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Heavy metal levels in cattle egrets (*Bubulcus ibis*) foraging in some abattoirs in Lagos State metropolis

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Abstract

Background: Heavy metal accumulation in the ecosystem constitutes a potential toxic effect which is hazardous to human health. Increasing environmental pollution has necessitated the use of cattle egrets to evaluate the levels of heavy metal contamination, to establish their use in biomonitoring of heavy metals and to provide data for monitoring pollution in the environment.

Results: The present study assessed the utilization of *Bubulcus ibis* in monitoring pollution in five abattoirs, namely Agege, Bariga, Kara, Itire and Idi-Araba, all situated in Lagos State. The concentration of five (5) heavy metals, cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) was determined in the liver, muscle and feather of Bubulcus *ibis* using the atomic absorption spectrophotometer. The trend of metal accumulation was in the order: Zn > Cu > Pb > Cd > Ni for all the sampled tissues. The mean tissue concentrations of the metals were significantly different ($p < 0.05$) among the sites. The highest levels of metal concentration were reported in the liver in all the locations. Mean concentration of Cd in Kara (0.003 ± 0.00058) was significantly ($p < 0.05$) higher than those found at Agege (0.0013 ± 0.00058) and Idi-Araba (0.001 ± 0.001). A significant difference ($p < 0.05$) was also observed between the mean concentrations of Cu in Bariga (0.01 ± 0.001) and Idi-Araba (0.003 ± 0.001).

Conclusion: All the studied heavy metals were present in the liver, muscle and feathers of the cattle egrets. The contamination levels were ascertained from the study which indicated that cattle egrets are useful in biomonitoring studies and the generated data will serve as baseline data which could be compared with data from other locations for monitoring heavy metal pollution.

Keywords: Heavy metals, Pollution, Abattoir, Cattle egret

Background

The advent of the industrial revolution brought about a dramatic increase in the incidence of pollution due to overexploitation of mankind on the resources of the earth. The impact of environmental factors on the health and well-being of human populations is becoming increasingly apparent (WHO 2010). The risks associated with environmental pollution are on the increase daily (Speth 2004).

To assess the health of an ecosystem and identify alterations in the environment that might be indicative of negating effects, a clear understanding of the corollary of the chemicals in such an environment is imperative. As a consequence of the discharge of pollutants via anthropogenic activities, large amounts of pollutants have made their way into the environment. These accumulate in ecosystems and are then transmitted along the food chain through trophic relations of organisms (Burger 2002; Kim and Koo 2007). The products of anthropogenic activities which in turn pollute the environment include heavy

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metals, inorganic chemicals and large complex organic molecules. Metals are particularly interesting because of their potential toxic effect, persistence and bioaccumulation in the environment (Censi et al. 2006). The concerns over heavy metal pollution are growing globally (Qadir et al. 2008), and it affects the functional and structural cohesion of an ecosystem (Qadir and Malik 2009).

In many parts of the world, anthropogenic activities which include animal rearing and meat processing have negating effects on the soil (Adesemoye et al. 2006). An abattoir is a place where animals are butchered and prepared for human consumption. Abattoirs are ratified by government regulatory agencies to ensure that the entire process of animal butchering, preparation and preservation is carried out with thorough sanitation (Alorge 1992). However, the disposal of the waste generated from slaughter houses is done without consideration to legislative conditions or principles (Olanike 2002). Studies have shown the presence of heavy metals in abattoir soils (Coker et al. 2001; Dedeke et al. 2016; Osu and Okereke 2015). These heavy metals could bioaccumulate in birds which scavenge on the wastes that could found on such soils. There is therefore a need to investigate the presence of heavy metals in these birds.

Studies have shown that birds can be used in the evaluation of the integrity of the environment (Dmowski 1999; Kim and Koo 2008; Jayakumar and Muralidharan 2011; Markowski et al. 2013). The liver, blood and feathers of birds have been employed in the evaluation of heavy metal build-up (Malik and Zeb 2009). Cattle egrets (*Bubulcus ibis*) are useful in biomonitoring of heavy metal pollution of the environment. They occupy high trophic levels, exposed to an array of contaminants, and are susceptible to bioaccumulation of contaminants (Malik and Zeb 2009; Malik et al. 2011). Therefore, the objectives of the present study were (1) to determine the concentration of heavy metals in the liver, muscle and feather of cattle egrets; (2) to establish their use in biomonitoring of heavy metal pollution in Lagos metropolis; and (3) to provide baseline data which could be compared with data from other locations for monitoring heavy metal pollution.

