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Research Article

Assessment of Heavy Metal Accumulation in Feathers and Droppings of Cattle Egret (Bulbucus Ibis), Soils and Grasses in Some Abattoirs in Rivers State, Nigeria

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Abstract

Abattoir is place where meat consumed by the public is prepared and serves as a pathway for the transmission of heavy metals to humans through meat consumption. It is hypothesized that contaminated samples from abattoir will lead to the contamination of the meat produced. This study was done in three semi-rural communities of Ogbogoro, Rumuosi and Choba. Four samples were collected namely: feathers, droppings, soils, and grasses. Each sample was collected at three sites (n = 36). The samples were sent to the laboratory for physico-chemical analysis to test for the presence of Cadmium (Cd), Lead (Pb), Chromium (Cr) and Argon (Ar) using the HACH DR 890 colorimeter (wavelength 420 nm). The ANOVA results shows that there is a significant difference in the concentration of the heavy metals in the different samples ($F_{3, 44}$ =3.29, P=0.03). The result show that bird's feather had the highest heavy metal concentration followed by soil, grass, and droppings. The order of heavy metal concentration is feather>soil>grass>droppings. Lead (93.27±44.03mg/kg) and Cadmium (31.66±14.14) concentrations were highest in feather while Chromium was highest in soil (10.64±3.23 mg/kg). Then Argon was highest in grass samples (0.60±0.09 mg/kg). In contrast, there is no significant difference in heavy metal concentration between locations ($F_{2, 45}$ =1.17, P>0.05). However, Rumuosi abattoir had the highest heavy metal contamination followed by Ogogoro and Choba. This study shows that heavy metal contamination of abattoir-related samples can lead to the establishment of a transmission pathway for the bioaccumulation of metals by the meat consuming public.

Introduction

An abattoir is a place where animals are slaughtered and sold to the public for consumption [1]. It is often sited close to the river or public drainage where water used to wash off the blood from dead animals flow into [2]. Studying the components and materials found around an abattoir is significant because of its direct or indirect impact on public health when meat from the abattoir is consumed [3] without proper sanitation or inspection [4]. Consuming meat from unhygienic abattoirs can lead to the proliferation of parasites and disease-causing agents [5,6]. This is because the animals are usually killed and prepared in unhygienic and filthy environments with overgrown weeds harboring rodents and insect pest. Most abattoirs are situated close to waste dump sites, derelict buildings, and makeshift sheds, which can lead to environmental hazard [7]. Sometimes it is close to open markets where a lot of commercial activities occur, which exposes the meat to flies and dust from the roadside [8]. The abattoir environment is made up of the animals that are being slaughtered (goats, cows, pork, and chicken), the soil, water, and the atmosphere. The animals are first killed before they are placed on fire started by car tires to remove their furs. During the burning of the animals the abattoir environment becomes filled with smoke and soot, which settles on the soil and objects around the abattoir. The soil is usually dark brown to black in color because of the ash and charcoal contents. The presence of charcoal in the soil is because of the use of wood and car tires to aid the burning of fur from the body of the slaughtered animals during preparation. This action eventually leads to the change in the coloration of the soil. Abattoir waste is used as organic manure in some crop farms and fruit garden [9].

There are different species of birds that visit the abattoir, but the most dominant species is the white colored cattle egrets. They are a regular visitor to abattoirs in this region. They scavenge for all kind of food items around the abattoir ranging from insects (e.g., flies), pieces of meat and plant parts. Their white feathers sometimes turn grey or black because of their contact with black soot from the grounds of the abattoir. The cattle egrets also visit nearby rivers where they feed on fingerlings and other aquatic organisms [10]. During their visit to the river, they pass out waste product at their brooding sites which is consumed by fishes and other aquatic organisms. This causes a trend of transfer and circulation of harmful substances from their waste products to other parts of the environment.

The dominant weed species found in most abattoirs are the carpet grasses (Axonopus compressus). They grow near the rivers and parts of the abattoir floor where they accumulate metals from the decomposed waste and soot from the burnt animals. They also harbor rodents and insects that serve as disease vectors that migrate into the abattoir animals [11]. Because of the migration of harmful heavy metals from abattoir to food consumed by humans [12]. It is thus necessary to compare the heavy metal concentration of abattoir-related products or samples. The objectives of this study, therefore are: (1) to determine the heavy metal concentrations in different abattoir-related products, (2) to compare the heavy metal concentration of abattoir-related products in different locations and (3) to compare the heavy metal concentration across taxa and cattle egret products.

