Circular Economy Lab & Observatory

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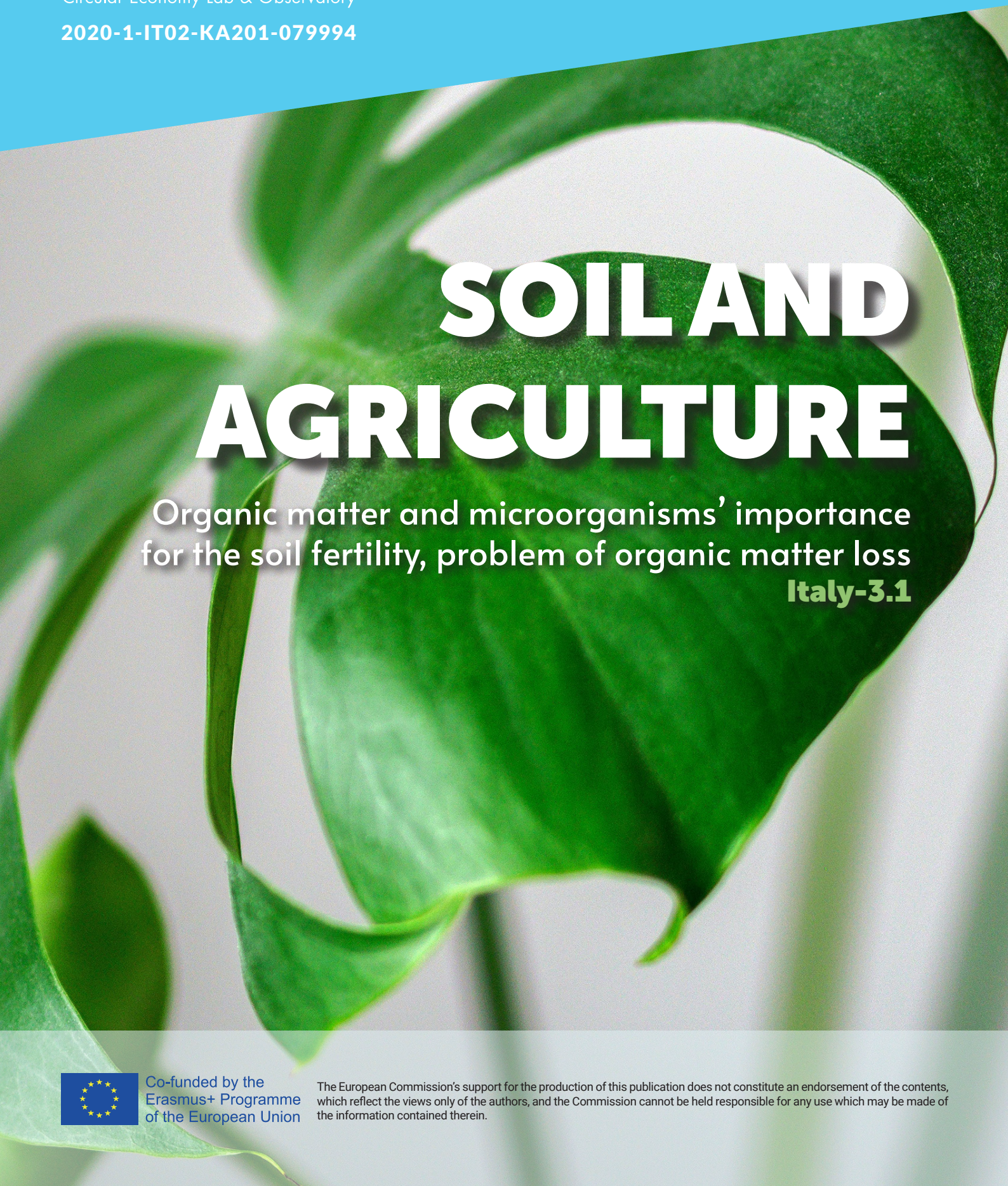

SOIL AND AGRICULTURE

Organic matter and microorganisms' importance for the soil fertility, problem of organic matter loss