Methods

Description of study area

Abattoirs within five Local Government Areas (LGA/LCDAs): Agege, Shomolu, Surulere, Mushin and Ado-Odo, were randomly selected as sampling locations for the study (Fig. 1). Lagos State is the commercial capital of Nigeria with a land area of 3600 square km, and a population size of 17.5million. The State has a high population density of over 4,000 persons per square km, and it is situated in the South-Western part of Nigeria within latitude 6°35′N and longitude 3°45′E (Lagos State Government (LASG) 2012 Reports). It has wet and dry seasons that borders on an equatorial monsoon climate. The highest temperature recorded in Lagos is 37.3 °C, and the lowest is 13.9 °C. The sites were chosen to represent the areas of maximum and minimum commercial activities. The studied abattoirs receive cattle from different parts of Nigeria and also from neighbouring Sub-Saharan nations such as Chad, Niger, Mali and Cameroon (Ademola 2010). They provide animal protein to the urbane population of Lagos, and this makes the abattoir a candidate for monitoring environmental pollution.

Study design

The samples (cattle egrets) were collected from five abattoirs within Lagos metropolis to determine the bioaccumulation of lead (Pb), nickel (Ni), cadmium (Cd), zinc (Zn) and copper (Cu). Sampling was between heavy to light rainy season. The choice of collection sites was based on the foraging habits of cattle egrets. The birds are known to be traditionally insectivores, feeding on insects, invertebrates and maggots from intestinal wastes and garbage from dumpsites. Cattle egrets demonstrate a symbiotic relationship with cattle, hence the suitability of the abattoir. Three bird specimens were collected from each location for heavy metal estimation.

Sample collection

Cattle egrets ($N = 15$) were caught from the wild using traps, three from each of the five locations and carried in cages to the animal laboratory and allowed to acclimatize for a few hours. The birds were sundered by decapitation of the neck, and their feathers were removed. The tissues (liver and muscle) were carefully extracted and kept in sterile universal bottles, labelled and preserved in the refrigerator before analysis.

Determination of heavy metals

Sample preparation

The samples (liver, muscle and feathers) were dried in an oven at 75 °C to get a uniform dry mass using the methods of Murtala et al. (2012). The dry samples were then pulverized into a fine meal, using mortar and pestle, and kept in desiccators to evade the accumulation of moisture.

Digestion of the sample

The method reported by Murtala et al. (2012) was employed in the digestion of the powdered samples. A portion (0.200 g) of each sample was weighed and digested using a 2.5 ml of Selenium/Sulphuric acid mixture. It was heated at approximately 200^0C until the sample fumed. 3 ml of 30% H_2O_2 was added to the sample

