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Carbon and heavy metal turnover in a Kastanozem complex of South Russia dry steppe

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The state of artificial forest belt of the age of 45 years after initial deep digger plowing (to 40 cm depth) on the dry steppe Kastanozems (chestnut soil) complex of South Russia (Rostov region) was studied. The soil agro-ecological properties of the Kastanozem complex are unfavorable for silviculture as a result of natural solonetzic processes and passive deep digger plowing (to 40 cm depth). These methods fail to create a stable on the long-term pattern soil structure adequate for root development.

A modeling experiment was conducted to study the soil solution composition of the Kastanozem complex and the properties, structure, and chemical calcium-carbonate equilibrium under the influence of biological processes and heavy metals. The activity of ions in soil solution determines the material composition, migration, and accumulation of salts into the soil aggregate system, vadose zone, saturation zone, and landscape, as well as the biosphere evolution.

In soil solution, the electrically neutral ion pairs $CaCO_3^{2-}$, $CaSO_4^{2-}$, $MgCO_3^0$, $MgSO_4^0$, and charged ion pairs $CaHCO_3^+$, $MgHCO_3^-$, $NaCO_3^-$, Na SO_4^-, $CaOH^+$ and $MgOH^+$ are formed. Interaction between the associated ions, organic matter and heavy metals in soil solution was characterized by thermodynamic mathematical model of the soil solution calcium carbonate equilibrium association and ion complexation as the drivers of mobility, transfer, and bioavailability of carbonates, organic matter, nutrients, and microelements including heavy metals. The calculation of the free and associated macro-ion form equilibrium compositions in soil solutions at 25˚C using the developed program ION-2 revealed that at high soil solution ionic strength the ions Ca^{2+}, Mg^{2+}, SO_4^{2-} and CO_3^{2-} are bound to associated ions. The association and complexation of ions in soil solution increases the transfer of carbonates, organic matter, and heavy metals in soil, and the transport of matter to the vadose zone.

A mathematical model of the soil dissolved organic matter transfer in Kastanozem complex was proposed. For semiarid steppe environment long-term soil geophysical sustainability, the 30–60 cm soil layer intra-soil milling was developed. Intra-soil watering was proposed to reduce dissolved organic matter and heavy metal mobility. Mineral and biological matter and waste recycling into the optimized soil aggregate system formed by intra-soil milling for to enrich and speedup the C, N, P, and heavy metals turnover, and to provide the high rate cycling was proposed for environment, energy and climate certainty.

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