



Proceeding Paper Unraveling Toxic Heavy Metal Accumulation in the Body Profile of Cattle Egret (*Bulbus ibis*) and the Implication for Environmental Monitoring: A Case of Punjab Province, Pakistan[†]

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Abstract: The accumulation of heavy metals in ecosystems can have potential toxic effects on human health. This is one of the most prominent consequences of anthropogenic developments, which threaten biodiversity and the quality of the environment. Industrial effluents and urban wastes contain a large number of heavy metals (Cadmium, Lead, Copper, and Zinc) that are highly toxic to biological systems. The present study investigated the status of heavy metals, including Zinc (Zn), Manganese (Mn), Lead (Pb), Copper (Cu), Cadmium (Cd), and Cobalt (Co), in the bones, feathers, hearts, muscles, and lungs of the cattle egret (Bubulcus ibis). Samples of cattle egrets were collected from the Faisalabad division with the help of the concerned wildlife department. Heavy metals were assessed using atomic absorption spectrophotometry and the protocols supplied by Perkin-Elmers Corp. The results revealed that the trend of heavy metals in bones was Zn > Pb > Cu > Mn > Cd > Co, and the same trend was followed in the case of feathers and hearts. However, the trend of heavy metals in muscles and lungs was in the order Zn > Mn > Cu > Co > Cd. Heavy metals were present in the bones, feathers, hearts, muscles, and lungs of cattle egrets. The contamination levels were ascertained in this study, which indicated that cattle egret is useful for biomonitoring heavy metals. The present study provides baseline data that could be further compared with data from other locations for monitoring heavy metal pollution. These investigations will be helpful for assessing heavy metal accumulation under semi-arid climates.

Keywords: heavy metals; toxic effects; industrial effluents; cattle egret; biomonitoring

1. Introduction

Heavy metal contamination is a great concern at the global, regional, and local levels and influences the functional and structural integrity of ecosystems [1]. Heavy metals are ubiquitous, highly persistent, and non-biodegradable with long biological half-lives [2]. Toxic concentrations of heavy metals affect the central nervous system and disrupt the functioning of internal organs of birds [3]. Heavy metal contamination, one of the most prominent consequences of anthropogenic developments, threatens both biodiversity and the quality of the environment [4]. Heavy metals have been identified worldwide in diverse environmental compartments. Many studies have been carried out to investigate the level of their occurrence, accumulation, and distribution in birds' bodies [5].

Monitoring of trace metal levels in different environmental compartments is of prime importance because of their bio-accumulative characteristics and several health risks to living organisms [6]. Studies have reported a variety of health effects caused by trace metal contaminants, including reproductive impairments, kidney failure, and neurological disorder. Many studies have shown that trace metals affect reproductive health and result



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Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). in increased embryo mortality, lighter eggs, failure of nest building, spermatogenesis failure, decreased egg production, eggshell thinning, reduced hatching success, and behavioral changes in birds [7]. Therefore, for the control of trace metal emission and threat to humans and wildlife, some agencies are concerned with monitoring trace metals in different environmental media at both the governmental and public levels [8]. Therefore, the present study was designed with the objective to determine the level of different heavy metals in different body parts of cattle egrets and compare heavy metal concentrations in cattle egrets residing/feeding in sewerage and canal-irrigated areas.

2. Methods

Samples were collected from two study sites comprising sewerage and canal-irrigated areas in Faisalabad, Punjab, Pakistan. Faisalabad is one of the major industrial hubs of Pakistan [9]. The study areas are also described in detail in [10]. The exponential population growth of the concerned region, coupled with the development of extensive steel factories, industrial activities, tanneries, leather garments, pigment factories, and sport equipment manufacturers, has resulted in widespread environmental degradation [5].

2.1. Sample Collection and Preparation

Samples of 8 cattle egrets were collected from each of the sewerage and canal-irrigated areas; the samples consisted of 4 males and 4 females from one site, and 2 males and 2 females from the other site. The samples were carried in cages to the animal laboratory. All of the cattle egret organs, i.e., bones, feathers, hearts, muscles, and lungs, were removed and kept in a refrigerator before analysis. The samples (bones, feathers, lungs, muscles and hearts) were oven dried at 75 °C to produce a uniform dry mass, following previous descriptions [11]. The dry samples were converted into a fine powder using a mortar and pestle, and then transferred to desiccators for evaporating moisture contents.

2.2. Digestion and Measurement of the Samples

The samples were digested by following a protocol described in previous studies [12]. A small portion, i.e., 0.200 g of each sample, was measured and digested by using Selenium/Sulphuric acid mixture (2.5 mL). The samples were heated at approximately 200 °C, 3 mL of H_2O_2 (30%) was added at room temperature, and the samples were again exposed to heating at 330 °C for two hours. Heavy metals were subsequently analyzed by means of an atomic absorption spectrophotometer (model 9100 Pye Unicamp), and the average mean values were recorded as the concentrations of metals in mg/Kg. All the data were subjected to analysis of variance (Anova), and the results were compared by using Fisher's least significant Difference (LSD) test. All statistical tests were performed by using SAS statistical software.

