Abstract

A major challenge facing mankind today is how to ensure the sustainable development of an ever–increasing population without adversely affecting the environment. One answer to this question is to implement the principles of the so called circular economy, i.e., the recovery of valuable raw materials and the widest possible reuse of waste generated by human activity. One of the ways in which the principles of the circular economy are implemented is broadly understood bioremediation – recently also entomoremediation, as a part of this. This process can be defined as the use of specialized insects and associated microorganisms to utilize, extract, sequester and/or detoxify contaminants from soil, sediment and biomass.

Insects are a group of animals that are the most species–diverse. They inhabit both terrestrial and aquatic environments in all climatic zones. Their natural importance can hardly be overestimated. Insects also play a very important role in the human economy in this latter aspect, one can speak of beneficial insects or pests. However, it should be remembered that the economic point of view does not necessarily coincide with the natural one, and an insect that is considered a pest to man can (and usually does) play an important role in nature. In recent years, insects have been used in waste management. A good example is the larvae of *Hermetia illucens* used for this purpose, which are linked to their high rate of bioconversion.

H. illucens, also known as the black fly or black soldier fly (BSF), belongs to holometabolous insects. Its developmental cycle consists of several stages: eggs, larvae, pupae and adults. *H. illucens* was originally found in the Americas. Currently, the species can be found in areas with subtropical, tropical and warm climates. Relevant to the scope of the dissertation are the larvae, which are saprophages (feed on dead organic matter, such as food scraps, animal dung or human excrement). Their biomass contains 32-58% protein and 15-39% lipids on a dry weight basis. The larvae can be a valuable source of nutrients for the production of feed, for example, for pigs, fish or poultry, as well as for pets such as reptiles and amphibians. Dog food containing *H. illucens* protein is now commercially available and is recommended, especially in the presence of food allergies to proteins from other animals, such as poultry. The exuviae (puparia) remaining after the adults (flies) hatch from the pupae may become an alternative source of chitin and chitosan. In addition, peptides produced by *H. illucens* larvae have been shown to have antimicrobial properties.

This dissertation deals with the management of nuisance waste, which is municipal sewage sludge, and its treatment with *H. illucens* larvae. The research focused on determining

the degree of bioaccumulation of micro–, macronutrients, and toxic elements in the different developmental stages of the insect *H. illucens*, as well as in the pupae exuviae. The dissertation consists of three articles, two of them have already been published and the third is at the review stage. The first study was concerned with determining the bioaccumulation potential of *H. illucens* on an optimal feed for the larvae, which also allowed a more accurate determination of the insect's survival parameters during rearing. In this study, the ability of *H. illucens* to bioaccumulate selected elements: Ba, Bi and Ga was demonstrated for the first time. Bioaccumulation of Cu, Fe, Hg, Mg, Mo, Se, Zn occurred in all insect life stages and in the exuviae, while *H. illucens* showed no ability to bioaccumulate Al, As, Co, K, Pb and Si. In addition, Ca, Cd, Ga, Mn, P and S were bioaccumulated only in some developmental stages of the insect.

In a second publication, a new index was proposed for determining the degree of bioaccumulation of elements – called the bioaccumulation index (BAI). The idea originated during the first study because the widely known bioaccumulation factor (BAF) could lead to interpretation errors in some cases. The proposed bioaccumulation index takes into account the initial concentration of metals in young larvae taken for experiments, and additionally allows determining the reduction of the content of a given element in the larvae bodies during the growth of the larvae, which the BAF does not allow.

The third publication (which is in the review stage) contains the results of studies of the bioconversion of sewage sludge by *H. illucens* larvae. It was also tested whether a small addition of optimal feed would affect the efficiency of sewage sludge utilization, the survival parameters of the larvae, and bioaccumulation of elements. The bioaccumulation of elements was described by two indices: the traditional BAF and the new BAI, proposed in the second article. Only a small number of elements were included: Ag, Ca, Cd, K, Mg and Mn bioaccumulated in *H. illucens* larvae, according to the BAF factor. In contrast, BAI showed bioaccumulation of 22 elements except: B, Cr, K, Mg, Mn, P, S and Si. The addition of optimal feed (20%) resulted in an approximately 1.35–fold increase in waste utilization.

keywords: black soldier fly, revalorization, circular economy, waste management, entomoremediation, sewage sludge, bioaccumulation, elements