A Bio-Remediation Lysimeter Examination In A Field With Dioxin Contaminated Soil Using New Mineral Salt

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Introduction

InOur 2004 Dioxin conference, we reported the result of lysimeter test using actual dioxin-contaminated soils and mixtures of microorganisms in landfill sites, in order to determine the degree of dioxin digestion by microorganisms in the field[1)]. The report has been indicated that dioxins in lysimeter were reduced by microorganisms. But we did not get a high level degradation range of dioxin. Therefore, we examined the lysimeter test added new mineral slot.

In this study, we reported the result of lysimeter test using new nutrient medium, mixtures of microorganisms and actual dioxin-contaminated soils in landfill sites.

Materials and methods

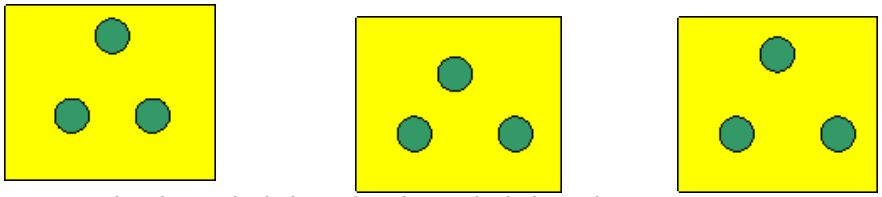
(1) Items measured in the experiment

Items measured in the experiment are as follows:

1. Dioxins (PCDDs, PCDFs, Co-PCB) variously, 2. water contents, 3.pH, 4.ORP (oxidation-reduction potential), 5. numbers of bacteria, and 6. temperature.

(2) Installation of the lysimeter

Three lysimeters were installed (D: Organisms mixture + nutrient salt + minerals (Mnso4, FeCl2, ZnSO4, CuSO4, Na2MoO), and E: Organisms mixture + nutrient salt + minerals + caustic silver). The lysimeter measured 1.35m×1.35m×0.4m. Deposition of the contaminated soils was adjusted so that it passed through a sieve of 1×2mm mesh in the lysimeter. 450kg of soil, 20kg of bacteria and 30kg of new dilution nutrient salt were placed in lysimeter D and 400kg of soils, 20kg of bacteria and 80kg of nutrition were pleased in lysimeter E. The concentrations of the dioxin based on toxicity equivalence quantity (TEQ) were D: 1,870 pg-TEQ/g, and E: 1,860pg-TEQ/g. The total dioxin concentrations were D: 129,600 pg/g and E: 119,200pg/g. These concentrations were determined by the method described in the next section. Measuring items of the sample was carried out periodically over a 1-month period from 3 points per each lysimeter, as shown in figure 1. Water was sprinkled periodically, and the moisture of the lysimeter was controlled.



A: Control D: bacteria (mixture) E: bacteria (mixture),

Nutrient and minerals nutrient salt, minerals and caustic silver

Figure 1 Conditions of lysimeter tests and sampling points (A and C were reported 2004 dioxin conference)

(3) Extraction and analysis of dioxins and Co-PCB

We determined concentration of dioxins based on the modified standard method of Ministry of the Environment in Japan[2]. After cultivation, from 5 g of cultured soil, the dioxins were extracted to 20 ml of ethyl acetate as shown below. The cultured soil was shaken vigorously for 10 min with a reciprocating shaker. Standing for several minutes separated ethyl acetate phase and solid phase, and Na_2SO_4 was used to dry the ethyl acetate phase. The extracted dioxins in the ethyl acetate phase were diluted and analyzed by gas chromatography-mass spectrometry (selected SIM mode) with JMS-SX102A and a fused silica SP-2331 capillary column (60 m by 0.22 mm i.d.).

The operating parameters for the GC were as follows: injector, 270℃; carrier gas, He; carrier flow, 0.8ml/min; injection method, splitless. The oven temperature was initially maintained at 100 ℃ for 1 min and then increased to 250℃ at 8℃/min and finally to 290℃ at 4℃/min and maintained at 290℃ for 5 min.

Results

(1) Changes in pH and ORP in the lysimeter

Changes in the pH in the lysimeter D were 5.5 -8.1, and in the lysimeter E were 4.8 -4.9. It was shown that ORP in Lysimeter D was 98 to 216 mV and that in E was 214 to 365 mV. The lysimeter D and E were aerobic condition.

(2) Reduction of dioxins in the contaminated soil based on total concentration

The percentages of reduction in total concentration of dioxin determined in the three lysimeters are shown in table 1. After 5 months, dioxins were reduced by 28.4% in lysimeter D. It was indicated that the strains in the lysimeter D might had the ability to degrade the dioxins.

Table 1. Reduction of total dioxins in the contaminated soil (pg/g)

	Start	After 5 month	Deference	Reduction %
*A	326,000	324,000	2,000	0.6
*C	304,200	250,600	53600	17.6
D	129,600	92,800	36,800	28.4
E	119,200	118,400	800	0.60

* previously report[1]

(3) Reduction of dioxins based on TEQ

The reduction based on TEQ of dioxin is shown in table 2. After 5 month, lysimeter D showed a dioxin reduction of

Table 2. Reduction of total dioxins in contaminated soil (TEQpg/g)

	Start	After 5 month	Deference	Reduction %
*A	5,207	5,069	138	2.7
*C	4,838	3,851	987	20.2
D	1,870	1,440	430	23.0
E	1,860	1,670	190	10.2

* previously report[1]

430 TEQ-pg/g, corresponding to about 23% reduction.

(4) Characteristics of Reduction of total dioxin concentration and TEQ

The characteristics of the reduction based of each kind of dioxin concentration and TEQ is shown in table 3. Lysimeter D showed a dioxin reduction of 430 TEQ-pg/g, corresponding to about 23% reduction.

Table 3 Characteristics of Reduction of total dioxin concentration and TEQ

lysimeter	Kind of dioxin	% of dixin reduced concentration	% of reduced TEQ
*C	TCDDs	13.3	20.7
	TCDFs	25.4	21.9
	Co-PCB	4.2	0
D	TCDDs	21.3	20.7
	TCDFs	32.7	25.6
	Co-PCB	18.8	15.1
E	TCDDs	3.3	0.2
	TCDFs	5.8	16.2
	Co-PCB	8.7	4.8

* previously report[1)]

Discussion

The examination of this study was performed in the same field as well as 2003 test[1)]. As shown in the above results, dioxins concentration based on TEQ decreased by about 23% and total dioxins were decreased by 28.4% in the sample of the lysimeter D. The degree of reductions of lysimeter D was higher than the previously reported average (C) [1)]. These data indicate that microorganism of D was got active by adding minerals. But in the lysimeter E, the degree of reductions of total dioxins and TEQ was 0.6% and 10.2%, each. The activity of microorganisms in the lysimeter E was lower than the lysimeter D or C. Caustic silver is strong toxic for the microorganism. The reason wa considered that caustic silver in the lysimeter E was attached in microorganisms, and did not degradated TEQ and total dioxins.

Acknowledgements

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References

1. IkuoSouta et al. (2004), Organohalogen Compounds Vol.66, 1296-1298

2. IkuoSouta et al. (2003), Organohalogen Compounds Vol. 63, 293