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The influence of surface crust development on pesticide transport through the unsaturated zone in drained clay soil

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Introduction

In the United Kingdom recent research on diffuse pesticide transport to surface waters has focused on drained soils for which preferential flow mechanisms in the unsaturated zone control the amounts and patterns of pesticide leaching. Soil surface conditions and rainfall characteristics are both key factors controlling the initiation and extent of pesticide-rich macropore flow and lateral throughflow to drains. The influence of rainfall characteristics (such as rainfall intensity, duration, sequence and timing) on pesticide transport has been widely studied[1,2]. However, the condition of the top layer of soil during and following pesticide application also has an important role to play in controlling the subsequent fate and transport of pesticide[3]. Little research to date has focused on the link between the development of a surface crust and the effect this process has on the subsurface transport of pesticide. This is despite the fact that the same winter-cereal cultivation techniques that are believed to be responsible for much diffuse pesticide transport to surface waters leave areas of soil bare, or with little cover, for prolonged periods during autumn and winter. This exacerbates aggregate breakdown, surface crust formation and soil erosion.

Core

The interplay between rainfall conditions and surface structure in drained soil, and the consequences for pesticide transport through the unsaturated zone, are the focus of this presentation in which we report the results of a combined field and laboratory-based research programme. This was designed to determine;

- the spatial and temporal extent of surface crust development in drained soil;
- the effect of surface crust development on unsaturated zone flow processes; and
- the influence of surface crust development on pesticide transport through the unsaturated zone to field drains.

Two drained arable hillslopes (under winter wheat and field bean cultivation) were instrumented for a period of one year each in order to establish the timing and extent of surface seal development using a combination of micromorphological and macroscopic observations. The unsaturated zone hydrology of the hillslopes was monitored using a combination of automatic weather station, automatic tensiometers and soil moisture probes. At each site tile drain discharge, and water quality parameters including pesticide (isoproturon and simazine) concentrations in drainflow were recorded during and following storm events.

Surface crust development occurred over both hillslopes in the winter months (December to February) in response to a combination of high rainfall intensity with associated perched water table development, and consequent saturation of the A horizon; surface water ponding in areas of lower micro-relief; and freeze/thaw action. The thickness and nature of the surface crust was highly variable across the hillslope and depended on location in relation to the tile drain network, and the micro-relief. Significant pesticide losses in drainflow were co-incident with periods of surface crust development in the field confirming the potential for sealing to impact on diffuse pesticide transport to surface waters.

In the laboratory, simulated rainfall experiments on repacked soil lysimeters allowed the relationship between soil surface crust development and subsurface pesticide loss in macropore flow and throughflow pathways to be developed under controlled conditions. Total losses of the phenylurea herbicide, isoproturon, through subsurface pathways increased from 0.025 % to 0.5 % of the total applied under surface sealed conditions. This was a result of two mechanisms; an increased volume of throughflow containing isoproturon under the wetter, sealed conditions; and increased concentrations of isoproturon in macropore and throughflow attributed to physical and chemical characteristics of the surface crust[4].

Conclusion

This research has demonstrated the potential importance of surface crust development as a factor controlling the extent of pesticide transport through subsurface pathways in the unsaturated zone. This research highlights the important role of unsaturated zone flow and transport processes for pesticide transport, and the linkages between soil

management, unsaturated zone processes and diffuse pesticide transport to surface waters.

References

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