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Sorption of estrogens and pesticides from aqueous solution by a humic acid and raw and processed plant materials

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The huge number of organic contaminants released in water as a consequence of anthropogenic activities have detrimental effects to environmental systems and human health. Industrial products and byproducts, pharmaceuticals, pesticides, detergents and so on impose increasing costs for wastewater decontamination.
Adsorption techniques can be successfully used for the treatment of wastewaters to remove contaminants of various nature. Humic acids (HA) have well-known adsorptive capacities towards hydrophilic and, especially, hydrophobic compounds. In the recent years, alternative low-cost adsorbents, especially originated from agricultural wastes and food industries residues, such as wood chips, almond and coconut shells, peanut and rice husks, are under investigation. Biochar is also considered a promising and relatively low-cost adsorbent, even if there are still knowledge gaps about the influence of feedstock type, pyrolysis conditions, physical and chemical properties on its potential and safe use.
In the present work, a HA from a green compost was used along with three other materials of plant origin to remove two estrogens, 4-tert-octylphenol and 17-β-estradiol, and two pesticides, carbaryl and fenuron, from an aqueous solution. The four molecules were spiked in water each at a concentration of 1 mg L-1. The materials were: a biochar obtained from 100% red spruce pellet pyrolysed at 550 °C, spent coffee grounds and spent tea leaves. Kinetics curves and adsorption isotherms studies were performed using a batch equilibrium method. Adsorption data obtained for each compound were fitted to a linear equation and non-linear Freundlich and Langmuir models.
Kinetics data of the four compounds onto all adsorbents showed an initial very rapid adsorption which was completed in few hours when it reached equilibrium. The two estrogens were adsorbed onto all materials more quickly than the two less hydrophobic pesticides. Significant differences among adsorbents and the compounds concerned both the model of adsorption and quantitative aspects. Biochar demonstrated an optimum adsorption capability for both estrogens and pesticides, which was comparable to that of HA or even higher. The trend of adsorption varied with the model and the compound, approximately it was: biochar $\geq$ HA > spent coffee grounds > spent tea leaves. A marked adsorption efficiency (high values of the sorption constants) was shown by all materials for the contaminants. That suggests a valuable and cost effective exploitation of such materials for the removal of hazardous contaminants from aqueous wastes before their worthwhile recycle.