LAND DISPOSAL AND SPILL SITE ENVIRONMENTS

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ABSTRACT

Land is a receptor of many chemicals through both intentional and unintentional depositions. Mitigation methods for control of the chemicals resulting from unintentional depositions such as unsuccessful landfills, spills, and leaks include excavation and disposal, entombment in place, and in some situations, in situ biodegradation. If genetically engineered bacteria could expand the number of situations where in situ degradation is applicable, then more economically efficient control methods resulting in the destruction of chemicals would be available.

This paper outlines the various processes affecting the fate of organic chemicals in the soil environment, summarizes the environmental conditions encountered by organisms, and reviews two case histories of biodegradation of chemicals within the soil environment.

Environmental conditions encountered by organisms are distinctly different in the two major soil zones: the unsaturated zone and the saturated zone. Chemicals may be present within the soil environment including the vapor phase, the adsorbed phase, and the soluble phase. These differences affect the fates of each chemical and result in greatly different rates of biodegradation of chemicals by naturally occurring microorganisms. Case histories discussed are that of a spray irrigation field treating wastewater from a creosote wood treating process, and that of an in situ biodegradation program for clean up of surface soils contaminated with pentachlorophenol. Recommendations for bacterial characteristics that could be
engineered to greatly expand the applicability of in situ biodegradation are made.

INTRODUCTION

The soil environment is the receptor of many chemicals. Intentional deposition of chemicals includes landfilling and land treatment systems. Unintentional deposition includes chemical spills, leakage, and unsuccessful landfills. Various mitigation techniques exist for the unintentional depositions, including excavation and disposal, entombment in place, and, in the case of biodegradable organic chemicals, in situ biotreatment. Genetic engineering of bacteria may present opportunities for enhancement of in situ biotreatment and land treatment systems for biodegradable organic chemicals.

The objectives of this paper are 1) to outline processes affecting the fate of organic chemicals in soil environments; 2) to summarize environmental conditions encountered by organisms in the soil environment; and 3) to review two specific case histories involving biodegradation of organic chemicals in the soil environment.

FATE OF CHEMICALS IN SOIL ENVIRONMENT

General

The fate of biodegradable organic chemicals in soil environments is a complex process. Figure 1 is a schematic diagram of the various factors affecting such chemicals in soil environments. The chemicals have three phases of interest: vapor, aqueous or soluble, and adsorbed. Each of these phases is subject to different transformations and transport, depending to some extent on its location in either the unsaturated zone or the saturated zone of the soil environment. The unsaturated zone is the layer of soil from the surface to the top of the water table; the saturated zone, the layer below the water table. Biodegradation and chemical transformation can take place in both zones. In the unsaturated zone, volatilization can be a factor in the fate of the chemical. Transport of the chemicals is normally by water movement, which is different in each zone. These processes are discussed in more detail in subsequent sections.

Chemical Phases

Vapor phase. If the chemical has a significantly high vapor pressure, it can volatilize in a gaseous environment. This process is significant in the unsaturated zone where the void spaces within the soil are not filled with water. Vapor can diffuse through the