3. Results and Discussion

3.1. Assessment of Heavy Metals in the Body Profile of Cattle Egrets Collected from Sewerage

The results revealed that among all organs of these cattle egrets, maximum concentrations of the heavy metals Zn (2.16), Pb (1.65), Cu (0.63), Mn (0.4), Cd (0.05), and Co (0.03) were recorded in feathers, followed by lungs with Zn (1.11), Pb (0.84), Cu (0.41), Mn (0.38), Cd (0.01), and Co (0.01) heavy metals. An analysis of these cattle egrets' bones revealed that they contained Zn (1.05), Pb (0.87), Cu (0.27), Mn (0.15), Cd (0.03), and Co (0.01). The overall trend of heavy metal accumulation in the body profile of cattle egrets collected from the sewerage area was Zn > Pb > Cu > Mn > Cd > Co (Figure 1).

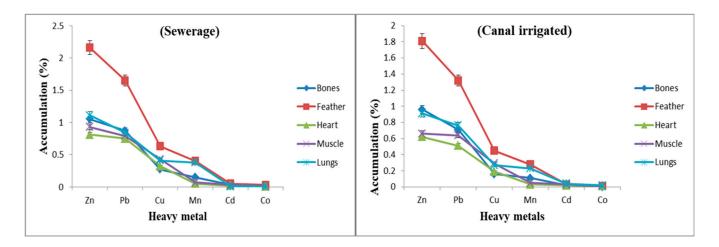


Figure 1. Assessment of heavy metals in the body profile of cattle egrets collected from sewerage and canal-irrigated areas.

3.2. Assessment of Heavy Metals in the Body Profile of Cattle Egrets Collected from Canal-Irrigated Area

The results revealed that among all organs of these cattle egrets, the maximum concentrations of the heavy metals Zn (1.81), Pb (1.32), Cu (0.45), Mn (0.28), Cd (0.03), and Co (0.01) were recorded in feathers, followed by lungs with Zn (0.91), Pb (0.76), Cu (0.27), Mn (0.23), Cd (0.04), and Co (0.02) heavy metals. An analysis of these cattle egrets' bones revealed that they contained Zn (0.96), Pb (0.71), Cu (0.16), Mn (0.11), Cd (0.02), and Co (0). The overall trend of heavy metal accumulation in the body profile of cattle egrets collected from the canal-irrigated area was Zn > Pb > Cu > Mn > Cd > Co (Figure 1).

In the comparison of the samples collected from the sewerage and canal-irrigated areas, maximum heavy metal concentrations were found in the sewerage samples. Heavy metals in the tissues and feathers of different species of birds have been reported in previous studies [13–15]. The results of the present study are in line with the findings of [16] Lucia et al. (2010), who recorded Cd in muscles and feathers of graylag goose, mallard, red knot, and gray plover. The results of the present experiment are in agreement with a previous study [17], which reported very low Cd concentration in the feathers of eiders. The survival and production of animals are impacted by high metal contamination levels [18]. Chronic metal exposure in birds can have negative effects on their development, ability to reproduce, behavior, resistance, and other physiological processes [19]. Cattle egrets can be collected easily, and they can also be helpful for long-term study of potential environmental dangers. The findings of this study provide credence to the notion that cattle egrets might be useful tools for environmental biomonitoring.

4. Conclusions

The present study determined the levels of different heavy metals in different body parts of egrets and compared the concentrations of heavy metals in egrets living/raised in a sewage irrigation area and a canal irrigation area. It is concluded that the cattle egret has a certain application value in the biological monitoring of heavy metals. This study can be further compared with data collected from monitoring heavy metal pollution at other sites and can help assess heavy metal accumulation in semi-arid climates.

