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Differences in fate, behavior and uptake of conventional- and nano-pesticides

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Nanopesticides, in which conventional pesticides are designed into nanoparticles, are now available and are marketed as having improved longevity and efficacy in the environment. Nanoparticles are known to have different properties to dissolved chemicals and as such it is possible that the fate and behaviour of nanopesticides differs from conventional pesticides. We present work on the synthetic pyrethroid bifenthrin to explore the implications of nanoencapsulation for the sorption, persistence and uptake of the active ingredient in soil-earthworm systems. Studies were done using the active ingredient, a traditional formulation and two nanoformulations.

In adsorption experiments conducted using five soils with a range of properties (pH 4.7 – 7.7; % organic carbon 1.2 – 5.2; texture silt loam to loamy sand), adsorption was well described by linear isotherms. Adsorption of analytical grade bifenthrin (Kd = 1800 – 7200 mL / g) was greater than that of a commercial formulation (Kd = 190 – 470 mL / g) which in turn was greater than that of nanoformulations (Kd = 52 – 150 mL / g). For all bifenthrin types adsorption increased with increasing soil organic matter content. Degradation rates of the analytical grade bifenthrin and commercial formulation were similar and faster than those of nanoformulations. Degradation rates were faster in non-sterile compared to sterile conditions. These results suggest that nano-encapsulation could lead to increased mobility and persistence of bifenthrin in the environment and therefore potentially increased exposure and bioavailability.

To investigate the effects of nanoencapsulation on uptake we carried out a series of uptake and excretion experiments using the earthworms Eisenia fetida and Lumbricus terrestris. Over the exposure period the concentration of bifenthrin in the soil decreased and increased in the earthworms. Rates of accumulation and excretion were greater for the nanobifenthrin than the non-nanoformulation and active ingredient. Dissection and analysis of earthworm tissues indicated that the accumulated bifenthrin from the nano exposure was concentrated in the earthworm gut whereas the accumulated bifenthrin in the conventional exposure was concentrated in the earthworm tissues. We used kinetic modelling to determine bioconcentration factors. The higher accumulation and excretion rates result in predicted lower bioconcentration factors for the nanobofenthrin compared to the conventional and analytical grade forms.

Our experiments demonstrate the differing behaviours of a conventional and nano-formluated pesticide therefore suggesting that current environmental risk assessment methodologies for conventional pesticides may not be appropriate for nanoformulations.