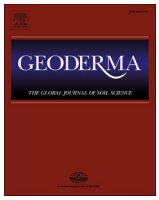
Geoderma 438 (2023) 116642

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma



Editorial perspective

Should soil classification be mandatory for manuscripts aiming to publish in Geoderma and Geoderma Regional?

With the use of soil classification in decline (e.g. Hartemink, 2015; Certini and Scalenghe, 2019), there is a recurrent discussion among soil scientists and journal editors whether or not a proper soil classification should be mandatory for submissions to soil science journals, such as Geoderma and Geoderma Regional. In a letter to the editor, Prof. Gudeta Sileshi argued that the inclusion of soil classification could facilitate meaningful comparisons between soil studies and streamline communication between scientists (Sileshi, 2023). It would also allow for integrating scientific results into follow-up studies, databases, *meta*-analyses, reviews and/or modeling initiatives. Others argue that the inclusion of soil classification is not a high priority: certain subdisciplines or hypotheses have fewer references to soil type e.g. in studies dealing with soil (micro)-biological aspects, geotechnics or certain aspects of soil chemistry, where a quantification of key soil parameters may be more informative. Moreover, soil studies can cover a range of scales, from continents to micrometers, and the different systems of classification all have their own strengths and limitations.

In this editorial, we therefore take the opportunity to clarify our position, and to explain why Geoderma and Geoderma Regional strongly encourage authors to include a soil classification according to one of the international systems officially approved by the International Union of Soil Sciences, i.e. the World Reference Base for Soil Resources (approved 1998 at the WCSS in Montpellier) and the Soil Taxonomy (approved 2014 at the WCSS in South Korea) and, if appropriate, additionally a published national classification system.

1. Why do we strongly recommend including a soil classification in a Geoderma or Geoderma Regional manuscript?

First and foremost, describing the object of research is indispensable in any rigorous scientific study and thus in scientific publishing. Assigning an object to a predefined category with a specific name is a first step in that delineation for most sciences. In the fields of plant, animal or microbial sciences for instance, it is obvious that the individual organisms being observed or handled need to be categorized into species, and named according to an established and widely accepted classification system, rather than providing a list with its properties, or – even worse - not moving beyond a generic reference like "trees", "animals" or "microbes". But it also holds true for other fields of study: e.g. a geologist will start with defining what rock type or formation a certain outcrop or specimen belongs to, a geographer will mention specific landforms, a chemist will define the type of molecules he is working with and so on.

Likewise, because soil is a highly variable natural body, sharing the same dignity as rocks, plants or microbes, and with specific properties depending on the environment and pedogenetic processes that characterize its formation, it must be identified in a distinctive way. A soil classification system condenses our knowledge of a specific soil and related characteristics and processes into a name. Comparable to classifications in biology, geology or chemistry, that name informs about and provides a link between soil characteristics, genesis and functions. From that perspective, it seems odd to study soils without naming or categorizing them. Nevertheless, with the development of increasingly powerful analytical methods, sensors, computing capacity, data analyses and modeling, defining the edaphic environment based on classical pedology using pits, augurings and field descriptions may seem old-school or outdated by today's standards.

So, when addressing the question '*should we still bother with classical soil classification in scientific publishing?*', it is crucial to recall that the emergence of soil classification was one of the biggest breakthroughs in the field of soil science. The realization that there was a simple overall functional logic to the endless complexity of the soil environment was truly revolutionary, and so disruptive that it is often described as the birth of soil science as an academic discipline (e.g. Brevik and Hartemink, 2010). Nearly a century of experience and fieldwork by generations of soil scientists and cartographers have perfected soil classification systems, documenting the threshold behavior that causes soil genesis to converge into a limited set of broad soil categories with similar processes and properties. These similarities extend to implications for soil management and ecosystem dynamics. Moreover, those broad soil categories can be assessed fairly easily based on diagnostic horizons, materials or properties, often recognizable by inexpensive field methods, allowing the development of detailed soil maps and spatially explicit management recommendations. Globally harmonized soil classification systems such as Soil Taxonomy (Soil Survey Staff, 2014), the FAO legend to the soil map of the world (FAO-Unesco, 1977) and the World Reference Base for soil resources (WRB; IUSS Working Group WRB, 2022) moreover gave a global leverage to local studies: studies on similar soil types around the world could be pooled and compared to advance knowledge in soil genesis, agronomy, land evaluation or soil management. It would therefore be careless or even foolish for the current generation of soil scientists to step over that effort lightly.

