Fine-Scale Spatial Variability of Soil Organic Carbon and Related Environmental Variables in a Protected Area of Sicily, Italy

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The institution of Natural Reserves has promoted, in Italy, the conservation and the environmental improvement of several areas and their physical and biological factors. Agriculture, forestry and every human activity are regulated to preserve their high ecological and naturalistic value. Land use, in particular, must follow careful rules to preserve the soil fertility and to limit the factors of landscape degradation. Maps of soil organic carbon (SOC) or soil organic matter (SOM) are of interest for agricultural management, resulting a very important soil fertility parameter, as well as in environmental policy related to the terrestrial sequestration of atmospheric carbon. Thus, a better understanding of the distribution of soil organic carbon (SOC) pool is necessary in order to manage soil fertility and to predict its potential responses to land use change. Geostatistics is widely used to map SOC at any scale level assessing also the statistical uncertainty. At fine scale level geostatistical methods that utilize spatially correlated secondary information increase the quality of the maps of SOC distribution (Simbahan, 2006). In fact, whereas are significant correlations between the target variable and secondary data hybrid techniques generally result in more accurate local prediction (Goovaerts, 1999; McBratney et al., 2000). The goals of this study were: i) to assess the SOC spatial variability in the Natural Reserve of S. Ninfa (Italy) and ii) to quantify the relationships among soil C, land use and some environmental variables.

Methodology

The study area, located in Western of Sicily, ranges from an altitude of 400 and 663 m a.s.l. The climate is Mediterranean semiarid. Land use are represented by: vineyards, arable lands, horticultural crops, olive groves, pastures, shrubs and woodlands (Eucalyptus and Pines). A set of soil samples were collected to quantify SOC in 0 to 20 cm (“A” layer) and in 20 to 40 cm (“B” layer) depth. Sampling scheme were transects oriented in West-Est direction with a sampling pass of 200 meters along each transect. Total sampling points were 154 uniformly distributed in the study area. At every sampling points two soil core were collected and spatially georefenced by GPS. Air-dried soil samples were analysed for SOC using the wet oxidation method with potassium dichromate.

Spatial variability was analysed by geostatistical procedures for every depth. To improve the spatial interpolation quality at fine scale a series of ancillary variables were acquired including several simple terrain indices derived from DEM and from recent landsat ETM+ images (NDVI). Recent land use and soil cover were mapped to be compared with SOC spatial distribution.

Results

Experimental variograms (Fig. 1) showed a long-range variability of SOC data. A nested model (nugget + exponential) was used to fit the experimental variograms and ordinary block kriging procedure was used to produce SOC interpolated maps for A and B layer (Fig. 2).

High nugget values in variograms indicate that the sampling scheme used not resolved most of the spatial variability in SOC. This suggests the possibility to increase the number of sample points trying to resolve the spatial variability at short range.

Maps show a variability structure similar in both depths. Spatial regression between SOC map values of A and B layer showed a significant value (R2=0.61; p<0.001). Comparing these with the land use map, the highest values of SOC was found in correspondence of pastures and the lowest in vineyards at lower quote but direct correspondences were not found between land use pattern and SOC distribution. No direct spatial correlations were found between SOC distribution and other environmental variables. While comparing SOC maps with the soil map, the distribution pattern of SOC, mainly for the B layer, seems to follow the soil pattern. In fact, clustering the map data of SOC by soil groups, the relative variability decrease remarkably in both A and B layer. The highest values of SOC were found for Mollic Gypsic Cambisols followed by Haplic Cambisols, the lowest values were for Haplic Regosols.

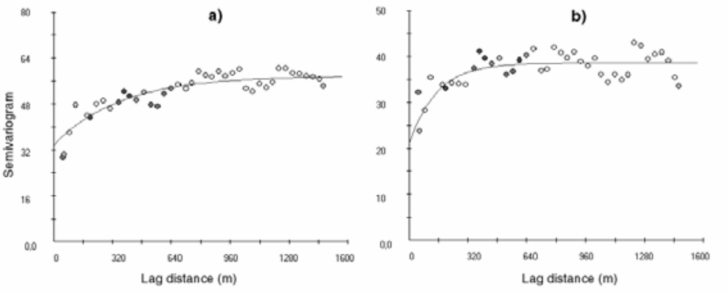

Fig. 1 – Experimental variograms and fitted models: a) A soil layer; b) B soil layer.

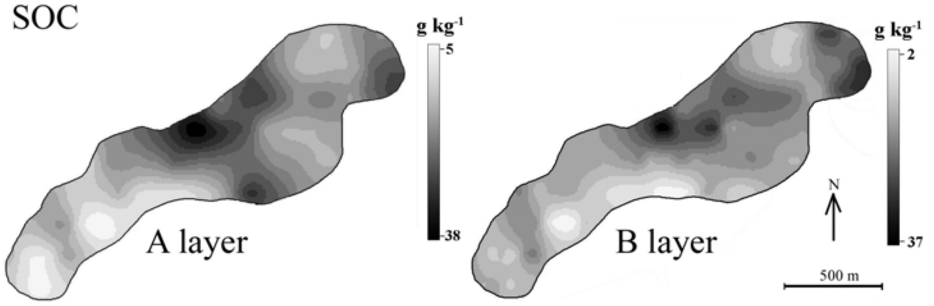

Fig. 2 – Maps of SOC at the two investigated depths.

Conclusions

The geostatistical analysis confirmed and quantified a high spatial variability of SOC in the study area. However the relatively high nugget effect indicates that the sampling scheme used not resolved most of spatial variation in SOC. A optimised second sampling step to thicken the spatial data could be useful to improve the spatial resolution of the SOC maps. Many studies have shown strong influence of terrain indices on the spatial variation of SOC (Mueller and Pierce, 2003). However, no direct correlation was found, in this study, between SOC, recent land use and considered environmental variables, rather its spatial structure seems more affected of soil genetic pattern.

References

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