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Ecological risks of Aluminum production and contaminated area by red mud in Western Hungary (Ajka)

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In October 2010, Hungary experienced one of the most severe environmental disasters: the dam wall of a red mud depository of an alumina plant in collapsed and more than 1 million m3 of toxic sludge flooded the surrounding area. Red mud is a strongly alkaline (pH of 9-12.5) by-product due to the high NaOH content. Apart from residual minerals and oxides, its components also include heavy metals such as Cu, Zn, Cd, Hg, Pb, Ni, Co. As it has already been assessed, red mud had considerable effect on soil properties and thus on soil biodiversity. The aim of our study was to determine the aftereffects of red mud pollution on the soil mesofauna (Collembola). Study plots were selected in the area affected by the toxic flood, in agricultural and grassland habitats, at different distances (0.3 to 12.5 km) from the contamination source. Control plots of each habitat types were selected for comparative analyses. Soil samples were taken during the summer of 2015, five years after the red mud disaster. From each of the selected plots, 5 soil cores of 100 cm3 volume (3.6 cm in diameter and 10 cm in depth) were sampled from which springtails were extracted within 14 days using a modified Tullgren apparatus. Simultaneously with the Collembola sampling, we collected soil samples on each plots in order to determine soil properties (pH, $CaCO_3$, particle size distribution) and the degree of heavy metal pollution. 25 heavy metals were measured (including total Hg) following the method of total (cc. HNO_3 + H_2O_2-soluble) and bioavailable (NH4–acetate + EDTA-soluble) element content using ICP-OES and AMA 254. The studied habitats presented neutral to moderately alkaline soils (pH 7.2-8.1). Total metal content was higher in the plots formerly affected by red mud flood. The Hg concentration ranged from 0.023 to 1.167 mg.kg-1, exceeding the threshold concentration (0.5 mg.kg-1) defined by Hungarian legislation for toxic trace metals in soil. The collected 1442 Collembola specimens belong to 32 species. Species richness and diversity were the highest in the uncontaminated grassland plots. Abundance was the lowest in the polluted and intensively managed agricultural plots (1167$\pm$433 ind./m2), while the most abundant community was found the control grassland plots reaching 10233$\pm$1567 ind./m2. Community structure comparison was estimated using cluster analysis based on the Bray-Curtis index, which well emphasises the difference between the habitat types, as well as the separation of the polluted and control sites. CCA analysis revealed that the most sensitive species to the red mud pollution and thus to the increased heavy metal concentration were Mesaphorura macrochaeta and Sminthurinus elegans, while Brachystomella parvula and most Protaphorura spp. appeared to be more tolerant to the changed soil conditions.