Development of an Extraction Method for Estimating Phytoaccessible Fractions of Bromacil and Tebuthiuron

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Bromacil and tebuthiuron were used from the 1960s to 1990s on industrial sites to control vegetation. Approximately 61,750 sites are contaminated when comparing total concentrations (estimated by 99 percent methanol extraction) against Alberta's remediation guidelines. Remediation sites requires soil treatment or removal to reduce concentrations below guidelines. As time passes from initial application, a portion of bromacil and tebuthiuron adsorbs to the soil solid phase. Total concentration in soil is comprised of adsorbed

(solid phase) and phytoaccessible (plant accessible) concentrations. Measuring risk to receptors through phytoaccessible concentrations in soil could avoid unnecessary ex-situ treatment or landfilling. Immobilization technologies could increase natural soil adsorption to reduce risk in-situ at sites with bromacil or tebuthiuron contamination.

Calcium chloride solution (0.01 M) is used to assess phytoaccessible nutrient concentrations nutrients and conduct adsorption/desorption studies of metals and organics. Here, it was used as an extractant to estimate phytoaccessible concentrations of bromacil and tebuthiuron in soil. A t-test for non-parametric data with homogeneous variances was used to compare estimated phytoaccessible concentrations to total concentrations (estimated by 99 percent methanol extraction of aged soil samples, or by spiking soils using a known concentration). Samples used contained a known concentration of bromacil (84 samples) or tebuthiuron (66 samples). Samples were extracted with 40 mL 0.01 M calcium chloride by shaking and centrifugation. Resulting 10 mL liquid extracts were sent to a commercial laboratory for analysis with High Pressure Liquid Chromatography (HPLC) using Mass Selective Detection. Median estimated total bromacil concentration was 0.300 mg/kg and median estimated phytoaccessible bromacil was 0.190 mg/kg ($W = 5131$, $p < 0.001$). Median spiked and aged tebuthiuron concentration was 0.273 mg/kg and median calcium chloride-extractable was 0.140 mg/kg ($W = 2694$, $p = 0.003$).

Organic matter and clay contribute most to bromacil or tebuthiuron adsorption. Categorical analysis of high or low organic matter and high or low clay content against estimated adsorbed fraction was conducted. A two-by-two Analysis of Variance (ANOVA) assessed if increasing percentage of clay and organic matter increased estimated adsorbed fraction. Estimated calcium chloride-extracted concentration was subtracted from the estimated total concentration and divided by the estimated total concentration. Mean estimated adsorbed bromacil fraction was higher for high organic matter compared to low organic matter soils ($F = 8.09$, $p < 0.01$). Clay did not significantly increase estimated adsorption of bromacil ($F = 2.36$, $p = 0.133$). Estimated adsorbed tebuthiuron fraction was significantly higher for high organic matter compared to low organic matter soils ($F = 25.89$, $p < 0.001$). Clay did not significantly increase tebuthiuron adsorption ($F = 0.03$, $p = 0.858$).

Estimated phytoaccessible concentrations of bromacil and tebuthiuron were less than the estimated total concentrations, likely due to adsorption on organic matter. Where there are large areas of marginal bromacil or tebuthiuron contamination, approaches are needed to reduce risk, meet regulatory requirements, and protect soil health. Soils with low phytoaccessible concentrations could remain in place and retain nutrients, organic matter, and structure, providing resiliency against current and future challenges to soil ecosystems.

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I have been an Environmental Scientist since 2013 and am currently working with Matrix Solutions Inc., based in Edmonton. Project work has involved Phase I, II and III Environmental Site Assessments, Risk Management Plans, remediation, groundwater monitoring and soil characterization and assessment. My graduate degree was a joint project between the U of A and InnoTech Alberta. InnoTech's Soil Sterilants Program is suite of applied research projects aimed to improve efficiency in addressing bromacil and tebuthiuron concentrations in soil and groundwater in Alberta. For further information on the Soil Sterilants Program, please contact Simone Levy, Research Scientist, Environmental Impacts at InnoTech Alberta (simone.levy@InnoTechAlberta.ca).