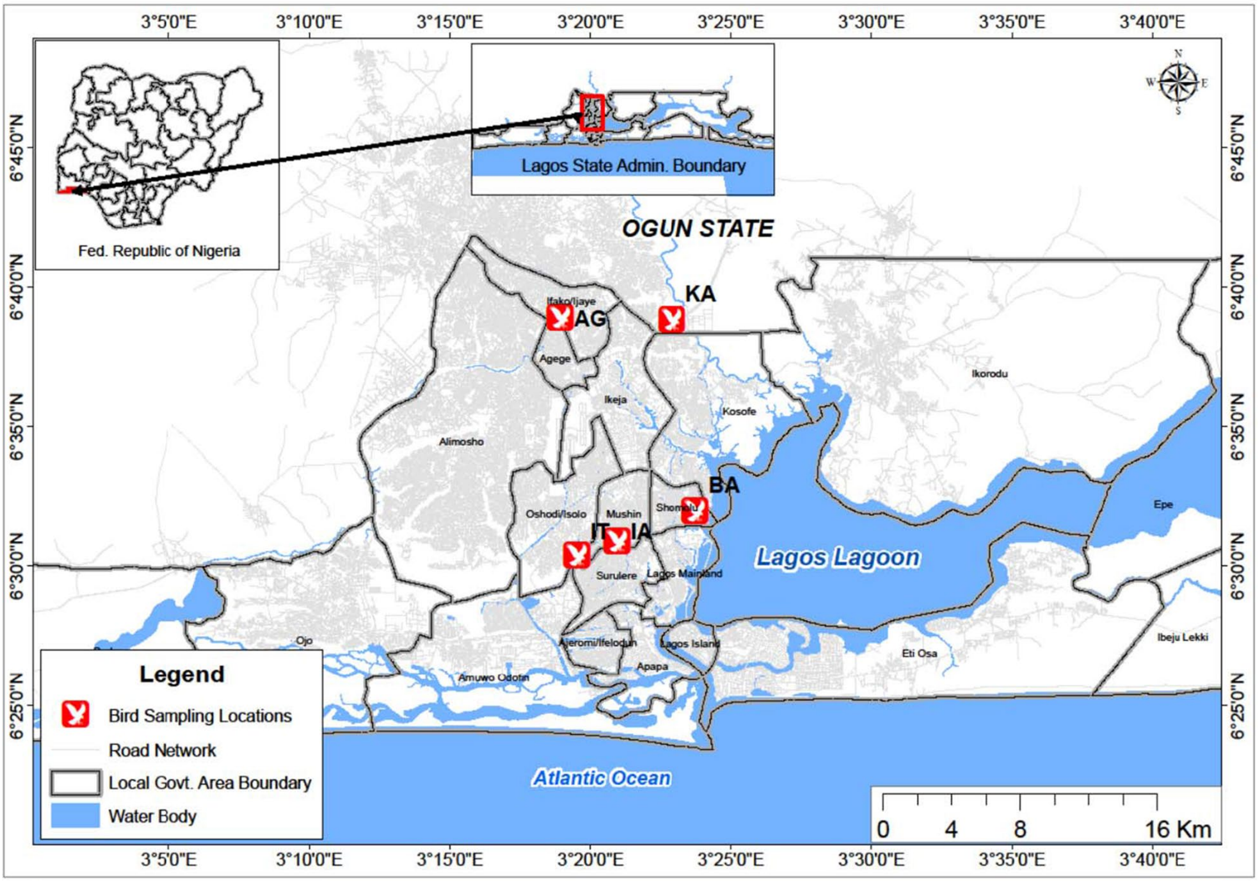

Fig. 1 A map showing the location of the abattoirs in Lagos State

after cooling and it was again heated to 330^{0}C for 2 h until a clear solution was formed. The heavy metals were subsequently analysed using atomic absorption spectrophotometer (model 9100 Pye Unicamp). This was done in triplicates, and the average mean values were recorded as the concentration of metals in mg/Kg.

Results

Heavy metal concentration of liver, muscle and feathers of Cattle egrets (*Bubulcus ibis*)

Heavy metals were found in varying concentrations in the liver, muscle and feathers of the fifteen cattle egrets that were sampled. The study revealed that Zn concentrations were most prominent in all the tissues, with the highest concentration found in the liver from Kara abattoir. Kara (KA) also had the highest concentration of Cd compared to birds from the other study areas. Lead concentrations were higher at Bariga and Itire, while Nickel was higher in Agege and Bariga. The concentration of the metals was measured in the liver, followed by the muscle and then the feathers from all the locations. Among the metals, the highest mean concentration was measured in the order Zn > Cu > Pb > Cd > Ni. The heavy metal concentrations in the liver, muscle and feathers of *B. ibis* from the five locations are presented in Figs. 2, 3, 4, 5 and 6.

Accumulation of heavy metals in the Liver samples

The concentrations of Cd, Cu, Ni, Pb and Zn in the liver of cattle egrets from the five locations are presented in Figs. 2, 3, 4, 5 and 6. The metal concentrations varied between the locations. The mean concentration of Cd was found to be 0.001 ± 0.001 mg/kg of tissue dry mass in Idi-Araba (IA) and 0.0033 ± 0.0006 mg/kg in Kara (KA). In egrets obtained at Itire (IT), the concentration was below the limit of detection. The Cu concentration varied between 0.010 ± 0.001 in Bariga (BA) and 0.010 ± 0.004359 mg/kg in Agege (AG). Ni was between 0.001 ± 0.001 in Itire (IT) and 0.0023 ± 0.00058 mg/kg in AG and BA. The concentration in KA was below the level of detection. Pb levels were between 0.0023 ± 0.0021 in AG and 0.0037 ± 0.0015 mg/kg in IT, and Zn was between 0.007 ± 0.0027 in IT and 0.0143 ± 0.0025 mg/kg in KA.

