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MONITORING OF ENVIRONMENTAL POLLUTION FOR PB, CD AND CR ELEMENTS USING THE FEATHERS OF THREE SPECIES OF BIRDS

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ABSTRACT

Despite the efforts made in most countries of the world to reduce the risks of environmental pollution, heavy elements still represent the most important environmental pollutants. Therefore this study was conducted with the aim of evaluating the use of feathers of three species of locally dominant birds, *Columba livia*, *Spilopelia senegalensis* and *Passer domesticus*, as a biomonitor for pollution by lead, cadmium and chromium. Samples were collected from 108 birds with an average of 38 birds of each species in two areas: urban and rural. All samples were analyzed using an atomic absorption spectrometer. The results showed higher concentrations of lead compared to cadmium and chromium in all samples, and higher concentrations of these elements in the urban area compared to the reference area in washed and unwashed feathers. The results of the statistical analysis showed significant differences for all elements between the two areas for unwashed feathers, which was attributed to the fact that unwashed feathers effectively reflect the state of external pollution. The presence of these elements in bird feathers and in high concentrations indicates a potential threat to the life of birds and other living things. Based on the results of this study, feathers can be used for any species of bird studied, and it is an effective tool for monitoring environmental pollution with heavy elements.

KEY WORDS : Monitoring, Birds, Heavy elements, Pollution, Urban environment.

INTRODUCTION

The environment in general and the urban environment in particular are exposed to many pollutants due to the population expansion, the increase of factories, vehicles and traffic density. Vehicles are one of the main sources of pollution in the city's environment because of the emissions and particulate that result from the friction and deterioration of tires and brakes (Rayson, 1990). One of the most prominent and important pollutants in the environment are heavy elements that can spread in soil, air and water. Industrial and electronic waste, pesticides, fertilizers and sewage are the most important sources of pollution for heavy elements (Agarwal, 2009; Nighat *et al.,* 2013). Heavy elements have been associated with harmful and dangerous effects on health, biodiversity and ecosystems due to their resistance to degradation and their tendency to bioaccumulation in the tissues of organisms and biomagnification in the food chain (Järup, 2003; Rzymski *et al.,* 2014). Biomonitoring systems are the best way to monitor environmental pollutants because they provide information on the transport and accumulation of pollutants in the tissues of living organisms (Alhesnawi *et al.,* 2018; Dmowski, 1999). For these reasons, feather tissues was used as a bioindicator for contamination with heavy elements (Carignan and Villard, 2002; Chambers, 2008). Heavy elements can be found in the feathers of birds in concentrations that make the analysis possible and more reliable. Moreover, it is possible to obtain the feathers of birds and repeat the sampling without sacrificing the birds(Goede and De Bruin, 1986; Swaileh and Sansur, 2006). Two main pathways can be distinguished for the presence of

elements in feather tissue: internal and external. The first path represents the metabolic processes involved in forming structures of feather before their growth is complete, while the external pathway is feather contamination through direct contact with the environment (air and soil) or with elements that are excreted with feces or glands (Dmowski, 1999; Goede and De Bruin, 1986).

The results of studies that used bird feathers for biomonitoring in different environments showed an association between the concentrations of elements in the atmosphere and bioaccumulation in their tissues (Brait and Antoniosi Filho, 2011; Nam *et al.*, 2004). Air dust is the most prominent pollutant in the city of Kerbala as studies indicated that it contains heavy elements with high concentrations through monitoring processes using devices (Alhesnawi *et al.*, 2019). Despite the importance of biomonitoring systems and their effectiveness in monitoring pollutants in the environment, local studies are very few and most of them focused on the use of plants. Therefore, this study was conducted to find out the concentration of some heavy elements using the feathers of three species of the dominant birds by comparing the washed and unwashed feathers in the two study areas to assess their efficiency in environmental monitoring.

MATERIALS AND METHODS

Study area

Two locations were chosen to conduct the study within the holy city of Kerbala : (1) a rural area is located between 32°40′35.52"N and 44°13′12.50"E away from pollution sources as a reference area. (2) The urban area is located between 32°35′19.04"N and 44° 1′14.11"E and is characterized by human activity and high population density and is more than 20 kilometers from the reference area.

