Acta Sci. Pol. Zootechnica 18(3) 2019, 15–20

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2019.18.3.03

ORIGINAL PAPER

Received: 25.06.2019
Accepted: 01.09.2019

HEAVY METALS IN THE DANDELION AND APPLE TREE POLLEN FROM THE DIFFERENT TERRESTRIAL ECOSYSTEMS OF THE CARPATHIAN REGION

Oleh Klym, Olha Stadnytska

Institute of Agriculture of the Carpathian Region, 5 Hrushevskoho Street, Obroshyno, Pustomyty district, Lviv region, 81115, Ukraine

ABSTRACT

Pollen load (dandelion and apple tree pollen) was collected from three beehives in three apiaries located in the mountain, foothill and forest steppe areas of the Carpathian region. Heavy metals (iron, zinc, copper, chromium, nickel, lead and cadmium) in the studied biological material were determined by atomic absorption spectrophotometer (S-115 PK). It was found that the dandelion and apple tree pollen, taken from the beehives located in the forest steppe area and the foothills of the Carpathian region, contained more iron, zinc, copper, chromium, nickel, lead and cadmium. A high level of these heavy metals in the dandelion and apple tree pollen taken from the beehives located in the forest steppe and foothill areas of the Carpathian region results from intensive urbanization and industrialization.

Key words: heavy metals, pollen load, apple tree, dandelion

INTRODUCTION

The sources of emissions of heavy metals and their release into the environment differ, but they mostly have a technological origin as a consequence of urbanization and industrialization. The development of industry, agriculture, energetics, transport and intensive mining has led to the situation, in which air, water, soil, and plants contain toxic mineral elements [Bohdanov et al. 2005, Butsiak and Pechar 2007, Bodnarchuk and Musialkovska 2008].

The migration of heavy metals in the environment resulted in their accumulation in soils, plants, tissues of honey bees and bee products [Bohdanov et al. 2005, Bodnarchuk and Musialkovska 2008]. Consequently, the character (altered flowering time) and allocation of vegetation (replacement of some honey plant species) changed, which led to reduced honey flow [Bodnarchuk and Musialkovska 2008, Eskov et al. 2008].

Heavy metals are involved in the metabolic processes in the body of honey bees [Bohdanov et al. 2005, Butsiak and Pechar 2007]. In particular, they affect the intensity of metabolism of proteins, lipids and carbohydrates in the bodies of the bees [Bohdanov et al. 2005]. Consequently, the provision of bees with energy, structural and biologically active material changes. All this affects the life of honeybees and productivity of bee families [Eskov et al. 2008]. Therefore, there is scientific and practical interest in the study of heavy metals in the pollen load depending on the environmental and ecological factors.

In recent years, an increased pollution of various areas (not only urbanised but also potentially ecological ones) with some elements has been observed. Therefore, it seems justified to continuously monitor the level of environmental pollution. The so-called phytoindicators are used for this purpose [Roman 2003].

Dandelion (*Taraxacum officinale*) is a geographically widespread plant species that commonly occurs in different habitats. Therefore, it is a very valuable phytoindicator used for the assessment of heavy metals content in the environment [Kabata-Pendias and Dudka 1991].

According to Czarnowska and Milewska [2000], dandelion is characterised by the high capability of chemical pollutant accumulation in comparison with other herbaceous plants.

✉ klum-oleg@ukr.net

Bee pollen is a pollen collected and processed by bees. According to Kędzia [2008], it contains more than 250 different substances (proteins, carbohydrates, lipids, fatty acids, phenolic compounds, enzymes, vitamins and elements, among others). The composition differs depending on the plant species, the period and place of collection [Nogueira et al. 2012, Paradowska et al. 2014]. The pooled samples of bee honey originate from a large area. Therefore, bee pollen may constitute a valuable indicator material for the monitoring of the level of environmental pollution [Madras-Majewska et al. 2014].

Taking the above into account, the aim of this study was to analyse the intensity of heavy metal accumulation in the dandelion and apple tree pollen, taken from the beehives located in the mountain, foothill and forest steppe areas of the Carpathian region.

