DETOXIFICATION OF DIOXIN IN SOIL BY ACTIVE LANFILL BIOREACTOR

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Introduction

During the invasion war in Vietnam, US army had sprayed about 80 million litters of herbicides including 45 million litters of Agent Orange over provinces in South of Vietnam. As scientific estimation about 170-600kg dioxin, the most toxic ever known, contained in 45 million litters of Agent Orange [1,2,3].

War had gone over 30 years but its consequences are still serious. Herbicides, especially Agent Orange/dioxin is existing in some areas with dangerous levels, so-called "hot spots". These hot spots used to be US air fields, army installations. There some common features of these areas: including herbicide storages, loading bases for mission air crafts, craft washing bases after missions and lands storage used herbicides casks. There exist lands contaminated with Agent Orange/dioxin from 1 to 5 ha; dioxin contents in soil from some thousands to some hundred thousands ppt. Particularly, once dioxin has permeated 1.5 m deep in soil with approximately concentration of 1.000 ppt.

Therefore, the decontamination and treatment of these contaminated areas have been raised imperatively. Vietnam scientists have conducted some solutions such as photochemical, chemical, dumping, biological methods... [4,5,6,7,8,9,10]. This paper is to present some initial results of research on active landfill bioreactor for dioxin decontamination in soil in hot spots in Vietnam.

Methods and Materials

- Isolation method: employing HDPE material with 1.5-2 m thick to isolate toxic compounds in contaminated soil away from environment and filted material such as environmat for adsorption toxic compounds. Bentonite in Vietnam is the main component in manufacturing filtration material environmat with following parameters:

+ *Mineral content of montnonrilonit 35- 40% in form of sodium*

* *Outter surface area:* $14.3\ m^2/g$
* *Inner surface area:* $28.0\ m^2/g$
* *Specific surface area:* $42.3\ m^2/g$
* *Average diameter of hole:* $51.5\ A^0$

+ *Ion exchange capacity: 60- 80 mEg/100g*

+ *Swelling capacity: 600- 800%*

+ *Dioxin adsorption capacity: >99.75%*

- Methods for biological decomposition of dioxin: base on the supply of products containing nutrients, substrates, minerals, stuffs, additives in order to promote the composition process of endemic microorganisms. The application of slow adsorption product (18-24 months) is to maintain supplying nitrients in a long time.

- Experimental scope: conduct active dumping compartments with scale of $10m^2$ and 100 m^3 of dioxin contaminated soil in hot spots. Monitoring, evaluating the biological variation and sampling, analyzing dioxin concentration in soil in dumping compartment with time.

- Analysis method: dioxin is determined by CALUX and low resolution GC/MS (GC 6890/MSD 5972A Hewlett Packard) following EPA methods 1613, 8280 and 8290. Determination of 2,4-D vµ 2,4,5-T was carried out on HPLC 1090 and EPA method 8321A.

Results and Discussions

Table 1. Parameters of Enviromat material

Parameter	Unit	Measuare method	Measuare equipment	Enviromat Vietnam	Reference material
Tensile strength	kN/m	DIN 53857/2	AIM 2661 India	7.6/5,5	8.1/6
Tensile elongating	%	DIN 53857/2	AIM 2661 India	9/8.5	8/8
Peel strength	N/10 cm	ATMD 413	AIM 2611/5 India	18.6	19.8
Permeability coefficient	x 10^{-11} m/s	DIN 18130	AIM 2676 India	5	4.5

- Similar characteristics have been seen in comparison between environmat from Vietnam and reference material (environmat from Italia). Most important parameters are permeability coeffcient and peel strength.

- No agent orange and dioxin permeation out of isolation compartment had been observed ater 2 years of monitoring. This proved that HPDE with 1.5-2 m thick and environmat material could completely restrain toxic compounds to surroundings which filtration materials showed excellent adsorption of organochlorine and dioxin compounds. Due to large swelling capacity (600-800%), bentonite had blocked pores on the dumping walls. Beside the high adsorption capacity (>99.75%); betonite in filtration material could be employed to be carrier for microorganism development which facilitate dioxin decomposition and other harmful substances.

- Results on variation of microoganisms: number of heterotrophic microorganisms increases from 10^4 MPN/g to 10^5, 10^6 and 10^7 MPN/g in the control lanfill bioreactor without application of bioremediation. In the active landfill bioreactor, the number of heterotrophic microorganisms increased to 10^9 MPN/g in dry soil.

- Results on dioxin decomposition in active landfill bioreactor: the total toxic equivalence in soil decreased 50-70%. Beside dioxin decomposition, other toxic chemicals such as 2,4-D, 2,4,5-T, chlorophenols were decomposed strongly by microorganisms; undetectable in soil after 2 years.

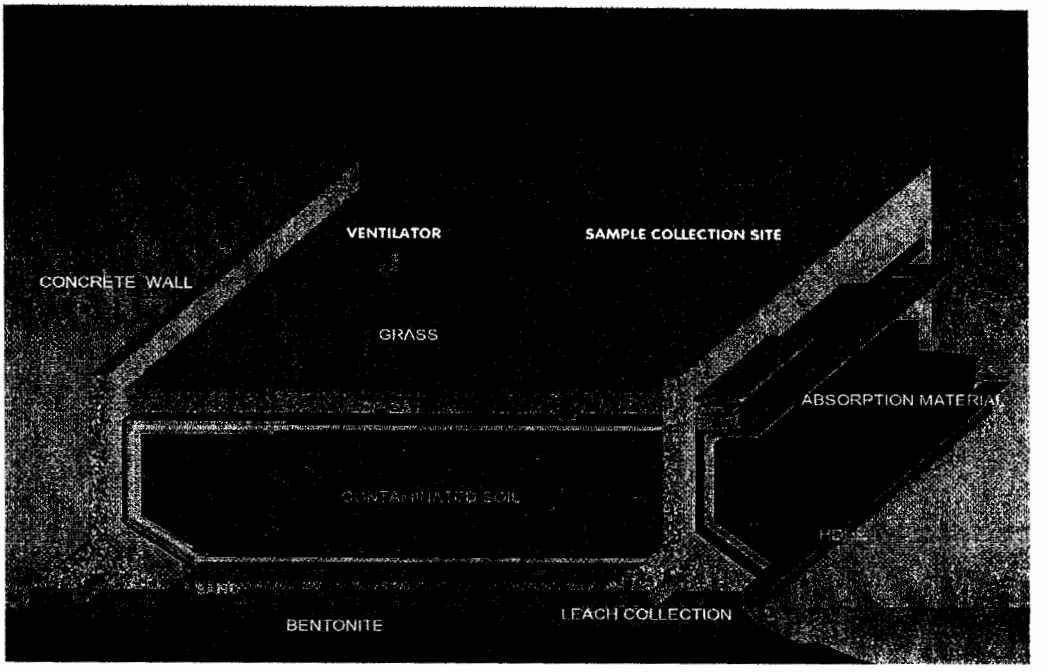

Figure 1. The model of active landfill bioreactor

Dumping compartment composed by isolating materials and filtration materials has created a bioreactor which facilitated the biological decomposition of dioxin. Some parameters could be controled actively for dioxin decomposition process such as humidity, temperature, pH, nutrients, substrates...

The results of experiment and trial had shown that active landfill bioreactor (isolation combined with adsorption and dioxin composition by microorganism) is a feasible method for dioxin decontamination in hot spots in Vietnam due to its reasonable cost and simple implementation.

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