Sample collection

Three species of birds, which are prevalent in the two study areas, *Columba livia, Spilopelia senegalensis* and *Passer domesticus* were chosen, and about 108 birds were collected, 36 for each species, as hunting traps were set during September and October of 2019. Nine feathers were collected from each species; three of each wing and three of the tail and very carefully placed in polyethylene containers.

Analysis of samples

All samples were dried in an oven at 60 °C for 24 hours, then the dried samples were weighed. About 0.5 g of the samples were digested using a mixture of nitric acid and hydrogen peroxide 1:1 and heated to a temperature of 200 degrees Celsius then the resulting solution was filtered and diluted to 25 ml with deionized water. Concentrations of lead, cadmium and chromium were measured using the atomic spectrometer.

Statistical analysis

The SPSS statistical software (version 23) used to analyze data, which represented by average ± standard deviation. And used t-test to compare between the rural and urban areas, while the use one-way analysis of variance (ANOVA) and the Duncan's multiple range test to compare between the bird species (p-value <0.05). The Pearson correlation coefficient was analyzed between the elements in the washed and unwashed feathers.

RESULTS

The study revealed the concentration of three heavy elements: lead, cadmium and chromium. These elements were chosen due to their extreme toxicity and seriousness. The results showed (Figure 1 and 2) that the arrangement of the elements in terms of concentration are lead > chromium > cadmium at the two study areas and the species of birds for the washed feathers. while their were arrangement in the unwashed feathers the lead > cadmium > chromium at the study areas and the species of birds.

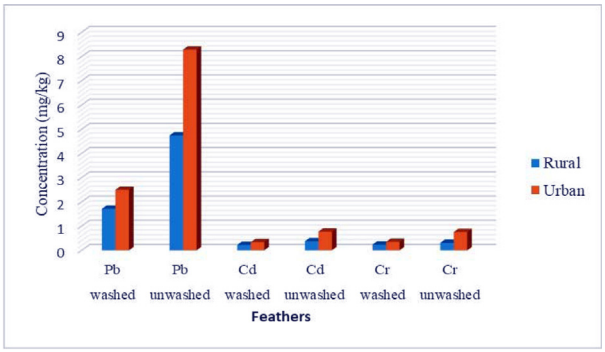

Fig. 1. The average concentration of heavy elements (mg/kg) dry weight in washed and unwashed feathers in the study areas.

Lead

The average lead concentration in washed feathers ranged from 1.46 to 3.36 mg/kg dry weight in rural and urban areas, respectively (Table 1). The highest

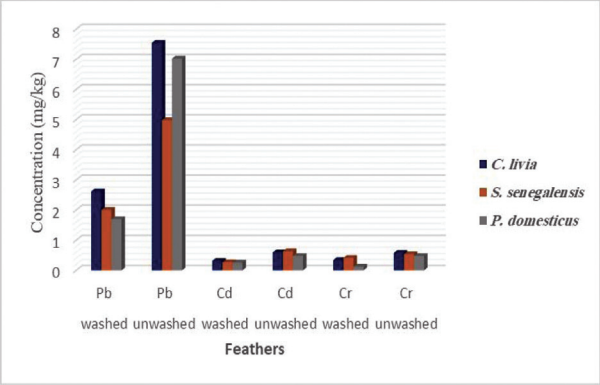

Fig. 2. The average concentration of heavy elements (mg/kg) dry weight in washed and unwashed feathers of studied species.

lead average was found in *C. livia*, while the lowest average was found in *P. domesticus*. The results did not show using ANOVA test, any significant differences between the species of birds studied, as well as no significant differences between rural and urban areas using the t-test. Correlation coefficient showed a moderate significant correlation between lead in washed and unwashed feathers ($r = 0.414$; $p<0.01$) (Table 3). As for unwashed feathers, the highest average of lead was 9.71 mg/kg dry weight found in *C. livia* in the urban area, while the lowest average was 3.47 mg/kg dry weight in *S. senegalensis* in the rural area (Table 2). The results showed no significant differences between bird

Table 1. The average and standard deviation (SD) of heavy elements for each bird species within the two study areas for washed feathers.

