

Humipedon

Subjects: Soil Science

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The soil covers our entire planet and corresponds to the most superficial part of the earth's crust. Exposed to the attack of atmospheric agents and living organisms, the soil is organized in layers recognizable to the naked eye, more organic towards the atmosphere or water (if submerged), more mineral towards the rocky part of the bottom. To facilitate its study, specialists divided the soil into three sections: richer in organisms part -> 1. Humipedon; bottom still in contact with the unaltered rock section -> 3. Lithopedon; in-between, central, mineral part -> 2. Copedon. The present encyclopedia entry describes the variability of the humipedons of planet Earth. They have been subdivided in ecological groups and classified into different humus systems. The aim is to display them and diffuse their knowledge.

Keywords: humus form ; humus ; soil ; litter

1. Humipedon

1.1. Introduction

The founding fathers of pedology of the past century (Dukuchaev, Jenny, Hartmann, Stevenson, Leadley Brown, Duchaufour, all the original FAO group, and many others ...) ^{[1][2][3][4][5][6][7][8]} were looking for pedogenetic processes. In this, they were preceded by Darwin, the father of ecology and natural evolution concepts who first studied the formation of vegetable mould by earthworms ^[9]. These fundamental classifications were "morpho-functional" (take note of those morphological aspects that facilitate the recognition of specific soil genesis and soil functioning). In 2003, 26 European forest soil specialists met in Trento (Italy) and founded the Humus group. They wanted to take stock on the classification of the European topsoils and realise a shared synthesis. In 2004 the group presented a first proposal of agreed reference at the Eurosoil Congress in Feibourg ^[10]. The group's classification commission met every year and in 2018 the Humus group published 78 articles parted in three Applied Soil Ecology special Issues (N. 122a, 122b and 123); in these issues, the organic and organo-mineral top section of the soil was called "Humipedon" ^{[11][12]}.

The humipedon corresponds to a living matrix that covers the whole planet. If you like Lovelock's concept of Gaia ^[13], you can see humipedon as a living film that encompasses like a skin the solid core of our planet. This membrane is not uniform. It is built by living beings in equilibrium with the rest of the biosphere. These living populations are dependent on the environment in which they develop, and adapt to it by changing both the environment and themselves over time, evolving with the planet as a whole. The ecologist's challenge is to discover how this matrix changes and goes over time, and how it interacts with the rest of the livings on the surface of the planet Earth. Because at the soil surface, what is alive or dying joins with what will come out from the ashes. It looks like a religious tale. The humipedon is only mysterious because little known, inhabited by invisible beings or strange small beasts, which can be scary only if magnified by the lens. Observed to the naked eye, a humipedon is composed of layers (called horizons by soil scientists) superimposed as in a sandwich with a total thickness varying from a few millimeters in the initial and young humipedons, up to an average of about ten centimeters in the more mature ones, with exceptions of even several meters in peat bog environments.

1.2. Definitions

Humus: Etymomologically it means "dirt, soil, earth". Homo or Human have a very similar meaning, "coming from dirt, earth, or made of dirt, earth". In practice, humus is characterized by the joint presence of two processes that occur in the superficial part of the soil: mineralization (return to the menereal components) and humification (construction of new organic molecules). The set of molecules and organic and organo-mineral aggregates that undergo this combined transformation process is called humus. In each environment the two processes which are mainly biological occur in a characteristic way and give different humipedons.

Humipedon: organic (codes: H, O) and organo-mineral (code: A) horizons of a soil.

Organic horizons (codes: H, O) are formed of dead organic matter (OM), mainly leaves, needles, twigs, roots and, under certain circumstances, other plant material such as mosses and lichens or remains of hydrophytes. This OM can remain not or little transformed when submerged (H: HF, HM, HS horizons) or be transformed in animal droppings following ingestion by soil/litter invertebrates and/or slowly decayed by microbial (bacterial and fungal) processes (O: OL, OF, OH horizons). A limit of 20% organic carbon (OC) by mass was established to define O horizons.

