ARTICLE IN PRESS

Applied Soil Ecology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Applied Soil Ecology

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

Pedogenesis: Humus forms and soils under spruce forest by a morphological approach

S. Chersich

Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy

ARTICLE INFO

Keywords:
Humus forms
Soil formation
Soil classification
Spruce forest
Alpine ecosystem
Sylvogenetic phases

ABSTRACT

Our investigation pointed out, with a detailed classification, a vast variability of forest humus and soil under spruce forests on two different sites with North and South exposition, permitting to identify a pedogenetic trend between different sylvogenetic phases of forest evolution and specific humus forms.

We identified the soil indicators that have to be checked for measuring soil changes relating to humus changing. First of all we noted a humus change on soil morphological features. Such features are produced by physical and biochemical pedofauna bioturbations. Pedofauna according to the peculiar microclimate of the soil, depends on the forest development. Biochemical litter environment produces specific humus form.

During the growth of a forest there is a policyclic soil evolution with physical-chemical changes that we can observe in time on soil and humus forms. The humus forms are related with the air (biospheric fluxes), with the organic-mineral components (as micro and macroelements cycles) and with pedofauna. We observe physical change (as structure, porosity, horizontation, particle-size, pattern, mineralogy) and chemical change (as for pH, C, N) in soil horizons which is due to humus change.

The humus forms have been investigated in relation to the development of vegetation growth, with the aim to identify a representative humus form of a specific sylvogenetic phase. Such research suggests an hypothesis that the humus form is a guide of the environment states to which it belongs. During the open canopy stage (that is the phase before the presence of very young plantations) it is possible to observe many different humus forms: from the acid one as Moder (Hemimoder), that is heredity of the previous use of the land, to the new form of Mull (Oligomull) that is the result of the new forest cycle, more suitable for spruce renovation.

1. Introduction

Thanks to the pedofauna action, humus can't be a single independent unit in the soil (Bernier and Ponge, 1994). The relations between soil and humus are not only binded on the superficial horizons of the soil (A horizons) but also on the deepest one (Chersich, 2004; Chersich and Frizzera, 2005; Bernier and Ponge, 1994).

Soil and humus are the result of the parent material transformation occurred in a circumscribed time under the climate and the biota action. The weight of each single factor depends on the pedogenesis. If a constant environment persists, the soil will tend towards a steady state in a static equilibrium. This situation it's only hypothetical because the natural environment is liable to a continual change and its equilibrium is dynamic. So, external events can have an influence on the soil and humus evolution. The soil is sensitive to changing outside conditions even if there is an inertia towards these outside conditions. This inertia can be seen in the long period ut in the short period it's very important to identify where, in the soil, we can read this change. If we consider a humus change, it will be shown in the organo-mineral horizon (Chersich et al., 2007).

The structure of the organic horizon is mainly a result of pedofauna, microbes and fungi action that contributes to the degradation of the vegetation residues and increases the organic matter content that have a reflex on the aggregate stability (Galvan et al., 2006; Guggenberger and Kaiser, 2003). The aggregate stability by organic matter is mainly due to physical stabilization chemical stabilization, biochemical stabilization of organic matter (Chersich et al., 2015).

2. Material and methods

2.1. Study area

This work is based on the study of humus profiles in Alpine spruce forest ecosystems with a morphological approach. We wanted to

Abbreviations: OL, humus horizon with bedding leaves; OF, humus horizon where the vegetation (leaves, branches) is still visible; OH, humus horizons with fine organic matter; A, organo-mineral horizon; yr, year

E-mail address: silvia.chesich@gmail.com.

https://doi.org/10.1016/j.apsoil.2017.10.038
Received 28 January 2017; Received in revised form 28 October 2017; Accepted 30 October 2017

Table 1
Soil and humus classification of the North exposition site.

