2.76 ± 0.45
Minimum	0.92	0.00	1.17	1.55	1.89
Maximum	7.32	14.93	7.34	3.67	3.42
MERCURY					
Mean ± S.E	3.79 ± 0.97	0.96 ± 0.51	0.40 ± 0.27	1.42 ± 0.62	0.97 ± 0.14
Minimum	1.88	0.00	0.00	0.62	0.73
Maximum	4.99	4.62	1.93	2.64	1.23

Table 4: Analysis of Variance (ANOVA) for heavy metal toxicity in feathers

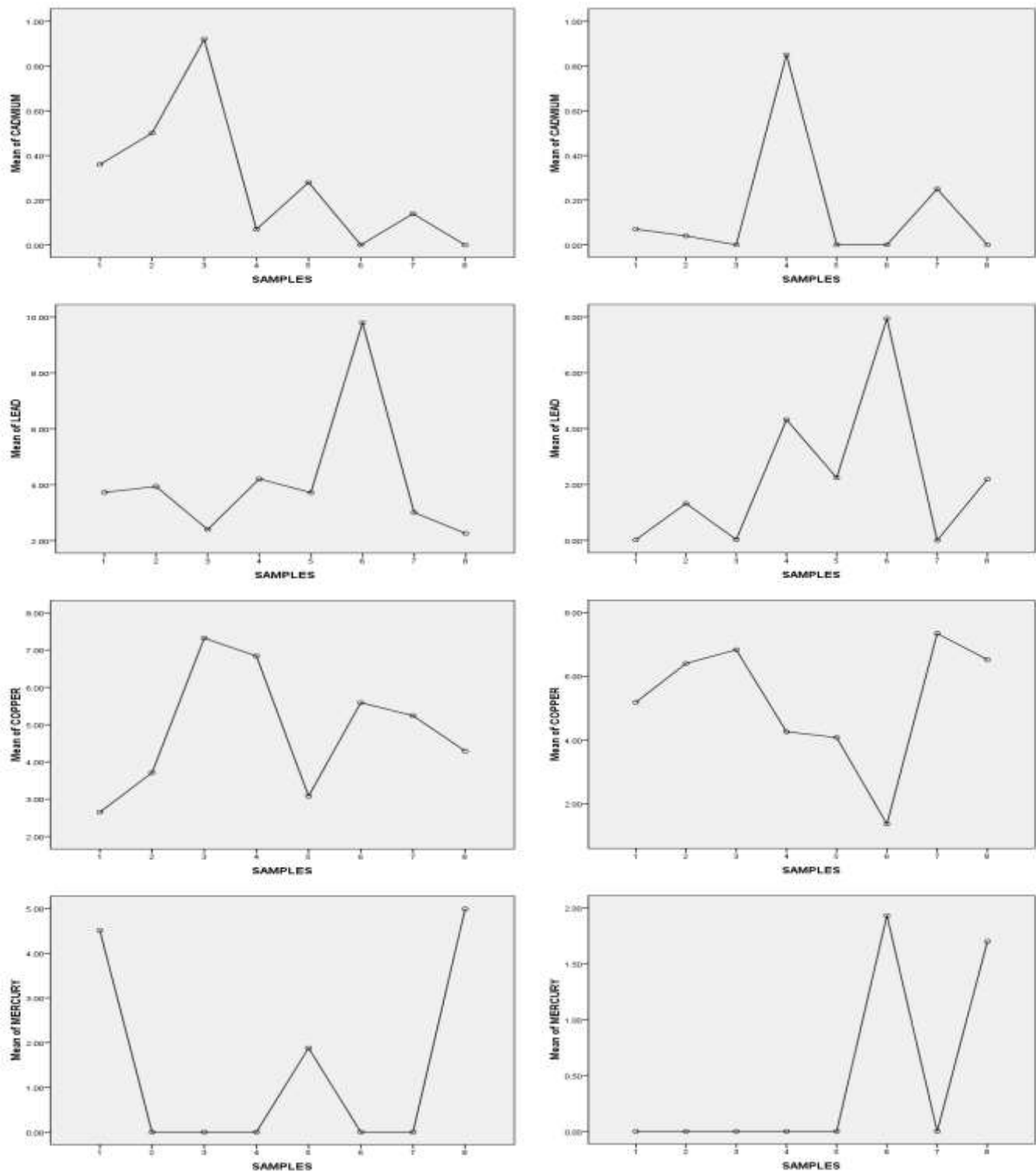
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	112.8153	3	37.60509	11.21572	5.23E-05	2.946685
Within Groups	93.88093	28	3.35289			
Total	206.6962	31				

