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Bioaccumulation of Heavy Metals in Tissues of House Sparrow (*Passer domesticus*)

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ABSTRACT

The purpose of this study was to determine the concentrations of heavy metals (Pb, Cd, Cu, Ni and Zn) in tissues of the house sparrow (*Passer domesticus*) grown in Mitrovica, Drenas towns (polluted area) and reference site (Ujmir village). A total of 30 house sparrows only male (10 from each locality) were analysed. The tissues analysed included liver, kidney, testes, femur and tibia. The concentrations of heavy metals were measured using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). We found mean tissue concentrations of some heavy metals to be significantly higher in sparrows from the polluted area when compared to tissues from the reference site. In tibia mean concentrations of Pb ($509.94 \pm 199.55 \mu\text{g g}^{-1}$), in kidney-Cd ($21.03 \pm 12.25 \mu\text{g g}^{-1}$), in kidney-Cu ($29.5 \pm 6.01 \mu\text{g g}^{-1}$), in femur-Ni ($31.415 \pm 13.177 \mu\text{g g}^{-1}$), in tibia-Zn ($342.83 \pm 124.89 \mu\text{g g}^{-1}$) were significantly higher ($p < 0.001, 0.01$) in sparrows from the polluted area (Mitrovica and Drenas) compared with reference site (Ujmir village). The concentrations of heavy metals recorded in the present studies suggested that house sparrow (*Passer domesticus*) could be considered as an indicator for environmental contamination.

Key words: Heavy metals, house sparrow, tissues, ICP-OES

INTRODUCTION

The natural environment has been gradually contaminated by various forms of pollution. A serious group of pollutants are heavy metals that pose a threat to all living organisms, with lead being especially considered as highly toxic (Swaleh and Sansur, 2006; Roux and Marra, 2007). Contamination by heavy metals is a major concern worldwide, regional and local level and influences the functional and structural integrity of an ecosystem. The sources of heavy metal pollution include natural sources (Miranda *et al.*, 2009), mining or metal smelting (Uhlig *et al.*, 2001), municipal waste, industrial effluents, application of sewage sludge and animal manure on agricultural land (Blanco-Penedo *et al.*, 2006). Heavy metals are naturally present in various natural segments. However, human activity exerted for stimulus provided by industrial development has changed the biogeochemical cycles influencing the transfer of these elements (Pereira and Kuch, 2005). A number of metal ions are essential but some other metals are non essential such as Pb, Cd (Johansen *et al.*, 2006). Quantification of trace element levels in different tissues of the organism is an indicator of the bioavailable fraction of the element in the environment (Esteban and Castano, 2009).

Recently biological indicators have become very common and have been found very useful. This is because living organisms have high sensitivity to changes in environmental components and conditions that constitute their living. However, different organisms respond at different degree to changes in some environmental parameters. Therefore, the biodiversity needs to be well understood when considering biomarkers of environmental pollution.

The use of living organisms to monitor heavy metal pollution provides more promising results than chemical and physical analysis. This results from the fact that obtained accurate data of bioavailability and bio transference of contaminants as well as observed some physiological and behavioral symptoms of induced toxicity. Birds are traditional objects for biological monitoring in polluted ecosystems. Birds can be exposed to heavy metals both externally, by physical contact and internally, by consumption of contaminated food.

Birds are easy to identify and their classification and systematic are well established. They are particularly well known organisms, with much research carried out on their ecology and behavior and this background knowledge of biology enhances their usefulness as biomonitors. It is very important to keep several criteria when selecting the bird species for biomonitoring. Among them common occurrence, easy capturing, clearly identified individual territory size, homogeneity of the material, well known biology of the species and bioaccumulation capacity should be taken into account.

Bioaccumulation of heavy metals in tissues of birds has received attention because of the lethal and sub-lethal effect of their accumulation, apart from the fact that birds are often located in high levels in the food chain which makes them suitable for use in bioaccumulation studies (Burger *et al.*, 1994). Studies on lead contamination in birds conducted in industrial areas showed a definite influence of environmental pollution on the levels of metals accumulated by birds Adout *et al.* (2007). Extensive studies on heavy metals concentration in birds have been conducted in many polluted regions. Recently, some researchers explored the potential of monitoring metals pollution using wild species such as doves (e.g., *Columba livia*), house sparrow (*Passer domesticus*), pigeons and great tits (*Parus major*) (Elezaj *et al.*, 2013; Miskovsky *et al.*, 2012; 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.