Materials and Methods

The study areas are three communities situated in Rivers State in the Niger Delta area of Nigeria (Figures 1 and 2). They are Ogbogoro community (N4’47.669o, E006’59.246o), which is sited near a small waterway that passes through a bridge close to a major market in the community. The second site is Rumuosi community, that borders the East-West Road (N4’52.812o, E656.663o), a trunk A road. This abattoir is sited near an abandoned burrow pit, which harbors accumulated rainwater and a refuse dump. The third site is the Choba community (N4’52.810o, E6’56.663o), and is close to the University of Port Harcourt. This site is also close to the Choba Creek where water flows into major rivers in the region e.g., Sombreiro River. These three study areas are in a region that has humid climate with rainfall occurring almost all throughout the year. There are two major seasons, wet (February-September) and dry (October-January) seasons [13]. It has a tropical monsoon climate, and rainfall occurs all through the year with a mean annual rainfall of 3567.4 mm year-1 [14]. The mean monthly temperature ranges between 26 and 30°C.

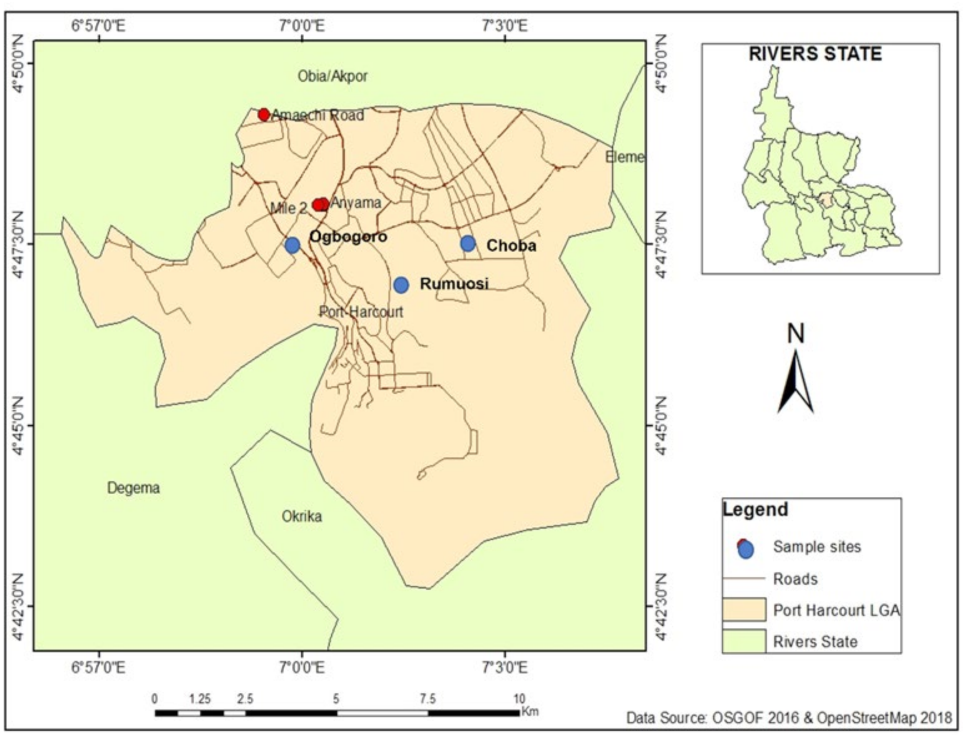

Figure 1: Map of study area in the Niger Delta area of Nigeria.

Sample collection

In each site three points were identified where the different samples were collected. Soil samples were collected with a hand-held soil augur at three points after which they were placed in black cellophane bags. The bird droppings were scooped from the soil and placed in a waterproof bag. Bird feathers were picked from the roosting area of the birds at the abattoir and placed in a waterproof bag and tagged. The grass sample (*Axonopus compressus*) was collected from the abattoir floor close to the area where the animals are slaughtered. Three samples were collected for each abattoir-related products making a total of twelve samples per site. For the three locations 36 samples were collected and sent to the laboratory for further analysis following the example of [15].

Figure 2: Study locations indicating abattoirs in (A) Ogbogoro, (B) Choba and (C) Rumuosi communities and (D) a place where animals are burnt at Ogbogoro community. The abattoirs are often situated in the market or close to a flowing river. There are also grasses around the sites with refuse littered in the vicinity.

Research Design

Three samples of different abattoir-related products were collected from the study locations, and the experimental and conceptual design is shown in Figure 3.

