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Heavy Metals Accumulation in Feaces of Wildlife around Ogun River in Old Oyo National Park, Nigeria

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Abstract: Knowledge of bioaccumulation of heavy metals (HMs) in wildlife of our national parks is poor. With the use of standard procedures, this study evaluated wildlife dungs in Old Oyo National Park for bioaccumulation of nickel (Ni), arsenic (As), zinc (Zn), cadmium (Cd), lead (Pb), cupper (Cu), chromium (Cr) and cobalt (Co). Composite dung samples of kob (K), cane rat (CR), crocodile (C), pattas monkey (PM), olive baboon (OB), civet cat (CC) and western hartebeest (WH) were collected along River Ogun. Concentrations were significantly different (α<0.05) among the dungs, ranging from 3.99±0.56 (CR) to 27.09±0.20 mgkg^{-1}(C) for Cu, 176.60±8.30(K) to 347.83±3.35 mgkg^{-1}(PM) for Zn, 7.29±0.04 (CC) to 43.07±0.19 mgkg^{-1}(C) for Pb, 37.64±1.39 (CC) to 157.57±0.19 mgkg^{-1}(C) for Mn, 24.75±0.48(WH) to 65.00±68 mgkg^{-1}(C) for Cd and 2.63±0.05(PM) to 5.76±0.07 mgkg^{-1}(C) for Cr. There were no traces of Ni and Co detection in the dungs, but concentrations of Pb, Mn, Cd and Cr were significant and positively correlated. It is likely that the river is a major source of HM contaminants. There is need for all wildlife dietary sources to be investigated.

Keywords: Arsenic, Cadmium, Chromium, Lead, Zinc

1. Introduction

Heavy metals (HMs) have been defined as natural constituent of soil with relatively high density and atomic number greater than 20. They may be injurious to the health of living organisms even at low concentrations (Pandey & Madhuri, 2014). Except for zinc (Zn), iron (Fe) and selenium (Se) that are required by the body in trace quantity, other HMs including copper (Cu), silver (Ag), lead (Pb), mercury (Hg), nickel (Ni), arsenic (As) and cadmium (Cd) are known to cause hazardous effect at toxic level when they bio-accumulate in various vital organs (live, kidney, heart) of the body. Of these, only As, Cd, Pb and Hg are considered highly toxic to most organisms (Lockhart et al. 2016; Pandey & Madhuri, 2014; Rajeswari & Sailaja, 2014).

Normally, wildlife encounter lots of challenges while exercising their daily activities, most especially during feeding. Among these challenges, exposure of wildlife to pollutants have been studied by scientists (Leonzio et al., 2009; Rajeswari & Sailaja, 2014), where higher concentrations of HMs were recorded in their reports. Although, these HMs were thought to have been acquired under the influence of some anthropogenic activities of various degrees (mining, agriculture etc) connecting to difference sources (soil, water and vegetation) utilized by wildlife through respiration, ingestion and contact through skin (Helal et al., 2013; Simon et al. 2016**;** Ametepey et al., 2018). Pandey and Madhuri (2014) stated that HMs are capable of causing a number of health hazards to both aquatic and terrestrial organisms including human. Prolonged exposures of wildlife to these HMs pose negative health impact and risk to their users. For this reason, HMs has been examined from muscle, liver, kidney, gills and intestine of animals (Ambedkar et al. 2017)**.** Ijeomah et al. (2015) investigated HMs composition in the tissues of invertebrate aquatic organisms. While some other studies used both animal dungs and their feathers. Studies investigating the excreta of birds for HMs constituents are abounds (Leonzio et al., 2009; Sharma & Vashishat, 2017; Sohi et al. 2019). Asides wildlife dungs, Omonona et al (2019) have also discovered HMs in the plants, soil and water of Kainji Lake National Park in Nigeria and suggested contamination.

