

ABSTRACT

Assessment of the impact of agricultural and forest management on the properties of industrial soils after sulfur mining in the Podkarpacie region

Mining and processing of sulfur is an economic activity that remarkably affects the natural environment condition, both within the mine and adjacent areas (Trafas, 1994; Gorylewski and Uberman, 1999).

The post-mining land reclamation in sulfur mining industry (borehole and opencast) is a complex and difficult problem, because this type of thriving industry invokes a number of natural environment transformations on a broad scale (Trafas, 1994; Gorylewski and Uberman, 1999; Baran 2006a, Gołda, 2000, Jońca, 2000, Krzaklewski, 2001; Warzybok, 2000).

An important issue for the protection of the environment in Poland has been the reclamation and management of areas degraded for many years, including those after sulfur mining in the Podkarpacie region.

The aim of the paper was to determine the influence of agricultural and forest management on the soil properties after sulfur mines exploited by the hole method (Jeziórko, Basznia) and the open-pit method (Machów). The detailed objectives of the study were to determine the state of physicochemical and chemical properties of selected soil profiles, including: granulometric composition, CaCO_3 content, acidity (pH, Hw, Alw, Hh), organic carbon and total nitrogen, available forms of phosphorus, potassium and magnesium, exchangeable alkaline cations (Ca^{2+} , Mg^{2+} , K^+ , Na^+), total forms of macro-nutrients (Ca, K, Na, Mg), total forms of microelements (Fe, Mn, Zn, Cu, Ni), total forms of selected trace elements (Cd, Cr, Co, Pb), microelements and some trace elements soluble in 1 M HCl, as well as sulfates (VI) content in soil extracts. Biomass and species composition of meadow sward was also determined on reclaimed areas of Sulfur Mines “Jeziórko” and “Machów”.

Based on the field studies, chemical analyses of soil material and statistical processing of the obtained results, the beneficial effect of post-mining land reclamation on changes in many soil properties, was found.

Land reclamation after the mining activity of the Sulfur Mines in Jeziórko and Machów with the use of post-flotation lime as a neutralizer of acidification resulting from the sulfur transformations, has a beneficial effect on the calcium carbonate content and has increased the

pH values both in H₂O and 1 M KCl, especially in the surface layers of soil. The content of calcium carbonate was differentiated in the studied soils after the sulfur mining in Podkarpacie region. Calcium carbonate in soils reclaimed for meadow and forest purposes, was subjected to accumulation in the surface layers and, to a lesser degree, in the subsurface layers. At the same time, there was a tendency to reduce its content with the depth of the soil profile. Hydrolytic acidity (H_h) for tested soils revealed significant differences for surface layers between forest, meadow, and degraded soil types. Degraded soils have shown higher H_h values than forest and meadow ones. Among studied soils, the highest hydrolytic acidity (49.6 cmol(+) \cdot kg⁻¹) was recorded for degraded soil localized in the area of sulfur storage site after Sulfur Mine “Basznia”. The average value of exchangeable acidity and exchangeable aluminum was significantly higher in the surface layers of degraded soils than in meadow and forest soils after sulfur mining in Podkarpacie region. Among the studied soils, the highest values of exchangeable acidity and exchangeable aluminum in the surface and subsurface layers, were characterized by degraded soil located in the area of the sulfur storage site after the Sulfur Mine “Basznia” [H_w and Al_w above 14 cmol(+) \cdot kg⁻¹]. In the area of this mine, statistically significant higher values of H_w and Al_w were found in degraded soils than in arable, forest and meadow soils, both in surface and subsurface layers. The sorption capacity and the sum of exchangeable alkaline cations did not show statistically significant differences in different layers of tested soils after sulfur mines in Podkarpacie region. In the surface layers of reclaimed soils, however, a tendency to predominantly higher values of these parameters has been observed. The content of alkaline cations in the sorption complex of studied soils after sulfur mining could be ranked in the following order: Ca²⁺>Na⁺>Mg²⁺>K⁺. The organic carbon and total nitrogen contents in the surface layers were statistically significantly higher in soils reclaimed for the forest rather than in for meadow purpose after sulfur mining in Podkarpacie region, while vice versa in the subsurface layers. Increased carbon and nitrogen contents in deeper layers of reclaimed soils may most likely be associated with the sewage sludge used for the reclamation of these soils. The contents of available phosphorus and potassium were usually very low and low, and only in the soils after the Sulfur Mine “Jeziórko”, there was a very high phosphorus content. Content of available magnesium in the studied soils was very variable (from very low to very high). The content of available phosphorus was significantly higher in the surface layers of arable soils than in degraded soils. The content of total forms of Na and Mg was statistically significantly higher in the surface layers of soils developed for the meadow purposes as compared to forest soils (regardless of the mine). No statistically significant differences were found between the

contents of total Ca and K forms, both in surface and subsurface layers of the soils, differently managed after sulfur mining. Contents of total forms of microelements (Fe, Mn, Zn, Cu, Ni) and selected trace elements (Co, Cr, Cd, Pb) in soils after sulfur mining varied depending on the mine, reclamation purposes, and depth of the soil profile. Contents of soluble microelements forms (Fe, Mn, Zn, Cu) were considerably higher in surface layers of meadow soils as compared to forest soils after sulfur mining in Podkarpacie region. In these soils, contents of soluble forms of selected trace elements (Co, Cr, Cd, Pb) was not subject to univocal changes depending on a depth of the soil profile nor their reclamation purposes. Natural content (0^0 - contamination) of zinc, nickel, lead, and cadmium (except from a single profile in Jeziórko), was recorded in all surface layers of soils after sulfur mining in Podkarpacie region. Two soil profiles in Machów were classified to a category of an elevated copper content (I^0), whereas one profile to soils weakly contaminated with this element (II^0). Content of sulfates (VI) in extracts of soils after sulfur mining in Podkarpacie region statistically significantly differed depending on the soil reclamation method. The S-SO₄ content in tested soils was within the range from 0.01 to 8.62 g·kg⁻¹. A mosaic of vegetation communities with diverse performance value and habitat requirements, was formed on soils reclaimed for meadow purposes. Most often, they are ruderal plant communities. Analysis of the species composition of the meadow sward on reclaimed soils revealed that on majority of them, there is a possibility to achieve satisfactory hay yields with appropriate quality provided reduced number of weeds and introduced systematic mineral fertilization using nitrogen, phosphorus, and potassium, as well as regular sward utilization.