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The characterization of biochars obtained from waste bagasse of licorice (*Glycyrrhiza glabra* L.) root

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Abstract: The licorice plant (*Glycyrrhiza glabra* L.) is distributed in Eastern Mediterranean and Southeast Anatolia regions of Turkey. The fibers obtained from roots of the plant are used for the production of a very popular local beverage/juice called as "Mayam" in these regions in the summer time. After maceration of roots into the water, they remained in the form of fibers as a waste bagasse. Biochar, which is a charcoal type obtained via carbonization of biomass sources, can improve the soil quality and structure, and increase the crop yield contributing a perennial carbon sequestration due to its high carbon stability. In this study, licorice root wastes were evaluated for the production of biochar. The carbonization experiments were carried out in a tubular furnace at different temperatures (i.e. 450, 550, 650 °C), heating rates (i.e. 10, 20, and 40 ˚C/min), and nitrogen flow rates (i.e. 50, 100, 200 and 300 mL/min) for 1 h. The fibers were ground and sieved into different particle sizes (i.e. 40, 60, 80 mesh) before the experiments. The yield of produced liquid bio-oil, biochar and gases were separately calculated to determine the best production parameters. The obtained biochar samples were analyzed using various spectroscopic (i.e. FTIR, EDX, XRF, XRD), microscopic (SEM) and calorimetric methods. The highest biochar yield (i.e., 45.52%) was obtained at 450 °C pyrolysis temperature and 10 ˚C/min heating rate with a nitrogen flow rate of 50 mL/min for 40 mesh size waste fibers. The heating value of the obtained biochar samples varied between 21-23 MJ/kg. The heating value of biochar is close to lignite and can be preferred to fossil fuels because they can be used for cleaner energy production compared to coal. The amount of ash in the produced biochar samples varied about from 16% to 25%, while the amount of sulfur is found as very low in the range of 0.016-0.039%. Most of the peaks formed in the FTIR spectrum of biochar samples were seen in the fingerprint region. In the structure of samples, some peaks belonging to the carbon bonds (e.g. C=O, C=C, C-O) were identified as well as the characteristic peaks of the CO_3 which is one of the major inorganic compounds in the chemical structure of glycyrrhizic acid of licorice root. The SEM/EDX results showed that fibers in the licorice root wastes were converted into a porous structure with a high yield of carbon after carbonization process. In particular, many of the plant cells were clearly observed on the fiber surface with the wall structures. According to the XRF analysis, the structure of biochar samples relatively consisted of the high content of carbon over 90%. Moreover, in the structure of all samples, the elements such as Si, Ca, Na, Mg and K were found in considerable amount as well as trace elements such as Al, Fe, P etc. Finally, XRD results indicated the crystalline regions of cellulose in the lignocellulosic root wastes disappeared due to high-temperature treatment and the structure were transformed into a more amorphous and carbonaceous state.
Keywords: Licorice, *Glycyrrhiza glabra* L., Maceration, Root, Carbonization, Bio-char