BACK TO EARTH; A CASE FOR PLURALISM

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ABSTRACT. We easily say "come back (down) to earth" when regaining realistic views. Ironically, 'soil' turns to be an elusive notion difficult to grasp. To this day, we can't precise the ultimate nature of its organic components. Now that soil sciences host an intriguing controversy regarding rival models, little will gain the scientific community drifting from relativism (too soft and permissive) to monism (too boorish and myopic). Here, we argue that this situation present us with a fine opportunity to both apply and test the active normative epistemic pluralism.

KEY WORDS. Soil, soil models, humus, relativism, monism, epistemic pluralism, systems of knowledge.

> To keep every cog and wheel is the first precaution
> of intelligent tinkering
> Aldo Leopold, *A Sand County Almanac*

SOIL'S MODELS

Soil's real organic components have not been yet properly identified. "Humus" is a technicalism taken directly from Latin to name organic residues. After Berzelius, it was clear that humic acids were definitely natural substances and, yet, certainly not ordinarily natural substances. Since then, the large evidence collected draw a parallel with polymers so tempting that it was almost inescapable for most scientists during more than a century (Tan 2014).

The polymer model (p-model), informed by the science of polymers and based on a multitude of studies (like the ultracentrifugation by Cameron, et al. in 1972), enjoyed more than a brief summer of acceptance. However,

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in the first years of the XXI century, applications of new techniques (spectroscopy, microscopy, pyrolysis, and soft ionization) pointed in the direction of a new model of hydro(phobic/gen-bond)-stabilized associations of low molecular masses (h-salma model). To a great extent, it seemed that precisely those biomolecules removed by the purifications process of the p-model play a key role in soil's constitution according to the h-salma model (Sutton & Sposito,, 2005).

Close from being the end of the story, a recent case against this model in particular and against any humic substances in general has been carried out. Lehman & Kleber have advanced a continuum model for soils organic matter. In the own words of its authors:

> The need for the soil sciences to move away from both the 'humification' model and associated 'humic' language has been much debated. Unfortunately, this objective has not been implemented with rigor and has largely been ignored in the neighboring fields of aquatic and environmental sciences. In many cases, the 'humification' model itself has been abandoned, but the 'humic' nomenclature is maintained (...) We argue that this compromise—maintaining terminology but altering its meanings in varying ways—hampers scientific progress beyond the soil sciences. The soil continuum model of soil organic matter does not allow a confusing middle path; it requires leaving the traditional view behind to bring about lasting innovation and progress (103). This is critical as scientific fields outside the soil sciences base their research on the false premise of the existence of 'humic substances'. Thus an issue of terminology becomes a problem of false inference, with far-reaching implications beyond our ability to communicate scientifically accurate soil processes and properties (L&K, 2015, 6).

We find the previous (long) quote very interesting for several reasons. To begin, the reference, the item "(103)" corresponds to a favorite piece of the philosophy of sciences' basic library: Kuhn's *The Structure of Scientific Revolutions* of 1962. Strangely, this is the unique reference to an epistemological source, it's made without any specific emphasize and it's not even made to the normally quoted 1970 critical edition. This single cite prefers to ignore more than fifty years of works in history and philosophy of science by presupposing that Kuhn's notions would simply save the case. As it is well known, Kuhn thinks scientific revolutions as paradigm shifts, from an old *one* to a new *one*. And that is precisely the problem: Kuhn was advocating in an unadvertised, unwarranted and uncritical fashion a monist view about science. Current history and philosophy of science now teach us that science is more plural than we have believed. Even more, such plurality is as desirable as needed. Science can and should afford multiple paradigms (Kellert, et al., 2006; Chang, 2006, 2012).

Having so stated, we want to prevent some misunderstandings. First, we are not directing invectives against the L&K model, but against the

view that conceptualisation in terms of a clash of paradigms is necessary or fertile. Second, we are not advocating a middle path nor a relativized panoply where all views are equally valid to the same degree. We are thinking in the advantages of maintaining the three views but differentiated both in vocabulary and status. We know that in order to get far one need to walk his own path. What is false is to think that paths are singular, that they never cross or that to one vision to flourish requires the suppression of the others. Different communities can pursuit the development of different models, even continuing with the old p-model. "*Conservationist pluralism* is the antidote here: retain previously successful theories and paradigms for what they were (and are) still good at, and add new theories and paradigms that will help us make new and fresh contacts with reality" (Chang, 2012, 224).

Here someone could protest. One must be blind in order to retain exceeded visions. But that would be, again, just monism on disguise. "Leaving the traditional view behind" is no guarantee of moving forward; loosen monistic prejudices, it is. "Lasting innovation and progress" comes with conservation, restoration and proliferation. We need to consider that:

1) Even the most promising models can go wrong.
2) Even the most compelling models cover only *some* of the observable phenomena.
3) Even if a model would perfectly serve our aims, other models may also be able to serve them in new ways.
4) Even a totally failed model can be suggestive or of some use in future developments.

Without counting the benefits from the interaction of multiple systems of knowledge (integration, co-optation, competition), mere allowance of coexisting models would bring benefits (Chang 2012, 5.2). In one response to the L&H article we find a line with this pluralistic flavor: "Critiques of the concept of humic substances require a substantial experimental background and sophisticated concepts on the chemistry of organic matter in soil. Such critiques should be used to improve experimental approaches and theoretical framework in humic substances research" (Gerke 2018, 12).