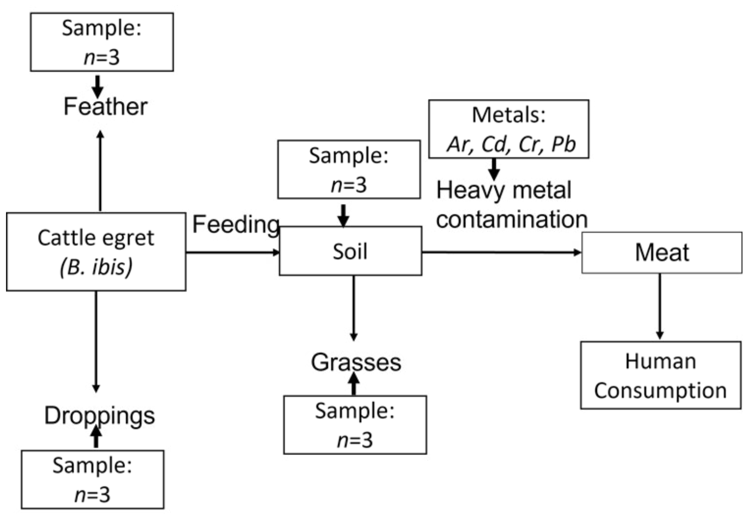

Figure 3: Research design of heavy metal concentration in abattoir samples collected from different sites in Rivers State, Nigeria.

Laboratory analysis

Heavy metal extraction followed the example of [16]. Aliquots of 0.25g of air-dried abattoir samples were weighed into a Teflon inset of a microwave digestion vessel and 2 ml concentrated (90%) nitric acid (Sigma-Aldrich, Dorset, UK) were added. The metals were extracted using a microwave accelerated reaction system (MARS Xpress, CEM Corporation, Matthews, North Carolina) at 1500 W power (100%), ramped to 175 °C in 5.5 min, held for 4.5 min, and allowed to cool down for 1 h. The cool digest solution was filtered through the Whatman 42 filter paper and made up to 100 ml in a volumetric flask by adding de-ionized water. All chemicals and reagents used were of analytical grade and of highest purity possible. Analytical blanks were prepared with each batch of the digestion set and analyzed (one blank for every set of 6 samples) in the same way as the samples. The detection limit for the three metals analyzed in mg/l ranged from 0.001-0,002.

Statistical analysis

An analysis of variance (ANOVA) was conducted to determine whether there was a significant difference in heavy metal concentration between the different abattoir samples [17]. The data was first log transformed to ensure that they were normal, and the variances were equal. Tukey HSD test was also conducted to determine where the significance lies. Bar graphs were then used to illustrate the significance and difference in concentration between samples. All analyses were done in [18].

Results

Heavy metal concentrations in different abattoir-related products

The ANOVA result (Table 1; Figure 4) indicates that there is significant difference in heavy metal concentration in different abattoir samples ($F_{3,44}=3.29$, $P=0.03$). Lead concentration was the highest in the bird's feather; Chromium concentration was highest in the soil sample; Cadmium concentration was highest in the bird feather and Argon concentration was highest in the grass sample. Bird's feather has the highest concentration in Cadmium and Lead. This is followed by soil, which has the highest concentration of Lead and Chromium. Therefore, the order of concentration of heavy metals is Pb>Cd>Cr>Ar. For the abattoir samples the order of concentration is feather>soil>grass>droppings. The Tukey HSD test shows that the most significant difference lies between Egret bird's feather and droppings at $P< 0.05$.

Abattoir samples		Metals (mg/kg)		
	Ar	Cd	Cr	Pb
Soil	0.50±0.16	2.59±0.71	10.64±3.23	18.43±5.59
Bird's droppings	0.47±0.10	1.91±0.44	3.80±1.08	6.16±3.84
Bird's feather	0.43±0.06	31.66±14.14	6.11±4.88	93.27±44.03
Carpet Grass (*Axonopus compressus*)	0.60±0.09	4.43±0.05	2.60±1.81	14.63±1.27

Table 1: Mean levels of heavy metals ± 1 SE in different abattoir samples in Rivers State Nigeria.

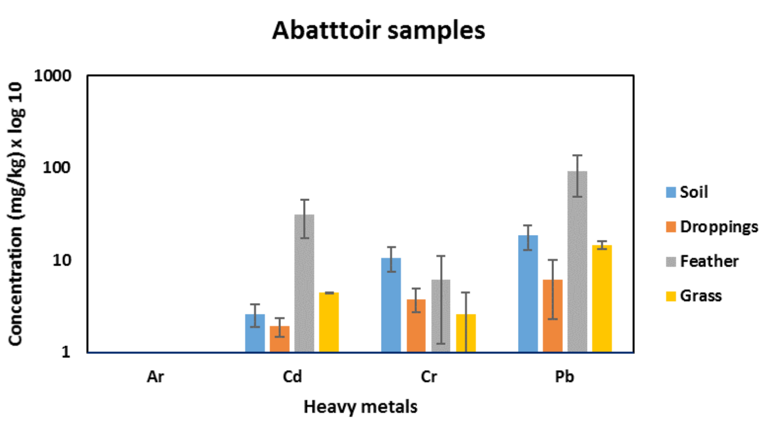

Figure 4: Mean concentration of heavy metals in some abattoir samples (birds feather, droppings, soil, and grass) across different locations in the Niger Delta.