Table 5: Analysis of Variance (ANOVA) for heavy metal toxicity in chest muscles

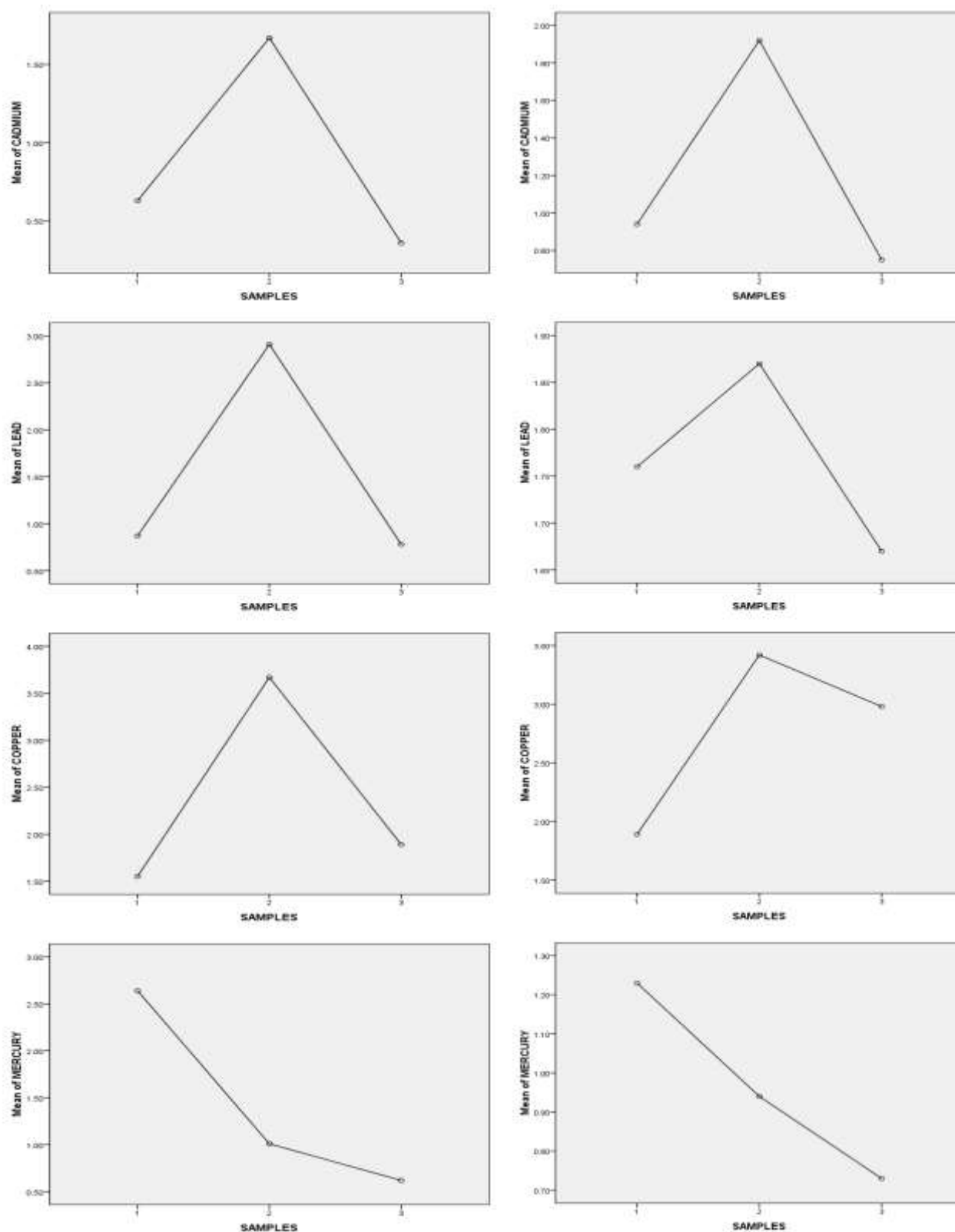
Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	122.069	3	40.68967	4.701516	0.008818	2.946685
Within Groups	242.3284	28	8.654585			
Total	364.3974	31				

