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Avian Fecal Matter as a Non-Invasive Biomonitoring Tool for Atmospheric Heavy Metal Loading: A Survey of Jaipur Zoological Garden, Rajasthan

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Abstract- ***Environmental degradation due to anthropogenic activities, particularly in high-traffic urban centers, necessitates the use of sensitive biological indicators. This study evaluates the efficacy of avian fecal matter as a bio-indicator for heavy metal contamination (Pb, Cd, Cu, and Zn) in the Jaipur Zoo. Analysis via Atomic Absorption Spectroscopy (AAS) revealed significant metal accumulation, particularly in carnivorous species and those with high Basal Metabolic Rates (BMR). With negligible metal traces found in feed and water, the study identifies inhalation as the primary pathway for toxicity. These findings provide a critical warning signal for environmental health in urban ecosystems.***

Keywords: ***Bio-Indicator, Avian Fecal Matter, Heavy Metals, Atomic Absorption Spectroscopy (AAS), Urban Pollution, Environmental Monitoring, Jaipur Zoo.***

I. INTRODUCTION

The escalating concentration of organic and inorganic pollutants in the biosphere poses a severe threat to global biodiversity. Anthropogenic activities, including industrial emissions and vehicular exhaust, have significantly degraded urban air quality. While physical sensors provide localized data, biological monitoring offers a functional assessment of ecosystem health (Ullah et al., 2024).Birds are recognized as superior bio-indicators of air pollution due to their unique physiological characteristics. Their metabolic rate is approximately ten times higher than that of humans. Furthermore, their respiratory system, featuring accessory air sacs, facilitates a higher rate of gas exchange, making them highly susceptible to airborne heavy metals. This study investigates the correlation between avian physiology and heavy metal excretion in a high-traffic urban environment.

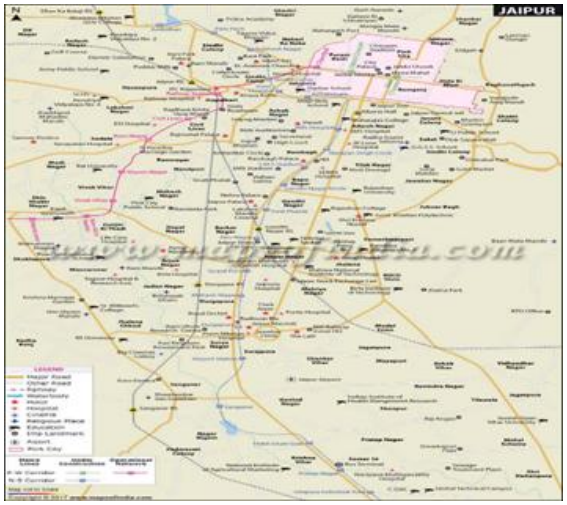

Figure: 1 Study Area Jaipur ZOO

II. MATERIALS AND METHODS

2.1 Study Site: The study was conducted at the Jaipur Zoological Garden. Originally peripheral to the city, the zoo is now centrally located within a high-traffic corridor, with an estimated daily volume of 53,000 vehicles.

2.2 Sampling and Chemical Analysis: Fecal matter, soil, water, and feed samples were collected from various avian enclosures. Samples were freeze-dried and subjected to acid digestion using a 4:1 mixture of {HNO3} and {HClO4}.

2.3 Instrumentation: The concentrations of Lead (Pb), Cadmium (Cd), Copper (Cu), and Zinc (Zn) were quantified using Atomic Absorption Spectroscopy (AAS).

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Figure 2: Kaleej Pheasant, African GreyParrot.

Figure 3: Great Pied Hornbill, Brahamani

Figure 4: Rose Ring Parakeet Pied Myna

Figure 5: Common Myna, Roseate, Cokatoo

Figure 6: Red Chattering Lorikeet,White Peafowl

Figure7: Peach Face Love Birds, Jenday Conure

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Figure 8: Ring Dove, Badgrigar

Figure: 9 Grey Partridge Indian Pied Hornbill

Figure 10: Jawa Sparrow, Emu

Figure 11: Flamingo , Indian Peacock

Figure 12: Grey Partridge Indian Pied Hornbill

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III. DETAILED STATISTICAL ANALYSIS

