Occurrence, Fate and Transport of 17ß-estradiol and Testosterone in the Environment

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OBJECTIVES

Naturally produced steroid hormones 17ß-estradiol (E2) and testosterone (T) including their metabolites estrone (E1) and androstenedione (A), respectively, are the most potent endocrine disrupters as compared to synthetic compounds [1], and consequently their public health as well as environmental concern is increasing. The objectives of this study include:

- To review the available publications, and summarize the current knowledge about the fate and transport of 17β-estradiol and testosterone in the environment; and
- To give an overview of the potential sources as well as recorded concentrations of these hormones in the environment.

SOURCES AND OCCURRENCE

The main sources of E2 and testosterone include wastewater and animal manure, and the path for surface and ground water contamination is illustrated in Figure 1.

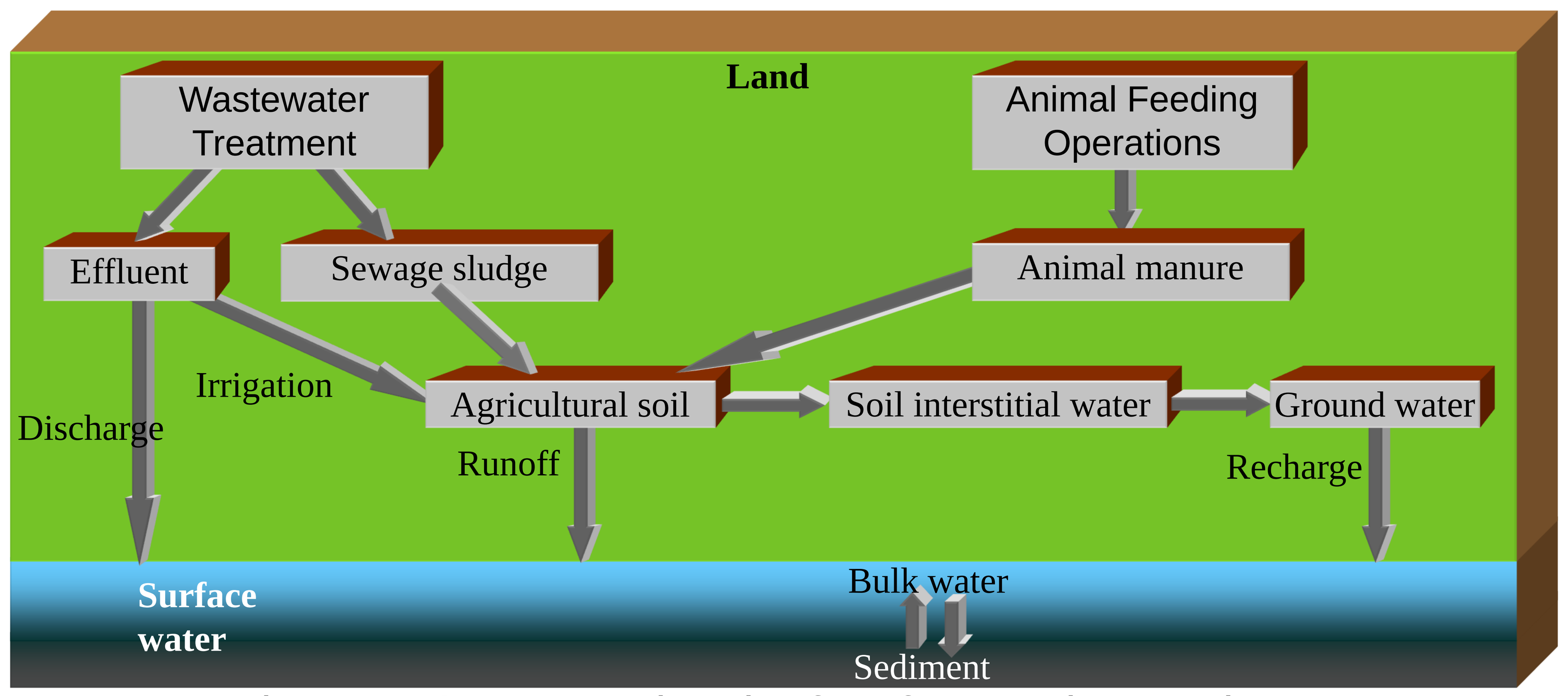

Figure 1. Source and path of surface and ground water contamination by steroid hormones.

Although laboratory studies showed a rapid biodegradation in soil as well as in water, significant concentration of these compounds (greater than effect concentration, 1 ng/l) were recorded in the environment (see Table 1).

