SUMMARY

The aim of the study was to determine the degree of concentration and the possibility of migration of potentially harmful elements in soils and in mining and metallurgical waste in the Silesia-Kraków region. The reason for the strong environmental degradation of this area is heavy industry, mining of metal ores and hard coal, and iron and non-ferrous metallurgy, as well as pollution by municipal and industrial sewage.

The research was carried out in selected locations of Katowice, Ruda Śląska, Świętochłowice, Bytom, and in the Olkusz region (Olkusz, Bolesław, Bukowno). The concentrations of metals (Ag, Ba, Ca, Cd, Cu, Fe, Mg, Mn, Pb, Sr, Zn, metalloids (As, Sb) and sulfur were determined in 70 soil samples (within a depth range of 0.0–0.3 m) and 16 slag samples.

Using the Pearson linear correlation coefficient, correlations between the analyzed elements were determined. Strong correlations of magnesium with calcium, antimony with copper and antimony with strontium were found. There is also a moderate but significant correlation of cadmium with arsenic, cadmium with copper, copper with silver, iron with arsenic, manganese with magnesium, lead with arsenic, lead with iron, sulfur with calcium, sulfur with magnesium, antimony with arsenic, antimony with cadmium, strontium with arsenic, strontium with cadmium, strontium with copper, zinc with arsenic and zinc with lead.

The use of factor analysis allowed identifying groups of elements of lithological, anthropogenic and mixed origin. The first factor groups the elements that come from the use of additives and fluxes in the steel industry (cadmium, copper, antimony and strontium). The second factor, grouping arsenic, lead, zinc, iron and silver indicates the historical and current exploitation of Zn-Pb ore deposits and the impact of mining and tailings waste as their main source in the environment. The third factor (calcium, magnesium, sulfur) explains probably the mixed origin of these elements, associated with the lithology of parent rocks of soils and/or with the activity of various industries. The fourth factor groups barium and manganese, which have anthropogenic origin.

The tests included: (1) determination of the pH of selected soil samples by the potentiometric method, (2) determination of the concentrations of chemical elements by the ICP-ES and ICP-MS methods after acidic solution (in the AcmeLabs laboratory in Canada), and (3) the analysis of chemical composition of soils and slags using scanning electron microscopy.

The analyses show alkaline or neutral pH of most of the studied soils, which hinders the migration of heavy metals and their accumulation in plants. The determination of chemical elements reveals their high concentrations at almost all locations. The following concentrations were found: silver 0.5–191.6 mg/kg, arsenic 5–10000 mg/kg, barium 8–4,998 mg/kg, calcium 0.13–20.3%, cadmium 0,5–1482.9 mg/kg, copper 3.2–9562.9 mg/kg, iron 0.88–58.61%, magnesium 0.07–8.53%, manganese 120–10,000 mg/kg, lead 9.4–10000 mg/kg, sulfur 0.1–10%, antimony 0.7–4,000 mg/kg, strontium 14–4658 mg/kg and zinc 34–10000 mg/kg. The soil pollution level assessment was based on the contamination factor (CF) and the geoaccumulation index (I_{geo}). These tests showed increased concentrations of metals, metalloids and sulfur, exceeding the level of regional geochemical background many times.

Analysis of the research results indicates that the degree of chemical transformation of the soils in the analyzed regions of Katowice, Ruda Śląska, Świętochłowice, Bytom and Olkusz is very advanced. The values of the indexes used to assess anthropogenic soil contamination (contamination factor CF, and geoaccumulation indices I_{geo}) allowed pointing out high concentrations of most of metals, arsenic, antimony and sulfur in the surface layer of soils (topsoil) due to historic Zn-Pb ore mining and zinc and iron metallurgy. The presence of both primary and secondary: metal sulfides, sulfates, carbonates, oxides/hydroxides, silicates and aluminosilicates was found in the mineral composition of soils and slags. A significant amount of sulfates in the composition of the soils indicates the anthropogenic origin of some of their components and may be the cause of deterioration of chemical properties.