QUANTIFICATION OF DISSOLUTION COEFFICIENT AND EQUILIBRIUM CONCENTRATION OF ORGANIC CARBON WITH DIFFERENT SOLID WASTE COMPOSITIONS

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1. Introduction

In order to seek the earlier stabilization of solid waste landfill and the reduction of environmental load derived from solid waste landfill, the structure of solid waste landfill and air supply condition which suitable to regional solid waste composition and climate should be applied. Authors have been studying the optimum landfill structure and air injection condition for landfills in developing countries by way of numerical simulation using a landfill model[1),2)]. However, further study is required for accurate determination of coefficients and constants in the model.

Fig.1 shows the transformation of organic carbon (OC) in the landfill model. Solid waste is divided into the solid phase, the liquid phase and the gas phase. OC in the solid phase is dissolved into the liquid phase, and dissolved OC is consumed by bacteria and transformed into gases such as carbon dioxide and methane.

In order to calculate the concentration of OC in the solid phase and the liquid phase, the mass balance equation of OC in the solid phase, Eq. (1), (Shimaoka et al., 1996) was applied in former studies.

$$\varepsilon_S \frac{\partial C_{C,S}}{\partial_t} = -\beta C_{C,S}(C_{C,Eq,L} - C_{C,L}) \qquad (1)$$

Where, ε_S (-) is the volumetric ratio of the solid phase, $C_{C,S}$ (kg/m^3) and $C_{C,L}$ (kg/m^3) are the concentrations of OC in the solid phase and liquid phase, respectively, and $C_{C,Eq,L}$ (kg/m^3) is the equilibrium concentration of OC in the liquid phase, β (m^3/kg/day) is the OC dissolution coefficient and t (day) is time. The right term is the dissolution term describing the amount of OC in the solid phase transferring to the liquid phase. One problem of the dissolution term is uncertainty of the dissolution coefficient and equilibrium concentration because there is no research to quantify them accurately.

This study aimed to quantify the dissolution coefficient and the equilibrium concentration of OC with different solid waste compositions by conducting a lab-scale OC dissolution experiment and the curve fitting between experiment and numerical simulation results.

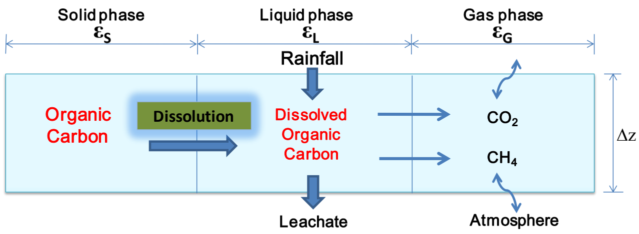

Fig. 1 Transformation of organic carbon in landfill model

2. Material and methodology

2.1. Material

The characteristics of the solid waste sample are shown in Table 1. Three experiments, which are different in solid waste composition, were conducted with various types of easily biodegradable (EB) and hard-to-biodegradable (HB). Solid waste sample was shredded to set maximum particle size to 10mm. EB contents of Experiment 1, 2 and 3 are 50, 60 and 80%, respectively.

2.2. Experiment

10 gram solid waste sample was put in flask and added 200 ml water with the ratio 1:20. The mix was shaking with 400 rpm in 6 hours. Temperature and pH were controlled at 30^{0}C and 7.4, respectively. 10 ml liquid samples were collected every 15 minute in the first hour. From the second hour, 10ml liquid samples were collected every hour. After that, liquid samples were diluted 10 times and measured by total organic carbon (TOC) analysis method. Experiment 2, 3 were repeated with the same steps.

2.3. Curve fitting

The OC dissolution in each experiment was numerically simulated using Eq. (1). With changing β and $C_{C,Eq,L}$, the change in $C_{C,L}$of simulation which best fitted to the change in experimental TOC was found by the least squares method.

