CLIMAT ACADEMY®
The Scientific Supplement

# Chapter Ten

## Tipping Points - Social - Soil


### Summary

This supplement makes the case that soil should be treated as a central, not marginal, issue in climate and sustainability debates. It describes soil as a living biogeochemical system rather than a passive agricultural surface, highlighting the importance of the clay-humus complex, water storage, nutrient retention and biological activity. The text shows how industrial agriculture, erosion, artificialisation and pollution have degraded soils and weakened their capacity to support crops, filter water and store carbon. Soil is also presented as a repository for many of the "new entities" introduced into the environment, linking it directly to one of the already transgressed planetary boundaries. By explaining how fundamental healthy soil is to food, water and ecological resilience, the supplement deepens the chapter's treatment of social tipping points. A society that neglects the condition of its soils is undermining one of the hidden foundations of civilisation and making long-term adaptation far harder.



© Nicolas Duquenne 2026
CREATIVE COMMONS: CC BY-NC-SA

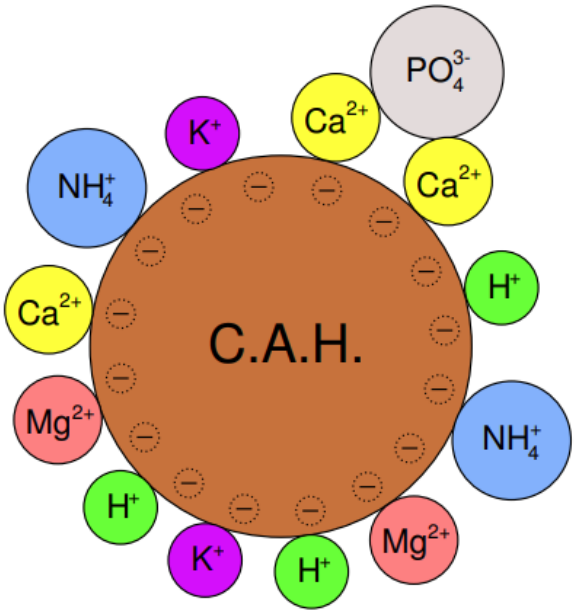
# SOIL, ESSENTIAL ELEMENT BUT FORGOT THE FIGHT AGAINST CLIMATE CHANGE

Finally, discussions on a European directive on the state of agricultural soils (as exists for air and water) are resuming after previous attempts in 2006 and 2013 failed due to vetoes by member states, including France.

Everyone agrees on the need for soil in good condition to ensure quality agricultural production. However, the excesses of the agro-industrial sector have led to the transformation of a rich and complex living environment into an almost sterile object, reduced to a support function.

Soil must first be understood in its biogeochemical nature, in which the argilo-humic complex plays a major role. It should then be considered as a place of storage and filtration of rainwater and runoff. The soil is also the receptacle of "new entities introduced into the environment", to quote one of the 9 planetary boundaries already overpassed. Finally, the degradation caused by the artificialisation and erosion of arable land is a truly existential problem for the whole of humanity.

**The Argilo-humic complex: CAH**




Soil has a dual nature; mineral with negatively charged clay particles and organic with humus molecules which are also negatively charged. The presence of positive ions (usually Ca2+ or iron hydroxides) allows these two negative entities to acquire stability and consistency in the soil.

The positive ions (cations) necessary for plant metabolism are thus captured by this argilo-humic complex. This prevents their leaching and excessive mobility in the soil. The figure also shows that anions (here $PO_4^{3-}$ phosphate) can also be captured and made available to vegetation.

Despite the effectiveness of ionic bonds, the coherence of this complex assemblage is reinforced by the biological action of all living things in the soil (earthworms, spores and fungal mycelium), which are at the origin of a wide variety of agglutinating glycoproteins associated with glomalin.

