

Monitoring Technique For Heavy Metal Assessment In Different Locations of Punjab Using Feathers of Feral Pigeons (*Columbia Livia*)

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Abstract

Heavy metals are one of the major environmental issues due to their large number of sources and their diligence. The amount of heavy metals in washed and unwashed feral pigeon feathers were investigated in this paper. The feathers were collected from five distant locations: Agronomy Farm Punjab Agricultural University, Ludhiana, Cold Storage Jalandhar Bypass, Cold Storage Mullanpur, Jalandhar FCI and Hoshiarpur FCI. Inductively coupled plasma optical emission spectrometry was used to analyse the concentration of heavy metals (Arsenic, Chromium, Cadmium and Lead). The high metal concentration in two areas (Hoshiarpur FCI and Jalandhar Bypass) as compare to other three areas is due to much more industries and anthropogenic activities. Mean values of As, Cd, Pb, and Cr were statistically significant different in the five collection sites. Metal concentrations are related to contact time or external exposure, as shown by significant differences in Cd, Pb, and Cr concentrations in washed and unwashed feathers. According to our analysis, bird's feather can be used to quantify the environmental heavy metals. It can also be recommended that unwashed feathers were proficient to explore exogenous and endogenous absorption of the heavy metals.

Introduction

Birds occupy almost every habitat on earth, are present in large numbers and in different variety and forms. In India, Agriculture sector experience the indiscriminate use of pesticides which leads to mortality of many birds (Dhindsa *et al* 1994). As a result of urbanisation and industrialization, a significant number of contaminants have entered the atmosphere. Heavy metals are the pollutants that enter the food chain through manmade as well as natural sources, becoming very harmful to humans and animals (Swailh and Sansur 2006). Metals enter the body through food and can be eliminated or accumulated. Metal elimination in birds occurs in feathers (Braune *et al.* 2002; Lewis and Furness 1991; Braune 1987). These pollutants include the pesticides and trace metals. Heavy metals are those elements that occur in small concentrations in the environment that is 5g/cm³ (Adriano 1986). Metals (Fe, Cu, Zn and Mn) are considered to be essential micronutrients for human survival. The main sources of metals in the atmosphere are pesticides, fertilizers, oil combustion, emissions from the vehicles, and burning of industrial residues (Tavares and Carvalho 1992; Egreja Filho 1993).

Bioindicators for environmental contamination include fish, amphibians, terrestrial avians and beast (Fisk *et al.* 2005). Birds are useful bioindicators as they get exposure from a range of chemicals. Feathers can uptake metals by three ways; by having direct contact with air, water and soil, through food and by preening process (Bianchi 2008). Feathers are used for metal contamination because they can be easily collectable without harming the bird (Goede and de Bruin 1986; Burger 1993). Metals may be processed, collected or even excreted until they've been absorbed into the body (Dauwe *et al.* 2000). Heavy metal levels estimated from bird's feathers is the total of endogenous and exogenous fractions. Exogenous exposure is during preening and direct exposure to air, water and soil. Endogenous exposure is due to ingestion of heavy metals with food then absorbed into the blood from the intestine and accumulates in the liver and kidney (Wayers 2002)

Pigeons are the birds that reside in urban areas, villages and other sites where there is plenty of food. Due to their higher respiratory rate, metabolic rate, reduced mobility, and feeding habit, pigeons are very attractive bioindicators (Nam and Lee 2006). Since, 1960s fringes have been used for metal biomonitoring (Burger and Gochfeld 1993), because this method is effective for metal quantification and collection of feathers does not harm the birds. A number of studies have been reported by using unwashed (Nam *et al.* 2004) and washed feathers (Almansour 2004; Dauwe *et al.* 2000; Swailh and Sansur 2006). The use of washed feathers in research allows for the study of metal concentrations deposited in the atmosphere and those absorbed by tissues.

Metals in bird feathers come from both endogenous and exogenous sources. Exogenous pollution occurs when feathers come into direct contact with the environment and endogenous contamination takes place by ingestion of heavy metals with food and get deposited in the feathers during their formation (Brait *et al.* 2010). In India heavy metal contamination studies on birds are limited. In this paper we quantify heavy metals in the washed and unwashed feathers of pigeon (*C. livia*) to determine the differences between the levels of metals in feathers.