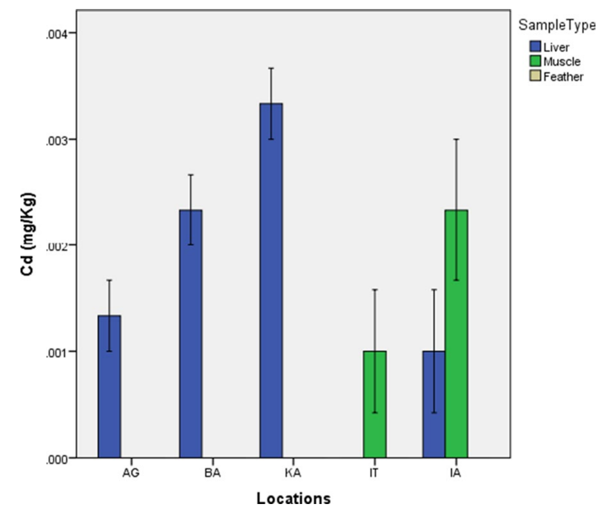

Fig. 2 Level of cadmium (Cd) in sampling locations (mg/kg)

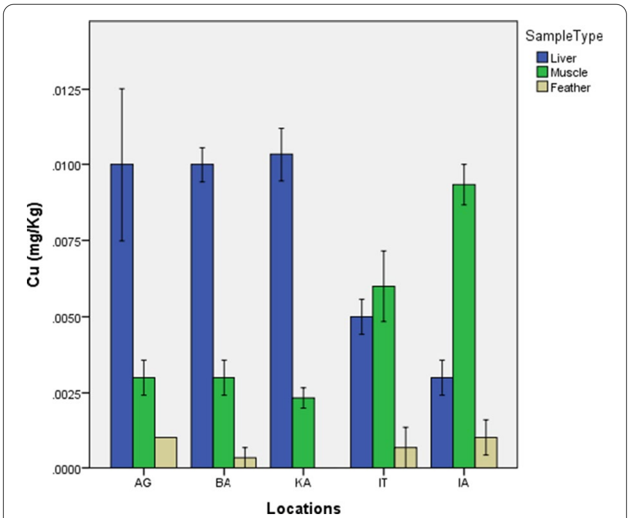

Fig. 3 Level of copper (Cu) in sampling locations (mg/kg)

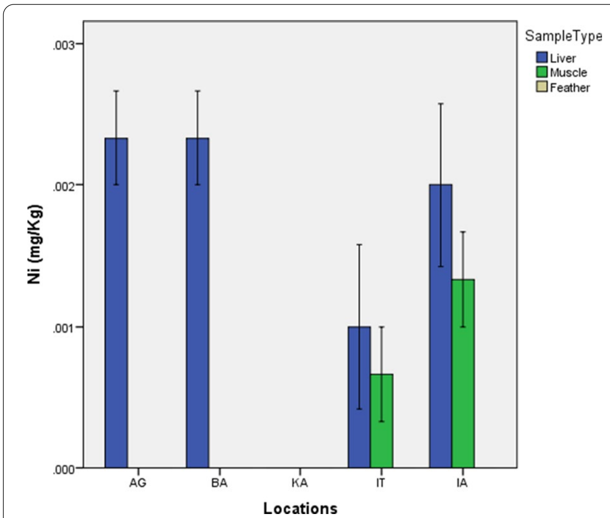

Fig. 4 Level of nickel (Ni) in sampling locations (mg/kg)

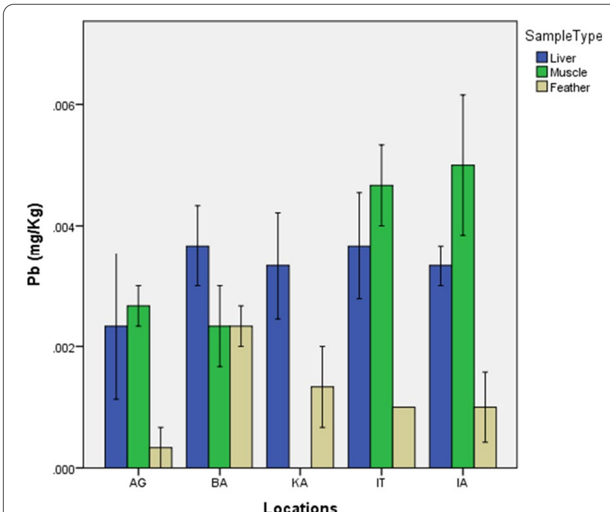

Fig. 5 Level of lead (Pb) in sampling locations (mg/kg)

