BIODEGRADATION OF DIOXINS IN FLY ASH BY THERMOPHILIC BACILLUS MIDOUSUJI

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Introduction

Contaminated water quality was adjusted by adding fly ash to the medium. From degradation rates of dioxin isomers and congeners tetra-chlorinated or greater in the fly ash, degradation capability (based on dioxin degradation rates) as well as clean-up capability (based on toxic equivalents) of SH2B-J2 strain of Bacillus midousuji for dioxin-contaminated water were determined [1)].

Materials and MethodsIn order to investigate the clean-up capability of SH2B-J2 strain for dioxin-contaminated water, flask experiment was conducted. Experimental conditions are shown below:Incubation device: Rotary shaker (Revolution per hour: 2800 rph) with temperature: 65 degrees Celsius, 24 hoursInnoculum: SH2B-J2 strain, innoculum population density: 1.2 X 107/mlTest vessel: Erlenmeyer's flask with baffles, vessel volume, number: 200 ml, 4 flasksMedium type, concentration: Soybean-Casein Digest Broth, 3 wt% solution, medium volume: 100 ml/flask X 4 flasksSubstrate preparation: 0.25 g of fly ash per 100 ml of medium (2.5 g/l)Control samples: Medium (3 wt. %) + SH2B-J2 strain (non-activated strains) + fly ash (0.25 g/ml)Test samples: Medium (3 wt. %) + SH2B-J2 strain (activated strains) + fly ash (0.25 g/ml)Fly ash was collected in Osaka City.

Control samples were prepared with consideration for absorption by proteins in the medium and the innoculum.

(Dioxin concentration of controls)
= (Dioxin concentration from fly ash)
- (Dioxin concentration absorbed by proteins)

(Dioxin concentration of test samples)
= (Dioxin concentration from fly ash)
- (Dioxin concentration absorbed by proteins)
- (Dioxin concentration degraded by SH2B-J2)

Therefore,

(Dioxin concentration degraded by SH2B-J2)
= (Dioxin concentration of controls)
- (Dioxin concentration of test samples)

Results

Table 1 shows the measured results of dioxin concentration for controls and test samples. ND indicates concentrations below the detection limit.

Figure 1 shows the concentrations and degradation rates of dioxin isomer/congeners for controls and test samples.Degradation rate was 50 % for SH2B-J2 when used against isomers and congeners of dioxins tetra-chlorinated or greater. Dibenzo-p-dioxins were degraded 57 %, and Dibenzo furan was degraded 41 %. By assumption that toxic equivalent can also be calculated in similar manner to

Table 1. Measured results of dioxin isomer/congener for controls and test samples

Dioxin isomer/congeners	Concentrations in controls (pg)	Concentration in test samples (pg)	Detection limit (pg)	Measurement limit (pg)
1,3,6,8-T4CDD	ND	ND	5	20
1,3,7,9-T4CDD	ND	ND	5	20
2,3,7,8-T4CDD	430	350	5	20
T4CDDs	4,900	4,200	5	20
1,2,3,7,8-P5CDD	1,500	1,100	6	20
P5CDDs	14,000	8,800	6	20
1,2,3,4,7,8-H6CDD	1,700	840	7	20
1,2,3,6,7,8-H6CDD	3,600	2,200	6	20
1,2,3,7,8,9-H6CDD	2,800	1,100	7	20
H6CDDs	35,000	18,000	7	20
1,2,3,4,6,7,8-H7CDD	45,000	22,000	7	20
H7CDDs	91,000	42,000	7	20
O8CDD	200,000	81,000	10	30
Total PCDDs	350,000	150,000	-	-
1,2,7,8-T4CDF	ND	ND	4	10
2,3,7,8-T4CDF	1,800	1,600	4	10
T4CDFs	47,000	34,000	4	10
1,2,3,7,8-P5CDF	3,800	2,600	4	10
2,3,4,7,8-P5CDF	2,400	1,900	5	20
P5CDFs	40,000	28,000	5	20
1,2,3,4,7,8-H6CDF	5,500	3,200	5	20
1,2,3,6,7,8-H6CDF	5,800	3,700	5	20
1,2,3,7,8,9-H6CDF	1,000	290	6	20
2,3,4,6,7,8-H6CDF	5,700	3600	6	20
H6CDFs	47,000	28,000	6	20
1,2,3,4,6,7,8-H7CDF	26,000	14,000	6	20
1,2,3,4,7,8,9-H7CDF	6,100	3,000	8	30
H7CDFs	45,000	23,000	8	30
O8CDF	38,000	16,000	9	30
Total PCDFs	220,000	130,000	-	-
TOTAL PCDDs+PCDFs	560,000	280,000	-	-