Table 6: Analysis of variance (ANOVA) for heavy metal toxicity in liver

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	131.3464	3	43.78214	14.37544	7.4E-06	2.946685
Within Groups	85.27738	28	3.045621			
TOTAL	216.6238	31				



Figures 6 (A &B): A, B, C, D: showing mean toxicity of metals in A) feathers B) Liver of *Bubulcus ibis*



(A: Sediment)

(B: Water)

Figures (7A &B) A, B, C, D: Showing mean toxicity of metals in the (A) sediment and (B) water

Table 7: Analysis of variance (ANOVA) for heavy metal toxicity in water

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	6.2149	3	2.071633	10.06502	0.024633	6.591382
Within Groups	0.8233	4	0.205825			
Total	7.0382	7				

Table 8: Pairwise comparison of heavy metal toxicity in the feathers

	Cadmium	Lead	Copper	Mercury
Cadmium	0	0.004626	0.000654	0.6992
Lead	5.203	0	0.06513	
Copper	6.313	1.11	0	0.01008
Mercury	1.539	3.664	4.774	0

P<0.01 for Cd, Pb and Hg

Table 9: Pairwise comparison of heavy metal toxicity in the chest muscles

0	CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	0	0.1016	0.04465	0.9987
LEAD	3.366	0	0.981	0.1387
COPPER	3.904	0.5379	0	0.06333
MERCURY	3.144	3.682	0	0.2217

P<0.05 for Cd and Pb and Cu

Table 10: Pairwise comparison of heavy metal toxicity in the liver

0	CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	0	0.1465	0.0001871	0.989
LEAD	3.104	0	0.01321	0.2569
COPPER	7.725	4.622	0	0.0002255
MERCURY	0.4458	2.658	7.28	0

Table 11: Pairwise comparison of heavy metal toxicity in sediment

0	CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	0	0.8777	0.9201	
LEAD	1.049	0	0.7563	0.9995
COPPER	2.457	1.408	0	0.6947
MERCURY	0.8889	0.1601	1.568	0

P>0.05

Table 12: Pairwise comparison of heavy metal toxicity in the water

0	CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	0	0.5751	0.0264	0.9424
LEAD	1.871	0	0.1676	0.3082
COPPER	5.181	3.31	0	0.01256
MERCURY	0.7861	2.657	5.968	0

P<0.05 for Cu and Hg

Table 13: Correlation between heavy metals concentrations in the sediment**Correlations**

Heavy metals		CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	Pearson Correlation	1	.992**	.956**	.086
	Sig. (2-tailed)		.000	.003	.872
	N	6	6	6	6
LEAD	Pearson Correlation	.992**	1	.986**	-.044
	Sig. (2-tailed)	.000		.000	.934
	N	6	6	6	6
COPPER	Pearson Correlation	.956**	.986**	1	-.210
	Sig. (2-tailed)	.003	.000		.690
	N	6	6	6	6
MERCURY	Pearson Correlation	.086	-.044	-.210	1
	Sig. (2-tailed)	.872	.934	.690	
	N	6	6	6	6

** . Correlation is significant at the 0.01 level (2-tailed).

Table 14: Correlation between heavy metals concentrations in the feathers of *Bubulcus ibis***Correlations**

		CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	Pearson Correlation	1	-.307	.197	-.301
	Sig. (2-tailed)		.069	.249	.075
	N	36	36	36	36
LEAD	Pearson Correlation	-.307	1	.185	-.442**
	Sig. (2-tailed)	.069		.280	.007
	N	36	36	36	36
COPPER	Pearson Correlation	.197	.185	1	-.561**
	Sig. (2-tailed)	.249	.280		.000
	N	36	36	36	36
MERCURY	Pearson Correlation	-.301	-.442**	-.561**	1
	Sig. (2-tailed)	.075	.007	.000	
	N	36	36	36	36

