

ABSTRACT

Environmental pollution is one of the most significant adverse human activities. Critical are emissions of various pollutants, among which are particularly relevant heavy metals. Special attention is required to soil pollution with heavy metals, because they can enter through the soil into the groundwater, plants and animals, thus the food chain.

Soils with heavy metals can be polluted from industry, transport, power generation, as well as military activity. Specific source of pollution are shooting ranges and activity that takes place there. At these facilities heavy metals are entering the soil in the elemental form (pellets, bullets). The main component of the bullets is lead (over 90%) with traces of copper, antimony and arsenic. After contact with the soil substances elemental lead is subject to various chemical processes, oxidation and further dissolving of oxidation products. With these chemical reactions lead is transformed to a more mobile species, which can also enter the food chain.

The concentration of certain heavy metals (Pb, Cu, Cd, As) in the soil of eight Slovenian military shooting ranges was determined. Based on the results of the total Pb a representative number of samples was chosen to perform sequential extraction according to modified "Tessier" scheme. Thus, we determined the proportions of different forms of Pb in soils.

Increased levels of Pb and Cu are found on the most of samples arising from the areas of protective dikes and targets at practically all shooting ranges. Highest determined values have exceeded 10,000 mg/kg for Pb and 1000 mg/kg for Cu. In the majority of samples where elevated levels of Cu and Pb were found, higher values were determined on the surface compared to deeper layer of soil for both elements. In the case of As and Cd extremely elevated concentrations at the different ranges were not found. Maximum Cd content exceeded 5 mg/kg, while the average and median for each zone ranges about 1 mg/kg. In the case of As concentration 50 mg/kg is exceeded few times, while the average concentration at particular regions of shooting ranges remains lower than 20 mg/kg.

The proportion of water-soluble Pb in any of the sample does not exceed 0.1 % of the total Pb. The proportion of Pb in exchangeable fraction in some cases exceed the level of 3%, in one of the ranges is even over 15%. A higher proportion of exchangeable Pb occurs at low soil pH values. At all except one shooting ranges the proportion of Pb in carbonate fraction is lower than 5%. For most of the examined ranges we have found that the proportion of Pb bonded to Fe and Mn oxides, bonded to organic matter and residual Pb is over 95 %.

Based on the content and the proportion of mobile fractions there is a risk of migration of Pb into the groundwater and into the food chain primarily on the shooting ranges Apače, Poček, Crnogrob and Bač.

Keywords:

SHOOTING RANGES, HEAVY METALS, SEQUENTIAL EXTRACTION, LEAD