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HEAVY METALS CONCENTRATION IN EXCRETA OF FREE LIVING WILD BIRDS AS INDICATOR OF ENVIRONMENTAL CONTAMINATION

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ABSTRACT

The purpose of this study was to determine the concentrations of heavy metals (Cd, Pb, Fe, Cr, Cu, Ni, Zn and Mn) in excreta of eight wild bird species so that it can utilized as a indicator for environmental contamination, The blue rock pigeon recorded lowest concentration of as (0.87 ± 0.18 ppm), Cd (0.28 ± 0.19 ppm), Cr (3.42 ± 0.12 ppm), Fe (1611 ± 519 ppm), Ni (9.98 ± 1.53 ppm) and Mn (128.66 ± 32.87 ppm) and cattle egret recorded lowest concentration of Pb (12.15 ± 3.22 ppm), Cu (32.35 ± 17.73 ppm) and Zn (196.94 ± 113.53 ppm) in the faeces. However, common myna recorded highest level of as (8.92 ± 3.35 ppm), Cr (109.16 ± 34.35 ppm), Fe (33788 ± 11856 ppm), Ni (53.78 ± 14.00 ppm), Zn (721.81 ± 125.84 ppm) and Mn (221.78 ± 112.33 ppm), red wattled lapwing recorded highest level of Cd (48.79 ± 19.27 ppm) and Pb (864.03 ± 383.83 ppm) and common babbler recorded highest level of Cu (150.75 ± 110.58 ppm). This variation in levels of metal concentrations may be attributed to different feeding behaviors of different species. Moreover, present observations also indicated that age groups as well as sexes may be a factor causing a wide range in the concentration of As, Cd, Pb, Fe, Cr, Cu, Ni, Zn, Mn in these species. Thus the concentrations of heavy metals recorded in the present studies suggested that excreta could be considered as an indicator of heavy metal contamination in wild birds.

INTRODUCTION

Heavy metal toxicities are of major concern in wild avian species. Once a metal has entered the body it can be stored or accumulated, or it can be excreted. In recent years there has been growing interest in using bioindicators for monitoring environmental pollution with heavy and toxic metals. Birds are traditional objects of biological monitoring in polluted ecosystems. Extensive studies on heavy metal concentration in birds have been conducted in many polluted regions (Mochizuki *et al.*, 2002; Kalisinska *et al.*, 2004). Recently, some researchers explored the potential of monitoring metal pollution using wild species such as doves (*e.g.*, *Columba livia*), pigeons (*Forma urbana*), and great tits (*Parus major*) (Janiga and Zemberyova, 1998; Nam *et al.*, 2004; Hoff Brait and Antoniosi Filho, 2011). These species are ideal bioindicators because they are common and widely distributed and have fast metabolic rates.

According to Wildlife Protection Act 1972, the capturing and killing of birds is legally banned by Govt. of India, therefore any analytical studies on the tissues of these animals are beyond the reach of scientists working in this area. Moreover, in India studies on heavy metal contamination in birds are limited. As the heavy metals have the potential for bioaccumulation and biomagnification in the food chains (Zhuang *et al.*, 2009). So the faecal material as indicator of metal pollution has shown to reflect the metal pollution level well in environment and food items, indicating especially the food chain contamination. Thus, excreta of bird is the only source, which if analyzed can give an assessment of the harmful of environmental contaminants on these animals.

The paper deals with the use excreta as indicator of environmental impact of heavy metals on wild birds with different feeding habits as clues for their use in management strategies and conservation of birds.

MATERIALS AND METHODS

Dry excreta of different bird species (blue rock pigeon, *Columba livia*; eurasian collared dove, *Streptopelia decaocto*; rose ringed parakeet, *Psittacula krameri*; common myna, *Acridotheres tristis*; house crow, *Corvus splendens*; common babbler, *Turdoides caudatus*; cattle egret, *Bubulcus ibis* and red wattled lapwing, *Vanellus indicus* were collected from their roosting , foraging and nesting sites in Punjab Agricultural University (agrifields, orchards, residences), dairy farm of Guru Angad Dev Veterinary and Animal Sciences University and residences of Ludhiana city during January 2010 to December 2011. These excreta samples were labeled appropriately with the source, time and date of collection.

The dry excreta samples of different bird species were pooled, 0.3-0.5 g excreta sample of each species taken and 4mL of conc. HNO_3 was added. These samples are then digested in microwave at 121ºC for 52 minutes. The final volume was made to 25mL with distilled water and the solution was filtered.