Accumulation of heavy metals in the muscle samples

The concentrations of Cd, Cu, Ni, Pb and Zn in the muscle of cattle egrets from the five locations are presented in Figs. 2, 3, 4, 5 and 6. The metal concentrations in the muscles varied between the locations as well ($p < 0.05$). Cd concentrations were detected between 0.001 ± 0.001 mg/kg of tissue dry mass in IT and 0.0023 ± 0.0012 mg/kg in IA. Egrets obtained at AG, BA and KA had concentrations below the limit of detection. Cu concentrations were between 0.0023 ± 0.00058 in KA and 0.0093 ± 0.0012 mg/kg in IA. Ni was between 0.0007 ± 0.00058 in IT and 0.0013 ± 0.00058 mg/kg in IA. Concentrations at AG, BA and KA were below the level of detection. Pb was found at concentrations from 0.0023 ± 0.0012 in BA to 0.005 ± 0.002 mg/kg in IA and Zn varied from 0.0057 ± 0.0015 in IT to 0.0067 ± 0.0021 mg/kg in IA.

Accumulation of heavy metals in the feather samples

The concentrations of Cu, Pb and Zn in the feathers of cattle egrets from the five locations are also presented in Figs. 2, 3, 4, 5 and 6. Cd and Ni concentrations, however, were below the limit of detection in all the locations. Mean Cu content was between 0.0003 ± 0.0006 mg/kg in BA and 0.001 ± 0.001 mg/kg in IA. Pb varied from 0.0003 ± 0.0006 in AG to 0.0023 ± 0.0006 mg/

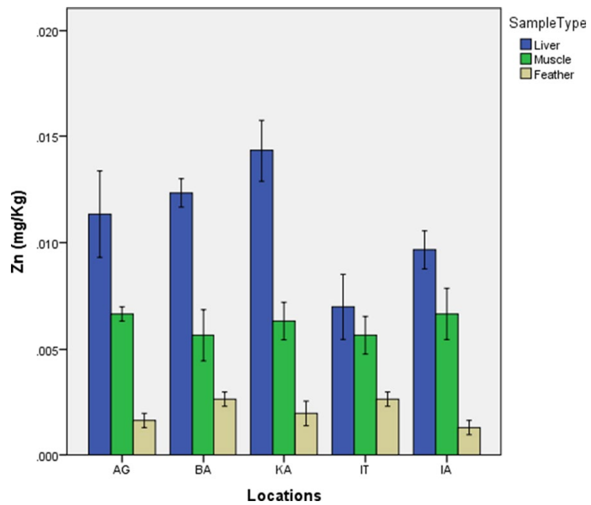

Fig. 6 Level of zinc (Zn) in sampling locations (mg/kg)

kg in BA and Zn varied from 0.0013 ± 0.0006 in IA to 0.0027 ± 0.0006 mg/kg in BA and IT.

Inter-site comparison of heavy metal content

One-way analysis of variance of metal concentrations in liver samples showed that there is a significant difference in the concentration of Cd, Cu, and Ni between the locations, while Pb showed no significant difference at $p < 0.05$. Multiple comparisons, however, showed that the mean Cd concentration measured in liver collected from KA was significantly different from the mean measured at AG, IT and IA. There was also a significant difference between mean concentrations measured at BA and IT. The mean Cu concentrations differed significantly between IA and AG, BA and KA, while Ni showed significant differences between KA and AG and BA. Furthermore, there was a significant difference in the concentrations within the muscles of Cd, Cu, Ni and Pb between the locations, while Zn showed no significant difference at $p < 0.05$. Mean Cd, Cu and Ni concentrations in muscles collected at IA were significantly ($p < 0.05$) different from those collected from AG, BA and KA, while Pb concentration differed ($p < 0.05$) significantly between KA and IT and IA.