The main objective of the present study was to provide the information on the concentration and distribution of Lead (Pb), Cadmium (Cd), Copper (Cu), Nickel (Ni) and Zinc (Zn) in different tissues of house sparrow (*Passer domesticus*), including consumption organs (liver, kidney, testes, femur and tibia).

MATERIALS AND METHODS

Study areas: The pollution of living environment in Mitrovica still presents an ecological problem (the area near foundry "Trepqa" closed since 2000). The main resources of pollution in Mitrovica, in the past had as starting point different technological departures (metals foundry, refinery, flotation, factory of accumulations and sulfuric acid battery) of "Trepqa" combine and also superphosphates fertilizer factory. The work of these departments has made Mitrovica of the most polluted cities in Europe. The pollution level can be illustrated from some informations by Popovac *et al.* (1981), who find that the quantity of the emitted lead dust everyday from the Trepça foundry in 1979 was 5-6 t. The concentration of lead in air in Mitrovica from the same period was 20-30 $\mu\text{g m}^{-3}$. Trepça Foundry was closed in August 14th 2000 from the United States Forces. The study that was done from (Shehu *et al.*, 2011) analysis of soil taken in the location around

Mitrovica had notice high concentration. More than 13 years have passed by but the pollution left from Trepça's activities, threatens seriously the local environment and people's health.

Drenas town is located 20 km far from Prishtina (capital of Republic of Kosovo) in the West. The smelter (Ferronickel) has operated since 1982. Ferronikeli has three open pit mines: the Dushkaja mine with estimated reserves of 6.2 Mt, the Suka mine-0.8 Mt and the Gllavica with 6.8 Mt. Ferronikeli smelter is well-known for final production of Ferro- nickel. In metallurgical processing the mineral base is treated by an oxide mineral of nickel (two sources) with the following average chemical structure: Ni+Co = 1.2%, Fe = 26.0%, SiO₂ = 47.0%, CaO = 2.5%, Cr₂O₃ = 1.2% and MgO = 11.0%. The produced slag has the chemical structure as follow: Ni-0.08%, SiO₂ 55-57%, MgO 10.0%, Fe total 20%, Ca) 4.0%. The capacity of the smelter in the technological lines (rotating furnace and electrical furnace) is about 12.000 t Ni/year (Rizaj *et al.*, 2008). In recent time, the smelter plant is active and it is known as "New CO Ferronickel".

Sample collection and preparation: The present study is done on the natural individuals of the population of house sparrow (*Passer domesticus*) who were caught in the city of Mitrovica (polluted area), the town of Drenas (area near the Ferronickel smelter, polluted area) and in rural areas-reference site (Ujmirë village, not a polluted area). In May (2014), a total of 30 house sparrows (*Passer domesticus*) only male (10 from each locality) were caught. After dissection of birds, samples tissues (liver, kidney, testes, femur and tibia) were gathered and stored at -20°C for further analysis. The concentrations of Pb, Cd, Cu, Ni and Zn were determined using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES).

Statistical analysis: The differences in metal concentrations were analyzed with Student's test (t). Significant differences were assumed at p<0.05. For all statistical analyses, Sigma stat program was used.

RESULTS AND DISCUSSION

Concentrations of the heavy metals in tissues (liver, kidney, testes, femur and tibia) of house sparrow (*Passer domesticus*) are presented in Table 1. All the results were performed in dry weight.

It observed that the different tissues in house sparrow had disparity in the mean metal concentrations, in general, the concentrations of the heavy metals, such as Pb, Cd, Cu, Ni and Zn were higher in tissues of house sparrow from polluted site (Mitrovica and Drenas city) in comparison with reference site (Ujmir village). The highest Pb concentration were 509.94±199.5 µg g⁻¹ d.w. in the tibia (polluted site). The lowest Pb concentration were 2.33±0.65 µg g⁻¹ d.w. in testes of house sparrow from reference site. The highest Cd concentration were 21.03±12.25 µg g⁻¹ d.w. in the kidneys (polluted site). The lowest Cd concentration were 0.154±0.05 µg g⁻¹ d.w. in testes of house sparrow from reference site. The highest Cu concentration were 29.50±6.013 µg g⁻¹ d.w. in the kidneys (polluted site). The lowest Cu concentrations were 0.3623±0.063 µg g⁻¹ d.w. in testes of house sparrow from reference site. The highest Ni concentration were 31.41±13.177 µg g⁻¹ d.w. in the femur (polluted site). The lowest Ni concentration were 0.119±0.013 µg g⁻¹ d.w. in testes of house sparrow from reference site.