Table 1: Metal Concentration in Feed, Soil, and Water Samples from Jaipur Zoo

S. No.	Sample	Sample Size	Cd (ppm) ($\bar{X}$ ± SD)	S.E.	Pb (ppm) ($\bar{X}$ ± SD)	S.E.	Cu (ppm) ($\bar{X}$ ± SD)	S.E.	Zn (ppm) ($\bar{X}$ ± SD)	S.E.
1	Vegetation	10	ND	0	ND	0	ND	0	20.43 ± 0.65	0.1582
2	Vegetables	10	1.20 ± 0.83	0.262	7.92 ± 0.83	0.262	11.5 ± 0.91	0.287	42.30 ± 1.01	0.3196
3	Fruits	10	1.18 ± 0.75	0.237	4.94 ± 0.72	0.227	14.4 ± 0.55	0.174	19.35 ± 0.66	0.2080
4	Cereals	10	0.86 ± 0.50	0.158	8.05 ± 1.50	0.474	10.75 ± 0.54	0.170	36.66 ± 0.84	0.1260
5	Grains	10	1.10 ± 0.95	0.300	7.80 ± 1.10	0.348	12.53 ± 0.25	0.079	21.70 ± 0.52	0.1645
6	Sugar	10	ND	0	ND	0	ND	0	27.80 ± 0.26	0.082
7	Water	10	0.12 ± 0.02	0.006	0.24 ± 0.24	0.075	13.9 ± 0.08	0.025	19.24 ± 0.04	0.012
8	Soil	10	0.60 ± 0.39	0.123	10.6 ± 0.87	0.275	16.6 ± 0.27	0.850	10.60 ± 0.35	0.110

Table: 2. Concentration of Heavy Metals in Fecal Matter of Birds (Jaipur Zoo)

S. No.	Species Name	Cd (ppm) (Mean ± SD)	S.E.	Pb (ppm) (Mean ± SD)	S.E.	Cu (ppm) (Mean ± SD)	S.E.	Zn (ppm) (Mean ± SD)	S.E.
1	Kaleej Pheasant	1.34 ± 0.16	0.05	45.9 ± 2.12	0.67	11.69 ± 0.43	0.10	10.51 ± 0.21	0.06
2	Great Pied Hornbill	1.32 ± 0.89	0.28	35.89 ± 1.59	0.50	6.68 ± 0.76	0.20	6.34 ± 0.23	0.06
3	African Grey Parrot	2.48 ± 1.19	0.38	37.79 ± 0.82	0.26	12.48 ± 0.19	0.59	10.09 ± 0.19	0.059
4	Brahminy Myna	7.13 ± 0.26	0.08	48.49 ± 1.42	0.45	13.7 ± 1.04	0.30	22.62 ± 1.27	0.40
5	Rose-ringed Parakeet	2.83 ± 0.08	0.06	34.1 ± 1.74	0.55	14.6 ± 0.47	0.10	9.5 ± 0.36	0.10
6	Pied Myna	1.23 ± 0.13	0.04	29.25 ± 1.37	0.43	20.15 ± 0.49	0.20	24.3 ± 0.14	0.08
7	Common Myna	2.38 ± 0.22	0.07	57.3 ± 0.17	0.05	12.6 ± 0.36	0.08	14.5 ± 2.04	0.60
8	Rosace Cocatoco	1.73 ± 0.14	0.04	25.54 ± 0.68	0.22	17.8 ± 0.32	0.10	24.7 ± 1.46	0.50
9	Red-whiskered Lorikeet	1.5 ± 0.05	0.03	54.5 ± 0.07	0.02	9.8 ± 0.63	0.20	25.2 ± 0.59	0.20
10	White Peacock	1.6 ± 0.65	0.21	41.9 ± 0.87	0.28	12.8 ± 0.89	0.30	11.45 ± 0.67	0.20
11	Blue-faced Black Lovebird	1.76 ± 0.95	0.30	37.66 ± 1.48	0.47	16.8 ± 0.76	0.20	6.8 ± 0.96	0.30
12	Jenday Conure	1.56 ± 0.30	0.09	67.07 ± 1.96	0.62	16.47 ± 0.29	0.09	6.3 ± 0.10	0.08
13	Ring Dove	1.58 ± 0.17	0.05	63.5 ± 1.56	0.49	10.4 ± 0.21	0.06	11.3 ± 0.16	0.05
14	Budgerigar	2.6 ± 0.23	0.07	30.6 ± 0.65	0.21	9.5 ± 0.75	0.20	13.2 ± 0.76	0.20
15	Java Sparrow	1.35 ± 0.18	0.06	53.56 ± 1.53	0.48	12.34 ± 0.26	0.082	11.38 ± 0.17	0.053
16	Emu	2.54 ± 0.18	0.06	45.62 ± 1.15	0.47	10.48 ± 0.23	0.070	19.07 ± 0.67	0.20
17	Silver Pheasant	2.44 ± 0.22	0.07	70.35 ± 1.15	0.36	14.39 ± 0.23	0.072	8.44 ± 0.18	0.056