Feathers showed no significant ($p < 0.05$) difference in the concentrations of Cu, Pb and Zn between the locations at $p < 0.05$.

The highest mean concentration of Cd was recorded in the liver from KA (0.0033 ± 0.0006 mg/kg), while the muscle and liver in IT and IA, respectively, had equal concentrations (0.001 ± 0.001 mg/kg). The feathers in all five locations, as well as muscles from AG, BA and KA, were below detectable limits. The concentration of Cu was also found to be highest in the liver from KA (0.0103 ± 0.0015 mg/kg) and lowest in the feather from BA (0.0003 ± 0.0006 mg/kg). The liver samples in AG and BA recorded equal concentrations of Ni (0.00233 ± 0.000577 mg/kg) and lowest in the muscle from IT (0.00100 ± 0.001000 mg/kg), while the muscle from KA, as well as the feathers from all the other locations, was below the detectable limits. Pb was detected in all the samples from all locations with the muscle in IA (0.005 ± 0.002 mg/kg) recording the highest concentration and the feather from AG (0.0003 ± 0.0006 mg/kg) recording the least concentration. Zn was also found to be highest in the liver from KA (0.0143 ± 0.0025 mg/kg) and lowest in the feather from IA (0.0013 ± 0.0006 mg/kg). KA recorded the highest concentration of heavy metal where the concentration of Zn in the liver was found to be (0.0143 ± 0.0025 mg/kg) and AG and BA recorded the lowest with equal concentrations of Pb and Cu, respectively, in the feathers (0.0003 ± 0.0006 mg/kg).

Discussion

Birds have been extensively used in environmental studies to assess the impact of heavy metals on the ecological health of ecosystems. The findings from this study resound the ubiquitous nature of heavy metal pollution and the need to constantly monitor uptake in biological systems. The level of heavy metals found in this study varied between the various components of the cattle egrets (*Bubulcus ibis*) and across the locations. Kara abattoir recorded the highest levels of Cd, Cu and Zn in the liver while Idi-Araba recorded the least. In Agege, Bariga and Kara, Cd and NI in muscle and feathers were below the limit of detection. The trend of accumulation of the metals is in the order: Zn > Cu > Pb > Cd > Ni. The liver recorded the highest mean concentrations of all the metals, followed by the muscle and feathers. However, Cd, Cu, Ni, Pb and Zn levels in the liver of the cattle egrets were lower than those reported in great tit and greenfinches from China (Deng et al. 2007). Accumulation of heavy metals in the tissues and feathers of different species of birds has been reported by several authors (Lebedeva 1997; Scheifler et al. 2006; Burger et al. 2008; Malik and Zeb 2009; Jayakumar and Muralidharan 2011; Markowski et al. 2013).

The variations in the concentration of heavy metals investigated in this study may be attributed to different modes of contamination between the abattoirs and the foraging strategies of the birds. Anthropogenic activities such as dumping of wastes containing heavy metals as well as atmospheric depositions could also be a contributing factor. Malik and Zeb (2009) reported that different contamination sources, as well as diet, were contributing factors to the concentration of metals accumulated in cattle egrets from different localities. Scheifler et al. (2006) also suggested that metals contained in insects or other prey of bird may become available to birds in local environments due to the persistence of these contaminants in soils and its transfer through the food chain.

The persistent nature of heavy metals has been associated with toxicity in living systems leading to physiological, behavioural and biochemical changes in birds. These metals are non-biodegradable, so they tend to accumulate in the feathers and internal tissues of birds, indicating concentrations present in their environment. The rate of change is, however, dependent on the concentration accumulated and dose delivered to the different tissues, where elevated levels in the body burden could be highly toxic. The concentration and distribution of a given trace metal in the body depend on the intensity and duration of exposure, speciation of the metals and their interactions with other toxins. The toxicity of many metals such as cadmium and lead depends on their transport and intracellular bioavailability (Walker et al. 2001). The liver is often the target organ for chemically induced damage and is usually a major organ perfused by substances that are absorbed in the gut due to its role in detoxification; thus, it is exposed to the highest concentrations of xenobiotics (Walker et al. 2001).

