

## ESGI73 Problem 7: Fractal Properties of Soil – Statement of Problem

P.J.J. Sweeney , *Syngenta Ltd, Jealott's Hill Research Station, Bracknell, Berks, RG42 6EY*

Registration of agrochemicals within the EU relies upon the use of complex process-based models of the environment to estimate their potential to enter ground and surface waters. The models simulate specific environmental scenarios representative of European agriculture and are parameterised using data from an extensive package of (predominantly) lab-based studies designed to quantify specific behaviours relevant to the environmental fate of chemicals. The breakdown of chemicals in soil is a key factor determining whether a chemical has the potential to enter into groundwater or surface water and a great deal of effort is spent by companies on understanding and quantifying this process. A regulatory limit of 0.1 µg/l for any active ingredient in groundwater has been set as the cut-off criterion for groundwater in the EU; this quantity represents approximately 0.2% of the mass of a typical 150g/ha application which places a high demand for accuracy on the predictions of these models.

The breakdown of agrochemicals in soil is represented in environmental fate models as a first-order process. Most agrochemicals are broken down in the top 1m of soil by microbial action; some are also degraded by the action of light (photolysis) which occurs in a thin surface layer of the soil (usually assumed to be 2mm) which can occur at a much faster rate than microbial degradation. Although this layer is very small compared to the layer in which microbial degradation is assumed to occur its effect can be significant. Agrochemicals generally enter into soil through the surface and the residence time in the photolysis layer can give rise to significant degradation by this route. This has been confirmed in field studies where breakdown products only produced by photolysis have been measured, and where degradation curves of parent material can show a marked bi-phasic pattern consistent with rapid photolysis followed by slower microbial degradation.

Environmental fate models represent the soil as a series of compartments. Photolysis can be included into these models by using a degradation rate observed in laboratory studies that is applicable to a compartment representing the top 2mm of soil only. The microbial degradation rate is used for compartments representing soil deeper soil layers. When this is done for chemicals that photolyse however, the degradation rate measured in field studies is almost never recovered by the model, leading to estimates of the environmental fate of chemicals inconsistent to that which is observed in the field.

Models treat the soil surface as effectively planar. However it is well-known that soil surface can be treated as a fractal. It is an open question the extent to which degradation via adsorption of photons into a fractal surface differs from that assuming a planar surface and whether this can explain the inability of models to represent the degradation of some substances. Although the fractal nature of soil has been studied, to date the consideration of soil fractal properties has concentrated upon soil water movement and tortuosity of micropores in the soil matrix and how this affects bulk properties. Similarly a consideration of the properties of fractal surfaces has, to this author's knowledge, concentrated upon scattering from a fractal surface, rather than deposition into one. It is interesting to note that the laboratory study designed to measure the rate of photolysis of a chemical in soil seeks to use a very thin (2mm) planar soil layer, rather than a surface that might be found in the field.

**Questions to address:** To what extent does treating the soil as a fractal rather than a planar surface alter the prediction of the amount of degradation by photolysis? How can this be incorporated into environmental fate models?