Profiles	Sylvogenetic phases	Main and significant plant species and/or features	Soil classification(FAO ISRIC and ISSS, 1998)	Humus classification and synthetic humus profile description: (Zanella et al., 2011a)
1	A	*Calamagrostis villosa* and *Vaccinium myrtillus*	Parahisti-Epigleyic PODZOL (Entic, Humic, Siltic)	Dysmoder OLn-OLv, OFnoz, OH ~ ,OHnoz//, migA//
2	A	Herbs species, the main one is *Adenostyles alliariea*	Humi-Gleyic UMBRISOL (Hyperdystric, Siltic)	Pachyamphi OLn//,OLv, OHmeA//, maA ~
3	A	–	Humi-Gleyic UMBRISOL (Hyperdystric, Siltic)	Dysmoder OLn,OLv, OF, OH, miA//
4	A	–	Haplic PODZOL	Hemimor OL,OF,OH ~ ,miA//
5	B	–	Hapli-Parahistic PODZOL (Humic)	Humimor OLn-OLv-OFnoz, OHnoz, OH ~ , nozA// OLn,OLv,(OF), OH//,OHnoz//
6	B	On stump	Histi-Haplic PODZOL (Protoumbric, Siltic)	Humimor OLn,OLv, (OFnoz), (OHnoz)/A//,miA//, AE ~
7	B	On granitic rock	Dystri-Protofolic HISTOSOL (Lithic)	Dysmoder OLn,OLv,(OF), OH//,OHnoz//
8	**C**	*Picea abies*	Enti-Protoumbrihumic PODZOL (Episkeletic)	Hemimor OL,(OFnoz), OH ~ , miA//AND Dysmoder OLn,OLv,(OFnoz), OHnoz ~ , miA//
9	D	*Picea abies*	Sapri-Folic HISTOSOL (Dystric, Protoumbric)	Humimor OL,OFnoz,OH,OFnoz,nozOH,OH ~ , miA and OLn,OLv, OFnoz, OHmiA//
10	D	*Picea abies*	Sapri-Folic HISTOSOL (Dystric, Protoumbric)	Humimor OLn,OLv,OFnoz//,OHnoz,OH, miA

investigate the mutual relations between humus and soil. In Trentino Alto-Adige Region (North-Estern Italy), about 1000 m^2 were selected at 1700 m a.s.l. on acid morenic sediments parent material. The first site facing to the North is located within the Municipality of Pellizzano in Val di Sole, near Mount Nambino. The second site, facing to the south, is located near Madonna di Campiglio, in Val Rendena, near Ritorto Mount. The mean annual temperature is 3,9 °C and the mean precipitation is 1311 mm. For both sites the soil temperature regime is frigid, whilst the moisture regime is udic (Soil Survey Staff, 1999).

2.2. Method

For the study of humus profiles, transects were traced so as to cut across the four principal sylvogenetic phases of forest evolution. 20 humus soil profiles have been studied (Klinka et al., 1981; Green et al., 1993), described and classified using the morphological approach (Green et al., 1993; Jabiol et al., 1995, 2004; Zanella et al., 2006, 2011a,b). The soil profiles have an identification of a number. In order to better understand the humus forms we did some thin sections by Kubiena boxes (1955) and described according to Bullock et al. (1985) with a micromorphological approach (Chersich and Solaro, 2007). The characteristics observed in field have been correlated with classical chemical and physical pedological analysis. We did the chemical horizons characterization of some parameters as structure, C, N, pH (H_2O) according the official Italian methods (M.I.P.A.F., 2000). Elemental analysis (C, N) was carried out using an Elemental Analyzer − Model EA 1108 (Carlo Erba Milan, Italy). The soil has been classified by World reference base for Soil Resources (FAO ISRIC and ISSS, 1998).

We studied two spruce environments with the following four sylvogenetic phases. The number of humus samples for each phases and exposition has been decided after a field survey in order to describe better the humus variability.

A: Open canopy. Dead vegetation cover includes herb species or short arboreous species; We studied 4 humus samples for each exposition;

B: Regeneration step. A grass patch between adult trees with an open canopy with 15 to 30- yr-old spruce stand with a height from 3 to 7 m; We studied 3 humus samples for each exposition;

C: Young growth, Intermediate step. Forestal phase of intense growth of 60 yr-old spruce stand and an average height of about 12 m; We studied 1 humus sample for each exposition because the environment was very homogeneous;

D: Mature forest. Mature phase of 90 to 150 − yr-old spruce stand and a height of about 29 m. We studied 2 humus samples for each exposition.

3. Results

Two spruce environments with North and South exposition with the corresponding four principal sylvogenetic phases show a marked hetorogeneity among vegetation, physical-chemical horizon characters that affect the soil and humus forms. Soils and humus forms have been classified (Tables 1 and 2) and some chemical observations of 20 profiles has been done. Dysmoder humus forms that show similar physical-chemical features (Fig. 7, Table 3) are the more frequent humus form in all sylvogetetic phases, Amphymull have preference on A and B phases, whilts Mor forms are more often present in C and D phases (Fig. 6).

In detail, the description of the profiles of the four sylvogenetic