

Feasibility Study on Bio-degradation System for Polychlorinated Dioxins In Contaminated Soil and Sediments

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Introduction

The purpose of this study is to build the lower and more ecological degradation system for polychlorinated dioxins in contaminated soils or sediments in compared with any of a thermal or chemical method. Until now, it has been obtained, as follows. (1) The SH2B-J2 strain, a gram-positive bacterium belonging to the genus *Geobacillus*, was an aerobic thermophile whose optimal cultivation temperature was 65°C^{1,2,4}. (2) The strain was a microorganism that directly cleaves the ether bond of dioxins at first step of the reaction^{2,3,4}. (3) The strain was able to decompose polychlorinated dioxins without re-synthesized any strongest toxic compounds, like 2,3,7,8-TCDD etc^{1,4}. (4) The crude cellular membrane enzyme produced by the strain will be a group of *glutathion-s-transferase*^{3,4,5}. From these results, each machine have been designed and manufactured, as follows; (1) the mill machine of 0.04m³ capacities and vibrating strainer to divide the silt/clay fraction from contaminated soils or sediments and to concentrate chlorinated dioxins into the silt/clay fraction^{1,4} and (2) the airlift type reactor of 0.01m³ capacities to evaluate the ability of the reaction with the enzyme and contaminated soils or sediments, as slurry⁴. In this paper, we will discuss the unit price (yen/ton) and the profitable region of the bio-degradation business for polychlorinated dioxins in contaminated silt/clay fraction by feasibility study on the basis of these results.

Method and Results

(1) The pathogenic and infective abilities for the SH2B-J2 strain were verified by observing changes of each mouse-weight to make sure the pathogenic safety at the operating environment during degradation of contaminated soils or sediments⁹. The pathogenic abilities of the SH2B-J2 strain are not recognized, because the strain was a thermophile whose optimal cultivation temperature was 65°C. The infective abilities were tested as follows; eleven mice were divided two groups. During 11days, 6 mice were injected once for all 100µL each, with 100mg/mL of the SH2B-J2 strain, and 5 mice were periodically injected once again 100µL each. Both of groups were not obtained any significant difference on the change of each mouse-weight⁹, as shown in Fig.1. Therefore, the infective abilities of the SH2B-J2 strain are not recognized.

(2) The culture medium which satisfies the lower cost and minimum nutrient compounds was picked and evaluated from the period injecting the culture medium and the SH2B-J2 strain by using the reactor of 0.002m³ capacities to operate under the best condition^{1,5,8}. First, compounds within Corn Steep Liquor (CSL) were analyzed by using the capillary electrophoresis and the IP-AES method. CSL as the lower cost culture medium includes many of organic acids and sugars. Especially, the major compounds are lactic acid, malic acid, citric acid and glucose^{1,5}. Moreover, the major metallic salts are K, P, Mg, Ca. CSL including these organic acids and metallic salts satisfies the minimum nutrient for SH2B-J2 strain. The ability of the semi-continuous cultivation by using a batch process was verified by the co-cultivation adding 10⁷counts/mL of the SH2B-J2 strain at intervals of 12 hours within CSL of 0.02% and Yeast Extract of 0.06%^{1,8}. This semi-continuous cultivation

method is able to keep the SH2B-J2 strain vivid during cultivation of above 120 hours.

(3) The reaction-rate and order were evaluated from the correlation between the reducing dioxins concentration (pg-TEQ) and the reaction-time by the co-cultivating with SH2B-J2 strain and the mixture of polychlorinated dioxins at the temperature of 65°C^{4,7)}. It is recognized that the reaction-rate is proportional to the concentration of dioxins at that time on the reaction, as shown in Fig.2. Therefore, this reaction is a first order so that the condensation of dioxins is necessary to enhance the reaction-rate by a pre-treatment operation before the bio-degradation^{5,9)}.

