Applied Soil Ecology 122 (2018) 42–55

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Applied field research article

Humusica 1, article 3: Essential bases – Quick look at the classification

Augusto Zanella[a,*], Jean-François Ponge[b], Rein de Waal[c], Chiara Ferronato[d], Maria De Nobili[e], Jérôme Juilleret[f]

[a] University of Padua, Italy
[b] Muséum National d'Histoire Naturelle, Paris, France
[c] University of Wageningen, The Netherlands
[d] University of Bologna, Italy
[e] University of Udine, Italy
[f] Luxembourg Institute of Science and Technology, Belvaux, Luxembourg

ARTICLE INFO

Keywords:
Humus
Humus classification
Terrestrial humus systems
Histic humus systems
Aqueous humus systems
Para humus systems
Anthropogenic humus systems

ABSTRACT

Terms and concepts have been defined in Humusica 1, article 1 and the functioning of humus systems has been discussed in Humusica 1, article 2. Here a short overview of the matter, showing humus systems in their environment, is provided for beginners, before making field investigations. The present work is intended as a part of the field manual (HUMUSICA 1 and 2), an illustrated, easy-to-use application tool for humus systems classification, helpful even for not (yet) expert pedologists. The present article gives also a fast look at the classification, sharing Terrestrial, Histic, Aqueous and Para humus systems, every group being defined by its characteristics set in synthetic tables, and suggests a step-by-step approach allowing everyone to classify and investigate humus systems and forms.

1. Quick look at the classification

Darwin (1881) described the first Mull humipedon. He discovered that earthworms tilled a grassland soil and could sink boulders, building a true "vegetable mould". Müller (1889) related humipedon, vegetation and soil, describing the first humus forms. In the same period, Dokuchaev (1889) published a famous soil-vegetation zonation in Russia. Hesselmann (1926), Hartmann (1944), Kubiëna (1953), Von Mückenhausen (1962), Babel (1971), Delecour and Kindermans (1977) described the morphology and ecology of specialized humus types (the upper part of a soil profile which is enriched in organic matter) in central Europe. With similar ecological approaches, but in wet environments, Jongerius and Pons (1962) and Levesque et al. (1980) proposed a classification of Histic soil horizons and peats. Jenny (1941) proposed an historical formula relating soil genesis and main ecological factors. Duchaufour (1960) and Scheffer et al. (1982) linked humus types, pedogenesis and soil classification. Bornebusch (1930), Omodeo (1952), Marcuzzi (1970), Wallwork (1970), Bouché (1972), Leadley Brown (1978), Bal (1982), Satchell (1983), Clarholm (1985), Ponge (1985), Paoletti (1988), Cluzeau and Fayolle (1988), Martin and Marinissen (1993), Fitter and Garbaye (1994), Bernier and Ponge (1994), Aerts (1997), Brauman (2000), Brown et al. (2000), Cole et al. (2002), Berg and McClaugherty (2003), Van der Heijden et al. (2008), Ponge et al. (2010), Blouin et al. (2013), Cluzeau et al. (2014), Ponge (2015) related ecological groups of soil animals with climatic conditions, phytocoenoses, bacteria, fungi, litter biodegradation stages and even anthropogenic land transformation and agriculture. In parallel, Dell'Agnola and Nardi (1987), Stevenson (1972, 1994), Piccolo (1996, 2001) and Kumada, 1988 focused on physical, chemical and biological properties of humic components of humipedons. All these researches and a huge number of synthesis books, such as Killham (1994), Benckiser et al. (1997), Gobat et al. (1998), Lavelle and Spain (2001), Sterner and Elser (2002), Ponge (2003), Coleman et al. (2004), Bardgett et al. (2005), Eldor et al. (2007), Legros (2007), Citeau et al. (2008) and Wall et al. (2012), nourished the idea of a more biological/ecological concept of soil. Following the way traced by the pioneers of the topsoil morpho-functional classification (Darwin, Müller, Dokuchaev, Jenny, Hesselmann, Hartmann, Kubiëna, Babel, Delecour and Kindermans, Jongerius and Pons, Duchaufour, Levesque, Scheffer) a series of field manuals were progressively published by Toutain (1981), Green et al. (1993a), Green et al. (1993b), Brêthes et al. (1995), Von Nestroy et al. (2000), Zanella et al. (2001), Jabiol et al. (2004), Broll et al. (2006), Van Delft et al. (2007), Jabiol et al. (2008) and Zanella et al. (2006, 2009, 2011), in order to enrich soil classifications with main features of

* Corresponding author and not cited author of figures.
E-mail addresses: augusto.zanella@unipd.it (A. Zanella), ponge@mnhn.fr (J.-F. Ponge), rein.dewaal@wur.nl (R. de Waal), chiara.ferronato2@unibo.it (C. Ferronato), maria.denobili@uniud.it (M. De Nobili), jerome.juilleret@list.lu (J. Juilleret).

http://dx.doi.org/10.1016/j.apsoil.2017.05.025
Received 9 December 2016; Received in revised form 23 May 2017; Accepted 24 May 2017
Available online 13 June 2017
0929-1393/