Heavy metal concentrations in different abattoir locations

The ANOVA result (Table 2; Figure 5) indicates that there is no significant difference across locations ($F_{2, 45} = 1.17$, $P > 0.05$). However, Rumuosi abattoir has the highest concentration of heavy metals followed by Ogbogoro and Choba communities (Figure 5). The order of concentration in terms of location is Rumuosi>Ogbogoro>Choba. Lead concentration was the highest in all locations followed by Cadmium, Chromium and Argon.

Study locations		Metals (mg/kg)		
	Ar	Cd	Cr	Pb
Choba	0.38±0.06	3.10±1.05	2.27±0.78	11.16±3.16
Ogbogoro	0.52±0.08	11.37±6.70	5.21±3.20	37.00±8.50
Rumuosi	0.61±0.09	15.97±10.11	9.88±2.85	51.21±15.70

Table 2: Mean levels of heavy metals ± 1 SE in different abattoir locations in Rivers State Nigeria.

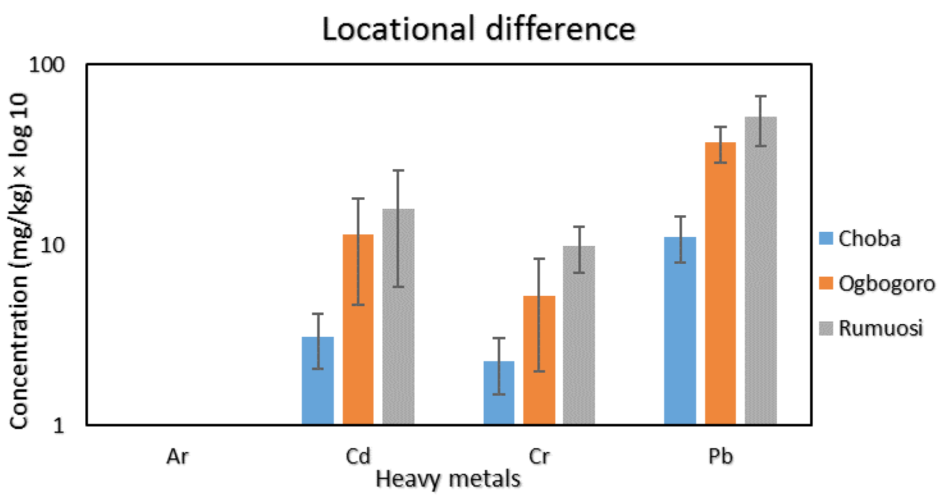

Figure 5: Mean concentration of heavy metals across different locations in selected sites in Rivers State, Nigeria.

Comparison of heavy metal concentration across taxa and bird components

The ANOVA result (Figure 6) indicates that there is a significant difference between plant and animal matter in the abattoir ($P < 0.05$). Similarly, there is a significant difference between bird's feather and droppings ($P < 0.05$). Components of cattle egret (i.e., feather and droppings) have more heavy metal concentration than the grass species.

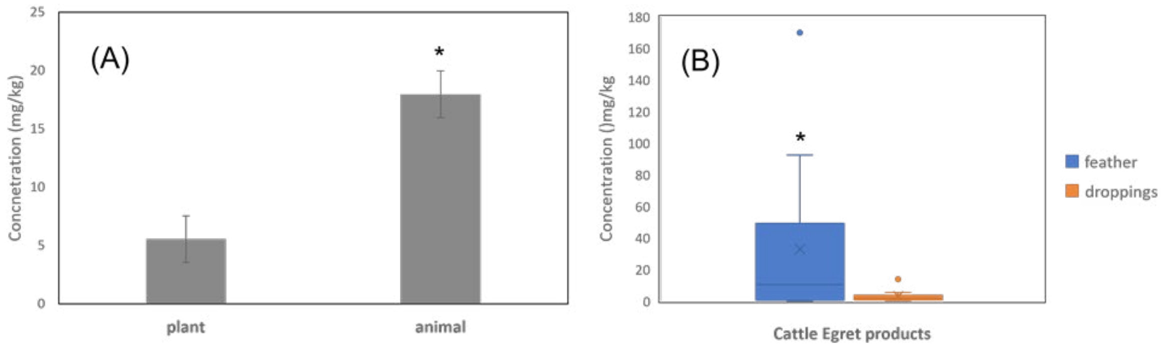

Figure 6: Comparison of heavy metal concentration of (A) plants and animal components and (B) feather and droppings of cattle egret in the abattoirs studied.

