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# ASSESSMENT OF LEAD, CADMIUM, AND MERCURY TOTAL CONCENTRATIONS IN CATS BASED ON THEIR LIFESTYLE AND FEEDING CONDITIONS

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***Abstract***

*Heavy metals are more ubiquitous as their uses have grown over the years. This research aimed to assess the total concentrations of some heavy metals (Pb, Cd, Hg) using cats' fur as an indicator, while also taking into consideration the age, living and feeding conditions of the cats. The fur samples were analysed by Inductively Coupled Plasma Mass Spectrometry. Generally, fur samples from cats that lived outdoors and that ate commercial food had higher total concentrations of heavy metals. The only exception is the total concentration of Cd, which was higher in the case of samples taken from cats living indoors compared to those living outdoors. In addition, samples taken from cats above the age of 5 had statistically significant higher Hg total concentrations compared to samples taken from cats between 3-5 years old. The findings of this research support the assumption that cats which are raised outdoors, in a polluted environment, accumulate higher total concentrations of some heavy metals. In addition, total concentrations of heavy metals also rise as the cats get older.*

***Key words****: lead, cadmium, mercury, fur, cats.*

## INTRODUCTION

In high concentrations, heavy metals have proven toxic effects in all live organisms. However, because of their benefits in various manufactures, they are still used, and exposure to heavy metal sources can cause intoxications.
Pb can be used for the manufacture of various household appliances, pipes, or paints, or as protection against X-rays (De Francisco et al., 2003; Gulbinska, 2014; Jensen, 2013; Rădulescu & Lundgren, 2019).
Absorption of Pb occurs in the small intestine, especially in the duodenum (Conrad & Barton, 1978).
Pb excretion occurs mainly in the urine. Other routes of excretion include bile, sweat, and saliva (Conrad & Barton, 1978; Saran et al., 2018).
Pb can be stored in bone in an inert form (Conrad & Barton, 1978).
Pb bone deposits can supplement circulating Pb long after exposure has ended (Fleming et al., 1997; Smith et al., 1996).
Pb has numerous toxic effects, including inhibition of heme synthesis, by blocking Fe incorporation (Haeger-Aronsen, 1960). Pb also decreases erythrocyte lifespan, being able to cause anaemia (Hernberg, 2000; Schwartz et al., 1990).
Due to its high pollutant potential, the use of cadmium (Cd) has decreased, but Cd is still used for alloys, pigments and, most commonly, NiCd batteries (Huff et al., 2007; Morrow, 2004).
After absorption, most Cd is bound to a cysteine-rich protein called metallothionein (Nordberg, 2004). Cd can also bind to cysteine, albumin, glutathione and other proteins with sulfhydryl groups. Metallothionein synthesis can be stimulated by Cd, over 90% of the amount of Cd in the intestinal cytosol being bound to metallothionein (Klaassen et al., 2009; Waalkes, 2003).
Cd accumulates mainly in the liver and kidneys, which are organs with high levels of metallothionein (Klaassen et al., 2009).
Finch et al. (2012) performed a study on cats and concluded that Cd is involved in the occurrence of hypertension, because hypertensive cats had higher urinary Cd levels compared to normotensive cats.

Cd can interfere with Ca metabolism and cause a decrease in bone density and a predisposition to fractures (Martelli et al., 2006; Huff et al., 2007).

Mercury (Hg) is the only metallic element in liquid form at room temperature (Blum, 2013; Senese, 2018).

Hg is used in several manufactures, such as manufacture of thermometers, barometers, dental amalgams, or liquid mirror telescopes (Akhavan, 2011; Hammond, 2000; Hickson & Lanzetta, 2003; Srivastava, 2008; Watt, 2005).

It is not completely understood by which mechanism Hg is absorbed in the gastrointestinal tract. Hg absorption appears to be related to thiol-containing compounds to which it can bind, and can be absorbed in the small intestine due to the amino acid and peptide transporters in enterocytes (Bridges & Zalups, 2005; Dave et al., 2004; Foulkes, 2000).

Methylmercury, an extremely toxic organic Hg compound, undergoes intensive enterohepatic recirculation, 90% being excreted in the faeces. Inorganic Hg salts are excreted in the urine and faeces (Goran & Crivineanu, 2016; Liu et al., 2008).

Hg, in any form, whether it is organic or inorganic, binds to sulfhydryl groups. Thus, Hg has the potential to affect any tissue, but mainly targets the brain (Bernhoft, 2012).

Hg can cause acute and chronic intoxication (Rustagi & Singh, 2010), and organic Hg compounds are more toxic than inorganic ones (Sin et al., 1983).