Organo-mineral horizons (code: A) are formed near the soil surface, generally beneath organic horizons. Coloured by organic matter, these horizons are generally darker than the underlying mineral layer of the soil profile. In the soil fraction $\varnothing < 2$ mm of the A horizon, organic carbon has to be less than 20% by mass. There are terrestrial A horizons that are not or only periodically asphyxiated (maA, meA, miA, sgA, msA), or more or less submerged (anaA, anA).

Humus system: category that contains morpho-functional equivalent humipedons. Visible to the naked eye or with a magnifying glass (x 10), some morphological characters allow in the field to assign the humipedons to a given humus system. Each humus system is generated by a functional group of living organisms that co-evolve in an ecologically circumscribed environment^[14]. Within each humus system, the thickness of particular diagnostic horizon allows to assign each humipedon to more specific **humus forms**. Each humus system enumerates 2-4 humus forms.

By making a hole in the ground of a forest, you discover a "face" of the soil, called a profile, on which three sections subdivided in horizons can be seen: a) Humipedon (horizons: H, O, A) = organic and organo-mineral soil horizons; b) Copedon (horizons: E, B) = mineral soil horizons; c) Lithopedon (horizon: C, and R layer) = rocky part of the soil, altered rock, top part of the solid Earth crust. The **humipedon** corresponds to the part of the soil richest in organic matter, pedofauna, microorganisms, seeds and roots of plants (**Figure 1**). It is also the most active part of the soil, where the processes of mineralization and humification of organic matter take place as well as the making of the organo-mineral aggregate of the soil.

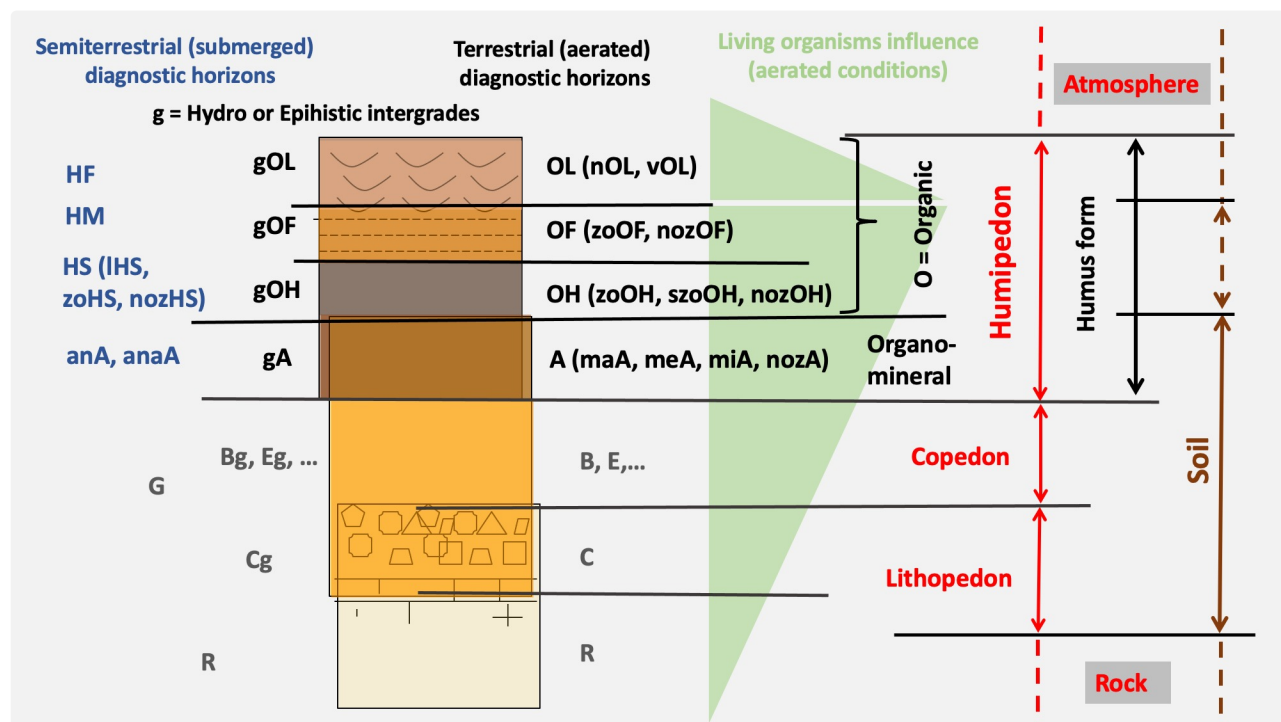


Figure 1. The distinction of Humipedon, Copedon and Lithopedon, with the list of diagnostic horizons in Terrestrial and Semi-terrestrial conditions.