Table 1 Characteristics of solid waste sample

Experiment No.	Composition ratio (% weight)							Initial index		
	Easily biodegradable			Slowly and Hard-to-biodegradable				Density (kg/m^3)	Moisture (%)	$C_{C,S}$ (kg/m^3)
	Rice	Vegetable	Potato	Ceramic	Garden	Paper	Plastic			
1	30	15	5	15	5	20	10	839	47.7	1411
2	40	15	5	15	5	15	5	1137	51.9	3047
3	50	25	5	5	5	7	3	1269	60.7	3355

3. Results and discussion

Fig. 2 shows the changes in TOC of the experiments and the numerical simulation results fitted to the experimental results. While the highest TOC in Exp. 1 (EB 50%) was about 800 mg/L, TOC of Exp. 2 (EB 60%) and Exp. 3 (EB 80%) were quite high, around 1300 mg/L. Concentration of TOC was increasing with EB content increase. It means as much higher percentage of EB waste accounts for, as much higher concentration of OC increases and faster the speed of dissolution reaction occurs.

Quantified dissolution coefficient β and equilibrium concentration $C_{C,Eq,L}$ are shown in Table 2 and Fig. 3. The value of β has been decreasing inversely with the increase of EB content. In Exp. 1 (EB 50%), value of β was highest, around 9.74 m^3/kg/day, while β was lowest in Exp. 3 (EB 80%), around 4.81 m^3/kg/day. In return, the equilibrium concentration $C_{C,Eq,L}$ was increasing as EB content was increasing. The equilibrium concentration was 0.793 kg/m^3 in Exp. 1 (EB 50%), 1.269 kg/m^3 in Exp. 2 (EB 60%) and 1.333 kg/m^3 in Exp. 3 (EB 80%).

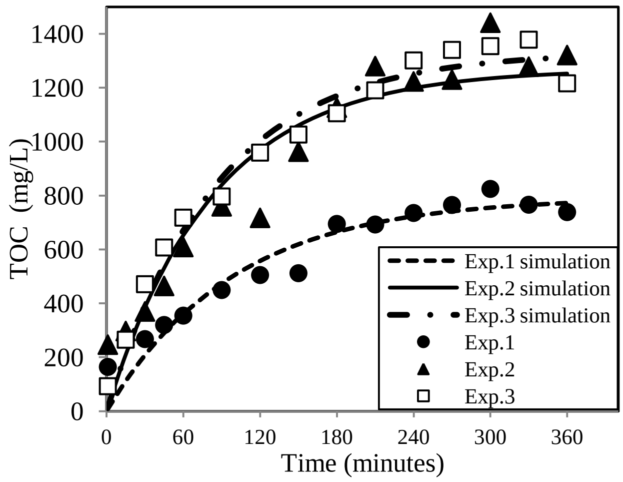

Fig. 2 The comparison of TOC between experiment and simulation

Table 2 Dissolution coefficient and equilibrium concentration

Item	Unit	Exp. 1	Exp. 2	Exp. 3
β	m^3/kg/day	9.74	5.44	4.81
$C_{C,Eq,L}$	kg/m^3	0.793	1.269	1.333

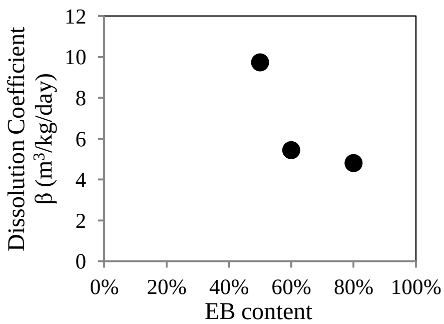

Fig. 3 Trend of coefficient β with EB content

4. Conclusions

Quantified dissolution coefficient β was in the range, 4.8 to 9.7 m^3/kg/day and quantified equilibrium concentration $C_{C,Eq,L}$ was in the range, 0.793 to 1.333 kg/m^3. To estimate the dissolution coefficient and the equilibrium concentration in real landfill condition, further experiments will be conducted with larger solid-liquid ratio and slower revolution rate in the elusion experiment.

References

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