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Application of Phytotechnologies for Cleanup of Industrial, Agricultural and Wastewater Contamination

Edited by
Peter A. Kulakow
Valentina V. Pidlisnyuk

Springer

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Chapter

Application of Phytotechnologies for Cleanup of Industrial, Agricultural, and Wastewater Contamination

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Obsolete Pesticides Pollution and Phytoremediation of Contaminated Soil in Kazakhstan

- A. Nurzhanova
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Abstract

In Kazakhstan, a deepening ecological crisis has been caused by contamination of the environment with obsolete and expired pesticides. Large-scale physical and chemical technologies for managing pesticide-contaminated soils are expensive and unacceptable for Kazakhstan because of limited financial resources. Phytoremediation is a promising innovative technology for managing pesticide-contaminated soils. Pesticide contamination is common on land surrounding destroyed warehouses that were part of the official plant protection service of the former Soviet Union.

We surveyed substances stored in 76 former pesticide warehouses in Almaty and Akmola oblasts of Kazakhstan to demonstrate an inventory process needed to understand the obsolete pesticide problem throughout the country. The survey areas were within 250 km of Almaty (the former capitol of Kazakhstan) and within 100 km of Astana (the new capitol). In Almaty oblast, a total of 352.6 t of obsolete pesticides and 250 pesticide containers were observed. In Akmola oblast, 36.0 t of obsolete pesticides and 263 pesticide containers were observed. Persistent organic pollutants (POPs) pesticides contaminated soil around 26 of the former storehouses where the concentration of POPs exceed the Kazakhstan MAC (maximum allowable concentration) for soil contaminated

by tens to hundreds of times. The POPs pesticides include metabolites of DDT (dichlorodiphenyltrichloroethane) and isomers of HCH (hexachlorocyclohexane).

We studied plant community structure at six "hot points" contaminated sites with three located in Almaty oblast and three in Akmola oblast. From these studies, 17 pesticide-tolerant plant species were selected from colonizing plants that grew near the centers of the hot points.

A greenhouse experiment using the pesticide-tolerant species showed some plant species have the ability to change plant growth characteristics when grown in contaminated versus uncontaminated soil. These characteristics include biomass production, rate of phenological development, peroxidase activity in roots and leaves, ratio of chlorophyll a to chlorophyll b, rate of evapotranspiration, and phytoaccumulation of organochlorine pesticides and their metabolites (4,4 DDE, 2,4 DDD, 4,4 DDT, α-HCH, β-HCH and γ-HCH).

We observed pesticide accumulation was influenced by plant species, plant biomass, and soil pesticide concentrations. Among the investigated species, four accumulated metabolites of DDT and isomers of HCH in plant tissue concentrations exceeding the Kazakhstan MAC (maximum acceptable concentration) for plant tissue by 400 times. The Kazakhstan MAC for DDT and HCH metabolites in plant tissue is 20 μg/kg. Species in this category included: *Artemisia annua L., Kochia sieversiana* (Pall.) C.A. Mey. *Kochia scoparia* (L.) Schrad., and *Xanthium strumarium* L. Three species exceeded the MAC by up to 90 times including *A. annua, Ambrosia artemisiifolia* L., and *Erigeron canadensis* L. Most pesticides accumulated in the root systems; however, among the species investigated, *K. scoparia, A. annua, Barbarea vulgaris* W. T. Aiton, and *A. artemisiifolia* demonstrated capabilities to translocate pesticides from roots to aboveground tissues.

To help identify the location of accumulated pesticides within plant tissue, we employed histological analysis whereby a few species indicated pesticides were distributed unevenly within different plant tissues. If a species had a dorsiventral and isolateral leaf type, then pesticides appeared to accumulate in palisade mesophyll tissue. If a species had homogeneous mesophyll, then pesticide appeared to accumulate in mesophyllous cells around conducting bunches. For example, *X. strumarium*. has a dorsiventral type of leaf; thus, pesticides collected in the palisade mesophyll. In the stem, pesticides accumulated in walls of xylem cells. In root tissue, pesticides accumulated in parenchymous cells and xylem walls.

We investigated cultivation methods to enhance plant uptake of pesticides. Use of mineral fertilizers resulted in stimulation of growth and biomass accumulation that increased phytoextraction. The concentration of DDT metabolites and isomers of HCH in soil and the application of fertilizers lengthened the rate of phenological development increasing plant height and biomass. In a greenhouse experiment using fertilizer applications to pesticide-contaminated soil, tolerant species showed increased phytoextraction of pesticides. Phytoextraction by *X. strumarium* increased from 0.3% to 0.6%, *A. annua* from 0.5% to 0.7%, and *Cucurbita pepo* L. *pepo* from 0.4% to 0.7%. *K. scoparia and Amaranthus retroflexus* L. showed high bioaccumulations factors but showed low biomass compared to other species and thus weak phytoextraction. *A. annua, K. scoparia, A. retroflexus*, and *X. strumarium* decreased pesticide concentration of rhizosphere soil 11–24% more in treatments with fertilizer compared to treatments without fertilizer. Field experiments using selected wild species demonstrated reduction of pesticide concentrations in soil in excess of reductions observed without plants and without fertilizers. Additional work is needed to determine if practically useful phytotechnology applications can effectively manage pesticide-contaminated soil at former storehouse sites.

Keywords

obsolete pesticides phytoremediation DDT HCH pesticide tolerance inventory

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