The Humipedon covers the entire surface of the planet Earth and it changes in space and time. It is therefore more appropriate to speak of a mosaic of different humipedons of which this cover is composed. They are essentially the physical spaces where, at the same time, both the decomposition of dead organic matter and the reconstruction of new organic matter take place. Depending on the environment of genesis and development, humipedons are different, as they are created by different organisms in equilibrium with the environment and with each other. In summary, we can say that these processes depend on the possibility of "oxidizing" (and/or "reducing") the organic matter in the air or in water. The components thus obtained interact chemically and physically and create new organic, organo-mineral or mineral structures, in more or less aerated environments. The pores of the matrix in which these processes take place may be filled by air or water in a dynamic exchange. The length of stay in the pores of water or air divides the humipedons into two broad categories: Terrestrial (long residence times of air = presence of oxygen) and Semiterrestrial (long residence times of water = lack of oxygen). However, there are also particular conditions of birth and development of these

humipedons. The "youngs" differ from the more developed ones. When young, they are highly dependent on external and dominant groups of organisms that build them and assign a recognizable appearance to humipedon. As they evolve, they converge into typical systems that we could define as "central references", characterized by a certain independence from the environment in which they develop. There are also humipedons characteristic of areas that are very difficult for living beings to inhabit, with high pressures and temperatures or strong acidity. For this reason, central humus systems and satellite humus systems can be seen in Figure 2. The central systems were named Terrestrial (red on **Figure 2**), Histic (blue) or Aqueous (green); the satellite ones, Para (grey). In the central part there are also two Anthropogenic humus systems, named Agro and Techno (black).