However, the sudden mass death of fish (Fig. 1) and staggered wildlife observed recently in and around River Ogun at Marguba range in Old Oyo National Park (OONP), after the first rainfall (pers. obs.) calls for investigation. Since wildlife are capable of excreting ingested HMs along with their dungs (Kler et al. 2014), understanding the health risk that might be posed by the River Ogun on wildlife and their users is important. This study therefore collected feaces of several species of wildlife from different spots around River Ogun and assessed them for HMs contamination.

Figure 1. Mass death of species of fish observed at River Ogun in Old Oyo National Park

2. Materials and Methods

2.1. Study area

This study was undertaken along the banks of River Ogun at Marguba range (in OONP), Oyo State, Nigeria. It remains one of the seven national parks in the country, until 2021 when 10 national parks were created in addition. It occupies an area of 2,512 km^2 which lies between latitude 8°10'N and 9°05'N and longitude 3°35'E and 4°20'E being about 910km close to Kano, 660km close to Abuja and Kaduna, 300km close to Lagos and 160km close to Ilorin. Common wildlife in the park includes roan antelope, kob, grey duiker, baboon, bush buck, water buck and warthog. Running through the park are four major rivers (R) that serve as drainage for all run-off water. While R. Tessi collects all runoff in the north-east of the park, R. Ogun, R. Owe and R. Owu collect all runoff along both the southern and central parts of the park (Oyeleke & Ogunniyi, 2017).

2.2. Data collection and analysis

With the help of rangers who had vast experience in identifying wildlife dungs, composite samples of fresh scat of mammals deposited in and around R. Ogun, located at Marguba range division of OONP were collected using plastic zip lock bags with the aid of hand gloves. Within August through September (2021), at least three to five representative samples of dungs of each wildlife species encountered along the banks of Ogun river were collected, air dried and analyzed for arsenic (As), lead (Pb), cadmium (Cd), cupper (Cu), chromium (Cr), nickel (Ni), cobalt (Co) and zinc (Zn), by using standard procedures as marked out by Udo et al. (2009) and Okalebo et al. (1993). The results were analyzed and compared with the use of one way analysis of variance and Tukey test ($p<0.05$) with statistical package of social science (SPSS). Values of means (±S.D) were determined from triplicate per sample.

3. Result and Discussion

Figure 2-7 showed the heavy metal constituents of dungs for seven species of wildlife; kob (K), patas monkey (PM), western hartebeest (WH), olive baboon (OB), cane rat (CR), civet cat (CC) and crocodile (C). Levels of accumulation of heavy metals in the feaces of wildlife significantly ($\alpha<0.05$) varies from species to species. The mean concentrations (±S.D) of Cu , Zn, Pb, Mn, Cd and Cr in wildlife feaces samples presented (in Fig. 2-7) ranged from 3.99 ± 0.56 (CR) to 27.09 ± 0.20 $mgkg^{-1}$ (C), 176.60 ± 8.30 (K) to 347.83 ± 3.35 $mgkg^{-1}$ (PM), 7.29 ± 0.04 (CC) to 43.07 ± 0.19 $mgkg^{-1}$ (C), 37.64 ± 1.39 (CC) to 157.57 ± 0.19 $mgkg^{-1}$ (C), 24.75 ± 0.48(WH) to 65.00±68 $mgkg^{-1}$ (C) and 2.63±0.05 (PM) to 5.76 ± 0.07 $mgkg^{-1}$ (C) respectively. This result is far more concentrated than that reported by Omonona et al. (2019) in the feaces of wildlife during the wet season (June, 2018) in Kanji Lake National Park, Nigeria; Cu (3.96 ± 3.40), Zn (7.68 ± 0.76) , Pb (0.26 ± 0.10), Mn (79.34 ± 47.56), Cd (0.36 ± 0.14) and Cr (0.62 ± 0.50). Thus, suggesting more contaminations and deleterious health implications for the wildlife of OONP, as larger quantities must have been absorbed before the fecal release. Consequently, the mass death of the fish observed (Fig. 1) and the staggered wildlife.