Material And Method

Study area PUNJAB: Punjab state is located in North West India alongside of Pakistan from 29°32' North and 73°55' east. In the North it is surrounded by J & K, in the east by Himachal Pradesh and in the South by Haryana and Rajasthan. It is one of the smallest states of India with geographical area of 50,362 square kilometres. Pigeon feather samples were obtained from five sites: Agronomy farm PAU, Jalandhar bypass Ludhiana, Mullanpur, Jalandhar FCI and Hoshiarpur FCI. The areas were selected because they were near to G.T. Road which accounts for traffic density and also due to industrial activities.

Pigeon feathers collection: Feather samples of *Columba livia* were collected from the nesting sites from above mentioned sites. Randomly twenty feather samples were collected without harming the birds and preserved them in zip lock bags by mentioning date and site of collection. They were placed in freezer till further analysis.

Sample preparation: After that, the samples were taken out of the freezer and put on a filter paper sheet to be condition. They were air dried in an oven for 24 hours at 60 degrees Celsius. Feathers were washed with distilled water followed by A.P acetone twice and samples were split into two groups: (1) washed feathers (2) unwashed feathers. After washing, samples were air dried at 60°C in oven for 24 hours.

Analytical proceedings: 1 gram of samples were weighed and put in digestion flask and to it 10ml of Diacid (Perchloric acid: Nitric acid in the ration of 3:1) was added. The flasks were then placed in oven with two blanks. In a 52 minute time, the temperature of the oven was steadily increased from room temperature to 121°C. After the digestion the extracts were transferred to a flask and its final volume was made upto 50ml. Then, the analysis was done using Inductively Coupled Plasma Atomic Emission Spectrometer (ICAP-AES) at The Department of Soils, PAU, Ludhiana. The standard conditions were maintained for the heavy metal estimation. The glassware was disinfected one night before with 5% nitric acid solution.

Statistical analysis: CPCS1 statistical software was used for statistical analysis and the differences were considered significant at $P \leq 0.05$ probability.

Results And Discussion

Table 1, Table 2 and Table 3 display the results of metal analysis in both types of feathers under study and then mean metal concentrations were compared (Table 4).

Lead

Lead (Pb) is the ubiquitous toxic metal present in low concentrations in the environments. Lead can originate from natural sources such as volcanos, erosion, disasters, ceramic industries and food industries.

In Figure 2 highest and lowest concentrations of lead were found at Jalandhar Bypass, Ludhiana. This is due to the air pollutants coming from vehicles emission and from the burning of fossil fuels. In washed feathers, collected at Jalandhar bypass, Agronomy farm PAU Ludhiana, Mullanpur, Jalandhar FCI, Hoshiarpur FCI has average contents of lead as 0.730, 0.104, 0.135, 0.121 and 0.394, respectively (Table 2). Mean lead concentration at Jalandhar bypass, Ludhiana (0.730 ppm) was significantly higher compared to rest of the locations and lowest was recorded at Agronomy farm, PAU (0.104 ppm).

Similarly, in unwashed samples of Jalandhar bypass, Ludhiana showed higher concentrations of lead with an average content of 1.2 ppm and lowest was recorded at Agronomy farm, PAU (0.200 ppm) and Jalandhar FCI (0.200 ppm) (Table 3). No significant difference in average lead concentrations was found at the Agronomy farm, Ludhiana and in Jalandhar FCI, which is due to less concentration of this metal in both the locations.

Tsuji *et al.* (2002) determined lead concentrations for several bird species in a heavily hunted region of Canada reported a range of lead concentrations more than 20 ug/g which indicates toxicity of lead in wild mallard ducks.

A study conducted by Kim *et al.* (2007) on two species of heron to study the metal concentration in feathers reported that lead concentration were different in two heron species. While studying the feathers of small birds in Punjab, India, Bianchi *et al.* (2008) discovered that lead concentrations are directly linked to feather exposure time. As a result, unwashed feathers are the most reliable indicator of lead levels in the water and soil.

Sani *et al.* (2019) conducted a study for the assessment of heavy metals in feather of birds reported highest concentration of lead followed by cadmium, chromium and manganese. So higher concentration of lead in unwashed feathers in Jalandhar bypass not only show the pattern of lead deposition but a way to monitor lead levels in the environment through feathers.