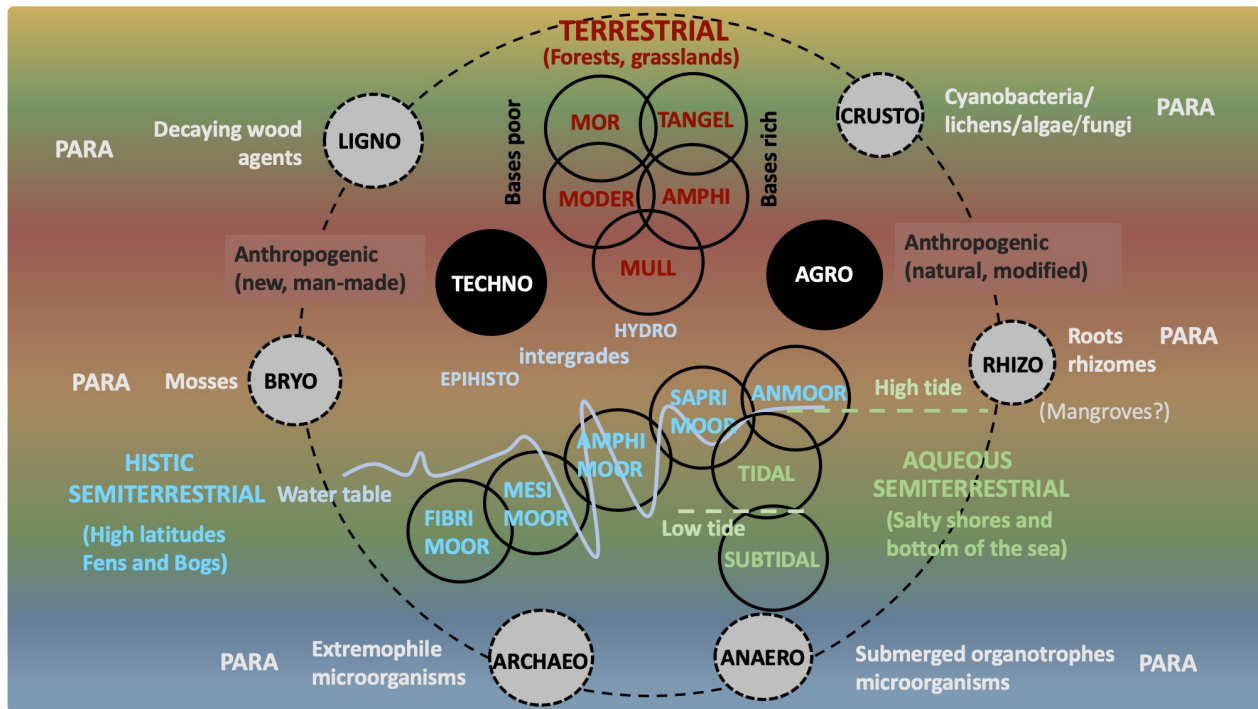


Figure 2. The humus system that cover planet Earth. Terrestrial (forests and grasslands): Mull, Moder, Mor, Amphi, Tangel; Histic (Fens and Bogs): Anmoor, Saprimoor, Anphimoor, Mesimoor, Fibrimoor; Aqueous (salty shores and bottom of the sea); Anthropogenic Agro (natural humipedons modified for agricultural purposes) and Techno (man made composts, dumps, hydroponic solutions,...). Para humipedons are represented as satellites of the "central" humipedons because they can either remain independent, or evolve towards the more developed ones, depending on the dynamics of the water and other ecological factors.

2. Main Ecological and Morpho Functional Groups of Humipedons

For ease of recognition and interpretation, humipedons can be assigned to four major ecological and morpho-functional categories: 1 - Terrestrial humus systems^[15]: not or submerged for a few days a year; 2 - Semiterrestrial humus systems: 2a - Histic humus systems^[16]: submerged but not subjected to strong daily tides; 2b - Aqueous humus systems^[17]: by the sea, in salt water and affected by tides with a daily rhythm. 3 - Para humus systems^[18]: These are humipedons either of initial soils or of soils linked to specific "out of standard" environmental conditions. They are represented in gray circles on figure 2; 4 - Anthropogenic humus systems: Agro humus systems^[19] or Techno humus systems. The Agro's are Terrestrial, Semiterrestrial or Para humipedons modified by man to be cultivated, and contain diagnostic horizons similar to the original natural ones. The Techno's instead are: 1) manure humipedons (different types of composts), 2) soil-free humipedons (from hydroponic solution to porous clay artificial aggregates), 3) dump humipedons (various types of landfills).

2.1. Terrestrial (Figure 3)

TERRESTRIAL

Humus systems of aerobic conditions, no water saturation, presence of terrestrial O or/and A diagnostic horizons, absence of H or anA horizons