Elements	Areas	Washed feathers						P-value (ANOVA)
		Species						
		C. livia		*S. senegalensis*		*P. domesticus*		
		Average	SD	Average	SD	Average	SD	
Pb	Rural	1.87 a	1.21	1.81 a	0.96	1.46 a	0.73	0.642
	Urban	3.36 a	1.75	2.20 a	0.76	1.94 a	0.99	0.052
	P-value (t-test)	0.052		0.357		0.265		
Cd	Rural	0.26 a	0.13	0.21 a	0.21	0.19 a	0.14	0.647
	Urban	0.36 a	0.20	0.32 a	0.26	0.32 a	0.25	0.909
	P-value (t-test)	0.226		0.32		0.19		
Cr	Rural	0.24 a	0.12	0.37 b	0.06	0.09 c	0.05	0.000
	Urban	0.44 a	0.24	0.45 a	0.30	0.15 b	0.13	0.019
	P-value (t-test)	0.052		0.428		0.209		

Note: * mean significant differences between the urban and rural area for each species ($p<0.05$).
Similar letters in rows indicate the presence of significant differences between the species of birds, while the different letters indicate significant differences ($p<0.05$).

Table 2. The average and standard deviation (SD) of heavy elements for each bird species within the two study areas for unwashed feathers.

Elements	Areas	Unwashed feathers						P-value (ANOVA)
		Species						
		C. livia		*S. senegalensis*		*P. domesticus*		
		Average	SD	Average	SD	Average	SD	
Pb	Rural	5.38 a	2.45	3.47 a	1.90	5.39 a	3.32	0.223
	Urban	9.71 a	4.54	6.50 a	2.80	8.66 a	3.19	0.187
	P-value (t-test)	0.023*		0.016*		0.049*		
Cd	Rural	0.44 a	0.35	0.33 a	0.43	0.35 a	0.20	0.747
	Urban	0.76 a	0.28	0.94 a	0.36	0.61 a	0.27	0.089
	P-value (t-test)	0.05*		0.004*		0.033*		
Cr	Rural	0.39 a	0.39	0.24 a	0.16	0.30 a	0.20	0.520
	Urban	0.77 a	0.35	0.84 a	0.24	0.66 a	0.25	0.417
	P-value (t-test)	0.042*		0.000*		0.004*		

Note: * mean significant differences between the urban and rural area for each species ($p<0.05$).
Similar letters in rows indicate the presence of significant differences between the species of birds, while the different letters indicate significant differences ($p<0.05$).

species feathers while there were significant differences between rural and urban areas. A weak significant correlation was found between lead and chromium (r = 0.294; p<0.05) in unwashed (Table 3).

Cadmium

The results showed, as in Table 1 that the lowest rate of cadmium in washed feathers was 0.19 mg/kg dry weight in *P. domesticus* in the rural area, while the highest rate was 0.36 mg/kg dry weight in *C. livia* in the urban area. The results of the statistical analysis showed no significant differences between species as well as between areas. As for unwashed feathers, average concentrations of cadmium were ranged between 0.33 - 0.94 mg/kg dry weight in *S. senegalensis* in the rural and urban areas, respectively (Table 2). The results of the statistical analysis showed that there were significant differences between areas, while no significant differences were observed between species. Correlation coefficient analysis showed a weak significant correlation between cadmium in unwashed feathers and lead in washed feathers (r = 0.342; p<0.05) and moderate between cadmium and chromium (r = 0.400; p<0.01) in unwashed feathers (Table 3).

Chromium

Average concentrations of Chromium for washed feathers ranged between 0.09-0.45 mg/kg dry weight in *S. senegalensis* and *P. domesticus* in rural and urban areas, respectively (Table 1). The results showed no significant differences between areas, while differences were found between species. The highest and lowest average chromium in unwashed feathers was 0.84 - 0.24 mg/kg dry weight in *S. senegalensis* in urban and rural areas, respectively. The results of the statistical analysis showed that there were significant differences between urban and rural areas for all species, while no significant differences were seen between the species. A moderate significant correlation was found between chromium and cadmium (r = 0.400; p <0.01) and weak correlation with lead (r = 0.294; p <0.05) in unwashed feathers.