MATERIAL AND METHODS

Pollen load (dandelion pollen – *Taraxacum officinale* Wigg. and apple tree pollen – *Malus domestica* Borkh.) was collected from three beehives in three apiaries located in the different areas of the Carpathian region. In particular, the material was taken from the private apiaries of the mountain (Slavske village in the Skole district), foothill (Stynava village in the Stryi district) and forest steppe (Myklashiv village in the Pustomyty district) areas of the Carpathian region. To determine the species of the selected dandelion and apple tree pollen, identification studies were conducted using computer-assisted programs such as "LUCIA" (Laboratory Colour Image Analysis) and "Pollen Data Bank". These programs give an opportunity to determine the main parameters of the pollen grain, which was captured with a video camera and a microscope, by overlaying the images and comparing them with the samples.

Heavy metals (iron, zinc, copper, chromium, nickel, lead and cadmium) in the selected samples of pollen load were determined by atomic absorption spectrophotometer (S-115 PK). The samples of the pollen load in the form of the solutions were tested in the atomic absorption analyzer. These solutions were obtained by dry ashing. To perform this experiment, the sample of the studied material was taken into the calcined crucible and dried in the oven at a temperature of 100–105°C. Then, these samples were burnt in a muffle furnace at a temperature of 450–500°C to the state of complete ashing.

The crucible cooled down when the ashing was completed and the ash was dissolved in 10 mL of 10% HCl. The acidic solutions of ash were tested according to the strictly defined wavelength on the atomic absorption spectrophotometer (S-115 PK) using a computer program, which provided information on the concentration of the studied heavy metals, taking into account the degree of dilution.

The data were analysed statistically using Student's *t*-test. Moreover, an arithmetic mean (M) and the standard error of the mean (±m) were calculated. The differences in the mean values were considered statistically significant at $P \leq 0.05$. The Origin 6.0 (OriginLab Corporation, Northampton, MA, USA) and Excel (Microsoft Inc., Redmond, WA, USA) programs were used for the statistical analysis.

RESULTS AND DISCUSSION

According to Altman [1985], the study of pollen accumulated by bees and the bee bread produced from it, is of great significance to the monitoring of environmental pollution. Bee pollen may contain different amounts of metals. Cadmium (like lead and arsenic) is undesired in apian products.

The contents of selected elements in the bee pollen from dandelion and apple tree are presented in Tables 1 and 2, respectively. In the present study, quite a clear regionalization of elements occurrence was found in the studied bee pollen samples. It was found that the dandelion pollen taken from the beehives located in the foothill and forest steppe areas of the Carpathian region probably contains more iron, zinc, copper, chromium, nickel, lead and cadmium in comparison with the pollen taken from the beehives located in the mountain area (Table 1). As can be seen from Table 1, the dandelion pollen taken from the beehives located in the forest steppe areas of the Carpathian region contained more above-mentioned heavy metals. The obtained data characterize the level of anthropogenic pollution of the territories in the studied terrestrial ecosystem.

It was found that the apple tree pollen taken from the beehives located in the forest steppe and foothill areas of the Carpathian region contained more iron, zinc, copper, chromium, nickel, lead and cadmium (Table 2) in comparison with the pollen taken from the beehives located in the mountain area. As can be seen from Table 2, the dandelion pollen from the forest steppe area of the Carpathian region also contained the greatest amounts of the above-mentioned metals.

The lead (Pb) content in the dandelion pollen obtained in the present study ranged from 1.05 to 2.53 $mg \cdot kg^{-1}$ dry matter (Table 1), whereas its content in the apple tree pollen ranged between 0.43 and 1.01 $mg \cdot kg^{-1}$ dry matter (Table 2). According to Jabłoński et al. [1995], pollen contains 30–100% more pollutants than honey. Mature honey contains 20% less heavy metals than the freshly collected nectar. The cited authors found that the farther the distance between the honey plant and the routs, the lower the content of heavy metals in the nectar, pollen and honey produced from them. On the other hand, Roman [2003] reported the lowest lead contents in the pollen compared with the honey in the