The case for Pluralism is strong. Instead of suffering the presence of rivals, we must celebrate it. For instance, by taking in advance their observational power as a reservoir of possible refutations to improve the scope of our favorite models.

Contrary to the claim of L&K, to the eyes of those who works with them, humic models present several advantages of interdisciplinary communication. While L&K model only emphasize biological reactions, the concept of humic substances also integrates physicochemical and biochemical reactions (Gerke 2018).

> Furthermore, the semantic ideology of these soil scientists when asking for the abandonment of the word "humus" is unclear and, above all, unsupported by a sound scientifically based alternative explanation of the chemical nature and reactivity of soil humic molecules. Their general description of soil processes may well be interesting to a large unprofessional audience, but somewhat confused to soil organic matter scientists. They substitute the commonly used term "humic substances" by a "soil continuum model" which is vague, devoid of chemical significance, and does not explain how this "continuum" would be molecularly arranged and thermodynamically protected from complete mineralization. Their scientific motivations for the iconoclastic refusal of the use traditional humic wordings do not appear to be objectively sufficient (Piccolo, 2016, 2).

Detractors of L&K also agree in other points. To simply criticize that some methods of extraction of humic substances may yield artifacts is far from having successfully argued that no humic substances exist in soil.

"Lehmann and Kleber stated that no humic substances exist in soil. They gave no argument for this statement, but simply criticised the method of extraction of humic substances with NaOH, which may yield artifacts" (Gerke, 2018, 12).

> Although the concept of soil organic matter as a super-structure of self-assembling relatively small heterogeneous molecules appeared to be well apprehended by exponents of this group of soil scientists, they, nevertheless, radicalized their holistic view of an undefined organic matter in soil by flatly dumping the "humic substances" notation. It is surprising that such invocation is based only on the possible artefacts created by the traditional extraction of humus from soil, rather than onto a more objectively rationale thinking. In fact, there is no single piece of scientific work with sufficient molecular resolution (NMR spectroscopy cannot single out molecular structures in heterogeneous humic mixtures) that directly proves that what is extracted with the traditional alkaline solution does not correspond to molecules existing in soil. A detailed structural identification of molecules needs a preliminary extraction in a suitable medium and further purification before characterization. By the same token, one may discard the characterization of biomolecules so far isolated from cells, just because a particular kind of extraction was applied for their study (e.g., soil DNA), and the molecules may not be the same when inside cells as in the soil! (Piccolo, 2016, 2).

Of course we cannot put a final word on this controversy, but we can advance a view regarding the way it is framed. To extreme precaution before discarding or accepting the existence of scientific entities is highly recommended. Crying victory or defeat before time is harmful. History of science posses a list of entities that do not refer according to the current state of the art, but also of entities that were presumably killed before time.

Prudence and humility, the two motivations of Pluralism are, indeed, of relevance here (Chang, 2012, 5.1).

Although far from Earth's earth, perhaps it would be convenient to remember a famous case from the history of science that matches the worries about the "issue of terminology" as exposed by Lehman and Kleber. Here we will just roughly mention the (in)famous case of the Martian canals (Nall, 2019). In 1877 the Italian astronomer Giovanni Schiaparelli, during a transposition of the planet described different patterns of colour within the red planet. The Italian word "canali" was translated into English as an artificial waterway "canals", instead of a natural waterway "channels". It could be said that for the American astronomer Percival Lowell, this terminological issue marked the beginning of a life quest. He devoted grand part of his work to complete the description and understanding of what he believed to be a magnificent Martian work of engineering. Although general public was very excited by these views, the majority of the scientific community remained skeptic and Lowell destroyed his academic reputation to a great extent. In the seventies, after NASA's Mariner missions, the existence of such canals was definitely refuted. Today it's still not clear what Lowell was seeing; perhaps an artefact product of his telescope, perhaps the pattern of blood vessels of his own eyes, perhaps nothing (Guthke, 1990).

If we briefly brought this case is because it also matches, to some extent, the strategies of argumentation here revised. As suggesting by the advocates of h-salma model, resemblance with polymers was an artefact created by the means of the p-model but not something to be found in nature. For L&K, humic substance, are almost an artefact produced by the *operational identification* of the scientific object.

Anyhow, the difference is also quite visible. The point is that Lowell couldn't anchorage in reality. He certainly did not advance nor redress the empirical or theoretical content about the red planet. The soil's models here discussed differ to a great extent; it is by them that we are having some contact with the reality of what is actually sustaining us.

Returning to the protest that to keep all these three models it's like keeping Martian stories in times of the *Curiosity rover*, and the response is easy: "nothing-but-artefacts" and "suspect-of-yielding-artefacts" are two quite different things. There are not flawless scenarios and the ones here discussed have shown to be good in advancing some knowledge. So no, none of them are Martian canals. Much we gain if we retain them by their advantages while promoting the advent of new theoretical and experimental insights. We should consider that here we are facing one of the biggest challenges ever: to understand the (un)organic limit. If we really pretend to walk along that thin dark line, we will need all possible tools inside the box. Let the cautious work!

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