Proposal of Biological and Physico-chemical Treatment Systems for Dioxins-contaminated Soils

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Introduction

Soil contamination caused by dioxins in and around sites of incinerators for municipal solid waste (MSW) is a concern in Japan. For example, scattering wastewater from a wet gas scrubber at an MSW incinerator facility in Nose, Osaka caused soil and surface water contamination. The concentration of dioxins in the soil was about 8,000 pg-TEQ/g. Other contamination sites include soils on which fly ash has been placed directly or improperly stored and landfill sites that have received bottom and fly ash over a long period. Some countermeasures are required immediately at these dioxins-contaminated sites.

We have previously developed bioreactor systems for dioxins-contaminated water and soil[1, 2], because biological methods are inexpensive and have a low potential to produce toxic by-products. We have shown that a fungus, *Pseudallescheria boydii (P. boydii)*, isolated from activated sludge treating wastewater that contained dioxins, can degrade highly chlorinated dioxins[1]. A reaction product of octachlorinated dibenzo-p-dioxin (OCDD) was identified as heptachlorinated dibenzo-p-dioxin[1].

In actual contaminated sites, we have to select proper methods for treatment of dioxin-contaminated sites, depending on site characteristics such as their concentration levels and distributions, types of soils (whether if including fly ash containing dioxins), and volume of contaminated soil. In the case where biological methods are not enough due to too high concentration of dioxins, physico-chemical methods should be combined with the biological methods.

We have developed physico-chemical and biological methods such as a solvent extraction process of dioxins from contaminated soils with ethanol[3] and a pretreatment process of contaminated water with ultraviolet light[3], and bioreactor system[4, 5]. In addition, post treatment processes have been developed such as a solvent extraction process of remaining dioxins from soils treated by bioreactor[5] and a sterilizing process of *P. boydii*[6]. These processes should be combined depending on the site characteristics.

Therefore, this study proposed an integrated treatment system for dioxin-contaminated soils and incinerated residue. In other words, we developed some treatment systems, by combination of physico-chemical and biological methods, especially depending on concentration levels of dioxins, and types of contaminated soil.

IRemedial strategy for dioxins-contaminated site

n general, there are two alternatives for remediation of contaminated soil: removal of soil or not removal (in-situ remediation). Decision Makers select the alternative, considering cost, period for remediation, technical and social feasibility and so on.

In the case of dioxins-contaminated soil, a concentration level in dioxins may be a critical criterion for selecting alternatives, because dioxins are highly toxic and reliable and urgent countermeasures are required. As shown in Figure 1, in the case of high concentration in dioxins, dioxins-contaminated soil are removed with prevention of contaminant spreading, and treated by bioreactor or other method such as incineration and melting. On the other hand, in the case of low concentration, in-situ bioremediation may be applicable after prevention of contaminant spreading such as vertical wall and capping.

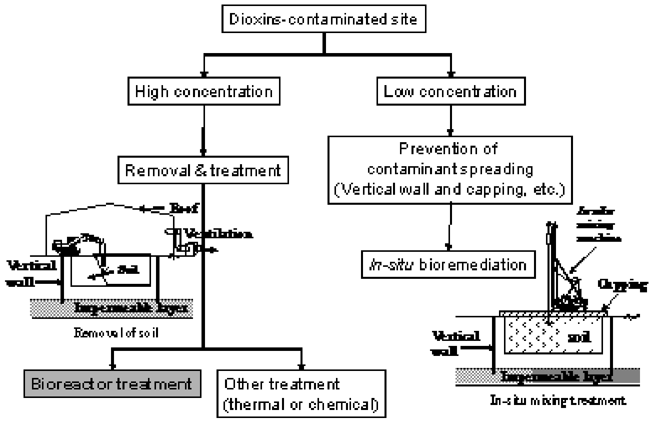

Figure 1 Remedial strategy for dioxins-contaminated site

Bioreactor treatment system of the removed soil

Figure 2 shows bioreactor treatment system of the removal soil, where there are two ways: liquid phase treatment and solid phase treatment.

Liquid phase treatment

In the liquid phase treatment, as shown in figure 3, dioxins are extracted from the contaminated soil with solvents such as ethanol and so on, and the extracted dioxins are concentrated and treated by bioreactor with *P. boydii* that is capable to degrade dioxins. If the amount of highly chlorinated dioxins is large, UV treatment may be effective to degrade the highly chlorinated dioxins.