The digested samples were analysed for heavy metals like Arsenic (As), cadmium (Cd), lead (Pb), iron (Fe), chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn) and manganese (Mn) by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICAP-AES). The readings taken on ICAP-AES were converted into parts per million (ppm = μg/g).

The data for different heavy metals in different bird species was statistically analysed by one way ANOVA.

RESULTS AND DISCUSSION

The heavy metals were studied in 5-15 pellets of different bird species. As, Cd and Pb are included in the category of non-essential elements and toxic whenever present. The others like Fe, Cr, Cu, Ni, Zn, Mn are essential elements needed in body to perform some specific functions. But all these essential elements are also toxic when present above threshold levels in human beings and birds too. All these heavy metals have been found to be present in excreta of all species and the concentration of each heavy metal is shown in Table 1.

The concentrations of heavy metals are usually low (1 ppm wet weight, which approximately represents 3 ppm dry weight) in most living organisms (Braune and Noble, 2009). In the present studies the concentration of As was below this value in excreta of blue rock pigeon, rose ringed parakeet, house crow and cattle egret and above this range in rest of the species i.e. eurasian collared dove, common myna, common babbler and red wattled lapwing. Thus, lowest concentration of As was in excreta of blue rock pigeon and it was its 2-fold in rose ringed parakeet, 3-fold in cattle egret, 6-fold in common babbler, 7-fold in eurasian collared dove, 9-fold in red wattled lapwing and 10-fold i.e. maximum in common myna. Highly toxic inorganic as found in some seabirds may act as an endocrine disruptor, bring about the death of an individual, produce sublethal effects, or disrupt reproduction (Kunito *et al.,* 2008). The type of food eaten by birds plays a predominant role in the as amounts they would accumulate. However, observations in the present studies reveal that the grainivorous blue rock pigeon has recorded lowest As in the faeces while the omnivorous common myna which lies high on a food chain has highest level of As but this gets greatly excreted in the faeces preventing it from its ill effects and thus helping this species to be dominant over others in agroecosystems as reported by Islash (2010).

The statistical data revealed that concentration of Cd varies significantly in eight species studied. Cd concentration was lowest in excreta of blue rock pigeon and it was its 7- fold in common babbler and cattle egret, 8- fold in rose ringed parakeet, 10-fold in eurasian collared dove, 14-fold in house crow, 36-fold in common myna and 174-fold *i.e.* highest in red wattled lapwing The high Cd accumulation in kidney demonstrates the role of this organ in the detoxification process and storage of nonessential elements. Cd is also responsible for upset-ting the activity of a number of cellular enzymes. It produces tetratogenic, mutagenic and carcino-genic effects. At higher concentrations, it may cause kidney damage, altered behavior, suppression of egg production, egg shell thinning and testicular damage. Battaglia *et al.* (2005) and Toman *et al.* (2005) inferred that kidney damage occurred in many species of birds when the Cd levels approached 20 ppm. Bravo *et al.* (2005) reported Cd level of 7.25 mg/L in plasma (2000 fold of Cd as found in human plasma) and high concentration *i.e.* 13.93 μg/g in excreta of black vulture (*Coragyps atratus*). Thus the concentration of Cd in the present studies lies in toxic range in excreta of red wattled lapwing (48.79 ppm). However, Burger and Gochfeld (2000a) considered Cd concentration of 2μg/g as a threshold concentration in feathers that may have adverse effects in kidneys. The concentration of Cd was greater in excreta of seven bird species (except blue rock pigeon) as compared to its concentration in feathers.

