BIOACCUMULATIVE AND BIOINDICATIVE ROLE OF FUNGI IN THE ENVIRONMENT

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INTRODUCTION

Mushrooms can collect lots of elements including toxic and radioactive ones. Mushrooms or single mycelia are considered as good biomass for binding heavy metals. Between various fungi known to bind heavy metals, mycelium of *Pleurotus sajor-caju* can be used to remove Cd by means of fungal biomass. *Pleurotus ostreatus* is one of broadly cultivated mushrooms as well as it can grow as saprotrophic organism on various substrates, f. ex. trunks. In our work we used naturally occurred *P. ostreatus* fruiting bodies as a potential marker of atmospheric radioactive pollution.

MATERIALS AND METHODS

The samples of *P. ostreatus* fruiting bodies were collected from the trunk of living lime-tree (*Tilia cordata*) growing on the side of the average busy road in the center of Opole. They were collected during two winter seasons: the end of November (2012), the end of December (2013) and the end of February (2014). Additionally the age of the fruiting bodies was qualified.

The measurements of activity concentrations of K-40, Cs-137 as well as Pb-210 and Pb-212 were carried out by means of a gamma-spectrometer with a germanium detector HPGe (Canberra) of high resolution: 1.29 keV (FWHM) at 662 keV and 1.70 keV (FWHM) at 1332 keV. Relative efficiency: 21.7%. Energy and efficiency calibration of the gamma spectrometer was performed with the standard solutions type MBSS 2 (Czech Metrological Institute, Prague, CZ) which covers an energy range from 59.54 keV to 1836.06 keV. Geometry of calibration source was Marinelli (447.7 ±4.5 cm^3) with density 0.99 ±0.01 g/cm^3, containing Am-241, Cd-109, Ce-139, Co-57, Co-60, Cs-137, Sn-113, Sr-85, Y-88 and Hg-203. Geometry of samples container was Marinelli, 450 cm^3. Measuring process and analysis of spectra were computer controlled with use of the software GENIE 2000.

Time (age)	a_{K-40} [Bq/kg]	Δa_{K-40} [kBq/kg]	a_{Cs-137} [Bq/kg]	Δa_{Cs-137} [Bq/kg]	a_{Pb-210} [Bq/kg]	Δa_{Pb-210} [Bq/kg]	a_{Pb-212} [Bq/kg]	Δa_{Pb-212} [Bq/kg]
November 2012 (mature)	1.059	0.040	4.76	0.64	<MDA*	–	<MDA	–
December 2013 (young)	0.941	0.039	5.30	0.75	45.2	44.9	<MDA	–
February 2014 (old)	1.050	0.033	10.08	0.46	<MDA	–	1.27	0.28

*MDA - minimum detectable activity

Table 1. The gamma radionuclides activity in dried samples of fruiting bodies of *P. ostreatus*

Fig. 1. Fruiting bodies of *Pleurotus ostreatus* in December 2013

RESULTS

Some radionuclides were determined in each sample, and some of them appeared in determinable concentrations only in single samples. In table the activity concentrations of radionuclides *a*, and the measurements uncertainties, Δ*a*, are shown. The values lower than minimum detectable activity (MDA) are marked with <MDA. The abundance of K-40 in potassium is 0.0119%. Because of the constant content, activity concentration of K-40 is the measure of the total potassium concentration. It was observed that potassium concentration in fruiting bodies was similar, though it was the lowest in the young specimen (tab. 1).

The Cs-137 isotope is the artificial radionuclide, with half-life time 20.1 years. Its circulation in environment started about 70 years ago. It was a product of a number of nuclear tests or incidental, uncontrolled releases, like for example, accidents in Chernobyl (1986) and Fukushima Dai-Ichi (2011) nuclear power plants.

The Cs-137 is present in environment up to now, and it was also determined in the investigated mushroom samples. Both, direct atmospheric deposition on the surface and transport from background via mycelium, could deliver Cs-137 to the fruiting bodies. Activity concentration of this radioisotope was also related with the age of the mushroom. The biggest concentration was determined in old specimen, while in the young and mature ones it was similar (tab.1). Probably growth of the fruiting body was associated with continuous intake of Cs-137 from surrounding.

The Pb-210 radioisotope was found in young mushrooms (tab.1), though the measurement uncertainty was significant. This radioisotope is the member of the natural uranium decay series. Is half-time time is 22.2 years, which is significantly longer than that for Pb-210 ancestors in decay series. It could be supposed that Pb-210 appeared primarily in mushroom and its presence is not a result of radioactive decay of its closest ancestors in decay series. In the mature and old mushrooms activity concentration of Pb-210 was lower than MDA. It could be concluded that this isotope appeared in mushroom surrounding only in a period of time, at the beginning of fruiting bodies growth. Subsequent increase in mass of mushroom caused decrease in Pb-210 concentration and fall of activity concentration below MDA.

In old mushrooms the Pb-212 isotope was determined (tab.1). It is a member of the natural thorium decay series. Its half-life time is not long (only 10.6 h). It possible source is Th-228 with half-life time 1.9 years. Occurrence of Pb-212 in fruiting bodies of old specimen supposed deposition of the radioisotope from atmosphere or migration from background. This process was slower than increases in mass of the mushroom.

Fig. 2. Fruiting bodies of *Pleurotus ostreatus*