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Emerging imaging techniques applied to chemical-physical and spatial characterisation of biochar

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Biochar, a carbon-rich material produced through the pyrolysis of agricultural biomasses (e.g. crop residues, wood biomass and animal litter) and solid wastes, represents a win-win solution for a rationale waste management. A sustainable biochar use requires an identification and standardization of certain qualities and characteristics because chemical, structural and morphological properties depend on burned matrix, pyrolysis conditions, rate of heating-slow versus fast pyrolysis and the duration of charring.
The aim of this work was to better identify the physical-chemical and spatial characteristics of biochars by applying two emerging imagining techniques, the 2D automated optical image analysis and hyperspectral enhanced dark-field microscopy (EDFM), in addition to SEM analysis. The biochars were obtained from three different biomasses: vineyard pruning residues (PR), anaerobic cattle digestate (CD) and litter poultry (PL) at two pyrolysis temperatures (350° and 550°C).
2D optical image analysis confirmed that the biomass composition and the pyrolysis temperature mainly influenced the different physical structures of the biochar samples. In particular, PR biochar was characterized by broken and fragmented structure with irregular and rough particle surface, completely different by the original PR wood cell. This result was also supported by SEM micrograph. The EDFM imaging analysis evidenced the disappearance of four endmembers due to the thermal degradation of PR vegetal products, composed primarily by hemicellulose, cellulose and lignin. As regards the biochar from PL, the pyrolysis produced smaller particles with regular and smoother surface compared to the original biomass. This phenomenon was more evident after the treatment at the highest temperature. The great susceptibility to the temperature might depend on minor morphological homogeneity of PL in comparison with other biomasses. Finally, beyond circularity and convexity increasing after CD charring, pixel intensity decreased by increasing the temperature, indicating changes in chemical composition. Indeed, CD biochar produced at 550°C exhibited the most regular particle size and shape, probably due to the formation of semi-crystalline aggregates. In conclusion, 2D automated optical image analysis and hyperspectral enhanced dark-field microscopy are resulted to be effective in determining the chemical-physical properties of biochar particles, and so they can be considered as promising imaging techniques in this filed. More investigations are need in order to validate both techniques on biochars from different origin.