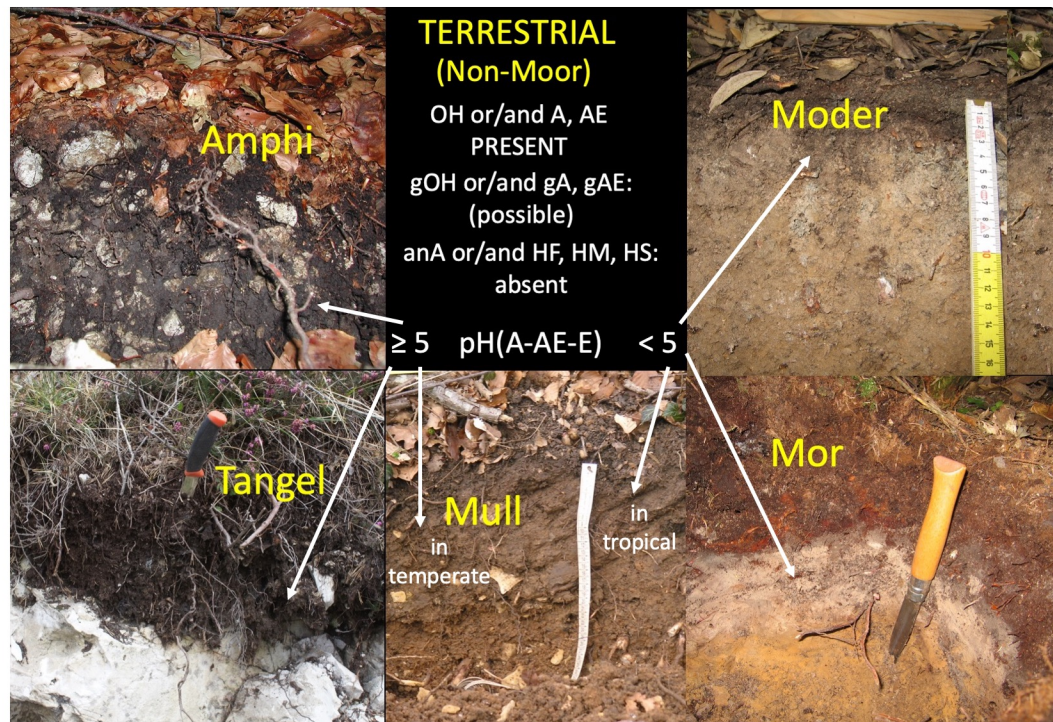


Figure 3. Terrestrial humus systems. We see that they are not in water and relatively dry. We are in forests, shrubs, grasslands, where you can walk without sinking. It is also seen that they have evolved, because they got a consistent thicknesses of about 5-50 cm. For this aspect concerning the evolution and thickness it is necessary to compare with Para systems. On this figure there are only forest and well developed humipedons. The Mull is made by animals that mix efficaciously organic matter and soil; no organic remains are seen with the naked eye when looking at the humipedon; the leaves become soil, organo-mineral lumps of soil, with the still uneaten litter that lays at the top, eventually. These animals eat all the litter that falls in the year, letting the soil nude before a new fall. The animals that originate this structure are earthworms or large insects larvae. In this case, what we call soil is 100% made of their excrement. The Mull is formed in temperate environments to which these animals are well adapted. The Mull is found in all temperate plains of the world. The environment changes as you go up in altitude, or go towards the Earth's poles. The actors of biodegradation and the formation of humipedons change. If the substrate is acidic, the humus system passes from Mull to Moder and then to Mor; if, on the other hand, it is carbonatic, it goes first to the Amphi and then to the Tangel. This is a general rule. In reality, it is also possible to meet Mulls in mountain sites and Mor in the plains, when the environment becomes locally temperate or protected in the first case, or decidedly acidic or difficult in the second. For a complete reading of the humipedon coverage it is also necessary to know the Para systems, which can be superimposed or juxtaposed with the more advanced ones. In the mountains, for example, the prairie is characterized by a Rhizo system under which a Mull system can develop. The dominant system is a Mull in the valley floor and in the lower part of the slope, the Rhizo becomes dominant when the humipedon is 10 cm or less thick, high on the clinal and near the outcropping rocks. To see illustrated examples of Terrestrial humus systems, please refer to:

2.2. Semiterrestrial

The Semiterrestrial systems contain humipedons more or less related to environments rich in water. At first the peaty's were distinguished from the more mineral ones, then those with a more or less prolonged duration of the submersion cycle from those that had an hourly cycle linked to the tides. The latter are also generally saltier than the former.

a. Histic (Figure 4)

Fens and Moors.

SEMITERRESTRIAL

Humus system strongly influenced by hygrophytes or peat mosses forming more or less submerged peat deposits (bogs, fens), or seaside and tidal zones.
MANDATORY: presence of H or/and anA diagnostic horizons.

