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Fate of Estrogens in Soils and Detection by ELISA

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Land application of manure can contribute to the release of estrogenic compounds in the environment. Estrogens may move from soils to water by processes such as runoff and leaching. The objectives of the present study were to determine the fate of estrogens in soils and to develop a detection method for these compounds. The sorption (soil sorption coefficient (K_d) and sorption coefficient per unit organic carbon (K_{oc})) of 17β-estradiol, estrone, estriol and equol were studied, using batch equilibrium experiments, in 121 surface soils from Alberta, Canada. The mineralization of $[^{4-14C}]$ 17β-estradiol was determined in soil microcosms in a subset of 36 samples. Quantitative relationships at the regional level were explored using partial least squares regression (PLS) (between K_d or K_{oc} values and soil properties) and by ordinary least squares regression (between K_d or K_{oc} values of different estrogens). Soil properties (r^2 0.51-0.87 for K_d and 0.32-0.44 for K_{oc}) provided better prediction models than using the data of different estrogens (r^2 0.38-0.71 for K_d and 0.18-0.40 for K_{oc}). PLS regression models for mineralization parameters of 17ß-estradiol had lower predictive power (lower r^2) than models developed for sorption parameters. In addition, it has become of primary importance to develop sensitive detection methods that are able to detect low estrogen concentrations (ng L^{-1}) in a wide variety of environmental matrices in order to validate the prediction of their fate and to study their presence in affected ecosystems. Conjugates were synthesized using a mixed anhydride reaction and two Enzyme-Linked Immunosorbent Assays (ELISAs) were developed using polyclonal antibodies. One ELISA was highly specific for 17β-estradiol (with an IC_{50} of 243 ng mL^{-1}) and the second allowed for the broader detection of 17β-estradiol, estrone and estriol (with an IC_{50} of 18 ng mL^{-1} for 17β-estradiol). The cross-reactivity of both ELISAs was studied against 13 compounds (natural, synthetic and conjugated estrogens, progestagens, androgens, corticosteroids and atrazine). Both ELISAs showed significant cross-reactivity (57 to 84 %) with two synthetic estrogens, β-estradiol-17-valerate and β-estradiol-3-benzoate, which are sometimes used in the cattle industry. When the characteristics of the 17β-estradiol+estrone+estriol ELISA were compared to those of a commercial ELISA, the commercial ELISA was both more specific and sensitive (0.4 pg mL^{-1} compared to 0.04 ng mL^{-1} for the 17β-estradiol+estrone+estriol ELISA) and its inter-assay variation was less (9.5% compared to 10%). However, the E1+E2+E3 ELISA had less intra-assay variation (4% compared to 5% for the commercial ELISA) and a shorter analysis time (5.5 hours compared to 20 hours). A solid-phase extraction method compatible with the 17β-estradiol+estrone+estriol ELISA showed good potential for determining estrogen concentrations in environmental samples (based on samples from an edge-of-field experiment) and could be used for the detection of estrogens in a variety of matrices such as surface waters in both urban and agricultural ecosystems.