The Role of Organic Carbon in Natural and Synthetic Oestrogens Sorption onto Soils

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***Abstract*—Among the compounds implicated as Environmental Endocrine Disruptors (EEDs), the most potent to alter the normal functions of the endocrine systems of organisms and humans are the natural and synthetic oestrogen. They are hydrophobic and ubiquitous and remain in the final effluents for the vast majority of sewage treatment plant. Land application of animal manures and sewage sludge as fertilizers has been reported to increase the amount of hormones in soil. However, the information on the factor that influences the occurrence of these compounds in this environmental compartment is limited. This study investigates the sorption affinity of these oestrogens on soils by determining its soil-water partition coefficient (K_d), sorption coefficient normalised to organic carbon (K_{oc}) and octanol-water partition coefficient (K_{ow}). In this study, different percentage of organic carbon was used. The results obtained shows that the K_{ow} is a good predictor of sorption among contaminants as the affinity of oestrogens in soils is strongly dependent to their K_{ow} values. This study also shows that the solid-water partition coefficient (K_d) of all oestrogens have good correlation to the organic carbon content. The calculated sorption coefficient normalised to organic carbon (K_{oc}) indicate a strong association of all oestrogens with organic carbon. Therefore it is concluded that the organic carbon is pertinent to the sorption of oestrogens in soils.**

***Index Terms*—Octanol-water partition coefficient (K_{ow}), solid-water partition coefficient (K_d), sorption coefficient normalised to organic carbon (K_{oc}), organic carbon, sorption affinity.**

I. Introduction

Steroidal hormones are relatively the most potent endocrine disrupters that may interfere the normal functions of the endocrine systems [1]. The most active oestrogens hormones which are secreted by the ovaries in woman of normal menstrual cycles and by the placenta in pregnant woman along with its metabolite oestrone is 17β-oestradiol. This naturally hormones are also being secreted by male as well as animals. Meanwhile, 17α-ethnyloestradiol (EE2) is one of the synthetic oestrogens which commonly used for oestrogen replacement therapy particularly in oral contraceptives formulations and hormone replacement therapy.

In the recent past, several studies reported detection of steroidal hormones at the surface waters and it has been revealed that even at 1 ng/l of 17β-Oestradiol (E2), it is able to reduce sperm fertility drastically as well as induce vitellogenin in male trout [1]. Previous researches show that the occurrences of steroidal hormones at surface water largely contributed from the incomplete removal in municipal wastewater treatment plant. The degrees to which contaminants from wastewater present a risk to human health depend on their concentration, mobility and fate to human receptors. As the steroidal hormones in aquatic environment has been extensively carried out unfortunately a very few study concerns to terrestrial organisms.

The exposure of soil to steroidal oestrogens is believed to occur from several sources such as land application of sewage reuse and animal manure and leaking from onsite sewage treatment. However, soil samples have largely been overlooked and the information on this environmental compartment is limited in the literature. Nevertheless, there is still evidence on the occurrence of these steroidal oestrogens in soils. Finlay Moore reported the detection of 17β-Oestradiol (E2) in a pasture topsoil (0 – 2.5 cm) after 4 days amendment with poultry litter with a concentration of 305-820 ngL^{-1} and after 88 days it was still detected in the range between 60-125 ngL^{-1} [2]. Meanwhile, Beck recently reported the concentration of oestrogens in the ranges between 3 $ngkg^{-1}$ and 25 $ngkg^{-1}$ for 17β-Oestradiol (E2) and Oestrone (E1) in a cropland soil that had been regularly amended with manure three times a year, and 2 $ngkg^{-1}$ and 12 $ngkg^{-1}$ respectively in an intensively grazed pasture soil (0-15 cm) which was also amended with manure [3]. A few studies reported that disposal of animal manure to agricultural land could lead to movement of these compounds into groundwater [4], [5]. Shore believed that a constant 17β-Oestradiol (E2) concentration of about 5 ngL^{-1} is spring waters was caused by infiltration through the soil profile to the groundwater following manure application to land [4]. Peterson in their work to study the impact of disposal of poultry manure by the poultry industry had measured 17β-Oestradiol (E2) concentrations ranging from 6 to 66 ngL^{-1} in mantled karst aquifers in Northwest Arkansas, an area where a large segment of the agricultural economy of United States of America is located [5]. Swartz attempted a study to understand the fate of organic sewage contaminants introduced to groundwater by installing a series of sampling wells immediately downgradient from a septic system that discharged sewage effluent to as hallow sandy aquifer of Cape Code, USA and reported the occurrence of 17β-Oestradiol (E2) and Oestrone (E1) with the concentrations

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