In case of acute intoxication with Hg salts, vomiting, haemorrhagic diarrhoea and necrosis of the intestinal mucosa can occur.

Chronic Hg salt intoxication is rare, with renal tubular necrosis or autoimmune glomerulonephritis being observed (Barnes et al., 1980).

In cats intoxicated with methylmercury, ataxia, weakness, tremor, and convulsions were observed (Chang et al., 1974; Charbonneau et al., 1974).

This researched aimed to assess the total concentrations of some heavy metals (Pb, Cd, Hg) using cats' fur as an indicator, while also taking into consideration the age, feeding conditions, and lifestyle of the cats.

## MATERIALS AND METHODS

A total number of 69 cats were used for the purpose of this study.

The cats were further divided into categories based on their age, type of feed they receive, and conditions in which they are raised, as shown in Table 1.

Table 1. Number of cats from each category used in the research

| | | |
|---|---|---|
| Age (years) | < 3 | 12 |
| | 3-5 | 27 |
| | > 5 | 30 |
| Food type | Commercial | 37 |
| | Homecooked | 10 |
| | Combined | 22 |
| Lifestyle | Indoor | 43 |
| | Outdoor | 26 |
| Total | | 69 |

In this sense, cats were divided into groups of individuals below the age of three (n = 12), between the ages of three and five (n = 27), and above the age of five (n = 30).

The cats were also divided into groups based on the type of feed they were receiving from their owners, either commercial food (n = 37), homecooked food (n = 10), or combined food, a mix of both commercial and homecooked food (n = 22).

Lastly, the lifestyle of the cats was taken into account, whether they were raised indoors (n = 43) or outdoors (n = 26).

For this study, from each cat a fur sample was collected. The fur samples were collected from the flank region and were placed in disposable paper envelopes. The envelopes were labelled and transported to the laboratory. Upon analysis, the samples were removed from the envelopes and placed in polypropylene test tubes. Each sample weighed roughly 0.5 g. The samples were digested using 5 ml $HNO_3$ and 1 ml HCl fuming. The samples were then diluted to 10 ml with ultrapure water. The total concentrations of Pb, Cd, and Hg were determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

Statistical analysis was performed using VassarStats: Website for Statistical Computation (http://vassarstats.net/). One-Way ANOVA was performed for all samples.

## RESULTS AND DISCUSSIONS

Several individuals had total concentrations of either Pb, Cd or Hg below the detection limit of the method. Of all cats, 2 cats had total concentrations that were below the detection limit for Pb, 6 for Cd, and 21 for Hg.

The mean Pb, Cd, and Hg total concentrations for the cats used in this study are shown in Figure 1.

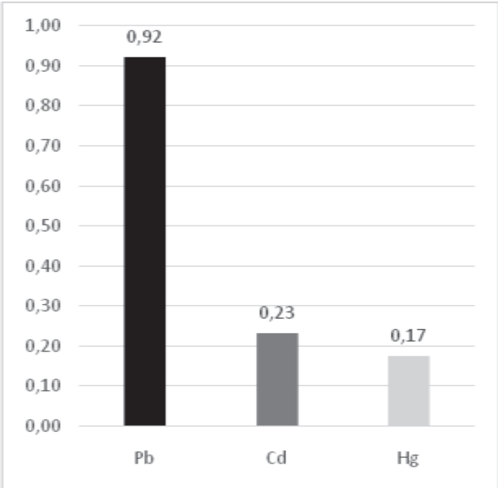


Figure 1. Mean Pb, Cd, and Hg total concentrations ($mg \cdot kg^{-1}$) for all cats

Regarding all the cats used in this study, the mean total concentrations of Pb were 0.92 $mg \cdot kg^{-1}$, mean total concentrations of Cd were 0.23 $mg \cdot kg^{-1}$, and mean total concentrations of Hg were 0.17 $mg \cdot kg^{-1}$.

Sakai et al. (1995) determined the Hg total concentrations in cat fur samples and found a concentration of 7.40 $mg \cdot kg^{-1}$ and 7.45 $mg \cdot kg^{-1}$ male and female cats, respectively.

Pb, Cd, and Hg mean total concentrations found when dividing the cats based on their age are shown in Figure 2.

Cats below the age of three had the lowest total concentrations of Pb (0.77 $mg \cdot kg^{-1}$), cats between 3-5 years old had 0.9 $mg \cdot kg^{-1}$, and cats above the age of five had the highest total concentrations of Pb (1 $mg \cdot kg^{-1}$), however the differences are not statistically significant.