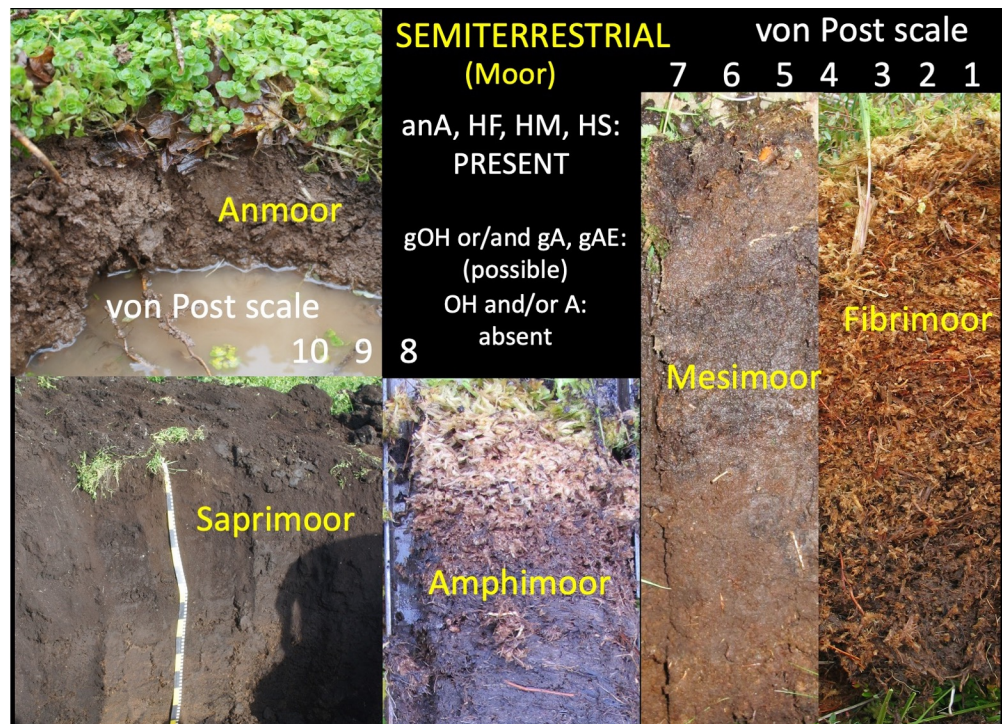


Figure 4. Semiterrestrial Humus Systems. In these environments there are hygrophilous plants and the rather organic matrix is generally dark. The figure shows the von Post scale which indicates the degree of decomposition of the vegetation in the humipedon horizons; this scale is low when the plant components are almost intact and visible, it becomes 10 when they have become dark soil. An easy way to distinguish the three main organic horizons is to squeeze a fistful of material: if clean water comes out, HF (little or not decomposed plant material von Post from 1 to 3); dirty water comes out, HM (von Post from 4 to 7); no water comes out but paste-soil if wet, HS (von post from 8 to 10). "Ana" (typical in Anmoor) is an organo-mineral diagnostic horizon, a paste similar to HS but with an organic carbon content $\leq 20\%$. Passing from left to right on the figure, we go towards increasingly submerged environments. To know more about these humipedons, refer to :^[20]

b. Aqueous

Tidalic seashores.

The Aqueous are still and strangely little studied. They would be very interesting because they correspond to the shallow edges of rivers, lakes, seas, oceans and tidal zones. They are the result of interaction with the remains and activities of aquatic microorganisms, animals and plants. They are different from Histic because they are more mineral, generally salty and with a clearer distinction between humipedons asphyxiated or periodically ventilated over the course of a day. They are certainly interesting for those who keep fish or crustaceans or aquatic animals in general. Basics of classification here:

2.3. Para Humus Systems

The study of Para systems is not accidental. It is impossible to understand other humus systems without first observing what happens when they are young or different from the standard ones. The normal growth series of humus systems is this: a) few and quite invisible microorganisms on any substrate (they are called microbial films; not considered in our classification); b) growing, these micro-humipedons become larger Anaero or Archaeo or Crusto in our classification, depending on the environment in which they generate; later, they may evolve into c) Bryo, then d) Rhizo, ending in e) Terrestrial, or Semiterrestrial, or Aqueous systems or f) Anthropogenic. If you look at them on Figure 5, you will find that you have already seen them somewhere. Other examples, here:^[18]

