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Mapping soil degradation using spectral reflectance measurements and geostatistics in a sample catchment in southern Italy

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Accelerated soil erosion by water and mass movements are the major causes of soil degradation in large areas of the Italian territory. In these areas mapping and monitoring of the soil degradation state form the basis for drafting and implementing rational development plans for a sustainable use of land resources. Soil degradation is conventionally evaluated by soil properties such as organic matter, calcium carbonate, texture, aggregation structure, infiltration capacity, etc. Conventional methods to quantitatively estimate these soil properties, based on field or laboratory analyses, are costly and time consuming. An alternative approach to determine these properties is based on the use of the radiation reflected/emitted from the soil surface. This approach is based on the knowledge that soil degradation modifies the chemical, physical and mineralogical properties of soil surfaces to produce distinct spectral features that can, to a certain extent, be spectrally detected using reflectance spectroscopy in the 350-2500 nm spectral region. Soil reflectance measurements in the visible (VIS), near-infrared (NIR) and shortwave infrared (SWIR) spectral range have the advantage to be rapid, non-destructive and inexpensive.

The aim of this work was to test the use of laboratory spectrometry in the 350-2500 nm spectral region, as a tool (i) to develop a prediction model to determine soil properties (organic matter, calcium carbonate, sand, silt and clay contents) and (ii) to mapping soil degradation conditions using geostatistical methods.

The test area is the Turbolo catchment (Calabria, southern Italy), extending over an area of about 30 km2, it can be assumed that representative of widespread sites in the same region, as well as of several zones in the Mediterranean belt, on the basis of its variegate but common lithological, topographic, pedological and climatic features, and its high susceptibility to soil degradation.

For this study, 215 topsoil samples, representative of different soil types and various soil degradation conditions were collected. Each sample was air-dried and sieved at 2 mm and then split into two sub-samples. One was used for spectroscopic measurements, the other was analysed to characterise organic matter, calcium carbonate, sand, silt, and clay contents.

The partial least squared regression (PLSR) analysis was applied to establish relationships between spectral reflectance and each soil property. PLSR was performed on 109 of the 215 available samples. The optimum number of factors to retain in the calibration models were determined by cross validation. The models were independently validated using data from the remaining 106 soil samples. Results revealed a high level of agreement between measured and predicted values with high coefficients of determination. Moreover they showed that soils are spectrally separable on the basis of their state of degradation/development, their topographic and lithological context and/or anthropic influence.

Cokriging was used to map the different soil properties and to study their spatial relationships.