Table 1. Heavy metals in the dandelion pollen, mg · kg^{-1} of air-dry weight (M ±m, n = 3)

Tabela 1. Metale ciężkie w pyłku mniszka lekarskiego, mg · kg^{-1} suchej masy (M ±m, n = 3)

Specification of metals Wyszczególnienie metali	Terrestrial ecosystems of the Carpathian region – Ekosystemy lądowe regionu karpackiego		
	Mountain – Góry	Foothill – Pogórze	Forest steppe – Step leśny
Iron, Fe – Żelazo, Fe	32.04 ±1.101	40.27 ±1.010**	49.95 ±1.144***
Zinc, Zn – Cynk, Zn	43.54 ±0.773	52.70 ±1.169**	62.51 ±0.803***
Copper, Cu – Miedź, Cu	3.34 ±0.181	4.80 ±0.307*	6.57 ±0.338**
Chromium, Cr – Chrom, Cr	2.99 ±0.124	5.20 ±0.171***	7.81 ±0.146***
Nickel, Ni – Nikiel, Ni	0.46 ±0.029	0.62 ±0.029*	0.90 ±0.043**
Lead, Pb – Ołów, Pb	1.05 ±0.083	1.87 ±0.047**	2.53 ±0.104***
Cadmium, Cd – Kadm, Cd	0.04 ±0.006	0.08 ±0.008*	0.13 ±0.008**

*P ≤ 0.05–0.02, **P ≤ 0.01, ***P ≤ 0.001

Table 2. Heavy metals in the apple tree pollen, mg · kg^{-1} of air-dry weight (M ±m, n = 3)

Tabela 2. Metale ciężkie w pyłku jabłoni, mg · kg^{-1} suchej masy (M ±m, n = 3)

Specification of metals Wyszczególnienie metali	Terrestrial ecosystems of the Carpathian region – Ekosystemy lądowe regionu karpackiego		
	Mountain – Góry	Foothill – Pogórze	Forest steppe – Step leśny
Iron, Fe – Żelazo, Fe	14.24 ±0.511	18.58 ±0.751**	24.00 ±0.513***
Zinc, Zn – Cynk, Zn	16.51 ±0.527	22.94 ±0.595**	28.70 ±0.638***
Copper, Cu – Miedź, Cu	1.23 ±0.049	1.91 ±0.060***	2.83 ±0.077***
Chromium, Cr – Chrom, Cr	1.21 ±0.072	2.09 ±0.081**	3.00 ±0.113***
Nickel, Ni – Nikiel, Ni	0.12 ±0.011	0.19 ±0.014*	0.30 ±0.020**
Lead, Pb – Ołów, Pb	0.43 ±0.024	0.62 ±0.032**	1.01 ±0.052***
Cadmium, Cd – Kadm, Cd	0.01 ±0.003	0.03 ±0.003*	0.07 ±0.005**

*P ≤ 0.05–0.02, **P ≤ 0.01, ***P ≤ 0.001

Lower Silesia area. Irrespective of the region of its origin, the average concentrations of this element did not exceed 0.35 mg · kg^{-1} dry matter. Several times higher lead concentrations in the bee pollen from the Pulawy area were found by Szczęsna et al. [1993]. These values ranged from 0.45 to 0.98 mg · kg^{-1} dry matter. Also Konopacka et al. [1993] determined the lead content in the bee pollen at the level of 0.66–1.69 mg · kg^{-1} dry matter.

In the present study, the cadmium (Cd) content in the dandelion pollen ranged from 0.04 to 0.13 mg · kg^{-1} (Table 1), whereas its content in the apple tree pollen ranged between 0.01 and 0.07 mg · kg^{-1} dry matter (Table 2). The considerably lower contents of this element in the Lower Silesia area were reported by Roman [2003]. The average Cd concentration in the pollen was generally low and did not exceed the maximum permissible concentration (MPC). The region with the greatest cadmium accumulation level in the pollen was the Walbrzych area, where the content of this element was 0.035 mg · kg^{-1} dry matter. Lipińska and Zalewski [1989] reported the cadmium concentration in the bee pollen at the level of 0.053 to 0.191 mg · kg^{-1} dry matter, similarly as Szczęsna et al. [1993], who found the values ranging between 0.032 and 0.154 mg · kg^{-1} dry matter. Considerably higher cadmium contents (0.101 to 0.263 mg · kg^{-1} dry matter) were found by Jabłoński et al. [1995] near Pulawy.