Cadmium

Cadmium (Cd) is contained in the atmosphere in very low concentrations. In washed feathers (Table 2), the concentrations were 0.005, 0.018, 0.0055, 0.025 and 0.017 ppm, respectively at Agronomy farm Ludhiana, Jalandhar bypass, Mullanpur, Jalandhar FCI and Hoshiarpur FCI. The highest cadmium concentration was recorded at Jalandhar bypass (0.18 ppm) and Hoshiarpur FCI (0.17 ppm) which were also statistical at par with each other.

Similarly, at Agronomy farm PAU, Jalandhar bypass Ludhiana, Mullanpur, Jalandhar FCI and Hoshiarpur FCI, the average levels of Cd were 0.01, 0.3, 0.01, 0.004 and 0.2 ppm in unwashed feathers. The highest concentration of cadmium in unwashed feathers was found at Jalandhar bypass (0.300 ppm) and Hoshiarpur FCI (0.200 ppm) (Table 3; Fig. 2), which is due to vehicular pollution and a number of factories in the region, resulting in higher levels of cadmium in the atmosphere. So, pigeons in urbanized areas are more contaminated as compared to rural ones (Nam and Lee 2006).

Jayakumar *et al.* (2011) demonstrated metal pollution in six bird's species, reported that level of cadmium was less than 1 ug/g in four species with significant variation (p greater than 0.05) with exception in Jungle Babbler and Common Myna.

Chromium

Chromium (Cr) is a vital element that can be present in trace amounts in the world. High chromium concentrations in animal tissue are due to agricultural activities, anthropic activities such as the production of bricks and emissions from vehicles (Movalli 2000). Our study showed low chromium levels in the washed feathers compared to unwashed feathers, with higher chromium levels at Hoshiarpur FCI (Tables 2 and 3). Figure 2 shows the order of mean concentrations respectively Hoshiarpur FCI > Jalandhar bypass > Mullanpur > Jalandhar FCI > Agronomy farm, which can be explained by TPS accumulation in urbanised bird feathers. This demonstrates that chromium exposure in covered or less urbanised areas comes from the animals' diet.

Muralidharan (2018) reported higher level of chromium, magnesium and iron in the feathers of young house sparrow residing in Mumbai city, India.

Sahu *et al.* (2019) revealed high chromium concentration that is 1.819 ppm in the feathers of pigeons (*C. livia*) at one site as compared to other selected sites at Ajmer city, Rajasthan.

Arsenic

Arsenic is a trace element found in the environment and in the living beings. It is released into environment through agricultural practices including the application of fertilizers and pesticides. The mean concentration of As at Hoshiarpur, Jalandhar FCI, Agronomy farm, cold storage Jalandhar bypass, cold storage Mullanpur, Ludhiana was 0.014 ppm, 0.004 ppm, 0.008 ppm, 0.033, 0.01 ppm in washed feathers and was 0.02, 0.005, 0.009, 0.05 and 0.03 ppm in unwashed feathers, respectively.

Wiemeyer *et al.* (1980) studied about the concentration in the four species of owls and the highest concentration found among them was 0.40 ± 0.30 mg/kg, that is lower than the concentration of 5 mg/kg found in the USA in an area of possible As pollution. Very limited studies were there to use the feathers for quantification of arsenic, which makes it difficult to determine whether the amount of As recorded is significant or not (Burger *et al.* 2015).

Conclusion

The birds' feathers contained different levels of heavy metals which significantly reveal the nature of the sites (Sani *et al.* 2019). Heavy metals do not undergo biodegradation in the environment instead these undergo biomagnification in the exposed organisms (Pandiyani *et al.* 2020). Bird feathers can be used for monitoring environmental pollution because it does not require sacrificing of birds and feathers have good correlation with concentrations of metals in the atmosphere (Swailah and Sansur 2006; Nam *et al.* 2004; Almansour 2004; Dauwe *et al.* 2002, 2003).

The heavy metals under study viz. Lead, chromium, and cadmium, are present in the atmosphere and are deposited in feathers of birds or reach the tissues through diet, according to our findings. Finally, the study of pigeon feathers can be used to measure and track metal concentrations in the environment (*C. livia*). Unwashed feathers are preferable for identifying metals ingested through the diet as well as those absorbed through the atmosphere, while the other type of feathers are effective for quantification metal pollution which originate from food and atmosphere.