degradation rates for each isomer and dioxins, overall clean-up rate was calculated as 34.8%. It was determined that dioxin isomers and congeners penta-chlorinated or greater can also be degraded. Also, if growth suppression substance in the solution is reduced by lowering fly ash levels, (L/S 1000) degradation rate rises to 70 % in terms of toxic equivalence. On the other hand, it is viewed that dissolved oxygen concentration supply is inadequate in flask experiments. Therefore it will be necessary to reconfirm clean-up capabilities as a way to assess performance of reaction system using full size clean-up systems.ConclusionsFlask-level clean-up experiment was conducted. Contaminated water quality was adjusted by adding fly ash. From the analytic results of degradation rates and toxic

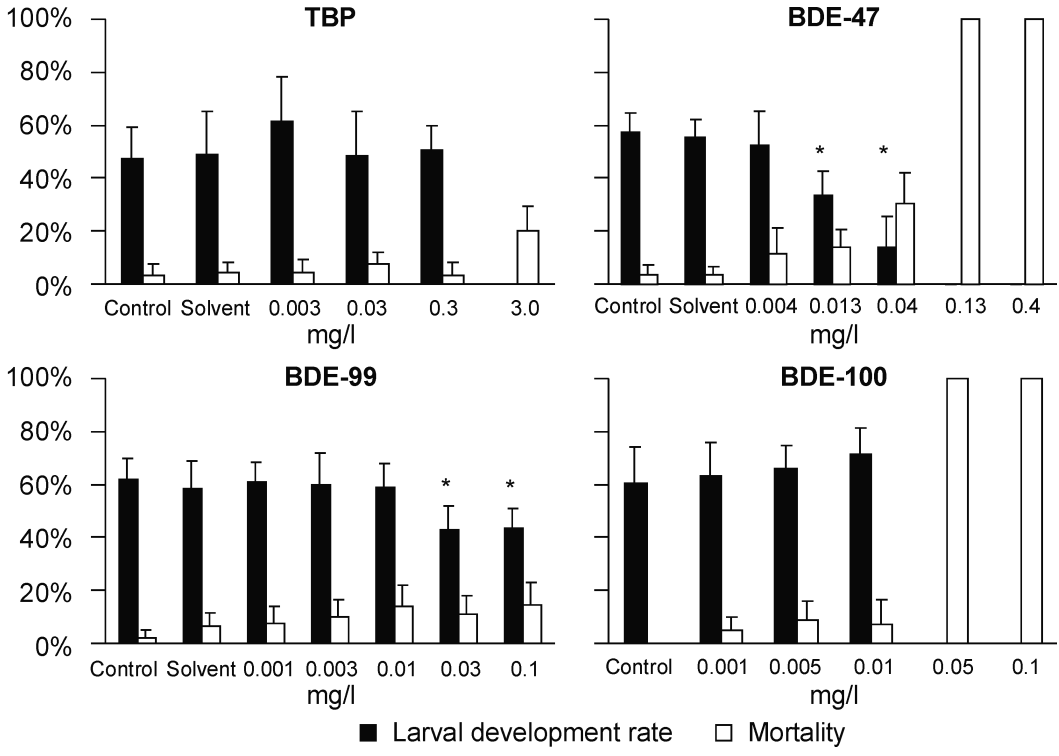

Figure 1. Concentrations and degradation rates of dioxin isomer/congeners for controls and test samples

equivalency for isomers and congeners of dioxins tetra-chlorinated or greater, degradation capability and clean-up capability of SH2B-J2 strain against dioxin contaminated water was investigated. Following results were obtained. 1 Clean-up capability of the SH2B-J2 strains was 50 % when shown as degradation rate for dioxins tetra-chlorinated or greater. Degradation rate was 57 % for Dibenzo-p-dioxins, 41 % for Dibenzo furans. On toxic equivalency basis, clean-up capability was 34.8 %. 2 It is of note that high degradation capability was seen for dioxin isomer and congeners penta-chlorinated or greater. For most microbes under study, degradation capability is limited to dioxins tri-chlorinated or less. SH2B strains possess clean-up capability for dioxins tetra-chlorinated or greater, and fact that there was no increase in 2,3,7,8-TCDD suggest clean-up process different from that of dechlorination reactions that recombine highly toxic dioxins. Elucidation of metabolic paths for these microbes is under way. 3 Even for highly concentrated dioxins, the results show that Dibenzo furan degradation rate is lower than that of Dibenzo-p-dioxins. In order to comprehend the difference in degradation rate stemming from chemical structures, it is necessary to elucidate degradation path of the dioxins by microbes.

Acknowledgements

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Reference

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