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Evaluation of soil biological quality in the red mud polluted area in Hungary

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Five years after the 2010 red mud disaster in Hungary an in situ investigation was conducted on soil properties and soil biota in the formerly flooded area to explore the ecological after-effects of soil pollution. Surveys were conducted in the Torna creek's valley in three habitat types (agricultural, grassland, woodland). Three polluted and three clean control plots were selected for samplings. Basic soil physicochemical parameters and a total of 24 heavy metals were measured. For soil microarthropod surveys, five soil samples of 100 cm3 were taken from each survey plots. To assess biological soil quality, the QBS-ar index was used, based on the classification of microarthropod groups extracted from the samples. In order to determine the relation between soil parameters (pH, SOM, silt and clay %, heavy metal content) and microarthropod taxa, CCA analysis was performed.
The pH of the control samples ranged from 6.0 to 7.7 indicating slightly acidic to slightly alkaline soils, while red mud flooded samples were slightly to strongly alkaline (pH: 7.5 to 8.5). Total content of major metal component Fe and Al showed significantly higher values in the red mud polluted soils. High total content exceeding the threshold concentrations defined by Hungarian legislation for trace metals was measured in the polluted plots for Cd (0.51–1.10 mg/kg); for Ni (14.1–50.5 mg/kg); and for Cr (29.7–97.5 mg/kg).
A total of 30,459 microarthropods of 21 different taxa were extracted from soil samples. Acari and Collembola were the most abundant taxa in the samples, representing 60.3% and 37.8% of the extracted microarthropods, respectively.
Average number of microarthropod taxa was the lowest in the agricultural fields with important groups such as Diplura, Pauropoda, Protura and Symphyla completely missing. Acari, Araneae, Collembola, Hymentoptera (ants) and holometabolous larvae occurred in all habitat types, while most groups, including Chilopoda, Diplopoda, Isopoda, Pauropoda, Protura, were limited to grass and woodlands. With respect to the red mud affected soil, we recorded fewer taxa in the polluted samples. Generally, microarthropod abundance was higher in the control plots with rare exceptions (Coleoptera larvae and Thysanoptera).
Values of the QBS-ar index fall within a wide range (30–177) corresponding to the distinct habitat types and also the pollution stress. The results highlighted superior soil biological quality in the unpolluted woody habitat (QBS-ar: 128–177), followed by the control grassland (QBS-ar: 96–140). The low richness of microarthropod taxa in the arable fields is well reflected also in the QBS-ar values (30 to 51). When comparing the polluted and control plots, significant differences (t-test, $p<0.01$) in QBS-ar values were observed in all three habitat types.
Based on the CCA analysis, Protura and Symphyla proved to be the most sensitive groups. Chilopoda, Diplura, Isopoda and Psocoptera were more prevalent in clean plots, whereas Acari, Collembola, Coleoptera, Thysanoptera and larvae of Coleoptera and Diptera were also present in considerable numbers in the polluted plots.

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