Hence, it is straightforward for Geoderma and Geoderma Regional to recommend using soil classification as the established approach for describing the object of research on a conceptual level. Below, we will explain how we translate that concept into practice.

https://doi.org/10.1016/j.geoderma.2023.116642

Available online 7 September 2023

2. How do we apply Geoderma and Geoderma Regional journal standards to the issue of soil classification?

Geoderma is a global journal of soil science, with a focus on interdisciplinary work on soil processes and functions. Geoderma Regional focuses on studies that increase understanding and advance our scientific knowledge of soils in all regions of the world. That scope implies that we welcome high-quality, relevant research from any soil science discipline or scale that either has global relevance (Geoderma) or advances soil science and solutions at national or regional level (Geoderma Regional). Editors are entrusted with upholding the scope, and therefore must decide if an incoming manuscript (i) has a clear focus on soil processes and functions, (ii) is novel, (iii) is of high scientific quality and (iv) is of interest to a general, global audience for Geoderma, or for a more targeted audience for Geoderma Regional.

These criteria are relevant in the soil classification debate:

2.1. Soil processes and functions

Soils are not generic, and therefore soil processes and functioning vary. As soil classification separates individual soils into classes or groups each having similar characteristics and potentially similar behavior, classification is a straightforward way of indicating the process environment that a study was conducted in, and the functioning that may be expected in that setting. Furthermore, it will allow to indicate the relevance of the studied soil for a certain process or function. E.g. indicating that a soil is a Histosol can aid in evidencing its relevance for a study on carbon sequestration, on biodiversity or on the impact of climate extremes on water resources.

2.2. Novelty

As soil processes and functions may be context specific, soil classification can be a useful tool for editors to assess if the study presents valuable new information, e.g. for circumstances with low data density.

2.3. High scientific quality

As described above, a general preamble for good research in any scientific field is an adequate description (or delineation) of the study object, in order to facilitate understanding of implications and limitations of the results as well as to facilitate replication. Hence, any study considered for publication in Geoderma or Geoderma Regional should contain a satisfactory characterization of the soils under study, sufficient to define the context of the scientific hypothesis tested in the manuscript. An internationally recognized soil classification is a very informative, well-evidenced and, at the same time, synthetic tool for defining the object of research.

2.4. Of interest to a global audience (Geoderma)

Although soil data are inherently connected to a particular place in the world, the global scope of Geoderma implies that the conclusions based on those data will advance knowledge on soil processes and functions, which transcend the specific region of the study. This means that readers must have sufficient information on the conditions in which an observation or experiment was conducted, to be able to judge if its implications apply to their own analyses, databases or sites of interest. Global soil classification systems such as WRB were especially designed to ease communication between soil scientists on a global level, and thus a smart use of soil classification may contribute to international relevance.

2.5. Of interest to a targeted audience at national or regional level (Geoderma Regional)

Geoderma Regional aims at publishing research helping to understand the wide variability of soils formed in different pedo-climatic zones and at the same time asks authors to discuss and illustrate the implications of their work or case studies for soil science in general. An internationally recognized and globally applicable soil classification is therefore indispensable information for the readers to identify the soils formed within the specific regional process environment that a study was conducted in.