DISCUSSION

Heavy elements are dangerous pollutants due to their ability to accumulate in the tissues of living organisms and their biomagnification in the food chain, so these pollutants has negative effects on the ecosystem and warns of a potential risk to the health of living organisms (M Almalki *et al.,* 2019; Torres *et al.,* 2010).

The reason for the high concentration of lead compared to cadmium and chromium is due to its multiple sources and its frequent use in industrial activities. Some research indicated the lead in the dust and air of Kerbala city at concentrations of 4.037 $\mu g/m^3$, nearly eight times the European Agency's determinants (Alhesnawi, 2018; EEA, 2017). The main reason for the rise in lead in the city air is the increasing number of vehicles in the city and the continued addition of lead to fuel.

Despite the higher concentrations of lead, cadmium and chromium in washed feathers in the urban area compared to the rural area, the results of the statistical analysis did not show significant differences between the two areas. This could be explained by that the high concentrations of heavy elements in the bodies of birds as a result of mixing with food or water leads birds to remove these elements from their bodies and accumulate them in the feathers as one of the important biological mechanisms for detoxification (Grove *et al.,* 2009; Naccari *et al.,* 2009). Because feathers, after their full

Table 3. Correlation coefficient between heavy elements in washed and unwashed feathers

	Correlations					
	Pb washed	Pb unwashed	Cd washed	Cd unwashed	Cr washed	Cr unwashed
Pb washed	1	0.414**	0.081	0.342*	0.133	0.153
Pb unwashed		1	0.078	0.142	0.14	0.294*
Cd washed			1	0.134	0.135	0.346*
Cd unwashed				1	0.171	0.400**
Cr washed					1	0.229
Cr unwashed						1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

growth, are cut off from it the blood supply, and thus physiologically isolated and have no effect on the birds' bodies (Lodenius and Solonen, 2013). For this reason, bird feathers have a limited ability to absorb pollutants and accumulate them in it.

On the other hand, the results showed significant differences for all elements between the rural and urban areas in relation to the unwashed feathers, and this means a high level of concentrations of these elements in the air, because the unwashed feathers reflect the state of external pollution (air).

What reinforces this is the presence of a significant correlation between the lead found in washed and unwashed feathers. As the rise in lead in the air leads to contamination of the bird's food and water as a result of its precipitation from the air, and thus the bird removes it and accumulates it in the feathers before completing its growth.

Based on this result, unwashed feathers of birds could be used as biomonitoring for air pollution. The results of this study are in agreement with some studies (Brait and Antoniosi Filho, 2011; Nam *et al*., 2004)

The results of the statistical analysis did not show significant differences for the elements between the species of birds in unwashed feathers, as well as for washed feathers, except for chromium. Significant differences were found between all species of birds in the rural area, while no differences appeared between species *C. livia* and *S. senegalensis*, and there were differences between them with *P. domesticus* in the urban area.

The *P. domesticus* species was found with the least accumulation of chromium in washed feathers. This can be attributed to that *P. domesticus* is less exposed to sources of chromium than the previous two species, or that it is characterized by its physiological ability to remove harmful concentrations in several different ways, such as faeces or eggs.

A positive correlation between the elements in unwashed feathers means that increasing the concentration of one of them results in an increase the other element and vice versa. This may be because these elements often originate from the same source.

CONCLUSION

The results of the research showed the possibility of using bird feathers in the biomonitoring of environmental pollution. It is preferable to use unwashed feathers of birds for environmental monitoring of heavy polluting elements in the atmosphere, while washed feathers are used to identifying contaminated elements for food and water. Unwashed feathers can be used for any species of bird studied in biomonitoring for external contamination with heavy elements. The presence of these elements (lead, cadmium and chromium) in the feathers of birds and their high concentration in the urban area indicates the presence of a potential threat to human life and other organisms.

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