Italy-3.1

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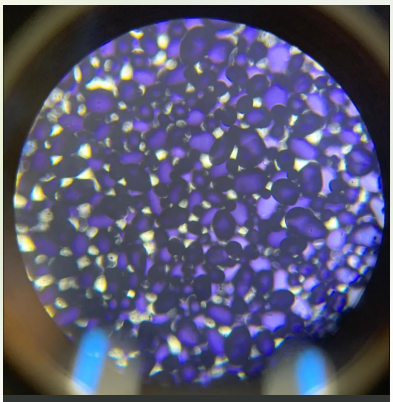
Introduction

Soil organic matter, known as SOM, is the organic constituent of soils. It is composed of organic material that comes from plant residues and living soil organisms, stable organic matter, also called humus, and that part of organic matter almost or already decomposed. Apart from the composition, the role of soil organic matter is extremely important: if the amount and diversity of soil organisms available is good enough to the point that there are no complications, soils are considered healthy and strong.



Bacteria seen under the microscope. Photo by Arianna Trivieri

That's because they play a vital role in enhancing the soil quality on three levels:
When we talk about the chemical aspect, organic matter is a huge contributor to the storage of essential nutrients and the retention of toxic elements. Moreover, the soil is less affected by the changes in soil acidity;
from a physical point of view, soil organic matter is the key to the improvement of its structure, giving plants roots and soil organisms a better living condition;
Lastly, the biological role: the organic matter of soils is the primary source of carbon, that gives energy and nutrients to soil organisms.

Moreover, it also lowers the CO_2 emissions to the atmosphere and as a result, the climate change is lower. That's because when the soil organic matter decays, it releases CO_2 into the atmosphere, when it's formed, it removes CO_2 from the atmosphere.

Speaking of soil microorganisms, there are several types, each of them performing an important role for the soil itself and life of the plants that grow there:
Bacteria: considered to be as "the most valuable of life forms in the soil"as they break down nutrients and release them to the plants roots;
Fungus: they live in the rootzone of plants and ensure them nutrients, just like bacterias do;
Actinomycetes: whose job is to maintain the biotic equilibrium of soil by cooperating with nutrients cycling;
Protozoa: they mineralize nutrients used by plants and other soil organisms afterwards;
Nematodes: whose role is important for carrying live microbes through soils and plant routes. [1-2]

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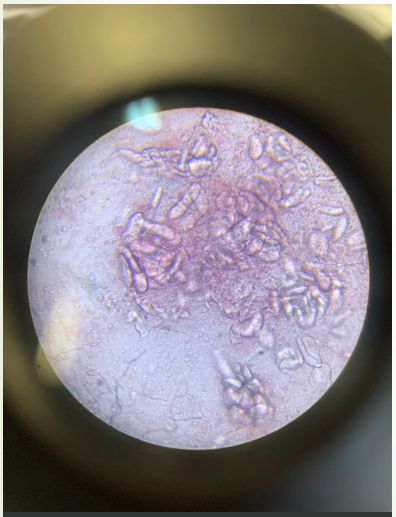
Normally, soils are in good condition only if every type of microorganism is available in it and exists a sort of "balance" among them: if the soil lacks only one type of the microorganisms listed above, then it suffers.

Why is organic matter in our soils so poor?
There are many things that we humans have done to disrupt the equilibrium and the organic matter cycle: just think about intensive agriculture, pesticides and fertilisers; but basically we were not able to follow the naturally occurring circularity of nature. Nature is circular: everything that grows (a fruit) is eaten, digested, decomposed, and it returns to the soil.


Bacteria seen under the microscope. Photo by Arianna Trivieri

What we have been doing for many ears just taking and taking and taking (trees from the forests, fruits and plants from intensive agriculture) ... and not giving back... to be more precise, we give back to soil poisons (heavy metals, toxic chemical) and send the precious organic matter to landfills and incinerators.

Problem description
Soil organic matter declines in number and species because of many and various reasons. Let's begin by saying that microorganisms are restricted to the top layers of soils. Of course, this can be a big problem if soil management practices cause soil loss, because it would inevitably cause the loss of organic matter, too. One of the problems is a bad land use: tillage, for example, increases the rate of organic matter decay because oxygen, mixed in the soil, causes the raise of its average temperature and this causes a reduction of organic matter.

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Vineyard. Photo by Adelaide Rizzuti

If the soil is poorly maintained, it leads to run-off soil erosion, washing away topsoil and humus and reducing the organic matter content because the fertile topsoil is removed. Under semiarid circumstances this may even lead to desertification. The problem here is that in all European countries the availability of living organisms (earthworms, bacteria and mites) has been negatively affected by the intensive use by humans, and almost half of European soils have low organic matter content.