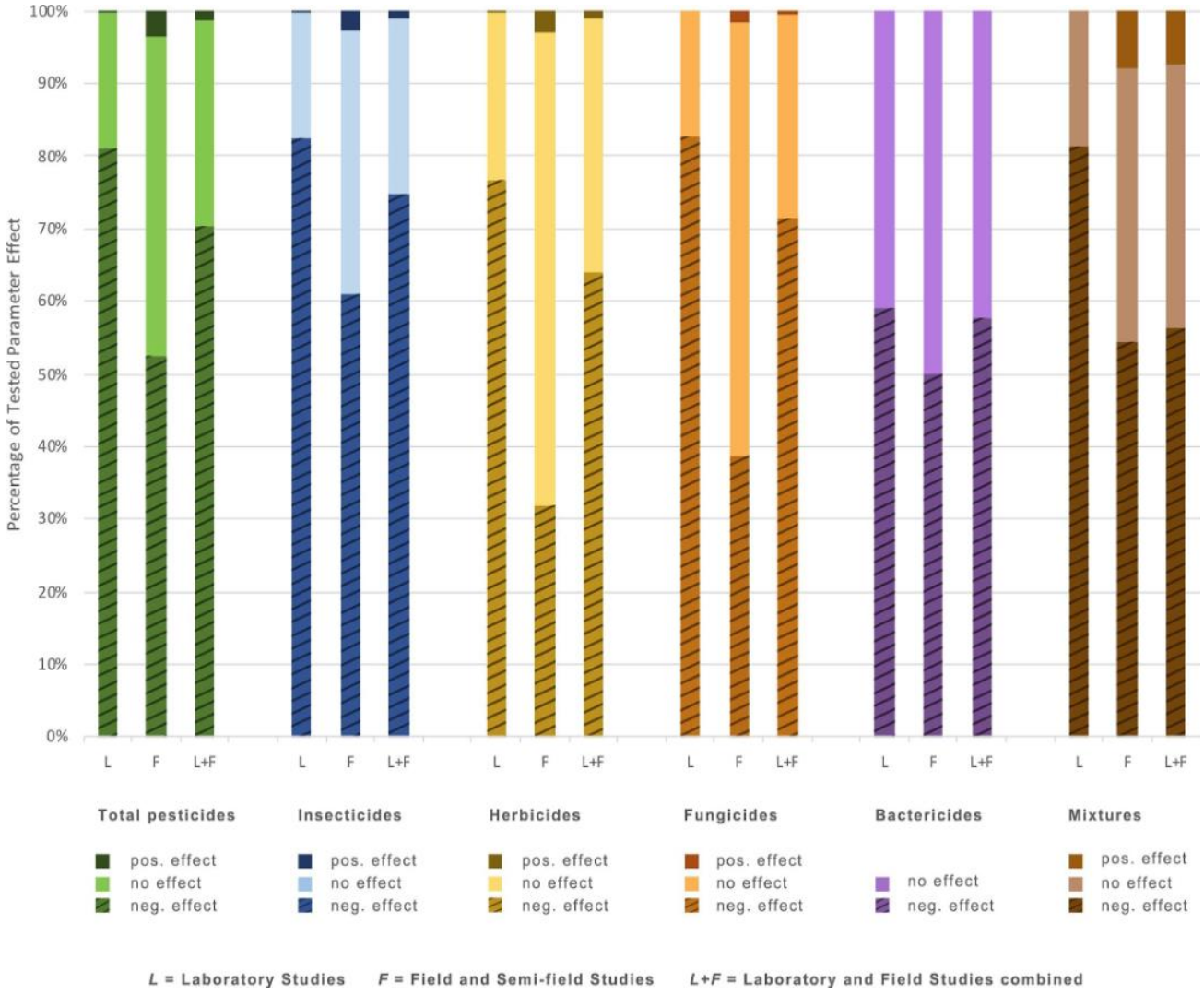
Here we understand the importance of maintaining a diverse and rich pedofauna and pedofloria, since the fertility of agricultural soils depends on the argilo-humic complex, which in turn depends on its biological activity. Unfortunately, decades of use of insecticides, fungicides, herbicides and other biocides have literally sterilised the soil. In addition, the almost complete removal of organic matter (leaves, stems and roots) makes it impossible to replenish even the argilo-humic complex. The soil is no longer able to act as a reservoir of nutritious mineral salts, water and $CO_2$.

Climate change sometimes has the opposite effect. Some regions will experience more droughts, while others will receive massive amounts of water during intense events. We have long known the importance of soil quality and vegetation cover in the consequences of such phenomena, but agro-industrial practices continue to ignore this. Soils are left bare in autumn and winter after the harvest. Worse still, from 2022 European derogations will allow fallow land to be cultivated. Soil erosion and loss of arable land is much greater on bare soil than on land covered with vegetation [(1)]. The same goes for the infiltration capacity of the soil.

[(1)] Yang, Y., Zhang, Y., Yu, X., & Jia, G. (2023). Soil micro-organism regulated aggregate stability and rill erosion resistance under different land uses. Catena, 228, 107176. https://doi.org/10.1016/j.catena.2023.107176

© Nicolas Duquenne 2026
CREATIVE COMMONS: CC BY-NC-SA

There are now hundreds of scientific publications on pesticides. Some studies focus on specific classes of pesticides (herbicides, bactericides, etc.), others on the soil taxa affected, and still others on environmental risks to human health. This multiplicity of work can shed light on the impact of these substances, but it makes it difficult to reconstruct an overall picture of the state of the soil. However, all these studies converge on particularly harmful effects on all soil organisms. In a large compilation study [2] dating from 2021, the results by class of pesticide are beyond appeal: the effects on soil invertebrates are more than 70 % negative!




To conclude this brief overview of the importance of soils in the fight against climate change, it is necessary to recall their role in the carbon cycle. [3]

It is the organic matter present in the soil (bacteria, fungi and all products resulting from the decomposition of living things) that accounts for the largest part of the carbon stock. When organic matter is decomposed by micro-organisms, CO2 is released as a result of respiration, but the carbon is fixed in the humus. A humus-rich soil, recognisable by its dark colour, is therefore an environment conducive to carbon storage.

One estimate of the carbon reservoir in soils is 2500 gigatonnes, or 80% of the total carbon stored by terrestrial ecosystems. This is more than three times the volume of the Earth's atmosphere. We therefore understand the urgent need to conserve our soils so that they can continue to support agricultural production and act as a carbon sink rather than a source of emissions.

[2] Gunstone, T., Cornelisse, T. M., Klein, K. A., Dubey, A., & Donley, N. (2021). Pesticides and Soil Invertebrates: A Hazard Assessment. Frontiers in Environmental Science, 9. https://doi.org/10.3389/fenvs.2021.643847
[3] ontl, T. A. & Schulte, L. A. (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35

© Nicolas Duquenne 2026
CREATIVE COMMONS: CC BY-NC-SA