(4) The roll of the mill machine and vibrating strainer for the pre-treatment was evaluated from the dioxins within each fraction of the silt/clay and sand/grave to reduce the real bio-degradation volume of contaminated soils or sediments^{5,9)}. Artificial contaminated soils, produced from fly ash from an incinerator and usual soil, was divided the silt/clay and sand/grave by the mill machine and vibrating strainer. Polychlorinated dioxins of 98.3% shift into silt/clay from the contaminated soils⁹⁾, as shown in Fig.3. Therefore, it is verified that the pre-treatment by the mill machine and vibrating strainer is useful to condense polychlorinated dioxins and to reduce the real bio-degradation volume of contaminated soils or sediments.

(5) The unit price and the profitable region of the bio-degradation business for polychlorinated dioxins in contaminated silt/clay fraction were estimated by this feasibility study, on the basis of above results⁹⁾. The sum of costs for the bio-degradation of contaminated soils or sediments (payroll t, rental of equipments, material, operation of equipments and overhead) were estimated, when polychlorinated dioxins were decomposed to 1,000pg-TEQ/g from 2,000pg-TEQ/g by the co-cultivation with SH2B-J2 strain and contaminated soils within the reactor. The batch type reactors of 5,000kg capacities for the contaminated silt/clay were installed at the site. The period of the bio-degradation was calculated by the reaction-rate, shown in Fig.2. As results, the required reactors are proportional to the total degradation weight (ton) of the contaminated silt/clay, as slurry and the bio-degradation costs are inversely proportional to the total bio-degradation weight⁹⁾, as shown in Fig 4. When the profitable cost is 100,000yen/ton below and the maximum of the required reactors are 20 sets to hold down the investment for installations (ca. 2.6 hundred million yen) constant and the bio-degradation period time is 49 days, it is analyzed that the profitable region is 100ton above and 4,000ton below⁹⁾, as shown in Fig.5.

Discussion

The infective abilities of the SH2B-J2 are not recognized. This semi-continuous cultivation method is able to keep the SH2B-J2 strain vivid during cultivation of above 120 hours. The reaction is a first order so that the condensation of dioxins is necessary to enhance the reaction-rate operation as the pre-treatment of the bio-degradation. The dioxins including in artificial contaminated soils shift into silt/clay at 98.3%. It is verified that the pre-treatment by the mill machine and vibrating strainer is useful to condense dioxins and to reduce the real bio-degradation volume of contaminated soils or sediments. This bio-degradation business is able to pay within a profitable region. After verifying the abilities of bio-degradation for contaminated soils by using the co-cultivation with the crude from SH2B-J2 strain, we will build the bio-degradation system by collaborating operation of the mille machine, the vibrating strainer and many of reactors, based on these data.

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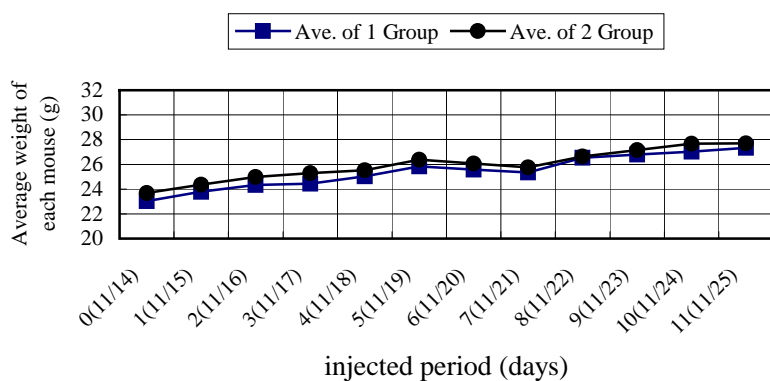