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Tables

Table 1 Average concentration, sample standard deviation (SSD) in samples from different collection sites

Mean concentrations in (ppm) in washed feathers

Heavy Metals conc. (ppm)	n	LOCATIONS					HOSHIA FCI
		AGRONOMY FARM	JALANDHAR BYPASS	MULLANPUR	JALANDHAR FCI		
Arsenic (As)	20	0.008±0.0004	0.033±0.0016	0.010±0.0005	0.004±0.0002		0.014±(
Cadmium (Cd)	20	0.005±0.0003	0.018±0.0009	0.006±0.0003	0.003±0.0001		0.017±(
Chromium (Cr)	20	0.078±0.0039	0.213±0.0106	0.072±0.0036	0.045±0.0023		0.296±(
Lead (Pb)	20	0.104±0.0052	0.730±0.0365	0.135±0.0067	0.121±0.0061		0.394±(

Mean concentrations in (ppm) in unwashed feathers

Heavy Metals	n	LOCATIONS					HC FC
		AGRONOMY FARM	JALANDHAR BYPASS	MULLANPUR	JALANDHAR FCI		
Arsenic (As)	20	0.0090±0.0005	0.0500±0.0025	0.0300±0.0015	0.0050±0.0003		0.0
Cadmium (Cd)	20	0.0100±0.0050	0.3000±0.0150	0.0100±0.0005	0.0040±0.0002		0.0
Chromium (Cr)	20	0.0800±0.0040	0.4000±0.0200	0.0900±0.0045	0.0700±0.0035		0.4
Lead (Pb)	20	0.2000±0.0100	1.2000±0.0600	0.2500±0.0125	0.2000±0.0100		0.0

Table 2: Mean heavy metals concentration in washed feathers from five collection sites

Location	As	Cd	Cr	Pb
Agronomy farm PAU	0.008 ^d	0.005 ^b	0.078 ^b	0.104 ^c
Jalandhar bypass, Ludhiana	0.033 ^a	0.018 ^a	0.213 ^a	0.730 ^a
Mullanpur	0.010 ^b	0.006 ^b	0.072 ^b	0.135 ^c
Jalandhar FCI	0.004 ^c	0.003 ^b	0.045 ^c	0.121 ^c
Hoshiarpur FCI	0.014 ^b	0.017 ^a	0.296 ^a	0.394 ^b

There is no significant difference at 5% probability level between means of each column which have one common letter at least

Table 3: Mean Heavy metals concentrations in unwashed feathers from five collection sites

Locations	As	Cd	Cr	Pb
Agronomy farm PAU	0.009 ^c	0.010 ^c	0.080 ^b	0.200 ^c
Jalandhar bypass, Ludhiana	0.050 ^a	0.300 ^a	0.400 ^a	1.200 ^a
Mullanpur	0.030 ^{ab}	0.010 ^c	0.090 ^b	0.250 ^c
Jalandhar FCI	0.005 ^c	0.004 ^d	0.070 ^b	0.200 ^c
Hoshiarpur FCI	0.020 ^b	0.200 ^b	0.400 ^a	0.700 ^b

There is no significant difference at 5% probability level between means of each column which have one common letter at least

Table 4: Mean metal concentrations in washed and unwashed feathers from the five collection sites

Metal	Average concentrations (ppm)- washed feathers									
	Agronomy farm, PAU		Jalandhar bypass, Ludhiana		Mullanpur		Jalandhar FCI		Hoshiarpur FCI	
	Washed	Unwashed	Washed	Unwashed	Washed	Unwashed	Washed	Unwashed	Washed	Unwashed
As	0.008 ^d	0.009 ^c	0.033 ^a	0.05 ^a	0.01 ^b	0.03 ^{ab}	0.004 ^c	0.005 ^c	0.014 ^b	0.02 ^b
Cd	0.005 ^b	0.01 ^c	0.018 ^a	0.3 ^a	0.006 ^b	0.01 ^c	0.003 ^b	0.004 ^d	0.017 ^a	0.2 ^b
Cr	0.078 ^b	0.080 ^b	0.213 ^a	0.4 ^a	0.072 ^b	0.09 ^b	0.045 ^c	0.07 ^b	0.296 ^a	0.4 ^a
Pb	0.104 ^c	0.20 ^c	0.73 ^a	1.2 ^a	0.135 ^c	0.25 ^c	0.121 ^c	0.2 ^c	0.394 ^b	0.7 ^b

