The "Soil Genetic Erosion": a new threat for soils?

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Introduction

During the 1990's the concept of pedodiversity started to be diffused in the scientific literature and the decrement of the soil diversity in space and time - particularly due to human activity - has been seen as a sort of underhand problem affecting soil ecosystems, considering that different soil types face gradual or drastic reduction or complete loss of their unique "genetic features".

Pedodiversity has received considerable recent interest, especially as peculiar aspect of biodiversity and has been assessed by several authors by applying diversity indices used in ecology.

This paper takes into consideration the influence of human activities on the loss of pedodiversity in a Mediterranean area due to large scale farming. In particular it examines the quantitative and qualitative soil changes in a period of 53 years evaluating the loss of soil diversity at soil subgroups level of the USDA Soil Taxonomy system.

Materials and Methods

To fit our aims, we took into consideration the soilscape evolution of Mazzarrone area from 1955 to 2008. Mazzarrone is a small town in South-East of Sicily, Italy (37.0849°N, 14.5590°E), with a typical Mediterranean climate (average annual rainfall: 452 mm; average annual temperature: 18 °C).

Its administrative territory covers an area of 3,457 hectares ranging from 115 m to 335 m a.s.l. From a litho-morphological point of view, it is characterized by a fairly flat morphology and by rock outcrops that, dating back to the Pleistocene and Holocene, are made by clay and sandy-clays, fossiliferous yellowish sandstones, fine quartzitic sands, weakly cemented sands, lacustrin and fluvial deposits and marly limestones.

To explore the human influence on soil diversity loss, we started from the findings of a sociological and ethnological essay (Lo Verde, 1995) coupled with soil data from unpublished soil surveys carried out from 1964 to 2008. These last were supported by aerial photo interpretation and land use maps in the years 1955, 1966, 1987, 1997, 2000, 2008 and were validated in field. The legend of every soil map shows the spatial distribution of the soils classified at subgroup level according to Soil Taxonomy.

A Geographic Information System (GIS) technology was used to manage and analyse land use and soil maps and their relationship and evolution in time.

The pedodiversity in the study area was assessed in different years using the soil map showing the original soilscape before any human intervention (1955), and soil maps in 1966, 1987, 1997, 2000 and 2008.

To estimate the changes of pedodiversity we used the following indices: richness; Shannon's diversity index; Simpson's diversity index; Shannon's evenness index; Simpson's evenness index. All the pedodiversity indices were compute in GIS environment using the Fragstats tool.

Results and Discussion

Spatial statistics and aerial photos show that in the 1960's, most of the study area, once covered by oak and maquis, was mostly used for arable farming, olive groves and almond groves grown on the soils that originally formed the Mazzarrone soilscape.

Such soils were represented by 5 soil orders: Entisols, Inceptisols, Vertisols, Alfisols and Mollisols, subdivided in 6 suborders, 8 great groups and 15 subgroups.

In particular, Soils in the more stable morphology (flat or very gentle slope), were Inceptic, Mollic and Typic Haploxeralfs i.e. moderately deep soils, with a rather shallow and not very thick argillic horizon that, depending on the morphology and mainly on the plant cover, might be overlaid by a mollic epipedon.

The less stable morphologies (gentle or moderately steep slopes), showed Vertic and Typic Haploxerepts, Typic Calcixerepts and Calcic, Entic, Pachic and Typic Haploxerolls, i.e. soils in general moderately deep with a cambic or a calcic horizon overlaid, in several cases, by a mollic epipedon.

The steeper morphologies and the slope side of the stream valleys were, and in some cases still are, characterized by Lithic and Typic Xerorthents, more or less shallow soils exposed to erosion.

The bottom valleys till today are characterized by Vertic Xerofluvents (deep soils strongly influenced by the features of the parent material) and by Typic Haploxererts and Typic Calcixererts (very deep and clayey soils).

In the Mazzarrone area, land use change and the soilscape reshaping started in a very visible way during the 1970's. The economic explosion was during the 1980's, when cultivation started to be converted everywhere producing not only a large land use change and a huge modification of the landscape but also a conspicuous increase in the per-capita income that, according to the findings of a sociological survey, reached even 400%. In that period, vineyards replaced arable land, almond-yards, olive groves and natural grazing with a consistent and evident transformation of the landscape through the application of pedotechniques consisting mainly in covering deeply ploughed soils with a 50-70 cm deep marly limestone stratum that was incorporated to the soils with another one deep ploughing. As previously highlighted, vineyards are almost the only land use in Mazzarrone.

The analysis of the transformation of the original soils in anthropic ones as well as the soil consumption and sealing due to urban expansion and construction of reservoirs highlights that the most transformed soils belong to the Mollisols followed by Inceptisols and Alfisols and that most of Mollisols, Inceptisols and

Alfisols subgroups almost completely disappeared due to the transformation in anthropogenic soils or by sealing.

We note, particularly looking at the Simpson index, a relatively high value of evenness (0.9) indicating a very high distribution of area among classes: therefore there is an even proportional contribution of each soil class in the system and there is not a dominance of any soil into the soilscape. Interpreting the diversity in the light of the evenness trend, we can affirm that the Mazzarrone soilscape was in past a well-balanced system, where soil classes are divided almost equitably. Soil transformation by large scale farming breaks the equilibrium of Mazzarrone creating in time a dominant soil class which makes uniform the soilscape and undermines, from a taxonomic point of view, the soil diversity.

Considering what we observed in time, we can surely affirm that the human intervention in soil transformation could lead the diversity in the landscape in an initial phase, but forwarding by large scale farming, the evident result is a huge loss of diversity in time, as our indices remarkably have shown.

Conclusions

Soils are described as the foundation of life and the unique structures and characteristics of various soils make them key support systems to the diversity of life on earth.

The potential negative effect of various human activities on soils has been an important topic of concern for soil science in these last decades.

As far as concerns the case study we considered, all the morphologies that didn't limit the use of mechanical means to set new vineyards, including also areas steeper, have been involved in an intense "entisolization" process, that caused a remarkable reduction of pedodiversity.

Most of the land in Mazzarrone was exposed to excessive anthropic pressure which, in few years, has led to a considerable improvement in the economic conditions of the local population as well as to the disappearance of unemployment.

But, these social and economic benefits were obtained at the expenses of the soils and pedodiversity. Farmers, in most cases of large farming, aim mainly at increasing economic profits and higher incomes overexploiting natural resources and particularly the soil, ignoring that each soil has his own evolutive configuration and his own activity that contributes to the natural functioning of the environment.

In such situations the soil resilience, namely the soil ability to counteract stress and alterations is very low and in some cases cancelled, because soil exogenous energy fluxes, after human actions, overcome largely all the critical thresholds. In our opinion, what happened in Mazzarrone is a sort of soil "genetic erosion", as it happens in biology when plant and animal species are lost, resulting in a substantial weakening of the whole ecosystem.

Keywords: *soil genetic erosion, anthropogenic soil, pedodiversity.*