There were no traces of Ni and Co detection in all the wildlife feaces. Concentrations of Cd, Cr, Pb, Mn and Cu were significant and positively correlated (Table 1). Although, Co and Ni showed no presence, however a significant positive relationship existed between Cu and Pb ($r= 0.834^{**}$), Cd ($r= 0.841^{**}$), Mn ($r= 0.460^{*}$) and Cr ($r= 0.849^{**}$); Pb and Mn ($r= 0.678^{**}$), Cd ($r= 0.715^{**}$) and Cr ($r= 0.933^{**}$); Mn and Cr ($r= 0.784^{**}$); Cd and Cr ($r= 0.710^{**}$). In general, among the heavy metals analyzed, Cu (3.99±0.56) appeared to have the lowest concentrations in the feaces of cane rat, followed by Pb (7.29±0.04) in the feaces of civet cat and Cd (24.75±0.48) in feaces of western hartebeest, while Zn (347.83±3.35) had the most abundant concentrations in the feaces of patas monkey, followed by Mn (157.57±0.19) in the feaces of crocodile, Cd (65±0.68) in the feaces of crocodile and Pb (43.07±0.19) in the feaces of crocodile. With the exception of Zn which has the highest heavy metal concentrations in patas monkey, the mean concentrations (±S.D) of all other detectable heavy metals were highest in crocodile (C) more than any other wildlife. This is not surprising, as crocodile is the only wildlife that utilize the supposed contaminated R. Ogun most (Fig. 2-7).

In Nigeria, studies on toxicity of wildlife and their habitat using feaces as bio-indicator are poor. However, the study of Ijeomah et al (2015) identified heavy metals composition in the tissues of some aquatic organisms (water snails, crabs, periwinkles and oysters) to range from 1.213 to 2.403mg/kg for Cu, 0.057 to 0.813 for Pb, 0.038 to 0.087mg/kg for Cr and 0.020 to 0. 40mg/kg for Cd. These ranges are far less than the ones identified in this study. The high concentration of HMs in wildlife feaces could be indications that wildlife has a great potential in ameliorating the toxic effect of the HMs through excretion (feaces) than fish. However, with the crocodiles being the most contaminated among all the wildlife, it may suffice to assume that the aquatic habitat is more polluted with heavy metals than the terrestrial habitat. This may not be unconnected to the fact that crocodiles have more contact with the contaminated aquatic habitat (where aquatic animals like fish were consumed for their food) than all other wildlife in the terrestrial habitat. This is a pointer to the cause of sudden mass death of the fish in the region in 2020 (Fig. 1).

Possible means through wish heavy metals could find their ways into the river is through anthropogenic activities of the people leaving around the park. Adedoyin et al. (2018) has described the anthropogenic activities of the people around OONP as uncontrollable and disastrous. For instance, an area usually called Bush, not far from the park is noted for its mining activities. The effluent from this area usually finds their ways into the park. Sometimes, one could easily see the colourful traces of the chemicals diluting with the river at different spots along R. Ogun at Marguba range (pers. obs.). Since feaces sample of wildlife were collected near the contaminated river, our expectations that chemical analysis of wildlife feaces will reflect the heavy metals ingested through drinking of the water along with wildlife diets may be correct. However, the part way to heavy metal contamination of diets of wildlife species may be linked to the mining area. According to Pandey and Madhuri (2014), the deleterious effect of mining and other anthropogenic activities to animals, fish and human are probable cause of cancers of vital organs of the body both directly and indirectly. The previous work of Powell (2017) also established how mining could cause ecological hazard to wildlife co-existent.

Farming activities has been reported as the main occupation of most occupants around the boundary of the park. The active ingredients in most of the pesticides, herbicides and synthetic fertilizers may be another possible source of heavy metals that may likely find their ways into the river during and after rainfalls. These agricultural chemicals have been reported to be often overused and abused; thus posing lots of health risk to the end users (Wilson & Tisdell, 2001; Nazarian et al. 2013). Poaching is another activity that has been recorded to be relatively high in OONP (Akinsorotan, 2017; Adedoyin et al. 2018, Adewale & Alarape, 2020) and may also be a contributing factor. Spent ammunition or fragmented of Pb-containing bullets used by the poachers may either be directly or indirectly ingested by wildlife (most especially birds) or disintegrate into runoff water during rainfall to find its ways into R. river. The presence of fragmented Pb-containing bullets around rivers has been reported by Adewale and Alarape (2020).

