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Using reflectance spectroscopy for detecting land-use effects on soil quality in drylands

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The rapid growth in the global population over the past few decades has resulted in the transformation of many natural ecosystems into human-dominated ones. Land-use (LU) dynamics are accompanied by an increase in resource exploitation, often causing deteriorated environmental conditions that are reflected in the soil quality. Soil quality differences between LUs can be observed and measured using near-infrared reflectance spectroscopy (NIRS) methods. The research goal was to apply, measure, and evaluate soil properties based solely on the spectral differences between both natural and human-dominated LU practices, in the dryland environment of the central Negev Desert, Israel. This goal was achieved through the development and implementation of chemometrics techniques that were generated from soil point spectroscopy. Soil quality index (SQI) values, based on 14 physical, biological, and chemical soil properties, were quantified and compared between LUs and geographical units across the study area. Laboratory spectral measurements of soil samples were applied. Significant differences in SQI values were found between the geographical units. The statistical and mathematical methods for evaluating the soil properties' spectral differences included principal component analysis (PCA), partial least squares-regression (PLS-R), and partial least squares-discriminant analysis (PLS-DA). Correlations between predicted spectral values and measured soil properties and SQI were calculated using PLS-R and evaluated by the coefficient of determination (R^2), the Root Mean Square Error of Calibration, and Cross-Validation (RMSEC and RMSECV), and the ratio of performance to deviation (RPD). The PLS-R managed to produce "excellent" and "good" prediction values for some of the soil properties, including EC, Cl, Na, Ca + Mg, SAR, NO_3, P, and SOM. Results of the PLS-R model for SQI are R^2 = 0.90, RPD = 2.46, RMSEC = 0.034, and RMSECV = 0.057. The PLS-DA classification of the laboratory spectroscopy was applied and resulted in high accuracy and kappa coefficient values when comparing LUs. In contrast, comparing the sampling sites resulted in lower overall accuracy (Acc = 0.82) and kappa values (K_c = 0.80). It is concluded that differentiation between physical, biological, and chemical soil properties, based on their spectral differences, is the key feature in the successful results for recognizing and characterizing various soil processes in an integrative approach. The results prove that soil quality and most soil properties can be successfully monitored and evaluated using NIRS in a comprehensive, non-destructive, time- and cost-efficient method.