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Soil formation in the landscapes of the Tula Region (Russia) impacted by sulfur coal mining

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Continuous and long-term (dozens of years) supply of technogenic material from abandoned spoil heaps to the environment led to changes in soil properties and transformation of soil cover. Patterns of transformation were determined by (a) mineral and chemical composition, texture and total amount of technogenic material incoming to the soil; (b) degree of inclusion of technogenic deposits into soil horizons (allocation on the surface in separate soil horizons and (or) admixture to soil mass); (c) composition of acid mine drainage (AMD); (d) distance from the source of exposure; (e) dynamics of soil transformation processes (whether technogenic fluxes keep going or they have stopped). All these factors influenced pedogenesis.

Several types of technopedogenesis (soil-forming process influenced by any human activity, related to industrial production and mining (Glazovskaya et al. 1985)) in the post-mining areas were characterized. Type I (dump trails in the immediate vicinity of spoil heaps): secondary technogenic lithogenesis prevailed over pedogenesis presented by the stage of organic matter accumulation due to functioning of microbecenosis. Type II (middle part of dump trails where migration rate of solid-phase material decreases): synchronous processes of lithogenesis and pedogenesis (synpedolythogenesis). There was considerable accumulation of organic matter due not only to microbecenosis but root litter as well. At the same time, the soil profile increased in height ("grew upward") due to pedogenic transformation of incoming solid-phase material from spoil heaps. Type III (edge parts of waste dumps): pedogenesis prevailed over lithogenesis. There was dense grass cover and woody vegetation was settled. Soils with well pronounced humus-accumulative horizon were formed on the surface of the deposit. Supply of solid-phase material of dumps is periodic, during extreme precipitation. Pedogenesis was influenced mainly by AMD with high mineralization. Type IV, agrotechnogenesis, referred to soils on agricultural plots. There was no technogenic deposit on the surface; technogenic material was admixed to soil due to plowing. The soil profile was characterized by high content of rocks particles in the arable horizon and gypsum formations in the sub-plough horizon. Type V, post-technogenic, was observed in soils with the above types of technopedogenesis when supply of technogenic material terminated. Within the soil profile, there was further transformation of technogenic material, with the gradual removal of excess of readily soluble compounds and the decrease in soil acidity. Type VI, technogenic-hydromorphic (two variations), was associated with subsidence areas. For subsidence areas conjugated with spoil heaps there was additional soil moistening and signs of hydromorphism along with pedogenic processes described in types I-IV. In subsidence areas not linked with spoil heaps automorphic formation of soils changed to semi-hydromorphic. In soil profile there were signs of gleying and peat accumulation along with increase of the depth of carbonates (in chernozems).