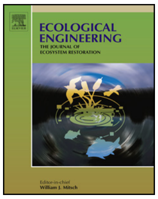
Ecological Engineering 60 (2013) 81–87

Contents lists available at ScienceDirect

Ecological Engineering

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



Soil functionality at the roadside: Zooming in on a microarthropod community in an anthropogenic soil

Sandra Magro[a,*,1], Mónica Gutiérrez-López[b,1], Miguel A. Casado[c], María D. Jiménez[c], Dolores Trigo[b], Ignacio Mola[d], Luis Balaguer[a]

[a] Departamento de Biología Vegetal I, Universidad Complutense de Madrid, 28040 Madrid, Spain
[b] Departamento de Zoología y Antropología Física, Universidad Complutense de Madrid, 28040 Madrid, Spain
[c] Departamento de Ecología, Universidad Complutense de Madrid, 28040 Madrid, Spain
[d] Sección en Restauración Ecológica, Servicio de I+D+i, Obrascón Huarte Lain, S.A., 28046 Madrid, Spain

ARTICLE INFO

Article history:
Received 20 February 2013
Received in revised form 11 July 2013
Accepted 14 July 2013
Available online 26 August 2013

Keywords:
Anthrosols
Embankments
Mesofauna
QBS index
Soil organic carbon

ABSTRACT

Earth movements for road construction give rise to nutrient-poor anthrosols. Early onset of soil processes in these environments has been reported on the basis of plant cover establishment. Evidences of full soil functionality, however, would reveal the emergence of a self-sustainable ecosystem on these man-made substrates. The aims of the present study involved (1) assessing soil functionality on six-year-old road embankments by means of the QBS index, based on microarthropod communities (2) elucidating soil properties responsible for the composition of soil microartrhopod communities, and (3) exploring the practical implications of soil quality for road embankment management. Road embankments were functional with QBS values comparable to those found in natural systems (>100). Soil quality in these environments depended on soil organic carbon dynamics. Among the 36 arthropod groups found, *Acari* and *Collembola* dominated the soil community. Variation in microarthropod community composition was best explained by higher abundances of *Brachypilina* (*Oribatida*, *Acari*) and *Symphypleona* (*Collembola*). These trends in soil community structure were intimately linked to soil organic carbon content, clay content and humidity. Given its relevance, the acknowledgment of the early functionality attained by these roadside anthrosols should lead to the revision of current protocols for roadslope monitoring and management.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

In the last two centuries, human activities have become main drivers of ecosystem transformation (Vitousek et al., 1997; Hooke et al., 2012). These changes have led to the term 'Anthropocene' (Crutzen, 2002), which describes a new age in which the Earth is undergoing a rapid human-mediated change, with evident consequences for biodiversity and ecosystem functioning. This new scenario is giving rise to ecosystems that emerge from within the pre-existing ones, but which exhibit differential attributes affecting their dynamics and ecological behavior (Hobbs et al., 2006). Within these emergent ecosystems, recently created substrates, known as anthropogenic soils (first introduced as a class in FAO, 1988), are the basis for pioneer community development.

Anthropogenic soils or Anthrosols (ISRIC-FAO, 2006) have been described as soils created or profoundly modified by human activities. A particular case of these soils are urban soils (*sensu* Lehmann and Stahr, 2007) characterized by high pH values as well as a large amount of coarse materials and soil organic matter, which influence porosity dynamics (Nehls et al., 2006). Among them, soils on road embankments also exhibit high pH values but clearly differ in their low levels of organic matter as they have been developed from parent materials poor in nutrients (Jiménez et al., 2011). However, neither the structural characterization nor even partial reports on nutrient processes account for the degree of functionality of these particular soils.

Soil functionality integrates the interactions between structure and processes (*cf.* TEEB, 2010). Within this integrative approach, soil functionality is also related with the soil quality concept regarding the soil capability to sustain biotic communities and air and water quality (Gardi et al., 2002). Recent studies have highlighted the importance of incorporating biological indicators to

---

* Corresponding author. Tel.: +34 913945055; fax: +34 913945034.
E-mail addresses: s.magro@pdi.ucm.es (S. Magro), mogutier@bio.ucm.es (M. Gutiérrez-López), macasado@bio.ucm.es (M.A. Casado), jimenezmd@bio.ucm.es (M.D. Jiménez), trigoaza@bio.ucm.es (D. Trigo), imola@ohl.es (I. Mola), balaguer@bio.ucm.es (L. Balaguer).

[1] First and second authors equally contributed to this work.

0925-8574/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.ecoleng.2013.07.061

evaluate the quality of anthropogenic soils (Hartley et al., 2008). The best indicators of soil quality will be responsive to land use or management (Doran and Zeiss, 2000). Thus, Parisi et al. (2005) proposed a soil-quality indicator focusing on soil microarthropod communities and tested in different land-use scenarios. Soil microarthropods play a vital role in the maintenance of soil functions and they have therefore been proposed as suitable indicators of soil quality for environments impacted by human activities (Parisi et al., 2005; Tsiafouli et al., 2005; van Straalen and Verhoef, 1997). Microarthropod communities are involved in pedogenesis, soil aggregate stability, hydraulic properties, and plant performance (De Deyn et al., 2003; Lavelle, 1996; Liiri et al., 2002; Neher, 1999). Particularly, soil microarthropods are always present in litter and they control soil functions, such as litter decomposition. They resize and fragment plant residues, increase surface area for microbial attack and the leaching of water-soluble constituents, and control the structure and activity of the decomposer community (bacteria and fungi) (Beare et al., 1997; Seastedt, 1984). Microarthropods therefore contribute directly to humus formation and police the soil, playing an important role in mineral turnover and the dynamics of soil organic matter (Butcher et al., 1971).