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References

- 1. Qadir, A.; Malik, R.N. Assessment of an index of biological integrity (IBI) to quantify the quality of two tributaries of river Chenab, Sialkot, Pakistan. *Hydrobiologia* **2009**, *621*, 127–153. [CrossRef]
- Burger, J.; Gochfeld, M.; Sullivan, K.; Irons, D. Mercury, arsenic, cadmium, chromium lead, and selenium in feathers of pigeon guillemots (*Cepphus columba*) from Prince William Sound and the Aleutian Islands of Alaska. *Sci. Total Environ.* 2007, 387, 175–184. [CrossRef] [PubMed]
- 3. Lee, C.S.L.; Li, X.; Shi, W.; Cheung, S.C.N.; Thornton, I. Metal contamination in urban, suburban and country park soils of Hong Kong: A study based on GIS and multivariate statistics. *Sci. Total Environ.* **2006**, *356*, 45–61. [CrossRef] [PubMed]
- Kim, J.-Y.; Oh, S.; Park, Y.-K. Overview of biochar production from preservative-treated wood with detailed analysis of biochar characteristics, heavy metals behaviors, and their ecotoxicity. J. Hazard. Mater. 2020, 384, 121356. [CrossRef] [PubMed]
- 5. Qadir, A.; Malik, R.N.; Husain, S.Z. Spatio-temporal variations in water quality of Nullah Aik-tributary of the river Chenab, Pakistan. *Environ. Monit. Assess.* 2008, 140, 43–59. [CrossRef] [PubMed]
- Deng, H.; Zhang, Z.; Chang, C.; Wang, Y. Trace metal concentration in Great Tit (*Parusmajor*) and Greenfinch (*Carduelissinica*) at the Western Mountains of Beijing, China. *Environ. Pollut.* 2007, 148, 620–626. [CrossRef] [PubMed]
- Dmowski, K. Birds as biomonitors of heavy metal pollution: Review and examples concerning European species. *Acta Ornithol.* 1997, 34, 1–26.
- Abdullah, M.; Fasola, M.; Muhammad, A.; Malik, S.A.; Bostan, N.; Bokhari, H.; Kamran, M.A.; Shafqat, M.N.; Alamdar, A.; Khan, M.; et al. Avian feathers as a non-destructive bio-monitoring tool of trace metals signatures: A case study from severely contaminated areas. *Chemosphere* 2014, 119, 553–561. [CrossRef] [PubMed]
- 9. Aftab, Z.; Ali, L.; Khan, A.M.; Robinson, A.C.; Irshad, I.A. *Industrial Policy and the Environment in Pakistan*; NC/PAK/97/018 Environmental Policy; United Nations Industrial Development Organization: Vienna, Austria, 2000; pp. 1–117.
- Khan, M.; Mohammad, A.; Ahad, K.; Katsoyiannis, A.; Malik, S.A.; Abdullaha, M.; Rashid, A.; Fasola, M.; Hussain, A.; Bokhari, H.; et al. Cattle egrets as a biosentinels of persistent organic pollutants exposure. *Environ. Geochem. Health* 2013, *36*, 375–384. [CrossRef] [PubMed]
- 11. Murtala, B.A.; Abdul, W.O.; Akinyemi, A.A. Bioaccumulation of Heavy Metals in Fish (*Hydrocynus forskahlii, Hyperopisus bebe occidentalis* and *Clarias gariepinus*) Organs in Downstream Ogun Coastal Water, Nigeria. J. Agric. Sci. **2012**, *4*, 51. [CrossRef]
- 12. Scheifler, R.; Cœurdassier, M.; Morilhat, C.; Bernard, N.; Faivre, B.; Flicoteaux, P.; Giraudoux, P.; Noël, M.; Piotte, P.; Rieffel, D.; et al. Lead concentrations in feathers and blood of common blackbirds (*Turdus merula*) and in earthworms inhabiting unpolluted and moderately polluted urban areas. *Sci. Total Environ.* **2006**, *371*, 197–205. [CrossRef]
- 13. Malik, R.N.; Zeb, N. Assessment of environmental contamination using feathers of *Bubulcus ibis* L.; as a biomonitor of heavy metal pollution, Pakistan. *Ecotoxicology* **2009**, *18*, 522–536. [CrossRef] [PubMed]
- 14. Jayakumar, R.; Muralidharan, S. Metal Contamination in Select Species of Birds in Nilgiris District, Tamil Nadu, India. *Bull. Environ. Contam. Toxicol.* **2011**, *87*, 166–170. [CrossRef]
- Markowski, M.; Kaliński, A.; Skwarska, J.; Wawrzyniak, J.; Bańbura, M.; Markowski, J.; Zieliński, P.; Bańbura, J. Avian Feathers as Bioindicators of the Exposure to Heavy Metal Contamination of Food. *Bull. Environ. Contam. Toxicol.* 2013, 91, 302–305. [CrossRef] [PubMed]
- Lucia, M.; André, J.-M.; Gontier, K.; Diot, N.; Veiga, J.; Davail, S. Trace Element Concentrations (Mercury, Cadmium, Copper, Zinc, Lead, Aluminium, Nickel, Arsenic, and Selenium) in Some Aquatic Birds of the Southwest Atlantic Coast of France. *Arch. Environ. Contam. Toxicol.* 2010, *58*, 844–853. [CrossRef]
- 17. Burger, J.; Gochfeld, M.; Jeitner, C.; Snigaroff, D.; Snigaroff, R.; Stamm, T.; Volz, C. Assessment of metals in down feathers of female common eiders and their eggs from the Aleutians: Arsenic, cadmium, chromium, lead, manganese, mercury, and selenium. *Environ. Monit. Assess.* **2008**, 143, 247–256. [CrossRef]
- 18. Janssens, E.; Dauwe, T.; Pinxten, R.; Bervoets, L.; Blust, R.; Eens, M. Efects of heavy metal exposure on the condition and health of nestlings of the great tit (Parus major), a small songbird species. *Environ. Pollut.* **2003**, *126*, 267–274. [CrossRef] [PubMed]
- 19. Dauwe, T.; Jaspers, V.; Covaci, A.; Schepens, P.; Eens, M. Feathers as a nondestructive biomonitor for persistent organic pollutants. *Environ. Toxicol. Chem. Int. J.* 2005, 24, 442–449. [CrossRef] [PubMed]

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