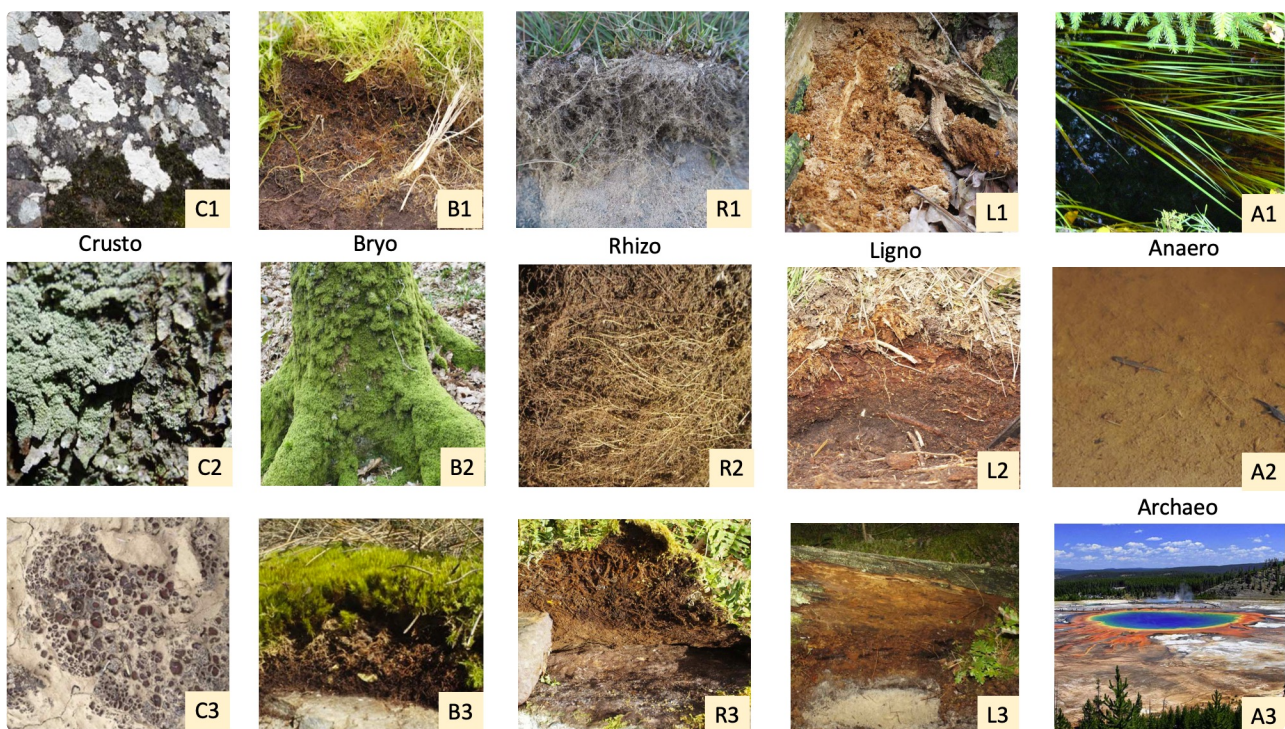


Figure 5. Para humus systems, in column from left to right, examples of Crusto, Bryo, Rhizo, Ligno, Anaero (A1,A2), and Archeo (A3).

2.4. Anthropogenic Humus Systems

Humans use humipedons to live (Figure 6). To produce the food we need, we change the vegetation cover by planting species of our own taste. In general, this turns all pre-existing natural humipedons into Agro Mull (or Agro Anmoor in wet environments). A Rhizo Mull (Rhizo laying on a Mull system) is found in all natural or artificially grazed graminaceous environments . Humipedons can also be completely artificial (Techno humus systems), as may be landfills, waste, concrete, compost heaps, even hydroponic solutions.