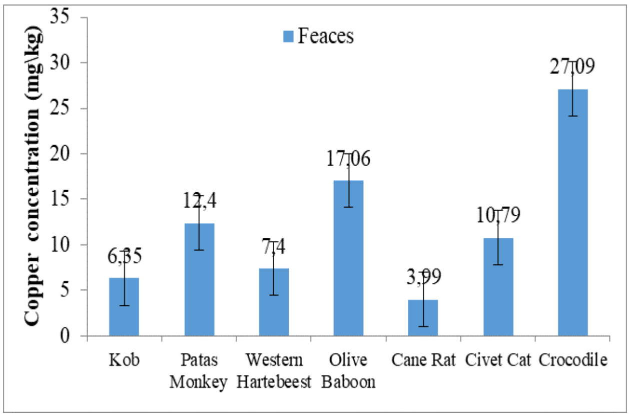

Figure 2: Variation in mean concentrations (±S.D) of copper (Cu) in wildlife feaces (Bars representing the standard deviation of the mean)

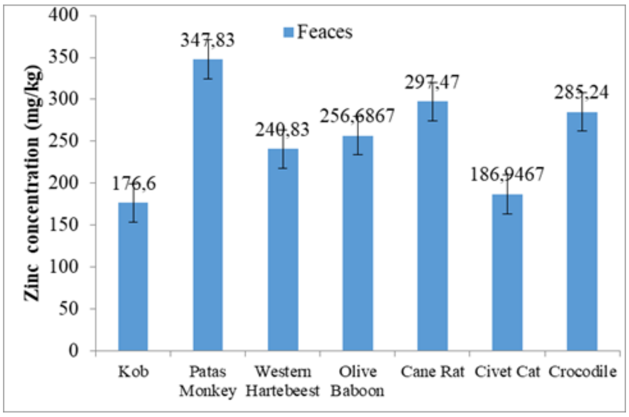

Figure 3: Variation in mean concentrations (±S.D) of Zinc (Zn) in wildlife feaces (Bars representing the standard deviation of the mean)

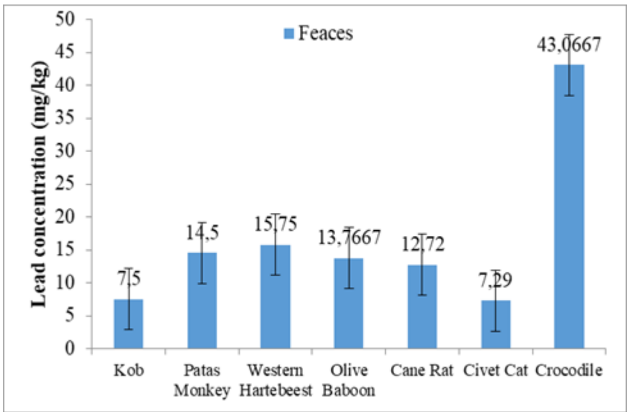

Figure 4: Variation in mean concentrations (±S.D) of lead (Pb) in wildlife feaces (Bars representing the stan23 dard deviation of the mean)

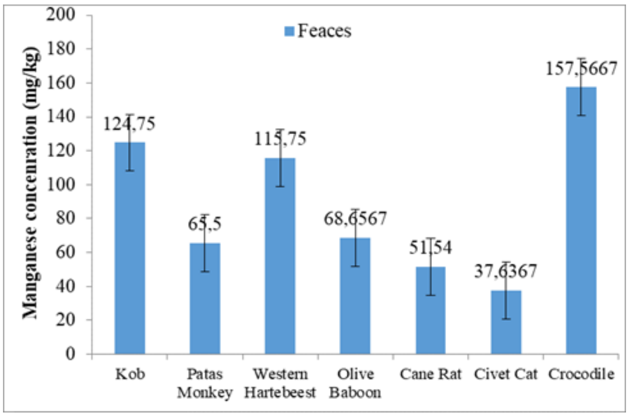

Figure 5: Variation in mean concentrations (±S.D) of manganese (Mn) in wildlife feaces (Bars representing the standard deviation of the mean)

