Soil scientists determine how abandoned arable land recovers

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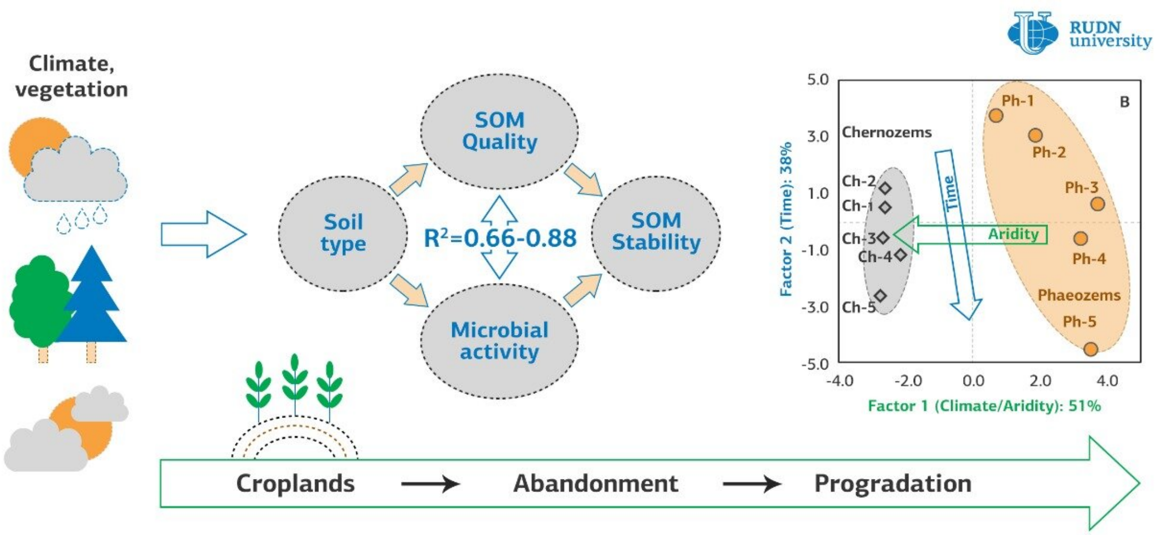

Credit: RUDN University

Soil scientists from RUDN University have found that the rate of accumulation of organic carbon in wild, cultivated, and abandoned soils depends mainly on the type and composition of the soil, and, to a lesser extent, on the time elapsed since it was no longer cultivated. This data will help more accurately calculate soil fertility and the total amount of carbon on the planet, as well as predict climate change. The results are published in the journal *Geoderma*.

Carbon on Earth is contained not only in the form of carbon dioxide CO_2, but also as various organic compounds: in animals, plants, and soil. The carbon content in soil depends on many factors: soil type, climate, species composition of bacteria, and types of carbon compounds.

There are 220 million hectares of abandoned arable land worldwide, according to the United Nations Food Program (FAO), a quarter of which is in Russia. It is of utmost importance to understand how agricultural and post-agricultural lands accumulate and release carbon, in order to build a comprehensive and accurate picture of its natural cycle. Long periods of land cultivation are known to reduce the amount of carbon in the soil. If plowing stops, the vegetation cover grows back, followed by the level of soil carbon. So, it is important to understand how exactly it occurs in each of more than 30 soil types under different geographical and climatic conditions.

The head of the Center for Mathematical Modeling and Design of Sustainable Ecosystems at RUDN University, Yakov Kuzyakov, and his colleagues found out exactly how the cessation of agricultural activities on certain cropland affects the processes of accumulation and decomposition of carbon in the soil.

The object of study was two types of soil. The first was phaeozem: dark soil, rich in humus and calcium, similar to chernozem, but characteristic of areas with a wetter climate. The samples of it were collected in the territory of the former deciduous forest in the European part of Russia. The second type was chernozem. It was collected in the steppes in southern Russia. Soil scientists were interested in precisely these two types, because together they make up more than half of the country's arable land and up to 44 percent of the lands abandoned after 1991.

The experts gathered several samples of each type of soil: soil that has never been used in agriculture, arable soil, and three or four samples of different soils that used to be plowed, but then abandoned at various points in time.

After that, to find carbon compounds contained in the soil, the samples were analysed in various ways: the method of nuclear magnetic resonance, differential scanning calorimetry, and thermogravimetry, among others. Gas chromatography helped determine the rate of CO_2 release from the soil (which indicates microbial activity in it).

The ratio of the rate of CO_2 release to the amount of carbon remaining in the soil determines the resistance of carbon compounds to decomposition and reflects the degree of the resistance. Lower values for the rate of carbon dioxide evolution indicate that more of it remains in the soil, which means it is more stable, and vice versa.

Data collected by RUDN scientists shows that carbon is released more easily from soils rich in carbohydrates: phaeozems. Soils that are, so to speak, harder to melt, i.e. chernozems, contain more aromatic hydrocarbons and release carbon more slowly. Therefore, phaeozems are damaged faster by agricultural use, and chernozems are more difficult to ruin. On the other hand, carbon is restored faster in phaeozems. The increase in the proportion of carbon in lands that have completely recuperated after use, compared with lands in use, amounted to 134 percent. In the meantime, the increase in chernozems was just 38 percent. As all types of soil recovered, the mass of all carbon-containing compounds increased, with O-alkyl being in the lead—it amounted to up to 53 percent of all soil carbon.

The increase in carbon dioxide release due to the respiration of microbes was also observed to increase, from cropland to virgin and fully recovered soils. But in the post-agricultural phaeozems, this indicator was still two to three times higher than in chernozems with the same history.

Soil scientists concluded that it is the type of soil that is the main factor that determines 45 to 88 percent of the differences in the accumulation and decomposition of carbon in the soil. At the same time, the number of years that the land remained in an abandoned state (from five to 35) plays a secondary role, and accounts for only 7 to 39 percent of the total variability.

Overall, chernozems contain more decomposition resistant carbon, and phaeozems contain more easily decomposed carbon compounds.

More information: Irina Kurganova et al. Mechanisms of carbon sequestration and stabilization by restoration of arable soils after abandonment: A chronosequence study on Phaeozems and Chernozems, *Geoderma* (2019). DOI: 10.1016/j.geoderma.2019.113882

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