The absence of these microorganisms leads to the alteration of the nutrient cycles essential for plant growth. Moreover, organic matter loss means soil ecosystem functions loss, too. In fact, soil texture is another crucial aspect of organic matter loss: if the soil is coarse-textured, they capture O_2 way easier than fine-textured soils, resulting in a faster decline of organic matter.

On the other hand, fine-textured soils hold nutrients and water in a better way, so plants can grow easily and the soil organic matter accumulates because the more the soil is wet, the less O_2 is available in the soil itself. Vegetation growth and its availability is linked to this condition since roots are a big contributor to soil organic matter.
Loss of soil organic carbon content can limit the soil's ability to provide nutrients for sustainable plant production, and this could also affect food security and the quantity of food in soils which is destined to the living organisms present there, hence reducing soil biodiversity.

Another kind of problem related to the loss of organic matter in soils is the preservation of archaeological material, with soils being important mediums, providing the ideal environment in which to slow the degradation of organic artefacts to very low rates.

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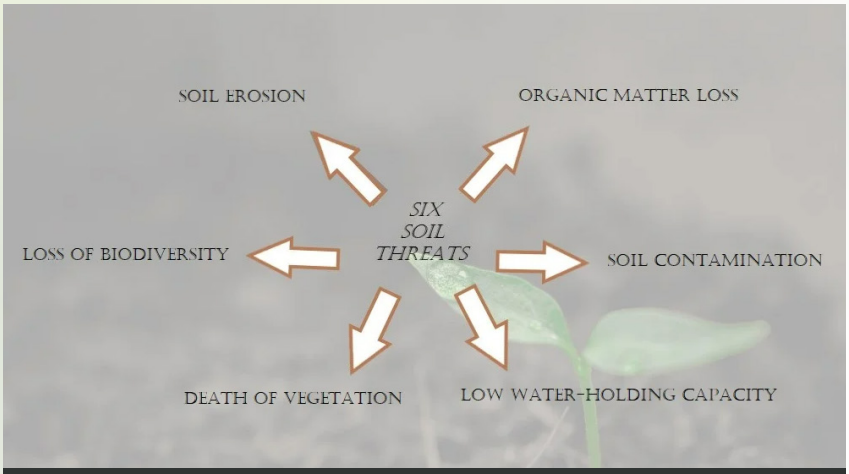
In fact, the loss of soil organic matter or a decline of its quality can have a direct impact on the archeological record. Moreover, global warming could be sped up because of the decay of organic matter content in soils as there would be more CO_2 released increasing greenhouse effect and climate change.



"Six Soil Threaths". Photo by Arianna Trivieri

Therefore the loss of organic matter has huge consequences on soil quality: a lowering of this precious contributor can cause the loss of structural stability, reduction in soil fertility, lower water-holding capacity and the impossibility to break down contaminants and filtering out pollutants, such as as heavy metals and organic pollutants.[3-4]

Possible solutions

The European Commission, in 2002, identified the problem of organic matter loss as one of the most serious causes of soil degradation. The climate is getting worse, the temperatures and the ground are getting hotter and heavy rains occur more often.

This situation speeds up the decomposition of organic soil matter and causes the loss of soil nutrients. Some methods of using the soil (such as vineyards) and soils that are not completely covered with vegetation suffer more from erosion, which also leads to loss of soil organic matter. What are the possible solutions to this problem? Farmers can try to limit carbon loss through decomposition, leaching through aquifers, and erosion.

They could also try to boost organic soil matter content by adding carbon inputs. This can be plant or animal waste produced on the farm, or organic material from outside the farm. It could also be thought of increasing the organic matter of the soil through reduced and non-processing practices, choosing crops that produce more varied organic residues, and applying crop rotations.

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Holding the ground busy for longer periods of time (for example with green manure, which consists in covers that are incorporated in the soil) could also increase the organic matter content.

Vineyard during autumn. Photo by Arianna Trivieri

Soils can also be improved on the biological quality aspect, infiltrating the soil with beneficial microorganisms or using "bioeffectors" that stimulate the biological soil activity.

To increase soil fertility, farmers often tend to give more space to the chemical elements of the soil and the use of chemical fertilisers, but the progress of soil fertility doesn't always have to be too important as an end goal.