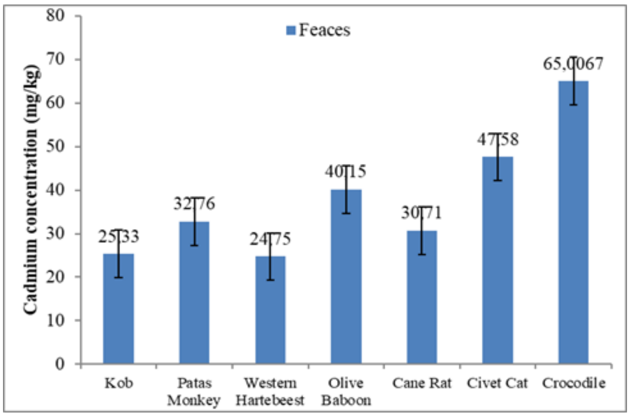

Figure 6: Variation in mean concentrations (±S.D) of cadmium (Cd) in wildlife feaces (Bars representing the standard deviation of the mean)

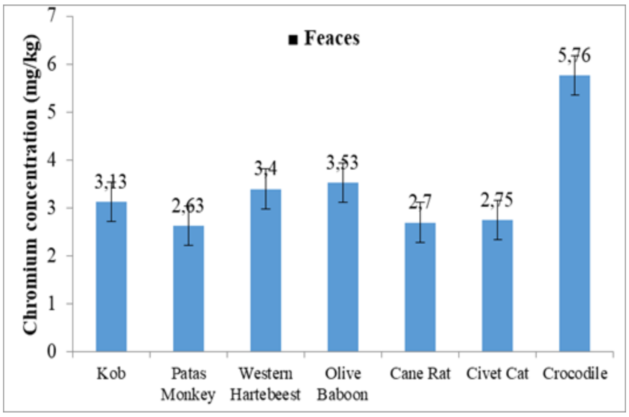

Figure 7: Variation in mean concentrations (±S.D) of chromium (Cr) in wildlife Feaces (Bars representing the standard deviation of the mean)

Table 1: Correlation analysis

	Wildlife	Cu	Zn	Pb	Mn	Cd	Co	Cr
Cu	0.544*							
Zn	0.077ns	0.260ns						
Pb	0.563**	0.834**	0.401ns					
Mn	-0.038ns	0.460*	-0.088ns	0.678**				
Cd	0.797**	0.841**	0.100ns	0.715**	0.231ns			
Co	-	-	-	-	-	-		
Cr	0.524*	0.849**	0.088ns	0.933**	0.784**	0.710**	-	
Ni	-	-	-	-	-	-	-	-

ns: not significant, (**) : significant at p≤0.01, and (*)**:** significant at p≤0.05

4. Conclusion

The result of this study asserts that wildlife bio-accumulated heavy metals, which was evident from their feaces and most likely as a result of various anthropogenic activities of the inhabitants of the surrounding villages of the park. Of these anthropogenic activities, mining effluents, which linked to the river Ogun from outside the park was thought to pose the greatest danger. Also, almost all the metals were more concentrated in crocodile than all other wildlife, thus implicating R. Ogun as major likely source of the pollution and as a probable evidence for the mass death of fish observed in the recent time. Regular evaluation of wildlife feaces as well as other bio-indicators of pollution (plant, soil, water, wildlife hair etc) would go a long way to forecast harbinger of doom. More studies should be carried out on the health status of the fish and other aquatic organisms of R. Ogun, in the park.

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