In liver and kidneys Pb, Cd and Zn concentration averages were significantly different (p<0.001; p<0.01) between polluted site and reference site. Ni, Pb, Cd and Zn concentrations in testes were higher, in significantly values (p<0.001; p<0.01) in sparrows from polluted site (Mitrovica and Drenas city) compared with reference site (Ujmir village). The concentrations of Pb,

Table 1: Mean±SD values for heavy metals (Pb, Cd, Cu, Ni and Zn) in house sparrow (*Passer domesticus*) by tissues and site (in µg g⁻¹ d.w.)

Tissues and metals	Reference site	Polluted site	
	Ujmir (n = 10)	Drenas (n = 10)	Mitrovicë (n = 10)
Liver			
Pb	9.397±2.059	10.450±5.668	14.980±5.85*
Cd	1.318±0.075	1.590±0.524*	2.210±0.737**
Cu	18.660±2.593	22.230±6.735	20.240±2.198
Ni	0.674±0.451	2.007±2.165	0.737±0.225
Zn	61.480±5.003	94.470±43.62*	68.250±11.61
Kidneys			
Pb	44.400±20.02	121.210±71.22**	99.510±54.1**
Cd	4.986±2.094	21.030±12.25**	11.940±6.575**
Cu	23.550±9.642	29.500±6.013	28.410±2.82
Ni	5.596±1.346	9.043±7.688	5.542±4.256
Zn	47.220±8.324	61.630±17.65*	77.760±9.027**
Testes			
Pb	2.338±0.653	45.850±41.90**	22.620±13.47**
Cd	0.154±0.058	8.970±7.317**	3.884±2.411**
Cu	0.362±0.063	10.410±3.687**	18.920±4.263**
Ni	0.119±0.013	10.760±4.767**	9.048±3.547**
Zn	30.490±6.813	63.360±19.72**	181.700±105.2**
Femur			
Pb	19.270±5.091	84.060±18.73**	506.800±181.9**
Cd	0.273±0.122	0.588±0.368*	0.957±0.491**
Cu	3.261±1.233	4.526±1.432*	17.030±9.444**
Ni	7.707±5.677	31.410±13.17**	10.030±10.57
Zn	179.300±24.62	218.200±58.08	225.300±74.17
Tibia			
Pb	12.070±4.548	84.980±20.48**	509.900±199.5**
Cd	0.335±0.139	0.729±0.347**	0.609±0.1**
Cu	2.782±0.906	4.952±1.759	3.509±1.979
Ni	7.982±2.852	11.660±8.04**	9.345±4.098
Zn	235.100±56.68	291.500±143.6*	342.800±124.8

*p<0.01 and **p<0.001

Cd and Cu in femur and tibia were significantly higher (p<0.001; p<0.01) in sparrows from Mitrovica and Drenas compared with Ujmir (reference). Pb concentration averages in femur (509.944 µg g⁻¹ d.w.) and tibia (506.885 µg g⁻¹ d.w.) of sparrows from Mitrovica were much higher than in the femur (19.273 µg g⁻¹ d.w.) and the tibia (12.069 µg g⁻¹ d.w.) of sparrows from Ujmir (reference site).

The results of higher concentrations of lead and zinc in tibia of house sparrow from Mitrovica and Drenas city are in accordance with results (Elezaj *et al.*, 2008), who showed very higher concentration of Pb, Cd, Cu, Ni and Zn in tibia, femur, kidney and liver of feral pigeons (*Columba livia*) from Mitrovica. The higher concentrations of Pb recorded in house sparrows from Mitrovica is in accordance with results of (Hutton, 1980) who in feral pigeons from London area recorded very higher lead concentrations. For example, several studies have shown that urban populations of house sparrows, starlings, pigeons tend to have higher heavy metals concentration

than rural populations (Getz *et al.*, 1977). Our data are compatible with data of (Swailah and Sansur, 2006), who used house sparrow as object of research for the determination of heavy metals in the environment.

CONCLUSION

The findings of this study have shown that house sparrow (*Passer domesticus*) have great capabilities to accumulate heavy metals in their tissues. The heavy metals contamination in study areas (Mitrovica and Drenas) can have harmful effects on an entire region, particularly in areas of active feeding or reproduction or migration routes and breeding sites.

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