The statistical analysis revealed that concentration of Pb significantly varies in eight species. The concentration of Pb was lowest in excreta of cattle egret and it was its two fold in blue rock pigeon, 4-fold in common babbler, 5- fold in eurasian collared dove and rose ringed parakeet, 9- fold in house crow, 17- fold in common myna and 120- fold *i.e.* highest in red wattled lapwing. Scheifler *et al.* (2006) indicated that Pb present in insects or prey items of birds may become available to birds in local environment. Thus this supported the observation of highest Pb level in excreta of insectivorous red wattled lapwing. For Pb, adverse effects in birds occur at levels of 4 ppm in feathers (Burger and Gochfeld, 2000b). Franson (1996) categorized liver tissue Pb levels of 2–6 μg/g to be subclinical exposure, 3-6 μg/g to be toxic and 5-20 μg/g to be fatal in Galliformes, Falconiformes and Columbiformes respectively. Thus the concentration of Pb in the excreta of eight species above these ranges indicating high exposure to the birds of eight species to Pb. However, Jayakumar and Muralidharan (2011) recorded the maximum concentrations of Pb (20.59 $\pm$ 9.07 μg/g) in muscles of jungle babbler which falls in the toxic category. Pb impairs the growth and survival of nestlings, causes haemolytic anemia in wild Pb-poisoned birds, has adverse effects on reproduction such as decreased plasma calcium and egg production and causes behavioural impairments. Pb causes behavioral deficts in animals due to its toxic effects on the nervous system, and may result in decrease in survival and growth rates, poorer fledging success, learning and metabolism (Dauwe *et al.,* 2005).

Bravo *et al.* (2005) reported the Fe concentration of 4823.76 ppm in excreta of black vulture (*Coragyps atratus*). Fe values excreted in human urine oscillate in the range of 60-100μg/ 24 hours. Fe concentration was also found to be lowest in excreta of blue rock pigeon and it was its 2-fold in house crow, 5- fold in rose ringed parakeet, 7-fold in common babbler, 8- fold in cattle egret, 12- fold in eurasian collared dove, 18- fold in red wattled lapwing and 21-fold i.e. highest in common myna.

Cr concentration was lowest in excreta of blue rock pigeon and it was its 2-fold in house crow, 7-fold in cattle egret, 9-fold in rose ringed parakeet, 10-fold in common babbler, 16- fold in eurasian collared dove, 25-fold in red wattled lapwing and 32-fold i.e. highest in common myna. According to Burger and Gochfeld (2000a) Cr concentration of 2.8μg/ g in bird's feathers might be associated with adverse effects. Studies by Malik and Zeb (2009) showed high Cr concentration (6.6μg/ g to 7.12/ g) in feathers of cattle egret. Thus these provide information that Cr lies in high concentrations in excreta of eight bird species. According to Kertesz and Fancsi (2003) Cr produces adverse effects on embryonic development, hatching and viability of the mallard.

Cu concentration was lowest in cattle egret excreta and it was its 2-fold in blue rock pigeon, rose ringed parakeet and house crow, 4 fold in common myna, 5-fold in eurasian collared

Table 1: Concentration of heavy metals (ppm) in excreta of different birds

Bird Species	Non essential elements			Essential elements					
	As	Cd[a]	Pb[a]	Fe	Cr	Cu	Ni	Zn	Mn
Blue rock pigeon	0.87 ± 0.18	0.28 ± 0.19	12.15 ± 3.22	1611 ± 519	3.42 ± 0.12	32.35 ± 17.73	9.98 ± 1.53	196.94 ± 113.53	128.66 ± 32.87
Eurasian collared dove	6.40 ± 4.16	2.73 ± 1.95	38.08 ± 23.42	19840 ± 13161	55.37 ± 41.08	85.49 ± 61.04	33.07 ± 19.42	412.36 ± 270.88	625.12 ± 399.09
Rose ringed parakeet	1.63 ± 0.26	2.13 ± 1.44	33.82 ± 23.56	8860 ± 575	29.94 ± 19.57	40.25 ± 20.20	24.71 ± 13.49	229.77 ± 153.06	323.77 ± 181.20
Common myna	8.92 ± 3.35	9.98 ± 1.41	122.14 ± 48.79	33788 ± 11856	109.16 ± 34.35	66.96 ± 19.52	53.78 ± 14.00	721.81 ± 125.84	1075.83 ± 151.92
House crow	0.92 ± 0.25	3.78 ± 2.85	61.71 ± 44.00	2455 ± 523	7.11 ± 3.96	44.13 ± 27.10	11.02 ± 7.49	358.61 ± 225.22	221.78 ± 112.33
Common babbler	4.93 ± 3.61	2.07 ± 1.38	25.86 ± 12.22	10793 ± 7753	33.77 ± 26.56	150.75 ± 110.58	19.20 ± 13.80	464.97 ± 314.10	401.43 ± 273.13
Cattle egret	2.36 ± 0.41	2.05 ± 0.91	7.23 ± 0.35	13223 ± 2588	23.45 ± 10.41	18.65 ± 2.49	10.83 ± 3.99	128.14 ± 8.06	242.31 ± 51.60
Red wattled lapwing	7.51 ± 5.45	48.79 ± 19.27	864.03 ± 383.83	29570 ± 13957	86.32 ± 31.46	87.43 ± 23.91	43.37 ± 14.01	473.99 ± 118.36	760.41 ± 402.43