Discussion

Heavy metal concentrations in different abattoir-related products

Different abattoir samples accumulate heavy metals at different rates. The high concentration of heavy metals in bird's feather is because of the bioaccumulation of heavy metals derived from their feeding on land and coastal areas and their exposure to atmospheric soot and ash. The cattle egret feed on discarded products in the waste dump site and on the abattoir floor, which lead to their picking up of soil particles contaminated with pollutants. They also pick up particles of ash when they feed on meat parts scattered around the abattoir. The abattoir soil serves as the source of non-point pollution to nearby streams and rivers [19]. The birds also visit streams where they feed on contaminated fingerlings of fish and other aquatic organisms [15]. The soil also supplies heavy metals to the grasses growing around the abattoir, which absorb them through their roots. The grasses in turn serve as the host to plant eating insects, which are consumed by visiting cattle egrets [10]. This feeding pathway increases the accumulation of heavy metals in the body parts of the cattle egret. This further leads to the deposition of heavy metal laden droppings. The high concentration of lead in the abattoir samples is because of the burning of car tires to remove the furs of killed animals. This results to high lead concentration in almost every object around the abattoir. Lead is also introduced from soot that comes from nearby industries in the area. The high concentration of Chromium in the soil is because of anthropogenic additions such as vehicular and industrial activities.

Heavy metal concentrations in different abattoir locations

Rumuosi community has the highest concentration of heavy metals because of its closeness to human habitation and road. This exposes the abattoir to car exhaust from passing traffic. The exhaust from cars on the East West Road expose the abattoir to soot. In addition, the closeness of this abattoir to a burrow pit that is used as a refuse dump site predisposes it to heavy metal contamination. As for the other two abattoirs they are not too close to the road as compared to the Rumuosi abattoir. This study shows that the siting of abattoir near major roads is detrimental to public healthy because of the accumulation of environmental pollutants in the animals to be slaughtered. Similarly, the grasses around the abattoir serve as a reservoir for heavy metals and disease-causing agents.

The burrow pit near the Rumuosi abattoir also serve as a reservoir for wastewater that comes from the washing of the animals. This wastewater can be a source of heavy metal contamination to the cattle egret that drink from the pool [20]. This is because the wastewater is often channeled directly into the pit without treatment [21,22]. The wastewater can also serve as a collection point for contaminants, which eventually percolate into the ground water aquifer [23]. A polluted aquifer can have its water recycled back to humans that drink from the bore hole sunk at the abattoir. The washing of slaughtered animals with water from the bore hole can also expose them to heavy metal contamination [24], which is then transferred to humans through the meat consumed. Furthermore, microbes from abattoirs affects ground water quality, which require constant monitoring [25] to prevent public health disaster.

Comparison of heavy metal concentration across taxa and bird components

There is higher bioaccumulation of heavy metals in the cattle egret components than in grass because birds are higher up the food chain than plants. Therefore, biomagnification increases up the food chain. Feathers too have higher heavy metals than droppings. Herons and egrets have been used as bioindicators of environmental health because they store heavy metals in their feathers [26]. Factors that influence heavy metal bioaccumulation in bird's feather include taxa, trophic level, and location [27]. Bird's feather thus serves as an effective bioindicator to trace elements in contaminated areas [28]. Birds' droppings have low heavy metal concentration because when deposited on the soil losses some of its heavy metals. Furthermore, it losses some of its metallic content as a result of digestion and absorption into the birds body.

Conclusion

The place where an abattoir is sited, and the materials found around it determine its safety and hygienic condition. The closer an abattoir is to houses and roads the more it is exposed to anthropogenic and traffic activities leading to higher heavy metal accumulation. This study has also shown that components around an abattoir can serve as an indicator of its heavy metal concentration. Constant monitoring of the heavy metals in plants and animals around the abattoir can help to determine the level of transmission and contamination of slaughtered products from the abattoir. The burning of car tires should be stopped to prevent the increase in heavy metals especially Lead in the abattoir environment. Since cattle egrets are regular visitors to the abattoir their feathers and droppings can be used as bio components to monitor the migration of pollutants. Grasses around the abattoir should also be trimmed to prevent it from serving as a reservoir for heavy metals and disease-causing agents.

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