

## The Interaction of Pesticides with Humic Fractions and Their Potential Impact on Non-Extractable Residue Formation

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The constant influx of pesticides into soils is a key environmental issue in terms of their potential retention in the soil, thus reducing their negative impact on the environment. Soil organic matter (SOM) is an important factor influencing the environmental fate of these substances. Therefore, the aim of this research was to assess the chemical behavior of pesticides (flufenacet, pendimethalin,  $\alpha$ -cypermethrin, metazachlor, acetamiprid) toward stable soil humin fractions (HNs) as a main factor affecting the formation of non-extractable residues of agrochemicals in soil. This research was conducted as a batch experiment according to OECD Guideline 106. For this purpose, HNs were isolated from eight soils with different physicochemical properties (clay content = 16–47%,  $\text{pH}_{\text{KCl}}$  = 5.6–7.7,  $\text{TOC}$  = 13.3–49.7  $\text{g}\cdot\text{kg}^{-1}$ ,  $\text{TN}$  = 1.06–2.90  $\text{g}\cdot\text{kg}^{-1}$ ,  $\text{TOC}/\text{TN}$  = 11.4–13.7) to reflect the various processes of their formation. The extraction was carried out through the sequential separation of humic acids with 0.1 M NaOH, and then the digestion of the remaining mineral fraction with 10% HF/HCl. The pesticide concentrations were detected using GC-MS/MS. The pesticides were characterized based on the different sorption rates to HNs, according to the overall trend: metazachlor (95% of absorbed compound) > acetamiprid (94% of absorbed compound) > cypermethrin (63% of partitioning compound) > flufenacet (39% of partitioning compound) > pendimethalin (28% of partitioning compound). Cypermethrin and metazachlor exhibited the highest saturation dynamic, while the other agrochemicals were much more slowly attracted by the HNs. The obtained sorption kinetic data were congruous to the pseudo-first-order and pseudo-second-order models related to the surface adsorption and interparticle diffusion isotherm. The conducted research showed that the processes of pesticide sorption, apart from physicochemical phenomena, are also affected by the properties of the pollutants themselves (polarity,  $K_{\text{OC}}$ ) and the soil properties (SOM content, clay content, and  $\text{pH}_{\text{KCl}}$ ).

Słowa kluczowe

sorption, soil organic matter, NER, pendimethalin, cypermethrin, acetamiprid, metazachlor, flufenacet

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