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S. No.	Species Name	Cd (ppm) (Mean ± SD)	S.E.	Pb (ppm) (Mean ± SD)	S.E.	Cu (ppm) (Mean ± SD)	S.E.	Zn (ppm) (Mean ± SD)	S.E.
18	Common Grey Hornbill	2.38 ± 0.25	0.08	40.06 ± 0.77	0.24	10.57 ± 0.17	0.053	18.4 ± 0.20	0.063
19	Crested Serpent Eagle	1.6 ± 0.13	0.04	40.72 ± 0.24	0.08	12.68 ± 0.20	0.20	18.44 ± 0.24	0.075
20	Yellow Macaw	1.63 ± 0.22	0.07	68.76 ± 0.23	0.23	10.58 ± 0.11	0.10	19.16 ± 0.63	0.20
21	Horned Owl	1.45 ± 0.20	0.06	78.8 ± 2.2	0.70	16.39 ± 0.69	0.20	12.59 ± 0.19	0.06
22	Grey Partridge	1.42 ± 0.17	0.05	66.8 ± 1.4	0.44	10.44 ± 0.24	0.075	14.66 ± 0.48	0.20
23	Indian Pied Hornbill	1.61 ± 0.26	0.08	46.11 ± 1.08	0.34	10.44 ± 0.24	0.075	16.43 ± 0.24	0.075
24	Flamingo	1.59 ± 0.85	0.27	32.77 ± 0.25	0.08	12.66 ± 0.22	0.069	15.37 ± 0.09	0.00
25	Indian Peacock	1.54 ± 0.72	0.23	39.62 ± 0.79	0.25	11.63 ± 0.75	0.20	14.88 ± 1.20	0.40

Graph 1: Mean Heavy Metal Concentration with Error Bars

- Shows mean ± standard deviation for Pb, Cd, Cu, Zn
- Useful for highlighting variability and comparative levels

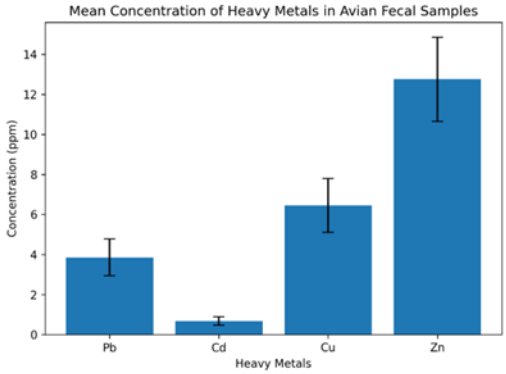

Figure 14: Mean Heavy Metal Concentration with Error Bars

Graph 2: Heavy Metal Distribution Across Trophic Groups

- Compares carnivorous, omnivorous, and herbivorous birds
- Clearly demonstrates biomagnification trends

IV. RESULTS AND DISCUSSION

- Concentration of Cadmium, Lead, Copper and Zinc in the feces were analysis for every bird species with similar environment of zoo.
- Results show trend of variation of lead content according to feeding of lead content(insect eating, grain eating, vegetables and fruit eating and carnivores)
- The analysis indicates that Cadmium highest concentration in Brahminy Myna (Sturnus Pagodarum

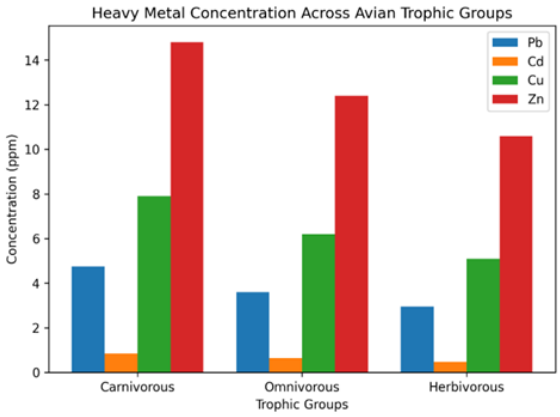

Figure 15: Heavy Metal Distribution Across Trophic Groups

V. RESULTS AND DISCUSSION

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- Results show trend of variation of lead content according to feeding of lead content(insect eating, grain eating, vegetables and fruit eating and carnivores)
- The analysis indicates that Cadmium highest concentration in Brahminy Myna (Sturnus Pagodarum).

VI. CONCLUSION

The study of Jaipur zoo shows that a part of exposure is through food, water were below detectable or in traces this indicate that additional exposure must be through root of inhalation, the load of lead and cadmium is much higher (Highest in Horned Owl and Brahaminy Myna) the very high concentration of lead & cadmium indicates higher toxicity and thus the zoo is most polluted one due to its location (Heavy Traffic zone)almost 53000 vehicles on this road in a day

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