Cats below the age of three had the lowest total concentrations of Cd (0.1 $mg \cdot kg^{-1}$), cats between 3-5 years old had 0.19 $mg \cdot kg^{-1}$, and cats above the age of five had the highest total concentrations of Cd (0.32 $mg \cdot kg^{-1}$), however the differences are not statistically significant.

Cats below the age of three had 0.11 $mg \cdot kg^{-1}$ Hg. Cats between 3-5 years old had the lowest total concentrations of Hg (0.09 $mg \cdot kg^{-1}$), and cats above the age of five had the highest total concentrations of Hg (0.38 $mg \cdot kg^{-1}$). The difference is statistically significant, at $p < 0.05$.

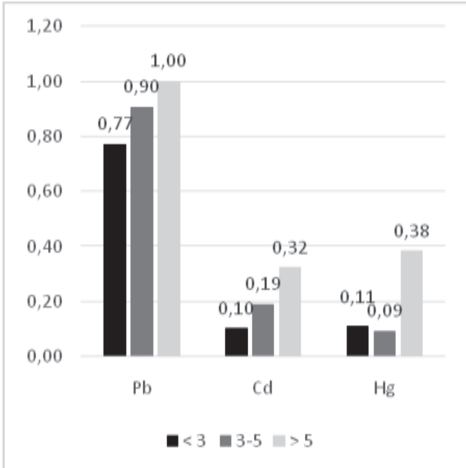


Figure 2. Mean Pb, Cd, and Hg total concentrations ($mg \cdot kg^{-1}$) based on the cats' ages (expressed in years)

Sakai et al. (1995) determined the Hg total concentrations in cat fur samples based on their age, and found 5.50 $mg \cdot kg^{-1}$ in cats aged less than 1 year and 17.99 $mg \cdot kg^{-1}$ in cats over 3 years old, the difference being statistically significant ($p < 0.01$).

Park et al. (2005) performed a similar study on dog fur samples. In dog fur samples, the mean Cd concentration was 0.03 $mg \cdot kg^{-1}$ for dogs below one year, 0.07 $mg \cdot kg^{-1}$ for dogs between 1-2 years old, and 0.14 for dogs over 2 years. The mean Hg concentration was 0.33 $mg \cdot kg^{-1}$, 0.67 $mg \cdot kg^{-1}$, and 0.73 $mg \cdot kg^{-1}$, respectively. The mean Pb concentration was 0.85 $mg \cdot kg^{-1}$, 1.21 $mg \cdot kg^{-1}$, and 1.35 $mg \cdot kg^{-1}$, respectively. Park et al. (2005) also observed and increase in the concentration of heavy metals with age, but there were also no statistically significant differences in heavy metal concentrations among the groups.

Pb, Cd, and Hg mean total concentrations found when taking into consideration the

feeding conditions of the cats are shown in Figure 3.
Cats eating commercial food had the highest total concentrations of Pb (1.06 mg•kg$^{-1}$) compared to cats eating homecooked food (0.54 mg•kg$^{-1}$) and cats eating combined food (0.86 mg•kg$^{-1}$), however the differences are not statistically significant.
Cats eating commercial food had the highest total concentrations of Cd (0.27 mg•kg$^{-1}$) compared to cats eating homecooked food (0.17 mg•kg$^{-1}$) and cats eating combined food (0.20 mg•kg$^{-1}$), however the differences are not statistically significant.
Cats eating commercial food had the highest total concentrations of Hg (0.23 mg•kg$^{-1}$) compared to cats eating homecooked food (0.02 mg•kg$^{-1}$) and cats eating combined food (0.12 mg•kg$^{-1}$), however the differences are not statistically significant.

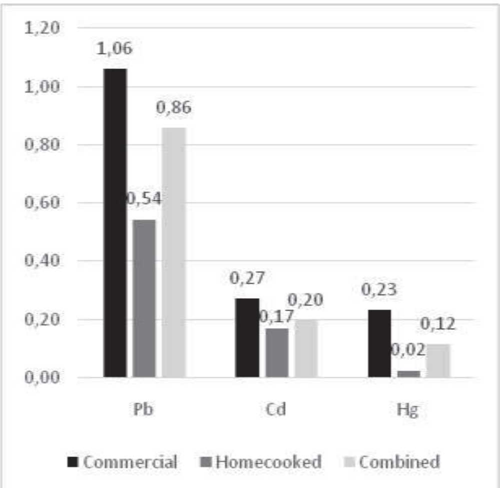


Figure 3. Mean Pb, Cd, and Hg total concentrations (mg•kg$^{-1}$) based on the cats' feeding conditions