The data is mean ± S.E. of 15 observations of pooled excreta of different bird species; [a] significantly vary in different species, Pdˆ0.05

Table 2: Concentration range of heavy metals (ppm) in excreta of different birds

Bird Species	As	Cd	Pb	Fe	Cr	Cu	Ni	Zn	Mn
Blue rock pigeon	0.50 – 1.27	0.03 – 0.75	7.63 – 20.00	430.00- 1793.65	3.13 – 3.50	9.74 – 75.75	6.26 – 12.25	54.49 – 475.00	81.49 - 208.75
Eurasian collared dove	1.29 – 16.60	0.26 – 7.50	3.90 – 95.08	3554.65- 52079.13	4.84 – 156.00	9.80 – 235.00	8.63- 80.64	80.39 – 1075.86	123.74 - 1602.53
Rose ringed parakeet	1.25 – 2.00	0.09 – 4.17	0.50 – 67.14	716.12- 17005.26	2.32- 57.55	11.69- 68.81	5.64- 43.79	13.35 – 446.19	9.94 - 637.59
Common myna	0.83 – 14.18	6.67 – 12.51	47.00 – 240.19	4824.69 – 50119.23	29.19 – 171.80	40.45 – 114.68	22.94 – 82.15	562.95 – 1029.99	830.25 – 1440.74
House crow	0.49 – 1.50	0.03 – 10.75	2.42 – 169.25	1673.65 – 3726.65	1.29 – 16.75	9.91 – 110.5	0.21 – 29.25	67.94 - 910	52.44 – 494.25
Common babbler	0.36 – 13.76	0.01 – 5.42	3.40 – 54.21	308.35 – 29748.78	0.20 – 98.83	12.85- 421.59	1.07- 52.96	79.19 – 1234.32	59.74 – 1069.61
Cattle egret	1.75 – 3.36	0.59 – 4.25	6.50 – 7.97	8102.15 – 19022.50	7.98 – 48.75	15.48 – 24.75	4.80 – 20.50	115.09 – 147.50	130.94 – 349.75
Red wattled lapwing	0.417 – 20.85	3.34 – 82.57	52.55 – 1680.93	10971.27 -63713.43	41.70 – 163.05	30.44 – 127.60	21.27 – 77.15	271.05 – 754.77	362.79 – 1311.88

The data is presented as range of concentration of heavy metals observed in 15 observations of pooled excreta of different birds dove and red wattled lapwing and 9 fold i.e. highest in common babbler. Bravo *et al.* (2005) reported Cu level of 20.26 μg/ g in excreta of black vulture (*Coragyps atratus*) which lies in non-toxic range. More than 100 μg/g of Cu in liver tissues of mute swan did not exhibit any sign of Cu toxicity (Jayakumar and Muralidharan, 2011). Thus the toxic concentration of Cu existed only in excreta of common babbler (150.75 ppm). At high doses, essential elements, such as Cu and Zn could also have toxic effects on kidneys and impair reproduction (Carpenter *et al.*, 2004).

Ni concentration was lowest in excreta of blue rock pigeon and it was its 2-fold in common babbler, 3-fold in eurasian collared dove and rose ringed parakeet, 4-fold in red wattled lapwing and 5-fold *i.e.* highest in common myna. Mean Ni concentration in feathers of cattle egret from Pakistan was recorded to be varied from 7.8μg/ g to 9.0μg/ g revealing the toxic Ni concentration (Malik and Zeb, 2009) thus depicting the high exposure of Ni in eight bird species. However, Bravo *et al.* (2005) reported Ni concentration of 15.19 μg/g in excreta of black vulture (*Coragyps atratus).*

Zn concentration was lowest in excreta of cattle egret and it was its 2- fold in blue rock pigeon and rose ringed parakeet, 3-fold in eurasian collared dove and house crow, 4- fold in common babbler and red wattled lapwing and 6- fold i.e. highest in common myna. Several cases of Zn toxicosis have been seen in Hispaniolan Amazon parrots (*Amazona vertralis*) with liver zinc levels ranging from 110 to 359 μg/g wet weight (Lewis *et al.,* 2001). Carpenter *et al.* (2004) reported that a trumpeter swan (*Cygnus buccinator*) that appeared to have died of Zn poisoning had 154mg/kg (154 μg/g) wet weight in liver. From these observations it can be concluded that level of Zn detected in excreta of eight bird species indicated the high risk to these species. Bravo *et al.* (2005) reported Zn concentration of 202.57 μg/ g in excreta of black vulture (*Coragyps atratus).*

