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Assessment of Phytotoxic Effects of PAHs and DDTs in Solid-Phase System Using Microalgal Bioassays

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Abstract

Assessments of phytotoxic effects of soil pollutants are commonly relied on standard plant bioassays such as seed germination/root elongation and early seedling growth tests. However, they are either of low sensitivity or time consuming, which diminish their values used in risk assessment and environmental management of contaminated areas. On the other hand, microalgae are relatively easy to handle, multiply rapidly and widely accepted as surrogates for testing phytotoxicities of chemicals to higher plants due to their sensitivity to various toxicants. Pilot experiments aimed at providing a fast and sensitive phytotoxicity screening option in terrestrial environments were performed with the newly developed direct-contact solid-phase microalgal bioassays. Standard plant tests were also conducted for comparison. A soil survey was carried out to study the PAH and DDT contaminations and the diversity of microalgae in the 138 soil samples collected throughout Hong Kong. There was a widespread contamination of PAHs and DDTs, but generally the pollution levels for all land use categories (urban parks, greening areas, country parks, rural areas, restored landfills, agricultural farmlands, orchard farms, crematoria, industrial and near highway areas) were below the recommended values for residential and general purposes stated in soil quality guidelines from different countries (Netherlands, Denmark, Canada and China), except a few hotspots with exceptionally high concentrations of PAHs in urban parks. Forty microalgal species were identified in Hong Kong soils. No significant difference was found for richness indexes among different land use categories and this was also true for Shannon indexes, except in restored landfills which was significantly higher than other categories. Based on the results, toxicity experiments using spiked sand were performed to study the effects of naphthalene, phenanthrene,

pyrene, DDT, DDD and DDE on the growth of microalgae and higher plants. The novel 4-day solid-phase microalgal bioassays were conducted using *Selenastrum capricornutum*, *Chlorococcum hypnosporum* (commercially available) and *Chlorococcum meneghini* (locally isolated) while *Lolium perenne, Cynodon dactylon* (grasses) and *Brassica chinensis* (vegetable) were used in the 5-day seed germination/root elongation and 28-day early seedling growth tests. The results indicated that solid-phase microalgal bioassay had a higher sensitivity using algal density than the standard plant tests using germination rate, length and biomass as endpoints. In general, *S. capricornutum* was more vulnerable to PAHs and *C. meneghini* to DDTs. Another set of comparison was conducted using soils collected from the field which were contaminated with heavy metals, PAHs and DDTs. Seed germination/root elongation tests were insensitive while biomass showed a higher sensitivity than shoot or root length in the seedling growth tests. In general, the solid-phase microalgal bioassays were more sensitive except certain endpoints (e.g. biomass) in higher plant tests which exhibited comparative sensitivities to the most sensitive microalga *C. meneghini*. This study clearly demonstrated the feasibility and applicability of using a 4-day direct-contact solid-phase microalgal bioassay for fast screening of phytotoxic chemicals in the edaphic system. It is a very promising alternative bioassay though at the same time it possesses certain limitations, with rooms for improvement.

Table of Contents