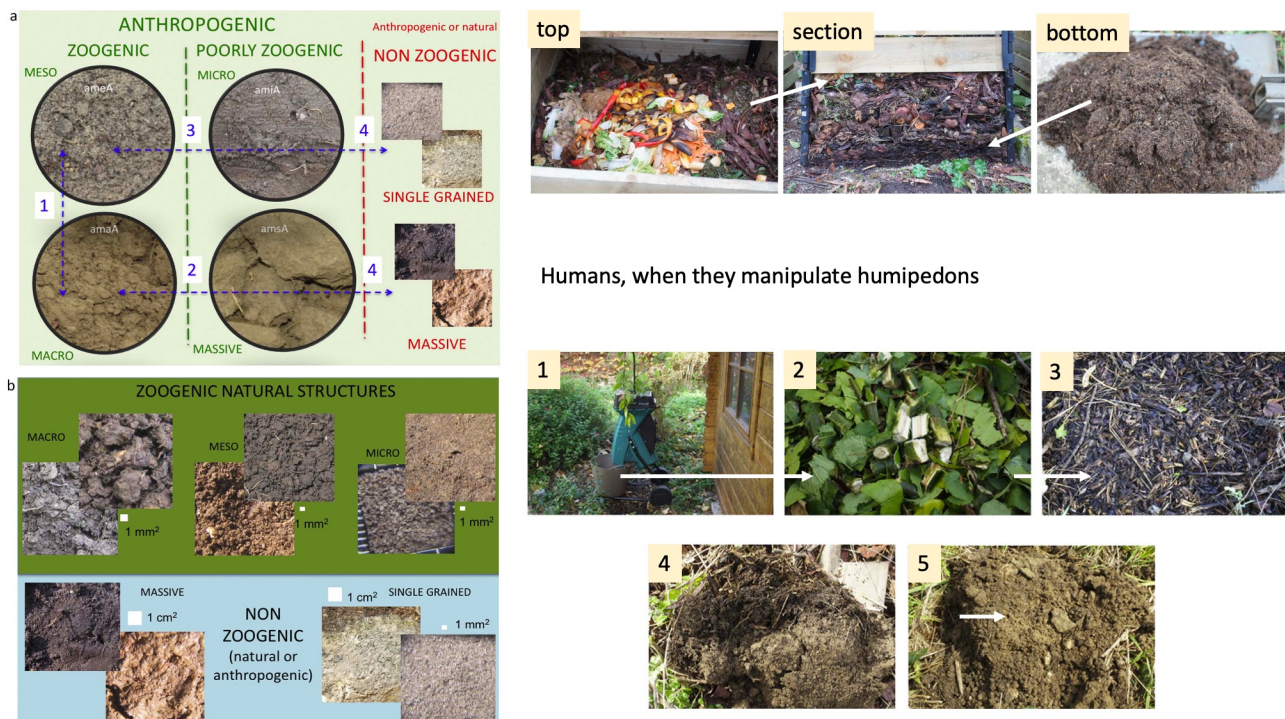


Figure 6. Agro Anthropogenic humus systems. a) and b): comparing natural and anthropogenic soil structures. Right part, homemade compost production (above), or direct and surface distribution of ground leaf and wood, to nourish the soil. To know more, please refer to: [\[17\]](#)[\[19\]](#)[\[21\]](#)

3. Perspectives

We have shown the broad lines of a much more complex general picture. All the bottoms and seabeds of the world are missing (oceans, seas, lakes and rivers). We know that to classify the Histic humipedons considering only the top 40 cm may be a nonsense; they can reach depths of meters. The frozen humipedons have not been classified and occupy areas that are thawing as a result of global warming.

We are far from having understood the functional difference between the humus systems. A Mull generated by earthworms is different from a Mull built by insects' larvae or crustaceans, even if the result (absence of OH horizon, litter disappearing in one year) looks very similar. There are groups of soil animals that can be associated with humus systems, but we are far from true lists of species. We know almost nothing about the microorganisms that can be associated with the different humus systems. DNA analyzes that have become much more affordable could help in this type of research.

The Para systems are a completely unexplored mine and of undoubted biological, ecological and economic interests. Message to young scientists: life came from the soil (probably a very liquid soil^[22]); understanding the soil is understanding the origin of life, a process still active even today.

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