All metals were characterized by a clear regionalization of their occurrence. Concentrations were higher in the foothill and forest steppe areas. The high level of iron, zinc, copper, chromium, nickel, lead and cadmium in the dandelion and apple tree pollen, taken from the beehives located in the forest steppe and foothill areas of the Carpathian region results from intensive urbanization and industrialization.

It should be stated that the studied heavy metals in the dandelion and apple tree pollen, taken from the beehives located in the forest steppe and foothill areas of the Carpathian region, are within the maximum allowable limits set by the state standards of Ukraine (SSTU).

CONCLUSIONS

The dandelion and apple tree pollen, taken from the beehives located in the forest steppe and foothills of the Carpathian region, contains more iron, zinc, copper, chromium, nickel, lead and cadmium.

The high level of iron, zinc, copper, chromium, nickel, lead and cadmium in the dandelion and apple tree pollen, taken from the beehives located in forest steppe area of the Carpathian region, results from intensive urbanization and industrialization.

ACKNOWLEDGEMENT

The study was funded as part of the research units' statutory activity.

REFERENCES

Altman, G. (1985). Belastung von Blutenhonig mit Schwermetallen und ihre Herkunft. Apidologie, 16, 197–198.

Bodnarchuk, L.I., Musialkovska, A.O. (2008). Minerals in bee products. Apiary, 8, 10–18.

Bohdanov, H.O., Polishchuk, V.P., Rivis, Y.F., Lokutova, O.A. (2005). Biological evaluation of the pollen basket. Scientific Journal of Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytskyi, 1, 14–19.

Butsiak, V.I., Pechar, N.P. (2007). Heavy metals in soil and foodstuff in private agricultural enterprise 'Berezhnytsia'. Scientific Journal of Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytskyi, 3, 121–125.

Czarnowska, K., Milewska, A. (2000). The content of heavy metals in an indicator plant (*Taraxacum officinale*) in Warsaw. Pol. J. Environ. Stud., 9(2), 125–128.

Eskov, E.K., Yaroshevych, H.S., Eskova, M.D., et al. (2008). Accumulation of heavy metals in the body of the bee. Beekeeping, 2, 110–117.

Jabłoński, B., Kołtowski, Z., Marcinkowski, J., Rybak-ChmieIewska, H., Szczęsna, H., Warakomska, Z. (1995). Heavy metal content (Pb, Cd and Cu) in the nectar, honey and pollen from the plants growing near communication routs [Zawartość metali ciężkich (Pb, Cd i Cu) w nektarze, miodzie i pyłku pochodzącym z roślin rosnących przy szlakach komunikacyjnych]. Pszczelnicze Zeszyty Naukowe, 2, 129–144 [in Polish].

Jabłoński, B., Kołtowski, Z., Marcinkowski, J., Rybak-Chmielewska, H., Szczęsna, T. (1995). Heavy metal content (Pb, Cd and Cu) in the nectar, honey and pollen from the plants growing near communication routs [Zawartość metali ciężkich (Pb, Cd i Cu) w nektarze, miodzie i pyłku pochodzącym z roślin rosnących przy szlakach komunikacyjnych]. Pszczel. Zesz. Nauk., 39(2), 129–144 [in Polish].

Kabata-Pendias, A., Dudka, S. (1991). Trace metal contents of *Taraxacum officinale* (dandelion) as a convenient environmental indicator. Environ. Geochem. Hlth., 13(2), 108–113. DOI: 10.1007/BF01734301.

