ESTROGENIC HORMONE DISSIPATION IN AGRICULTURAL SOIL

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Methodology

Results

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Abstract

There is growing concern about the risks associated with endocrine disrupting chemicals (EDCs) being released into the environment. Agriculture could potentially be a source of environmental EDCs through the land application of biological wastes containing elevated levels of 17β-estradiol and estrone, and in the case of municipal waste, 17α-ethynylestradiol. Consequently, the persistence and pathways of dissipation of these potent hormones in agricultural soil were established in laboratory microcosm incubations. The hormones were rapidly dissipated in loam, sandy loam and silt loam soils under a range of moisture and temperature conditions. 17β-Estradiol was oxidized to estrone in both autoclaved and non-sterile soil, suggesting that its removal was microbially mediated. Both [4-14C]-estrone and [4-13C]-estrone formed non-extractable residues, and soil-bound residues were only slowly mineralized, suggesting that their bioavailability was low. Dissipation of 17α-ethynylestradiol was restricted to non-sterile aerobic soil. Under anaerobic conditions, 17α-ethynylestradiol was recalcitrant. Dissipation of the hormones correlated closely with removal of total estrogenicity as determined by a recombinant yeast screen bioassay. This finding indicates that extractable estrogenic transformation products did not accumulate. In summary, 17β-estradiol, estrone and 17α-ethynylestradiol were readily biodegradable under a range of conditions typical of a temperate growing environment.

Background

The Endocrine System

• Complex network of chemical signals and messages that control many immediate and life-long bodily responses and functions.
  ✔ reproduction, growth, development and behavior

Endocrine Disruptors

• Mimic or partly mimic hormones
• Block, prevent and alter hormonal binding to hormone receptors
• Alter production and breakdown of natural hormones.
• Modify the making and function of hormone receptors.

Effect of temperature on 10 mg/kg [4-13C]-17β-estradiol dissipation in a loam soil. Top panel: 17β-estradiol concentration determined by HPLC-UV. Middle panel: Estrone concentration determined by HPLC-UV. Bottom panel: Total estrogenicity measured with the YES assay, expressed as 17β-estradiol equivalents. The soil was incubated at 4°C (closed circles), 10°C (open circles), 19°C (closed triangles), or 30°C (open triangles).

Persistence of 1 mg kg⁻¹ [4-13C]-17β-estradiol in a sandy loam soil (triangles), a silty loam soil (squares), and a loam soil (circles). The soil was non-sterile (left panels) or autoclaved (right panels). Top panels: Total extractable radioactivity. Middle panels: Distribution of radioactivity in 17β-estradiol (open symbols) and estrone (closed symbols) as determined by HPLC-RD. Bottom panels: Total estrogenicity measured with the YES assay, expressed as 17β-estradiol equivalents.

Results

Estradiol dissipation (con't):
• 17β-Estradiol and estrone were labile in three different soils over a range of moisture and temperatures. 17β-Estradiol is initially converted to estrone via an abiological process. Subsequent removal of estrone proceeds via biological mechanisms. The YES assay demonstrated that there were no other estrogenic compounds produced.
• Dissipation of 17β-estradiol involves the formation of non-extractable residues; these residues were only slowly mineralized, suggesting that their bioavailability was low.

Ethynylestradiol dissipation:

Dissipation of 1 mg kg⁻¹ 17α-ethynylestradiol by a loam soil adjusted to a moisture content of 13%, and incubated at 30°C. Non-sterile soil was incubated under an atmosphere of nitrogen gas (left panel) or air (centre panel). Soil sterilized by autoclaving was incubated under air (right panel). Error bars indicate standard deviation.

• 17α-Ethynylestradiol was rapidly dissipated in the three soils under a range of moisture and temperature conditions.
• Using the YES assay, it was determined that extractable estrogenic transformation products did not accumulate.
• 17α-Ethynylestradiol dissipation proceeds via a biologically mediated process.

Conclusion

17β-Estradiol, estrone and 17α-ethynylestradiol were readily biodegradable in soils under a range of temperature and moisture conditions and we predict that they would be rapidly dissipated in aerated agricultural soils following application of manures or municipal biosolids during a temperate growing season.