In the present study, mean metal concentration in the liver of *Bubulcus ibis* ranged from 0.001–0.003 mg/kg (Cd), 0.003–0.01 mg/kg (Cu), 0.001–0.002 mg/kg (Ni), 0.002–0.004 mg/kg (Pb) and 0.007–0.014 mg/kg (Zn) in the five abattoirs and was lower than levels reported in nestling Ciconiiformes from Florida by Spalden et al. (1997) which indicated that geographical locations affected Pb and Cd concentrations. Zaccaroni et al. (2003) reported higher concentrations of Pb and Cd in little owl (*Athene noctua*) from Italy compared to this study and suggested that levels can be indicative of chronic exposure to low and background amounts of pollutants of no toxicological consequence, as they are well below the toxic thresholds defined for the metals. Mean Pb, Cd and Cu concentrations in this study were also very low compared to those reported in the liver of black-headed gull (*Larus ridibundus*) from South-Western Poland (Orłowski et al. 2007).

Kojadinovic et al. (2007) indicated that tissue factor influences the distribution of metals which in most cases varies significantly. Various tissues are classified according to their ability to concentrate these metals and are reflected in the metal burdens in the studied tissues. The liver is considered a long-term storage tissue for most metals (Walsh 1990), indicating that large birds with a long-life span accumulate high burdens of these elements. Pérez-López et al. (2006) reported Cd concentrations in the liver of Razorbills from Spain, indicating that levels were mainly associated with natural processes as a result of accumulation and storage, rather than from global sources of pollution.

The results for heavy metal concentration in the muscles of *Bubulcus ibis* in this study also differed significantly between the locations and were lower than those reported by other authors (Kojadinovic et al. 2007; Orlowski et al. 2007). Lucia et al. (2010) also reported Cd in muscles and feathers of Greylag goose, Mallad, Red knot and Grey plover from the Atlantic coast of France and concluded that the discrepancies may have been due to dietary habits, habitat, absorption and/or excretion capacity and the rate and extent of moult.

Heavy metal contamination in feathers can result from external deposition from a contaminated environment, excretion of the uropygial gland on the feathers during preening (Kim and Koo 2007) and to a higher degree, linked to food chain transfer from soils. External contamination can result in a higher concentration of most of the heavy metals in feathers (Dauwe et al. 2002a, b). The results of previous studies on the feather concentrations of heavy metals are quite variable. Burger et al. (2008) reported that site differences in metal concentration could result from differences in local exposure, atmospheric deposition, or be related to foraging spectrum of bird species. Scheifler et al. (2006) reported a higher Pb concentration in blackbirds from France compared to the present study. Orłowski et al. (2007) also reported higher levels of Cd, Cu and Pb concentrations in black-headed gull (*Larus ridibundus*) from South-Western Poland, suggesting marked contamination of the breeding colony surroundings. Burger et al. (2008) also reported very low Cd concentration in the feathers of eiders of the family Anatidae from Aleutian Island. In general, metal concentrations in feathers are representative of circulating concentrations in the bloodstream during the period of feather formation, which in turn represents both local exposure and mobilization from internal tissues (Monteiro 1996). High levels of metal contaminants affect the survival and productivity of wildlife (Janssens et al. 2003). Chronic metal exposure to birds can result in detrimental effects on growth, reproduction, behaviour, resistance to diseases and other physiological mechanisms (Dauwe et al. 2005).

Conclusion

A precise assessment of the heavy metal content of cattle Egrets (*Bubulcus Ibis*) foraging in some abattoirs in Lagos metropolis was carried out. Heavy metals were found in all the components of the cattle egrets studied. The study revealed that cattle egrets are very useful in biomonitoring of heavy metal in the environment. The heavy metal presence in the cattle egrets could be linked to their foraging strategies and anthropogenic activities such as dumping of wastes containing these metals near the abattoirs.

It is recommended that abattoirs should maintain good hygiene practice and should be sited away from dumpsites. This study has generated a baseline data that will be useful in monitoring heavy metal pollution.

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Authors' contributions
OOB did the conception and design of the work. SEA did analysis of data. EAA drafted the manuscript. MLR revised the manuscript. All authors have read and approved the manuscript.

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Availability of data and materials
It has been reported and cited in the methodology section of the manuscript.

Declarations

Ethics approval and consent to participate
Not applicable in this section.

Consent for publication
Not applicable in this section.

Competing interests
The authors declare that they have no competing interests.

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