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Quantification by image analysis on thin sections of lessivage and bioturbation rates in soils in response to land use change and recycling of organic residues

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Land agricultural management has strongly influenced soil evolution during the so-called anthropocene and agricultural practices have to be now assessed according to their influence on soil processes. However, there is a lack of quantitative data about agricultural effect on soil processes and their dynamics especially at generational time scale (10-100 years). Lessivage (i.e. clay translocation) and bioturbation by burrowing animals (mesofauna and macrofauna) are two major pedologic processes in temperate climate. They are of crucial importance as they imply the clay size fraction. This study aims at characterizing the dynamics of these processes and quantifying their intensity after (i) a change in land use and (ii) the introduction of a widespread agricultural practice i.e. organic amendments spreading.

In our investigation, we built an anthropo-chrono-sequence of three Luvisols located on a plateau in Feucherolles (Yvelines, France). The first one is under a deciduous forest and the second one is under conventional agricultural management both with no change in land-use for the past two centuries. The last one is a cultivated Luvisol with regular manure spreading since 1998. Undisturbed soil samples were collected in each horizon of the three Luvisols and large thin sections (57 cm2) prepared according to the method of Guilloré (1985). Clay illuviation features and macropores of biological origin (>100 μm) were quantified by image analysis on the thin sections to evaluate the intensity of lessivage and bioturbation respectively. Size and shape of the macroporosity were used to quantify the activity of mesofauna and of endogeic and anecic worms.

In case of cultivation, we can note a global increase of macroporosity and clay coatings abundance. The greater macroporosity observed on cultivated profiles was undoubtedly due to endogeic and anecic worm activities. Moreover, whereas macroporosity is preferentially located on soil surface under forest, it is better allocated all along the soil profile after cultivation. The greater abundance of clay coatings shows an increasing intensity of lessivage under cultivation. These facts clearly suggest that formation and maintenance of a biological large porosity promoted these preferential transfers of fine clay particles. Biological macropores and clay coatings abundances tend to decrease after 15 years of organic matter spreading when compared to cultivation without manure spreading. It would lead us to believe that this agricultural practice lowered the intensity of bioturbation and lessivage.

Cultivation was found to induce an acceleration of bioturbation and lessivage on time scales as short as a few centuries. We support the conclusion that bioturbation favours lessivage by modifying soil poral network characteristics. It is our opinion that organic residues spreading would further reduce lessivage intensity if performed on longer time scales. Finally, our study points out the fact that (i) lessivage is active in soils under present climatic conditions on shorter time scales than commonly thought (generational ones) and that (ii) land use change act notably on clay particles transport through complex interactions linking bioturbation and soil morphology. Soil evolution after a change in land use may be predicted by this way and associated changes in the intensity of soil ecosystem services may be thus foreseen.