Lines with averages followed by the same letter for the same collection site are not significantly different from each other

Figures



Figure 1

Location of the state of Punjab (left) and study areas (right) which are Jalandhar, Hoshiarpur and Ludhiana Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

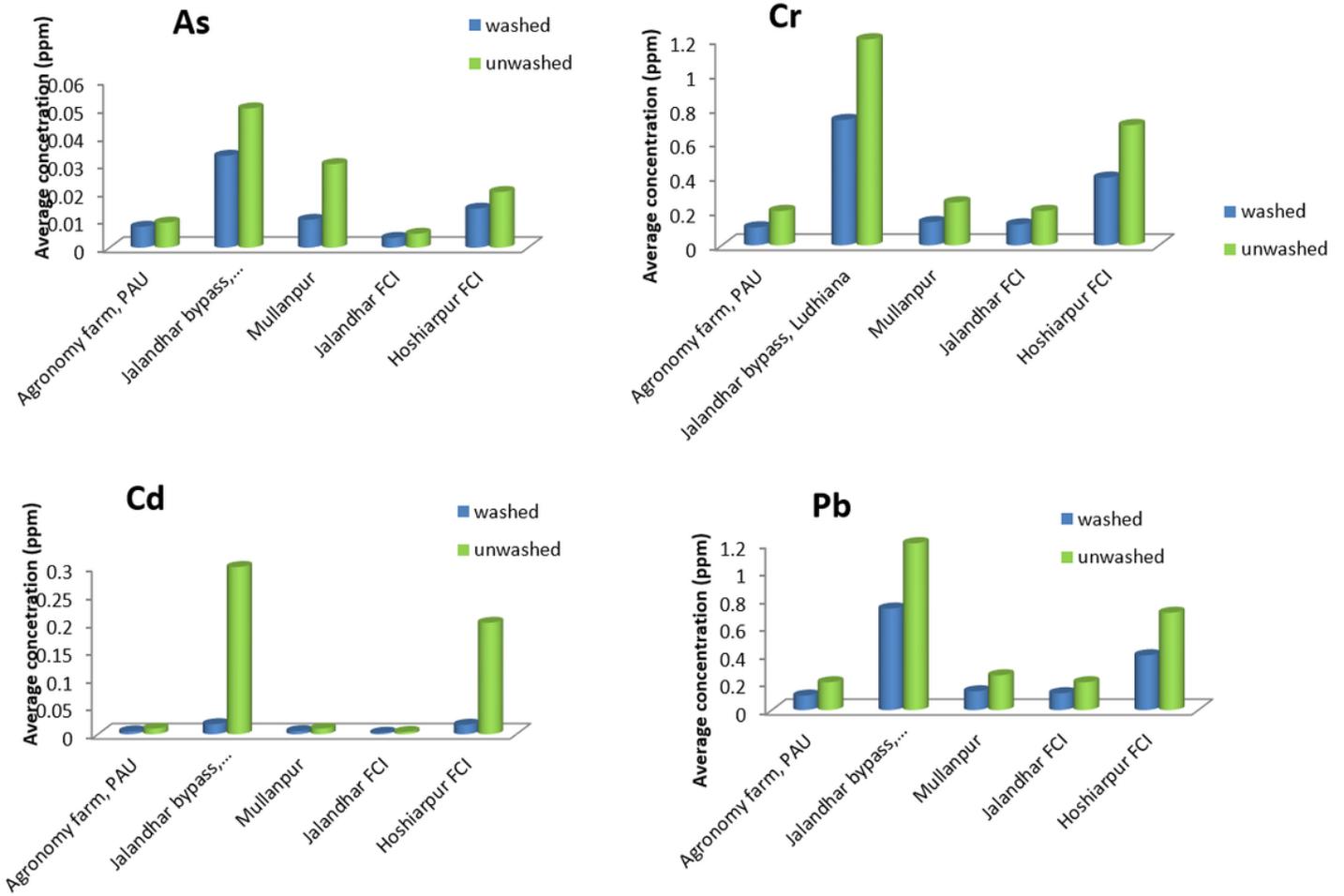


Figure 2

Mean concentrations of Fe, Pb, Cd, and Cr in washed and unwashed feathers