Park et al. (2005) also determined the total concentrations of Pb, Cd, and Hg in dog fur samples taking into account their food type, dividing the dogs in two groups: dogs fed commercial food and dogs fed combined food. Therefore, the mean Pb concentration was 1.15 mg•kg$^{-1}$ for dogs eating commercial food and 0.93 mg•kg$^{-1}$ for dogs eating combined food. The mean Cd concentration was 0.09 mg•kg$^{-1}$ for dogs eating commercial food and 0.02 mg•kg$^{-1}$ for dogs eating combined food. The mean Hg concentration was 0.83 mg•kg$^{-1}$ for dogs eating commercial food and 0.32 mg•kg$^{-1}$ for dogs eating combined food. A statistical significance was found for Cd concentrations in dogs eating commercial food compared to dogs eating combined food ($p < 0.01$).
Pb, Cd, and Hg mean total concentrations found when taking into consideration the lifestyle of the cats are shown in Figure 4.
Cats living indoors registered lower total concentrations of Pb (0.74 mg•kg$^{-1}$) compared to cats living outdoors (1.22 mg•kg$^{-1}$), however the difference is not statistically significant.
Cats living indoors registered higher total concentrations of Cd (0.32 mg•kg$^{-1}$) compared to cats living outdoors (0.11 mg•kg$^{-1}$), however the difference is not statistically significant.
Cats living indoors registered higher total concentrations of Hg (0.25 mg•kg$^{-1}$) compared to cats living outdoors (0.03 mg•kg$^{-1}$), however the difference is not statistically significant.

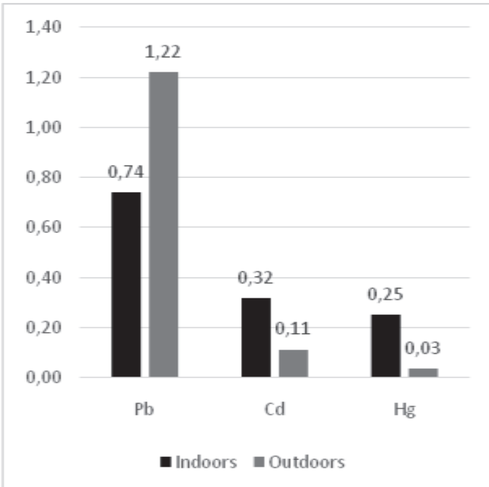


Figure 4. Mean Pb, Cd, and Hg total concentrations (mg•kg$^{-1}$) based on the cats' lifestyle

Skibniewski et al. (2013) performed a study to determine the total concentrations of Pb in cat fur samples based on the lifestyle of the cats, and found 1 mg•kg$^{-1}$ in pet cats and 2.89 mg•kg$^{-1}$ in feral cats.
Sakai et al. (1995) determined the Hg total concentrations in cat fur samples based on their feeding conditions, and found a concentration of 5.61 mg•kg$^{-1}$ in cats eating commercial food and 12.11 mg•kg$^{-1}$ in cats eating homecooked food.

Park et al. (2005) also determined the total concentrations of Pb, Cd, and Hg in dog fur samples taking into account their lifestyle. Thus, in dog fur samples, the mean Cd concentration was 0.05 mg•kg$^{-1}$ for dogs living indoors, 0.07 mg•kg$^{-1}$ for dogs living outdoors (cement), and 0.15 mg•kg$^{-1}$ for dogs living outdoors (sand). The mean Hg concentration was 0.75 mg•kg$^{-1}$, 0.17 mg•kg$^{-1}$, and 0.19 mg•kg$^{-1}$, respectively. The mean Pb concentration was 1.12 mg•kg$^{-1}$, 0.77 mg•kg$^{-1}$, and 0.85 mg•kg$^{-1}$, respectively. No statistical significance was found for Pb, Cd, or Hg concentrations between these groups.

## CONCLUSIONS

The mean Pb, Cd, and Hg total concentrations found in this study were similar or lower compared to other total concentrations found in scientific literature.
The total concentrations of the analyzed heavy metals rise as the cats get older. In addition, cats above the age of five had statistically significant higher Hg total concentrations compared to cats between 3-5 years old.
Cats eating commercial food had the highest total concentrations of all the analyzed heavy metals compared to cats eating other feed types, however no statistical significance was found.
The findings of this research support the assumption that cats which are raised outdoors, in a polluted environment, accumulate higher total concentrations of some heavy metals.

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