Nevertheless, given the diversity of topics, subdisciplines and scales featured in both journals, it is impossible to come up with a set of strict rules for the criteria mentioned above. For instance, for a study about spatial variability of soil carbon stocks on a global level it is probably sufficient to include a decent classification to Reference Soil Group or Soil Order level to define the soil environment, while such a classification may be of little use to a study on spatial variability of substrate-decomposer interaction at micro-niche level. Reference to a Soil Order or Reference Group may e.g. also not be sufficient for to describe or exclude topsoil variability, as soil types that differ in their diagnostic horizons may have similar topsoil properties, or variability within one soil group may still be considerable.

Hence, depending on the scope of the study, a soil classification therefore may or may not be sufficiently detailed for the processes or scale that is investigated or may not suffice to ensure replicability, and a detailed description of soil properties may be more useful. On the contrary, e.g. for studies at ecosystem scale or in a space-for-time setup, a list of basic parameters may not suffice as illustrated in the figure below. From this example, it is also evident that, in the case of sampling by depth, other than to supply a soil classification, a soil morphological description including thickness of horizons would be helpful. Indeed, fixed depth sampling may produce samples made by different proportion of O, A and even B horizons and, hence, with different physical, mineralogical, chemical and biological properties.

Ideally, manuscripts submitted to Geoderma or Geoderma Regional should therefore contain both a thorough soil classification as well as a comprehensive and elaborate description of relevant soil properties. Yet, we consider soil classification ultimately as a means of supporting and reporting the study of soil processes, not as a goal in itself. We therefore leave the decision to topical editors, that are entrusted with judging whether the authors have achieved this adequate identification of the edaphic process environment, if their choice of characterization method is appropriate in relation to their manuscript's hypothesis, goals and set-up, and if these justify the inclusion of a soil classification or not.

3. Why do we recommend World Reference Base or Soil Taxonomy as soil classification systems

Another point of discussion is related to the soil classification authors should use. Many national and local systems have great merit, but, as manuscripts in Geoderma and Geoderma Regional should be understandable to a global audience, we strongly encourage to use on of the two systems recognized by the International Union of Soil Sciences and, if appropriate, additionally a published national classification system.

These two internationally recognized systems are World Reference Base for Soil Resources (approved 1998 at the World Congress of Soil Science in Montpellier and currently in its 4th edition; IUSS Working Group WRB, 2022) or Soil Taxonomy (approved in 2014 at the Congress in Jeju and currently in its 13th edition; Soil Survey Staff, 2014). These classifications were developed as a global reference, are very well defined in easily accessible manuals provided freely online and are

Fig. 1. Illustration of profiles in dry (loamy) sands, with roughly the same carbon content (1.8–2.3 %), pH (3.4–3.9) and nutrient availability (base saturation < 30%) in the topsoil. Nevertheless, they are very different in their functioning and sub-soil properties, as obvious from their classifications. From left to right, they are an Alic Pretic Umbrisol (Epi-arenic, Endoloamic, Anthric); an Albic Carbic Podzol (Arenic) and a Plaggic Anthrosol (Arenic, Thaptospodic) (classification by S. Dondeyne, J. Deckers and K. Vancampenhout; IUSS Working Group WRB, 2022).

regularly updated by a group of dedicated and experienced scientists. Other useful international standards include the Guidelines for Soil Description (FAO, 4th edition, 2006) and the Field book for describing and sampling soils (Schoeneberger et al., 2012).

National classification systems may provide additional valuable information, e.g. where international systems are too general for nuances that are important at a local level, or when the local name is useful in linking the information in a paper to policy and practice. E.g. the Genetic Soil Classification System of China (GSCC) or Chinese Soil Taxonomy (CST), are widely used in agriculture, environment, and ecology research and application in China, so mentioning them can help implementing the outcomes of the research. Nevertheless, for international researchers not familiar with the Chinese systems, those names can be confusing or misleading. Moreover, a soil class in one classification system may not be directly or completely correlated to a soil class in another, so care should be not to "translate" soil classes by replacing names between systems. Thus, we encourage including a local or national soil class whenever relevant, but always along with doing a full soil classification according to WRB or Soil Taxonomy.