We tried to extract dioxins from the contaminated soils that was sampled from Nose, Osaka (we call the sample Nose sample) and searched an optimum conditions[3]. As a result, we found that ethanol (concentration 80% (v/v-water) at 78.3^{o}C for 1 minute) could extract 99% based on TEQ of dioxins from the Nose sample. The extraction rate seemed to be relatively high, because most of dioxins seemed to exist on the surface of soil particles. In the case of fly ash, ethanol could not extract any dioxins from fly ash. Therefore, this extraction process with ethanol can be effective for treatment of contaminated soils, from which dioxins can be extracted easily.

With regard to ultraviolet light treatment, when extracted dioxins (400ng/mL-ethanol) were added to water and allowed to react for 90 minutes, dechlorination reaction was confirmed as shown in Table 1. In addition, we confirmed that *P. boydii* could degrade about 85% of the remaining dioxins after UV treatment[7].

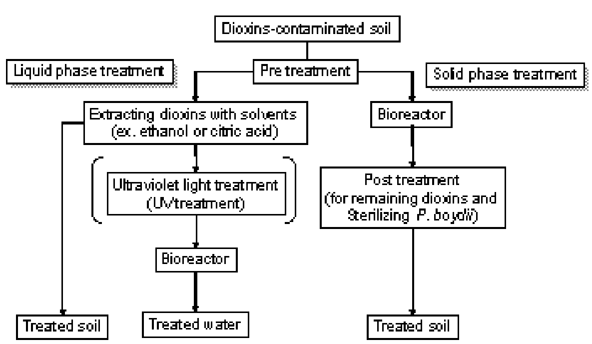

Figure 2 Bioreactor treatment systems for the removed soil

Table 1 UV degradation of dioxins in ethanol extract from contaminated soil[3]

	TCDD	P5CDD	H6CDD	H7CDD	OCDD

	+TCDF	+P5CDF	+H6CDF	+H7CDF	+OCDF
Degradation ratio (%)	-50	68	40	57	71

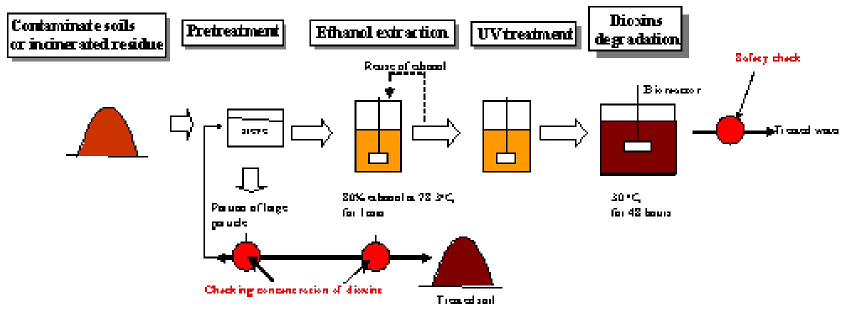

Figure 3 Liquid phase treatment system for treatment of dioxins contaminated soil

Solid phase treatment

In the case where it is difficult to extract dioxins from contaminated soil such as soil mixed with fly ash, the solid phase treatment system might be effective, as shown in figure 4. We tried to treat two kinds of contaminated soils with fly ash using bioreactor (5 L), in which 70% water content slurry (1 kg of soil and 2.4 L of water) was agitated with *P. boydii* at 30^{o}C and for 48 hours to 96 hours. As a result, dioxins were degraded about 40 to 60% (initial concentration 173pg-TEQ/g and 2,210pg-TEQ/g to final concentration 66pg-TEQ/g and 1,340pg-TEQ/g, respectively)[5].

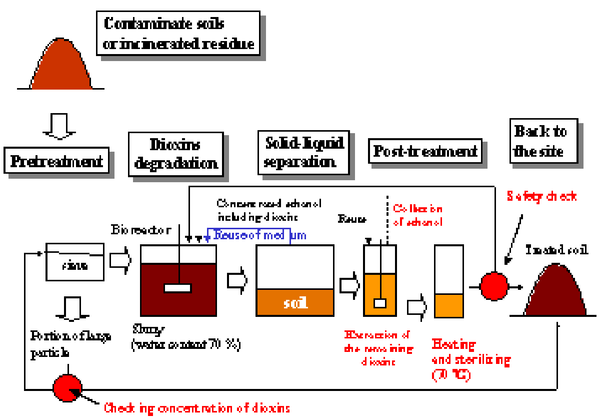

Figure 4 Solid phase treatment system for dioxins-contaminated soil[5)]

Since *P. boydii* is a weakly pathogenic fungus, ranked at the lowest level in Japanese guidelines, a heating sterilizing process was added to the system. The sterilizing conditions have been reported by Ishii et al.[6].

Acknowledgments

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