** . Correlation is significant at the 0.01 level (2-tailed).

Table 15 : Correlation between heavy metals concentrations in the chest muscle of *Bubulcus ibis*

		CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	Pearson Correlation	1	-.178	.165	.889**
	Sig. (2-tailed)		.300	.336	.000
	N	36	36	36	36
LEAD	Pearson Correlation	-.178	1	-.692**	-.288
	Sig. (2-tailed)	.300		.000	.088
	N	36	36	36	36
COPPER	Pearson Correlation	.165	-.692**	1	.311
	Sig. (2-tailed)	.336	.000		.065
	N	36	36	36	36
MERCURY	Pearson Correlation	.889**	-.288	.311	1
	Sig. (2-tailed)	.000	.088	.065	
	N	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

Table 16: Correlation between heavy metals concentrations in the liver of *Bubulcus ibis*

		CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	Pearson Correlation	1	.023	.029	-.439**
	Sig. (2-tailed)		.892	.867	.007
	N	36	36	36	36
LEAD	Pearson Correlation	.023	1	-.925**	.636**
	Sig. (2-tailed)	.892		.000	.000
	N	36	36	36	36
COPPER	Pearson Correlation	.029	-.925**	1	-.407*
	Sig. (2-tailed)	.867	.000		.014
	N	36	36	36	36
MERCURY	Pearson Correlation	-.439**	.636**	-.407*	1
	Sig. (2-tailed)	.007	.000	.014	
	N	36	36	36	36

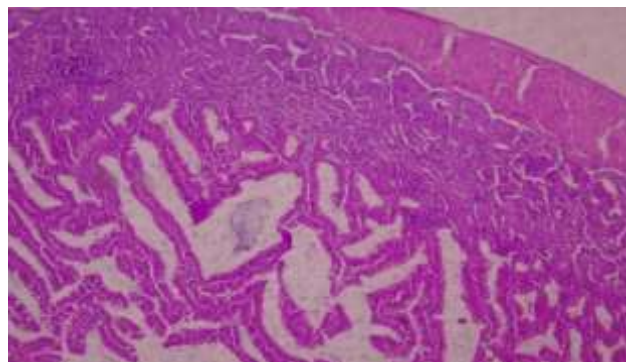
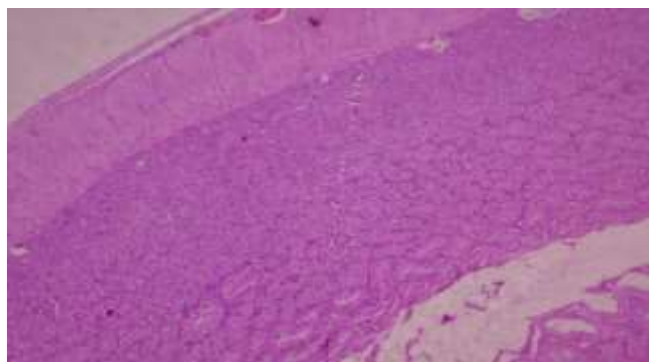
**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 17: Correlation between heavy metals concentration in water**Correlations**

		CADMIUM	LEAD	COPPER	MERCURY
CADMIUM	Pearson Correlation	1	.972**	.557	.342
	Sig. (2-tailed)		.001	.251	.507
	N	6	6	6	6
LEAD	Pearson Correlation	.972**	1	.346	.553
	Sig. (2-tailed)	.001		.501	.255
	N	6	6	6	6
COPPER	Pearson Correlation	.557	.346	1	-.590
	Sig. (2-tailed)	.251	.501		.218
	N	6	6	6	6
MERCURY	Pearson Correlation	.342	.553	-.590	1
	Sig. (2-tailed)	.507	.255	.218	
	N	6	6	6	6

** . Correlation is significant at the 0.01 level (2-tailed).

4. HISTOPATHOLOGICAL RESULTS

Plates 1A & B: A: Histologic sections of intestinal tissue show normal intestinal mucosa.

B: Histologic sections of intestinal tissue show sloughing.