Kędzia, B. (2008). Chemical composition and adaptogenic activity of honeybee-collected pollen. Part I. Chemical composition [Skład chemiczny i adaptogenne działanie pszczelego pyłku kwiatowego. Cz. I. Skład chemiczny]. Postępy Fitoterapii, 1, 47–58 [in Polish].

Konopacka, Z., Pohorecka, K., Syrocka, K., Chaber, J. (1993). The contents of cadmium, lead, nitrates and nitrites in the honeybee-collected pollen from the different locations near Pulawy [Zawartość kadmu, ołowiu, azotanów i azotynów w obnóżach pyłkowych pochodzących z różnych miejsc w okolicach Puław]. Pszczel. Zesz. Nauk., 37, 181–187 [in Polish].

Lipińska, J., Zalewski, W. (1989). The contents of microelements and harmful elements in bee products from Poland [Zawartość w produktach pszczelich mikroelementów i pierwiastków szkodliwych dla zdrowia człowieka]. Pszczel. Zesz. Nauk., 33, 113–119 [in Polish].

Madras-Majewska, B., Jasiński, Z., Zajdel, B., Gąbka, J., Ochnio, M., Petryka, W., Kamiński, Z., Ścięgosz, J. (2014). Content of selected toxic elements in bee products [Zawartość wybranych pierwiastków toksycznych w produktach pszczelich]. Przegląd Hodowlany, 3, 49–51 [in Polish].

Nogueira, C., Iglesias, A., Feás, X., Estevinho, L.M. (2012). Commercial bee pollen with different geographical origins: A comprehensive approach. Int. J. Mol. Sci., 13(9), 11173–11187. DOI: 10.3390/ijms130911173.

Paradowska, K., Zielińska, A., Krawiec, N. (2014). Composition and antioxidant properties of colour fraction isolated from the bee pollen [Skład i właściwości antyoksydacyjne barwnych frakcji wyodrębnionych z pszczelego pyłku kwiatowego]. Postępy Fitoterapii, 4, 209–215 [in Polish].

Roman, A. (2003). The element contents in selected bee products from the Lower Silesian region [Zawartość wybranych pierwiastków w produktach pszczelich z rejonu Dolnego Śląska]. Żywność 4(37) Supl., 368–377 [in Polish].

Szczęsna, T., Rybak-Chmielewska, H., Arciuch, H. (1993). The use of anodic inversive voltamperometry to determine the level of cadmium, lead and copper in pollen loads [Zastosowanie anodowej woltamperometrii inwersyjnej do oznaczania Cd, Pb i Cu w obnóżach pyłkowych]. Pszczel. Zesz. Nauk., 37, 171–179 [in Polish].

POZIOM METALI CIĘŻKICH W PYŁKU MNISZKA LEKARSKIEGO I JABŁONI W RÓŻNYCH EKOSYSTEMACH TERYTORIALNYCH REGIONU KARPACKIEGO

STRESZCZENIE

Pyłek mniszka lekarskiego i jabłoni było wzięto z trzech uli w trzech pasiekach położonych na obszarach górskich, podgórskich i leśnych strefach stepowych w rejonie karpackim. Metale ciężkie (żelazo, cynk, miedź, chrom, nikiel, ołów i kadm) w badanym materiale biologicznym wyznaczono za pomocą spektrofotometru absorpcji atomowej S-115 PK. Stwierdzono, że pyłek mniszka lekarskiego i jabłoni, pozyskiwany z uli znajdujących się w stepie leśnym i w przedgórzu regionu karpackiego, zawiera więcej żelaza, cynku, miedzi, chromu, niklu, ołowiu i kadmu. Wysoki poziom tych metali ciężkich w pyłku mniszka lekarskiego i jabłoni, pozyskiwany z uli znajdujących się w leśnej strefie stepowej i podgórskim obszarze Karpat jest wynikiem większej urbanizacji i industrializacji.

Słowa kluczowe: metale ciężkie, pyłek, jabłoń, mniszek lekarski.

Oleh Klym https://orcid.org/0000-0002-6330-8489
Olha Stadnytska https://orcid.org/0000-0001-6574-4068