Mn concentration was lowest in excreta of blue rock pigeon and it was its 2-fold in house crow and cattle egret, 3- fold in rose ringed parakeet and common babbler, 5- fold in eurasian collared dove, 6- fold in red wattled lapwing and 9- fold i.e. highest in common myna. Teratogenic effects (such as micromelia, twisted limbs, haemorrhage and neck defects), behavior impairments, altered growth rates and reduction of haemoglobin formation have been linked to sub lethal Mn exposure in animals and avian embryos. Mn concentration was reported in feathers of cattle egret (26.9μg/g from Pakistan and 36.6 μg/ g from Hongkong). However, in present work concentration of Mn was much higher in excreta of eight bird species as compared to concentration reported in feathers of cattle egret.

In the present studies the concentration of all heavy metals varied from species to species. The variation in concentrations of metal residues often attributed to interspecies differences (Gomez *et al.,* 2004, Taggart *et al.,* 2006). Discrepancies may be explained by dietary habits, habitat, excretion and/or absorption capacity of different species of birds (Elliott and Scheuhammer, 1997). However, the presence of these heavy metals in excreta of different species of birds indicates that these birds are exposed to the heavy metals contamination in the environment. The blue rock pigeon recorded lowest concentration of As, Cd, Cr, Fe, Ni and Mn and cattle egret recorded lowest concentration of Pb, Cu and Zn in the faeces. On the other hand, common myna recorded highest concentration of As, Cr, Fe, Ni, Zn and Mn and red wattled lapwing recorded highest concentration of Cd and Pb and common babbler recorded highest concentration of Cu. This variation in levels of metal concentrations recorded may be attributed to different feeding behaviors of different species. Trophic-level relationships have been reported for a range of species and for a number of contaminants (Burger, 1993; Lemly, 1993, Sundlof *et al.,* 1994; Barron, 1995). In general, species that are higher on the food chain accumulate higher levels of contaminants. It has been demonstrated that plant consuming species accumulated fewer metals than species feeding at higher trophic positions on food chain. Secondly, it may be due to physiological differences between the different species as metabolic rates of small passerines vary inversely with body weight and directly with activities such as flight and rest.

There exists a wide range of each heavy metal in every bird species studied (Table 2). Lucia *et al.* (2010) reported as was influenced by sex. Female birds displayed higher concentrations in liver and feathers than did male birds. Taggart *et al.* (2006) also observed that for all bird species studied, sex was a significant factor with respect to liver As. Age was one of the main factors affecting Cd accumulation, as observed in waterfowl from southern Spain (Gomez *et al.,* 2004). Adult birds displayed higher concentrations of Cd compared with juvenile birds (Lucia *et al.* 2010). Lucia *et al* (2010) reported that feathers were more contaminated with Pb in juveniles as compared with the adult birds. Decreased Pb concentrations in feathers of adult birds can be explained by the achievement of moulting in adults and this mechanism enables the excretion and removal of metals. However, in the present observations as the excreta was collected from the fields and it included birds of different age groups as well as sexes which may be responsible for variation in the concentration of As, Cd, Pb, Fe, Cr, Cu, Ni, Zn, Mn in these species.

Thus it was concluded that as compared to the concentrations of heavy metals in the body tissues of some of the bird species the levels of As, Cd, Pb, Cr, Cu, Ni, Zn and Mn recorded in the present studies were found to be in already reported toxic range. This reveals that all these birds get heavy metal contaminations from their environment. These present observations and earlier reports revealed that the chronic exposure of birds to potential toxic metals insufficient to produce outright mortality or other acute effects may lead to profound consequences on birds such as decreased reproductive function, increased susceptibility to diseases or other stresses and changes in behavioral patterns. These observations further throw light that significant fluctuations in contaminated levels are present in the environment where these birds live.

Thus it can be concluded from the present studies that presence of heavy metals in excreta of different bird species make excreta a source of indicator of heavy metal contamination in birds. Moreover differences in heavy metal concentrations in excreta of different bird species may be attributed to their different feeding habits.

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