Within microarthropod communities, apterygote *Acari* and *Collembola* are generally dominant both numerically and in terms of biomass (Seastedt, 1984). *Acari* are often the most numerous group in soils with a well-developed O-horizon rich in mor-type humus. In most ecological studies *Acari* are traditionally divided into four suborders *Oribatida*, *Gamasida* (the current O. *Mesostigmata*), *Actinedida* (the current O. Trombidiformes) and *Acaridida* (now taxonomically included within *Oribatida* but considered functionally different) (following the classification of Krantz and Walter, 2009). Although they all include macrophytophages feeding on decaying higher plant materials, *Oribatida* are microphytophages, feeding mainly on bacteria, yeasts and fungi; *Gamasida* are mainly predators of small invertebrates; *Actinedida* exhibit mixed feeding habits and *Acaridida* are mainly saprophagous. The intimate relationship between these soil invertebrates and their ecological niches (van Straalen, 1998), coupled with the fact that some (i.e. oribatids) lead sedentary lives characterized by low mobility and, in many cases, low growth rates make these groups sensitive to disturbance (Maraun et al., 1999). *Collembola* community composition has also been observed to be sensitive to human-induced disturbances, a fact that reduces the presence of rare or restricted distribution groups, mostly *Isotomidae* and *Onychiuridae*, and increases the number of expansive or not so demanding species in terms of soil moisture and organic matter content, these mainly being *Entomobryidae* and *Neanuridae* (Sousa et al., 2003). Other *Apterygota* (*Protura*, *Diplura* and *Thysanura*), *Micromyriapoda* (*Simphyla*, *Pauropoda* and *Polyxenidae*) or small *Diptera* larvae and *Coleoptera* may be locally important (Lavelle and Spain, 2001).

In the present study, we attempt to elucidate to what extent anthropogenic soils from road embankments are functional or impaired, using microarthropod communities as a soil quality proxy. Although this crucial feature of ecosystem functioning and dynamics has been studied in depth in other anthropogenic soils (Arshad and Martin, 2002; Giller et al., 1997; Lavelle, 1996), it remains largely unexplored in new soils created by earth movements and urbanization, such as road embankments. To date, previous studies have addressed soil functionality on roadslopes through plant cover response (see for instance Ferrer et al., 2011). However, under Mediterranean conditions, plant cover is only descriptive at best during the first stages after road construction (Jiménez et al., 2011). In order to tackle roadslope soil functionality from a more accurate perspective, we applied the QBS index (*Qualitá Biologica del Suolo*) on six road embankments, which have been monitored since their construction. The QBS index is an eco-morphological index based upon the degree of linkage between the microarthropod character syndrome and soil environment (Parisi, 2001). Due to the fact that soil microarthropods are highly heterogeneous in space and time (Ettema and Wardle, 2000) we conducted our study during two consecutive years. We specifically attempt to address the following questions: (1) Are anthropogenic soils from road embankments functional based on their QBS values? (2) If so, which processes determine soil community structure and hence soil quality? Finally, we wished to explore the practical implications of soil quality for road embankment management.

2. Materials and methods

2.1. Study area

The study area was located on the M-12 and M-13 highways (Barajas International Airport, Madrid, Central Spain 40°29′ N, 03°34′ W; Fig. 1). These highways were both built from January 2002 to June 2004. Average annual temperature from 2009 to 2010 was approximately 15 °C and total annual precipitation was 360 mm. Soils in the surrounding area are nutrient-poor, characterized mainly by silica sands and presenting basal conglomerates, gravels, silts and clays, corresponding to river floodplains (Blanco-García et al., 2007). For further information see Mola et al. (2011) and Jiménez et al. (2011).

2.2. Experimental design and background of sites

We selected six embankments (T1–T6) constructed in 2004, upon which topsoil was spread. All of them had similar slope angles (32.1° ± 0.75) and size (12.0 ± 2.5 m). Distances among road embankments ranged from 1900 to 20 m, with an average distance of 769.12 m ± 236.54 between them. The plant cover of each embankment was visually surveyed every spring from 2005 to 2010 by two different observers. Because of the strong influence on soil functionality of feedbacks between belowground and aboveground communities (Bever et al., 1997), we decided to set up our study from 2009 to 2010 when plant cover was stabilized (Fig. 2). On each embankment, four points for soil and microarthopod samplings were established at medium-slope level and separated one meter from one another.

2.3. Soil properties

On each embankment, we collected four soil samples (12.5 cm × cm 12.5 cm × 5 cm) of approximately 500 g weight previously removing the vegetation from on top. Samples were air-dried and sieved through a 2 mm mesh. In each sample, soil texture was determined following Guitián and Carballas (1976); as well as percentage of organic carbon by means of micro-plates (adapted from Anne, 1945) and percentage of nitrogen with the Kjeldahl method, as described by Page et al. (1982). We also analyzed soil porosity (percentage of pores in soil), soil humidity (percentage of these soil pores occupied by water) and soil aeration (percentage of soil pores occupied by air) from four soil cores of known weight and volume collected on each embankment, following Guitián and Carballas (1976).

2.4. Microarthropod sampling and QBS index

Four vegetation-free soil samples (25 cm × 25 cm × 10 cm) were collected on each embankment for microarthropod extraction. Microarthropods were extracted from 2 kg of homogenized soil

Download English Version:

https://daneshyari.com/en/article/6302351

Download Persian Version:

https://daneshyari.com/article/6302351

Daneshyari.com