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NIR & MIR spectroscopy as an effective tool for detecting urban influences on soils

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Soil supports ecosystem functions and services, sustains ecosystems and biodiversity, yet in the urban spreading world of today, soil as a resource is in constant danger. Human society takes for granted the services provided by open green patches allocated within and nearby cities, with no consideration of ramifications of urban development on those areas. The urban ecology science recognizes the need to learn, identify and monitor the soils of cities – urban soils. The definitions of those soils are mainly descriptive, since urban soils do not submitted to the pedological process as natural soils. The main objective of this paper is to characterize urban soils in open green undisturbed patches by mineralogical composition. This goal was achieved using field and laboratory spectroscopy across visible near, short wave infrared regions and laboratory thermal mid infrared region. The majority of the studies on urban soils concentrate on identifying and mapping of pollution mostly heavy metals. In this study a top-down analysis (a simple and intuitive spectral feature for detecting the presence of minerals, organic matter and pollutants in mixed soil samples) is applied. This method uses spectral activity (SA) detection in a structured hierarchical approach to quickly and, more importantly, correctly identify dominant spectral features. The applied method is adopted by multiple in-production tools including continuum removal normalization, guided by polynomial generalization, and spectral-likelihood algorithms: orthogonal subspace projection (OSP) and iterative spectral mixture analysis (ISMA) were compared to feature likelihood methods. A total of 70 soil samples were collected at different locations: in remnant area within the city (edge and core), on the borders of the neighborhoods (edge) and in the fringe zone and in 2 locations in the protected park. The park samples were taken in locations found more than 100m from roads or direct anthropogenic disturbances. The samples were collected outside the setback of the residential areas (edge), and the fringe samples were taken away from the edge, where construction debris or waste was no longer visible – approximately 18 m-50 m down the slopes. The samples were taken from the upper layer of the soils, after the course organic or trash residues were removed. A soil sample drill, 5 cm in diameter and 10 cm deep, was used collecting up to 100 ml sample caps. The samples were air-dried, sifted through a 2 mm sieve to remove large particles and rock fragments and ground to <200 nm samples for spectral analysis across 400-2500 nm and laboratory mid-IR analysis. A ratio between the spectral features of soils' aliphatic and aromatic groups and calcite or hydroxyls to estimate the total organic matter via method proposed by Dlapa et al., 2014; base on the ratio indices between aliphatic hydrocarbons (3000-2800cm–1) to calcite mineral (peak area at 875cm–1, central wave length) and between carboxyl aromatic groups (1800-1200cm–1) to calcite mineral, were calculated for soil total carbon estimation. Results of the proposed top-down unmixing method suggest that the analysis is made very fast due to the simplified hierarchy which avoids the high-learning curve associated with unmixing algorithms showed that the most abundant components found in the all the samples taken within city boundaries were organic matter. In the "organic matter" category, we summarized all forms of vegetation end-members including coarse vegetation and organic carbon. The second component was concrete followed by plastic and bricks. We found traces of concrete in all the urban study samples, even samples taken as far as 150 m from the edge of patches. In the park soils, we found a low diversity of materials and only two identifications of anthropogenic substances. The results of the soils pH, measured electrometrically and the particle size distribution, measured by Laser diffraction, indicate there is no difference between the samples particle size distribution and the pH values of the samples but they are not significantly different from the expected, except for the OM percentage. The suggested method was very effective for tracing the man-made substances, we could find concrete and asphalt, plastic and synthetic polymers after they were assimilated, broken down and decomposed into soil particles. By the top-down unmixing method we did not limit the substances we characterize and so we could detect unexpected materials and contaminants.