Table 1. Recorded concentration in the environment

System	E2 (ng/l)	T (ng/l)	E1 (ng/l)	A (ng/l)
Stream	19-120	200[2]	0.4-12	20-60
Ground water	6.0-160	6.3	0.4	NA
Effluent	1-10	5-10	3.3-82.1	4.5
Runoff	20-2,530	11-2,520	NA	NA
Sea water	0.1-71	NA	NA	NA

NA = Not Available

SORPTION/DESORPTION

Sorption and desorption determine the fate and transport of E2 and testosterone in the environment. While studying these two key processes, considering the following points is essential: Organic carbon content, method, initial concentration, type of clay minerals, and mechanism of interaction.

- Sorption of E2 and Testosterone including their metabolite E1 and Androstenedione, respectively, are positively correlated with organic carbon content, clay mineral and salinity.
- Sorption rate constant estimated in undisturbed soil column study is lower than in the batch equilibrium test due to advective transport [3].
- At environmental related concentration desorption rather than sorption was indicated to be the determining factor for the fate and transport of E2 and Testosterone as well as their metabolites.
- In addition to hydrophobic interaction, hydrogen bonds, covalent bonds, and intercalation (sorption between kaolinite structure) are the main mechanism of interaction.

BIODEGRADATION

- Although photolysis eliminates some, the biodegradation process determines the complete removal of E2 and testosterone including their metabolites in the environment. Factors that affect biodegradation includes temperature, aeration, moisture content in soil, availability of inhibiting factors and viable microbial biomass.
- Under aerobic conditions, rapid degradation of E2 and testosterone was reported at a temperature of higher than 12°C and a soil moisture content of 15% in the absence of inhibiting factors such as antibiotics.
- Under strict anaerobic conditions, complete biotransformation of both E2 and testosterone is limited or their metabolites E1 and androstenedione, respectively accumulate.
- In soil amended with animal manure, agricultural practices including tillage, grass strips and soil aeration enhance incorporation of manures into the soil, consequently reduce surface runoff, and increase the biotransformation of these compounds.
- Steroid hormones are persistent in dry sand soil or saturated soil as well as in anaerobic sediment.

LINKING SORPTION AND BIODEGRADATION

- As sorption and biodegradation are the main governing processes in the fate and transport of E2 and testosterone, understanding the causal link of these two key processes is of paramount importance.
- Limited data show that the degradation half-life of testosterone is inversely related to the distribution coefficient K_d (Figure 2).

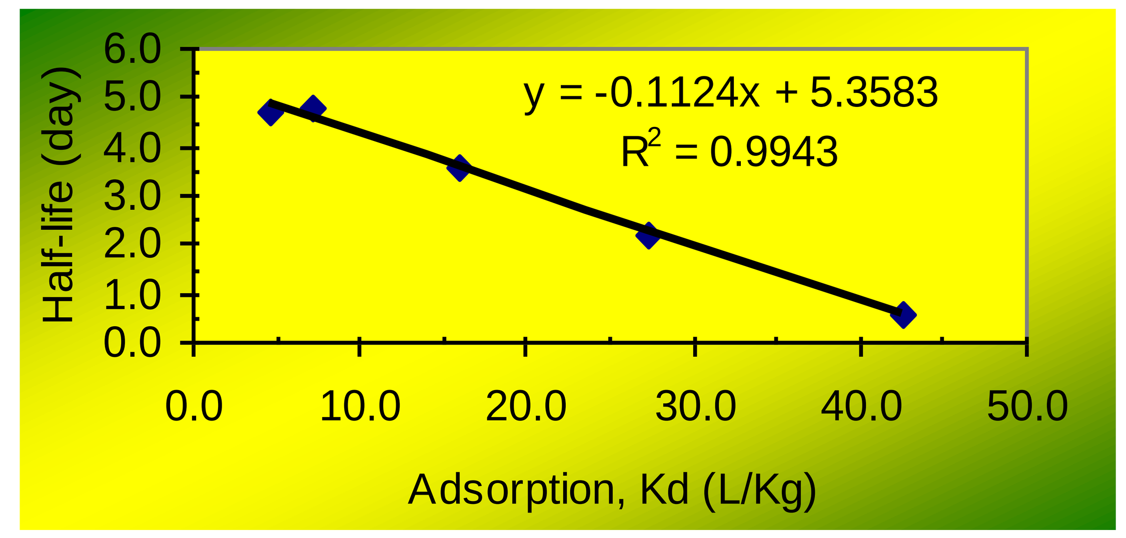

Figure 2. Sorption versus degradation of testosterone in aerobic soil calculated from [4]

TAKE HOME MESSAGE

- Laboratory studies show that natural steroid hormones biodegrade faster, and therefore would not persistent in the environment, whereas field studies indicate these compounds are persistent in agricultural soils under anaerobic conditions, saturated or dry.
- Recorded concentrations in the environment confirm that 17β-estradiol, testosterone and their metabolites could reach surface water as well as ground water at significantly higher concentrations than effective concentration, 1 ng/l. For better understanding of factors and processes that affect the fate and transport of steroid hormones, conducting further research is required.

ACKNOWLEDGEMENT

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