Fig.1 Average body-weight changes on 1 group and 2 group of tested mice

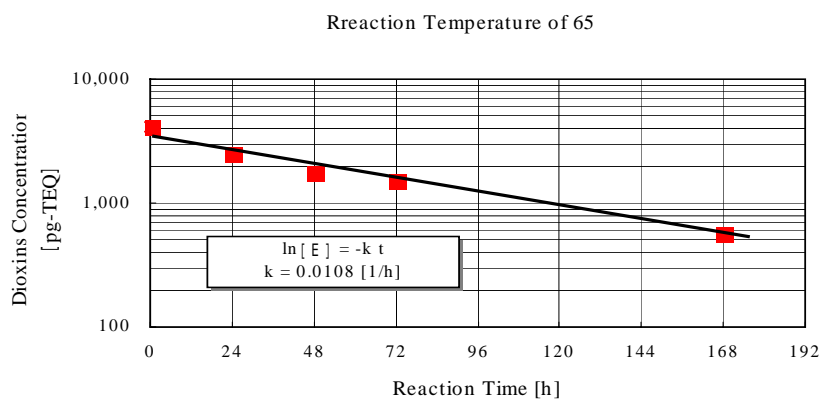


Fig.2 Correlation between polychlorinated dioxins concentration and reaction-time

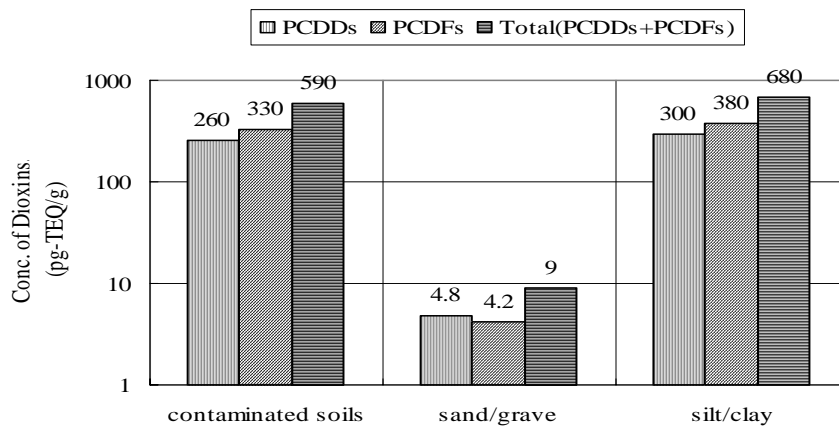


Fig.3 Effect of Condensation for dioxins in artificial contaminated soils by pre-treatment

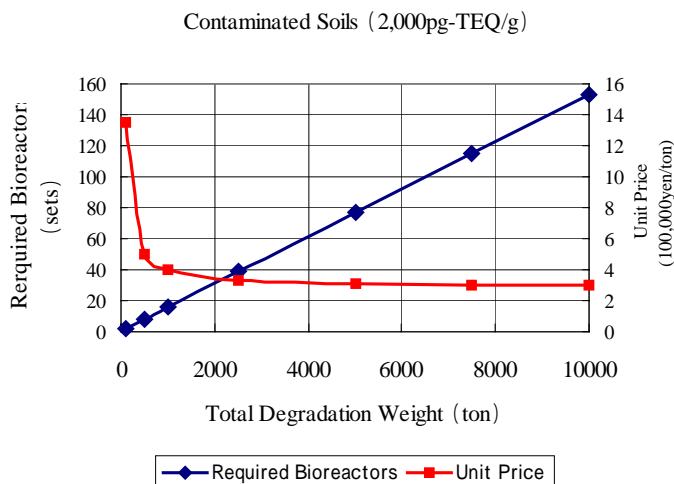


Fig.4 Correlation among required bio-reactors, unit price and total degradation weight

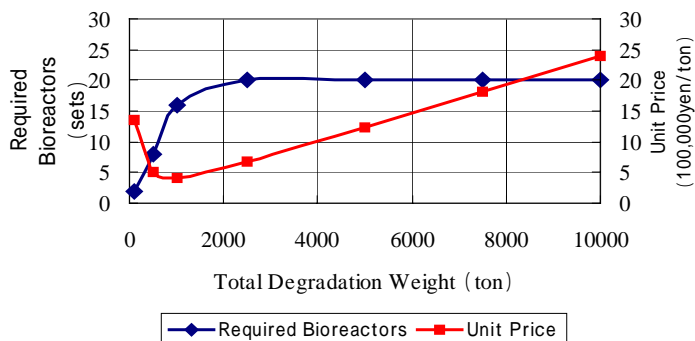


Fig.5 profitable region of bio-degradation business by 20 sets of reactors during the period of 49 days