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Estimation of soil organic matter using proximal and satellite sensors after a wildfire in Mediterranean Croatia

Iva Hrelja, Ivana Šestak, and Igor Bogunović
University of Zagreb, Faculty of Agriculture, Department of General Agronomy, Croatia (ihrelja@agr.hr)

Spectral data obtained from optical spaceborne sensors are being recognized as a valuable source of data that show promising results in assessing soil properties on medium and macro scale. Combining this technique with laboratory Visible-Near Infrared (VIS-NIR) spectroscopy methods can be an effective approach to perform robust research on plot scale to determine wildfire impact on soil organic matter (SOM) immediately after the fire. Therefore, the objective of this study was to assess the ability of Sentinel-2 superspectral data in estimating post-fire SOM content and comparison with the results acquired with laboratory VIS-NIR spectroscopy.

The study is performed in Mediterranean Croatia (44° 05' N; 15° 22' E; 72 m a.s.l.), on approximately 15 ha of fire affected mixed *Quercus ssp.* and *Juniperus ssp.* forest on Cambisols. A total of 80 soil samples (0-5 cm depth) were collected and geolocated on August 22nd 2019, two days after a medium to high severity wildfire. The samples were taken to the laboratory where soil organic carbon (SOC) content was determined via dry combustion method with a CHNS analyzer. SOM was subsequently calculated by using a conversion factor of 1.724. Laboratory soil spectral measurements were carried out using a portable spectroradiometer (350-1050 nm) on all collected soil samples. Two Sentinel-2 images were downloaded from ESAs Scientific Open Access Hub according to the closest dates of field sampling, namely August 31st and September 5th 2019, each containing eight VIS-NIR and two SWIR (Short-Wave Infrared) bands which were extracted from bare soil pixels using SNAP software. Partial least squares regression (PLSR) model based on the pre-processed spectral data was used for SOM estimation on both datasets. Spectral reflectance data were used as predictors and SOM content was used as a response variable. The accuracy of the models was determined via Root Mean Squared Error of Prediction ($RMSE_p$) and Ratio of Performance to Deviation (RPD) after full cross-validation of the calibration datasets.

The average post-fire SOM content was 9.63%, ranging from 5.46% minimum to 23.89% maximum. Models obtained from both datasets showed low $RMSE_p$ (Spectroscopy dataset $RMSE_p$ = 1.91; Sentinel-2 dataset $RMSE_p$ = 0.99). RPD values indicated very good predictions for both datasets (Spectrospcopy dataset RPD = 2.72; Sentinel-2 dataset RPD = 2.22). Laboratory spectroscopy method with higher spectral resolution provided more accurate results. Nonetheless, spaceborne method also showed promising results in the analysis and monitoring of SOM in post-burn period.

Keywords: remote sensing, soil spectroscopy, wildfires, soil organic matter

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