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Title

Analysis of Soil Contamination Effects on Maize Plant using UAV-Mounted Multispectral Camera

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Abstract

The contamination of the environment with toxic substances is nowadays a critical issue. The dynamics of contaminations can be related to different natural and anthropic factors, such as chemical reactivity, accumulation, and transformation capacity in plant and animal organisms. Contaminants are more dangerous if they are more capable of accumulating. These properties are matched by potentially toxic elements (PTEs) and polycyclic aromatic hydrocarbons (PAHs), which represent a risk to the health of animal and plant organisms as well as humans. Traditional methods for assessing soil contamination over large areas involve field data collection, chemical laboratory analyses, and geostatistical interpolation, which are expensive and time-consuming [1, 2]. In this context, the monitoring of vegetation changes around areas with contaminated and unhealthy soil represents an effective alternative due to the rather narrow tolerance of plant communities towards soil factors, which makes them representative of the site's conditions. Changes in the morphological and physiological features of vegetation can be exploited as a meaningful bioindicator of the surrounding environmental situation due to the close plant-soil interaction. Since the vegetation attributes influence its spectral properties, remote and non-contacted spectroscopic monitoring offers an effective alternative method to detect plant distress, even before the appearance of visual symptoms, thus controlling the effects of contaminants before causing irreparable impacts [3]. However, vegetation health management requires frequent and reliable remote sensing data at high spatial, spectral, and temporal resolution. Consequently, the application of unmanned aerial vehicles (UAVs), equipped with sensors in different spectral ranges, for monitoring plant trait alterations caused by soil conditions is receiving increasing attention, as they as they offer high-resolution spatial details without destructive sampling[4, 5].

Therefore, in this study, multispectral data (Micasense Altum) acquired from a UAV was used to evaluate the effect of PTEs and PAH soil contamination on maize plant development. In particular, UAV data were collected at two different times during the vegetative stage of maize seedlings grown on a calcareous soil contaminated by a mixture of three heavy metals (Cr, Zn, and Pb) and a polycyclic aromatic hydrocarbon (benzopyrene) [6, 7]. The same soil was also treated with a solution of humic acids, which have been widely demonstrated to positively influence soils' physical, chemical, and biological properties, as well as the mobility and bioavailability of contaminants in soils. Although pot experiments showed only small differences between contaminated plants and control ones, drone-based multispectral data proved successful in detecting these differences.

Indeed, among the vegetation indices calculated from drone-based multispectral data, both the normalized difference vegetation index (NDVI) and Modified Soil-Adjusted Vegetation Index (MSAVI) were effective in discriminating slight differences in plant status, providing consistent results with the ground-based measurements [8, 9]. Moreover, we observed that maize plants grown on soils treated with humic substances (both control and contaminated soil) produced values indicative of better health status. In conclusion, this study represents a preliminary step that allows us to glimpse the potential of UAV-based multispectral analysis

for predicting plant trait change due to soil alterations, providing information for enhancing environmental monitoring efficiency.

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