4. To conclude

For the reasons stated above, although not strictly required, we highly recommend using WRB or Soil Taxonomy in every publication, as a well-evidenced and scientifically sound starting point for ensuring quality and global relevance of papers addressing soil processes and functions. And although we agree that adequate soil classification or characterization requires considerable effort, we oppose the idea that describing essential soil features beyond the topsoil and/or checking them against a list of well-defined classification criteria would be too difficult or troublesome for studies within scope for Geoderma. Hence, in order to address the issue and advise authors better in their choice of journal, we emphasize in the instructions for authors that a classification is highly recommended or, if a classification is not possible or feasible, a thorough characterization of the soil is absolutely required.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors wish to thank Dr. Gudeta Sileshi for his letter to the editor, which stimulated this editorial. We appreciate the help of Dr. Jozef (Seppe) Deckers and Dr. Stefaan Dondeyne for their help with the historical background on soil classification and for reviewing the classification of the profiles in Fig. 1. We also acknowledge discussion and input on soil classification systems by Dr. Peter Schad, and the valuable information provided on Chinese soil classification systems by Dr. Zhao Youncun of the Institute of Soil Science of the Chinese Academy of Sciences.

References

Brevik, E.C., Hartemink, A.E., 2010. Early soil knowledge and the birth and development of soil science. Catena 83 (1), 23–33.
Certini, G., Scalenghe, R., 2019. Unnamed soils, lost opportunities. Environ. Sci. Technol. 53 (15), 8477–8478.
FAO, 2006. Guidelines for Soil Description, 4th ed. Food and Agriculture Organisation of the United Nations, Rome, p. 2006.
FAO-UNESCO, 1977. Soil Map of the World, Volume VI. United Nations Educational, Scientific and Cultural Organisation, Paris.
Hartemink, A.E., 2015. The use of soil classification in journal papers between 1975 and 2014. Geoderma Reg. 5, 127–139.
IUSS Working Group WRB, 2022. World Reference Base for Soil Resources. International soil classification system for naming soils and creating legends for soil maps, 4th ed. International Union of Soil Sciences (IUSS), Vienna, Austria.
Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., Staff, Soil Survey, 2012. The Field book for describing and sampling soils, version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.
Sileshi, Gudeta W., 2023. Do soil names matter in scientific publications? Geoderma 439, 116663.
Soil Survey Staff, 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC Guidelines for Soil Description (FAO, 4th edition, 2006).

Karen Vancampenhout[a], Alberto Agnelli[b,c], Jan Willem van Groenigen[d], David Laird[f], Budiman Minasny[e], Ingrid Kögel-Knabner[g,h]

[a] *Dept. of Earth and Environmental Sciences, KU Leuven Campus Geel, Kleinhoefstraat 4, 2440 Geel, Belgium*

[b] *Dept. of Agricultural, Food and Environmental Sciences, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy*

[c] *Research Institute on Terrestrial Ecosystems (IRET), National Research Council (CNR), Sesto Fiorentino, Firenze, Italy*

[d] *Soil Biology Group, Wageningen University, The Netherlands*

[e] *School of Life and Environmental Sciences & Sydney Institute of Agriculture, Faculty of Science, The University of Sydney, Sydney, New South Wales, Australia*

[f] *N-Sense, Inc. & Dept of Agronomy, Iowa State University, Ames, IA, USA*

[g] *Soil Science, TUM School of Life Sciences, Technical University of Munich, Emil-Ramann-Str. 2, 85354 Freising-Weihenstephan, Germany*

[h] *Institute for Advanced Study, Technical University of Munich, Lichtenbergstraße 2a, 85748 Garching, Germany*