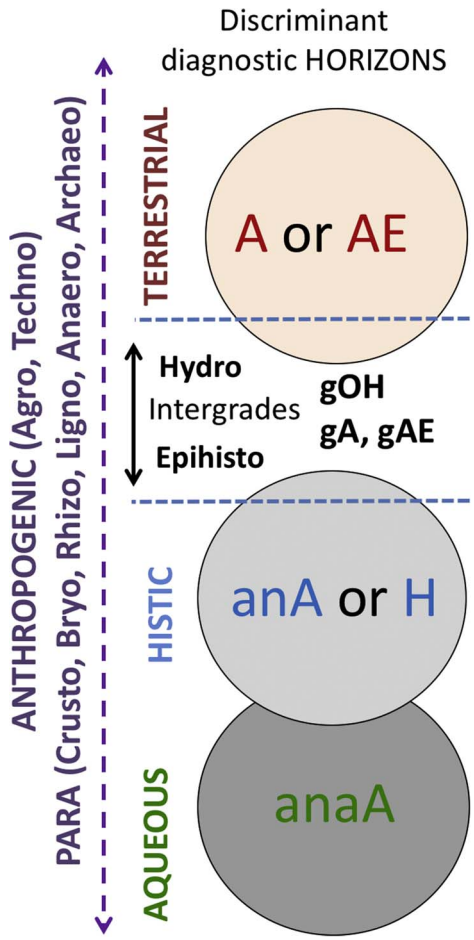
biological horizons.

The present classification has been conceived around forest soils, for which more information and historical datasets are available, and for soils of grasslands, pastures and wetland areas, with negligible to strong human impact. Originally it was not suited to tilled agro-ecosystems, because tillage periodically destroys the "natural" organization and radically alters the functioning of surface horizons. Recently we considered the possibility to apply our system of classification even to anthropogenic soils, with the purpose of comparing their morpho-functional properties to those of more natural soils. In the long run, the final goal might be to decrease the functional distance between exploited and natural soils, by comparing them and adjusting properties of the former at regular intervals, thereby ensuring the incessancy of their ecosystemic functions and a sustainable production of food. The authors of this manual propose a classification of anthropogenic Agro (agricultural, modified from natural humus systems) and Techno humus systems (artificial, newly man-made) as a tool for monitoring and managing exploited soils.

The humus form classification is based on the sequence and morphological characteristics, including morphological evidence of biological activity, of organic and/or organic-mineral soil horizons observed and described in the field. In some cases, a few basic chemical data (pH, organic carbon content) are required. A complete set of diagnostic organic and organic-mineral horizons, which are mutually exclusive, is defined. The classification keys use diagnostic horizons and other complementary humipedon (humus profile) or environmental data. These last complementary data are not part of the classification, but can help in circumscribing the classified units and understanding their peculiar functioning. Every mineral horizon cited in this paper has been classified and named using the manual of the Guidelines for Soil Classification (FAO, 2006).

The classification consists in a scheme that tries avoiding strict cleavages between soil types, allowing intergrades to be classified. A first look at the surface of our planet allows distinguishing:

- well-drained soils (Terrestrial humus systems, potentially forest/shrub/grassland ecosystems);
- wet soils (Histic humus systems, potentially forest/shrub or aquatic plants ecosystems; Aqueous, sea tidal zones and sea beds);
- intergrades (dry Histic = Epihisto Histic humus systems; wet Terrestrial = Hydro Terrestrial humus systems);
- other natural soils (Para humus systems: soil systems strongly influenced by archaea = Archaeo; soil systems strongly influenced by anaerobic bacteria = Anaero; soil systems strongly influenced by lichens, algae, fungi = Crusto; soil systems strongly influenced by mosses = Bryo; soil systems strongly influenced by fern, grass, ericaceous root systems = Rhizo; soil systems strongly influenced by organisms living in decaying wood = Ligno);
- anthropogenic soils (Agro: natural soils transformed for agricultural and sylvicultural purposes; Techno: new man-made humus systems).



Ecosystem		Biological activity		
Water dynamic and parent material		High	Moderate	Low
TERRESTRIAL	Base-rich	Mull No climatic or nutritional constraints	Amphi Periodic unfavourable conditions for animal activity	Tangel Mountain conditions on base-rich rock
	Mixed			
	Base-poor		Moder Unfavourable conditions for anecic and endogeic earthworms	Mor Very unfavourable condition on base-poor rock
HISTIC	Brooks, small rivers, small floodplains, small streams	Anmoor Not in dynamic floods and fast currents	Amphimoor Moderately moist base-poor soils in brook valley systems or base-rich soils in half-drained fens	Fibrimoor Wet very base-poor soils in brook valley systems, bogs
	Fens and bogs, large floodplains, large extended systems	Saprimoor Partial processes of sedimentation possible, fens	Mesimoor Wet very base-poor soils in brook valley systems, bogs	
AQUEOUS	Sea tidal zones and sea beds	Oxitidal Shallow tidal, between mean and high tide levels	Reductitidal Deep tidal, between mean and low tide levels	Subtidal Under low tide level

Fig. 1. Panorama of Terrestrial, Histic and Aqueous humus systems, with their main ecological determinants and diagnostic horizons. Hydro and Epihisto are prefixes used in transitional cases. Hydro is adopted as a prefix when gOH, gA or gAE horizons are present in Terrestrial humus profiles even without other diagnostic horizons; Epihisto is adopted as a prefix when gA or gAE are present (gOL, gOF and gOH possible but not sufficient) in Histic humus profiles (= in addition to anA or H horizons).