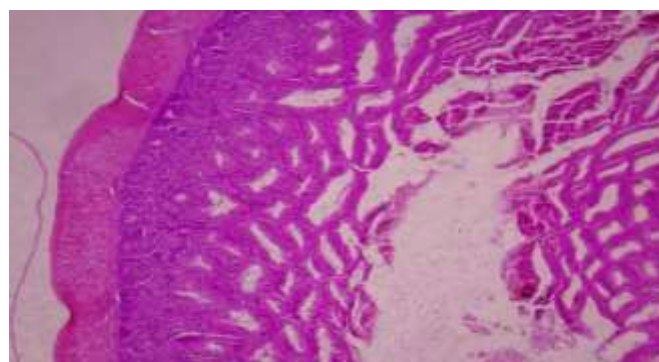
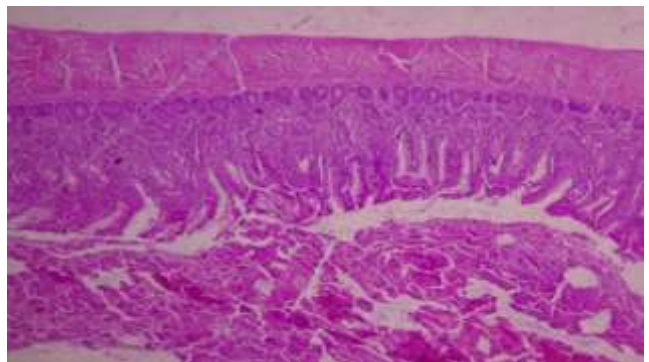


Plate 2 (A &B): A; Histologic section of the Intestine showing normal Mucosa.

B: Histologic sections of intestinal tissue show infiltration of mucosa by dense aggregates of lymphocytic inflammatory cells.

5.0 DISCUSSION

In this study, four heavy metals have been detected in feathers, livers and chest muscles of cattle egret (*Bubulcus ibis*) from the abattoir area in Oko-baba. The heavy metals of interest in this work includes; Mercury (Hg), Copper (Cu), Lead (Pb) and Cadmium (Cd) were detected in various samples of avian tail feathers shown in Table 1 and 2. These metals were considered in this research because they are widely reported to be potentially toxic on living tissues (Daivadar et al., 2021).

Figure 2, shows a peak in the concentration of Pb (highest) and Cu in the feather of *Bubulcus ibis* for all the samples while the control indicated a presence in the level of Cu in the feather. Figure 3 indicates that the concentration of Cu was highest in sample 4 while the concentration of Cd was almost insignificant but Pb was detected in the control. Also figure 4 indicated varying increase in Cu contamination including the control while the peak concentration of Pb recorded was observed in sample 5.

Figure 3 is a chart showing heavy metal concentration in sediment samples at different locations in the project site with sediment 2 having a peak concentration of Cu at 3.67mg/l while sediment 2 had the least Pb contamination of 0.36mg/l. figure 5 indicates a peak in Cu concentration of 3.42mg/l for water contamination while water 1 and water 2 had the same concentration of Pb and Hg of 0.94mg/l.

Table 3 above indicates the varying mean, standard error, minimum and maximum values for heavy metal toxicity in the varying monitoring units including sediment and water. The highest mean values was obtained in the chest (0.74 ± 0.48). A high value of 0.89 ± 0.40 was also obtained in the sediment due to bioaccumulation. Cd was not detected in the chest and liver of *Bubulcus* while the peak value of 4.53mg/l was recorded in the chest. The water samples surprisingly had an higher value of Cd than that of the sediment. The feathers had the highest concentration of Cu followed by that in the chest of 4.07 ± 0.98 . The least value was recorded in water (1.20 ± 0.36). Cu was not detected in some samples of the birds while a maximum concentration of 9.70mg/l was recorded in the chest muscles. Pb had the highest bio concentration in the liver (4.79 ± 0.76) followed by the chest muscles. Pb was also higher in the water samples (2.76 ± 0.45) than that of the sediment. The maximum concentration of Pb was observed in the chest muscles, which was about twice of the other monitoring units. Some of the birds assessed lacked Hg contamination in both the chest muscles and the liver. Highest Hg accumulation was realized in the feathers while the liver had the least Hg contamination. Water samples observed also showed a higher Hg contamination than the sediment.