In many wine-growing areas, for example, the best quality wines are produced from the vineyards they grow in not very fertile soils.

If the goal is to increase the amount of carbon in the soil, then the practices that favour a slow down in the decomposition rate of soil organic matter are the most effective.

However, reducing or slowing down thedecomposition rate could limit the supply of nutrients to crops. Ensuring a stable level of soil organic matter might be the best solution. [5] Another strategy could be the so-called "Regenerative Agriculture": it consists of farming and grazing practices that can rebuild and generate that part of soil organic matter that has been lost, hence restoring degraded soil biodiversity and ecosystems, making the soil itself more fertile and resilient.

Dry areas in the Calabrian countryside (vegetation used to grow there). Photo by Arianna Trivieri

But this is not all: in fact, these practices influence the plants photosynthesis, cleanse the atmosphere of legacy levels of CO_2, and enhance crops' resilience and their density in terms of nutrients. Moreover, these practices can result in an increased soil water retention ability. [6]

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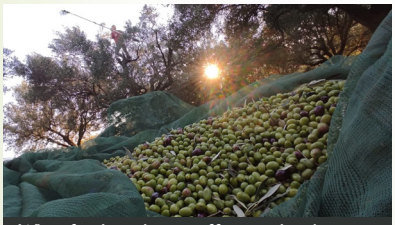
Conclusions

In conclusion, the soil is very delicate, and every slightest change can lead to its loss. The problems that cause soil loss are many, starting from those incorrect management procedures that make the soil itself suffer (the temperature increases, desertification can occur, also affecting the life of living organisms). Moreover, a not so healthy soil can capture O_2 way easier: this can affect its texture to become more coarse, the growth of vegetation is mitigated, as well as the soil's ability to provide nutrients for sustainable agricultural production.

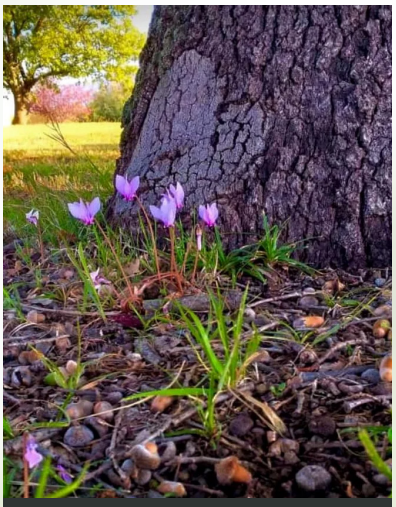
That's because plant productivity is linked closely to organic matter (in fact, it is certain that landscapes with variable organic matter usually show variations in productivity).

High organic matter increases productivity which in turn increases organic matter).



What fertile soils can offer us: olive harvest. Photo by Arianna Trivieri

If the soil is not in good conditions, food security could be affected, also leading to a reduction in the amount of food in soils destined for living organisms. Furthermore, global warming could be accelerated due to the decay of organic matter content in soils, as more CO_2 would be released as climate change increases. Some of the possible solutions listed above are the limitation of carbon loss through some techniques.



Rich soil gives sweet findings (acorns for the fauna) and flowers . Photo by Arianna Trivieri

Plant or animal waste or biological material from the external company, could be produced in the farm.

Another thing we thought of is increasing the organic substance of the soil through alternative practices, choosing crops that produce more varied organic residues and applying crop rotations. In fact, keeping the earth occupied for longer periods of time could also increase the organic matter content. Soils can also be improved in terms of biological quality by infiltrating the soil with beneficial microorganisms. Another possible solution could be limiting the use of pesticides and herbicides: in fact, if the concentration of organic matter in the topsoil decreases, the contamination of the environment by herbicides is likely to increase.

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Many organisms either disappear completely or their numbers are reduced drastically. Did you know that soils have the ability to restore their life-support processes? The fact is that organic matter and biodiversity of soil organisms are the driving factors in this restoration.

If the soil organisms availability decreases, the resilience of soils decreases, too. By saying "resilience" we refer to the ability of a system to recover after alteration. Guess what? Soil resilience also depends on the availability of organic matter and soil organisms, which conserve and improve soil properties that are related to soil resilience. [7]

In conclusion, we should take care of this precious source of life of which we still have the availability now, because it is not so certain that in the future we will be able to take advantage of it and that it will give us the same gifts that we receive nowadays.

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GROUP

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