

Silver and zinc transfer from the environment to the selected bee products

Transfer srebra i cynku ze środowiska do wybranych produktów pszczelich

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The aim of the study was to determine the level of accumulation of silver (Ag) and zinc (Zn) in soil as well as green parts and flowers of melliferous plants, honey bee (*Apis mellifera* L.), multifloral honey and beeswax collected from two areas with different anthropogenic activity. The samples were mineralized using microwave oven (Multiwave 3000, Anton Paar, Austria). Content of the examined elements were determined using atomic absorption spectroscopy (AAS) method. It was found that in all investigated samples the concentration of Ag was lower than Zn. Interaction between content of silver and zinc in samples of the green parts of plants had antagonistic character, and in soil samples and bees - synergistic one. The concentration of examined elements in honey and wax was correlated with the content of Ag and Zn in the environment from which investigated bee products originated. Monitoring the presence of toxic trace elements in biological materials is an extremely important. Deficiency and excess of these elements result in serious consequences for plants, animals and products of animal origin. The physiological function of silver is not clear. An elevated concentration of Ag can cause a damage of plant cell membranes or reduce uptake of some ions. In case of animals, higher concentration of silver causes necrosis of the body tissues. Zinc in plants is an active ingredient of several enzymes, its deficiency causes disturbances in metabolism and development, while the excess can cause chlorotic and necrotic changes on leaves and limiting the growth and germination of seeds. Elevated concentration of zinc in animals is considered to be one of the causes of cancerous changes. Presumably, silver and zinc are the antagonistic elements [Kabata-Pendias, Pendias 1999]. Samples of soil, green parts and flowers of melliferous plants, honey bee (*Apis mellifera* L.), multifloral honey and beeswax were collected between June and July 2015 at the two areas of the Lower Silesia with different anthropogenic activity: the ecological area which covers the largest Landscape Park "Dolina Baryczy" in Poland, protected within the framework of "Natura 2000" program and the industrial area belonging to the Legnica-Głogów Copper District. The investigated samples were homogenized and mineralized in closed teflon vessels, to eliminate the loss of elements, using microwave oven (Multiwave 3000, Anton Paar, Austria). The content of silver and zinc was determined by atomic absorption spectroscopy (AAS). All statistics were performed using Statistica™ 10.0 PL software (StatSoft Inc., Tulsa, OK, USA). It was noted that in all investigated samples from both selected areas, the concentration of Ag was always lower than Zn. The concentration of zinc in soil, green parts of melliferous plants and beeswax was lower in samples from the ecological area in comparison with industrial one. In case of samples of honey, honey bees and flowers of melliferous plants, zinc content was higher in samples from ecological area. Samples collected from the Landscape Park "Dolina Baryczy" demonstrated higher concentration of silver (except soil samples) and differences between both selected areas were statistically confirmed in relation to samples of green parts of melliferous plants ($p < 0.01$) and honey ($p < 0.05$). The differences ($p < 0.05$) in the zinc level were noted in the samples of honey bees between two areas.

There was significant positive correlation between the content of Ag and Zn in soil ($r = 0.492$) and honey bees ($r = 0.550$) samples and negative correlation in case of the green parts of melliferous plants ($r = -0.562$). Thus, our results indicate that the interaction between the content of silver and zinc in relation to the green parts of melliferous plants had an antagonistic character, while in case of the soil

and honey bees – synergistic character. Additionally, interactions between the content of silver in green parts of plants and honey bees, honey as well as beeswax, also between honey bees and bee products and between honey and beeswax were found. It was stated that a content of Ag and Zn in honey and beeswax strongly depends on a level of concentration of silver and zinc in an environment from which investigated bee products originated.