One way ANOVA indicates a very highly significant variation in the mean values of heavy metal toxicity in feathers, with $P < 0.0001$ as shown in table 4. Table 5 also indicates $P < 0.01$ for heavy metal toxicity in chest muscles of *Bubulcus ibis*. Heavy metal toxicity in the liver of the bird showed $P < 0.0001$; showing a very high level of significance as shown in table 6. Heavy metal toxicity in sediment

indicated $P > 0.05$ as shown in Table 7. However, Table 8 showed a significant heavy metal toxicity in water, $P < 0.05$.

Pairwise comparison for heavy metal toxicity showed a high level of significance in Cd with Pb at $P < 0.05$ and very high level of significance with Cu ($P < 0.001$). Cu with Hg showed a level of significance with $P < 0.05$ in the feathers. Cd only showed a significant level with Cu, with $P < 0.05$ in the chest muscles as shown in Table 10. Cd and Cu showed a very high level of significance with Cu and Pb and Cu showed a level of significance ($P < 0.05$), while $P < 0.0001$ for Cu and Hg showed a very high level of significance as shown in Table 11 for heavy metal toxicity in the liver. Table 12 indicate that there wasn't any level of significance for heavy metal toxicity in the sediment ($P > 0.05$). Cd and Cu showed that $P < 0.05$ while Cu and Hg also shows $P < 0.05$.

The Pearson correlation as indicated in Table 13 showed a lowly negative correlation between Pb and Hg. Cu showed a highly negative correlation and Hg. Hg and Pb also showed a lowly negative correlation, while Hg and Cu indicated a high negative correlation for heavy metal toxicity in the feather of the cattle egrets, all at 0.01 level of significance (2-tailed). From Table 13, Cd and Hg indicated a very highly positive correlation while Pb and Cu also indicated a high but negative correlation. Cu and Pb also indicated this while Hg and Cd indicated a very high level of significance at a significant level of 0.01 (2-tailed) for the chest muscle of the cattle egrets. Cd and Hg indicated a lowly negative correlation, but Pb and Cu are highly negatively correlated. Pb was however positively correlated with Hg. This was also observed in Cu and Pb. Hg with Cd was negatively correlated but positively correlated with Pb. All these were observed at 0.01 (2-tailed) level of significance. Cu was lowly negatively correlated Hg, while Hg was also negatively correlated with Cu at 0.05 (2-tailed) level of significance as shown in Table 14 for heavy metal concentrations in the liver. Table 16 showed a very highly positive correlation with Pb and Cu. Pb also showed a very highly positive correlation between Pb and Cu. This same applied to Pb and Cd with Cu. Cu also indicated a very highly positive correlation of Pb and Cu for heavy metal concentration in the sediment. All these were significant at 0.01 level (2-tailed) for the sediments obtained at Oko-baba. The water obtained from these project sites as shown in Table 17 only indicated a very highly positive correlation between Cd and Pb at 0.01 level of significance (2-tailed).

Histopathological results showed infiltration of mucosa by dense aggregates of lymphocytic inflammatory cells. Some of the internal tissues also shows sloughing while some others showed normal mucosa cells.

We can deduce from this study that heavy metals bio accumulate more in the chest muscle of *Bubulcus ibis* than the other monitoring units and the increase in one heavy metals in the bird leads to a corresponding increase in the other metals present but at times lead to a decrease. Pb and Cd are however found to be positively correlated, particularly in the water samples.

From the results of this study, it can be concluded that monitoring units and also the abiotic factors (sediment and water) can be used as indicators of environmental contamination from heavy metals and their adverse effect on living organisms. Due to scientific and conservation-

related cause it is necessary to analyze occurrence of metals (essential and non-essential) and in-depth studies of the association between them. The biological characteristics of birds can make them useful sentinels for bio monitoring programs, as they can act as adequate local monitors of contaminant levels. Lastly, variations in heavy metal concentration among the species throw light to the fact that there are significant fluctuations in the level of contamination of the environment where these birds lives and feeds. The feeding guilds of these birds will provide a useful guide in determining the sources of the pollutants in the environment. From the outcome of this study, it is recommended that; Periodic monitoring should be done to determine whether heavy metal concentration in the Oko-baba vicinity is getting to levels that will pose health threat to the birds and humans and additional research should be carried out for improvement on organism used as bio indicators and to ascertain the extent of mercury exposure to the populace.

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