CONTRIBUTION OF BIOLOGICAL HYDROLYSIS AND PHYSICOCHEMICAL DISSOLUTION IN MUNICIPAL SOLID WASTE DECOMPOSITION

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1. Introduction

With the precipitation (rainfall) and bacteria activities, organic waste inner landfill body by time will be dissolved as leachate. So far, there has been little discussion about how the solid phase of organic carbon in municipal waste is being released into the liquid phase. Recent studies by several researchers have introduced two possible processes: biological hydrolysis and physicochemical dissolution. The first process is involved with the microbiological degradation which means solid waste is degraded by microorganism. The second process is non-involving microbiological factor which means solid waste is physically washed-out by rainfall. Thus, this research aims to determine the influence of precipitation factor (physic-chemical dissolution) and bacteria activities factor (biological hydrolysis dissolution) on organic waste degradation in landfill body by separating the degradation process into two types: 1st. physicochemical degradation, using antimicrobial substances in degradation process to eliminate the degradable dynamics of microorganism, only physicochemical process occurs; 2nd. biological dissolution, verified by the variation between the normal dissolution and physicochemical degradation. The results of the research can be applied to control or interfere the waste degradation process or improve leachate quality if we know which factor plays the main role in the process.

2. Material and methodology

2.1 Material

- Municipal solid waste (MSW) used in the study was comprised 80% of easily biodegradable waste (food waste), 12% of slowly biodegradable waste (paper, cardboard) and 8% of hardly biodegradable waste (plastic). MSW was shredded less than 1 cm^2 size and filled into four cylindrical columns with the same amount. Initial waste contains 58% of moisture, 1.027 (kg/m^3) of density and 76 (%) of loss of ignition.
- Chemical agent used must be inorganic substances. Among biocides, antiseptic agent, Copper Sulfate ($CuSO_4$) was chosen because of its antimicrobial, antibacterial in aquatic environment and its non-organic degradable ability.

2.2 The effect of antimicrobial agent

Agar medium test method was used to confirm the effect of antimicrobial agent $CuSO_4$. Several tests achieved positive results at the concentration of 10 mg/L or higher. **Fig. 1** shows the agar medium test results. The case using $CuSO_4$ had very less bacteria colony compared with the case using de-ionized water.

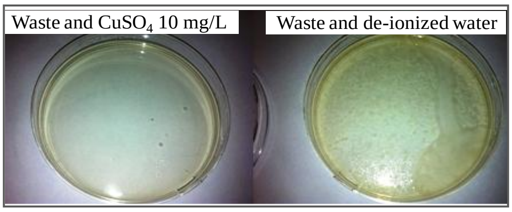

Fig. 1 The antimicrobial effect of $CuSO_4$ on waste

2.3 Experimental methodology

Four laboratory scale column experiments named A, B, C and D were conducted at 25^0C (**Fig. 2**). Column A and C were under saturated condition, while B and D were under unsaturated one. Saturated condition means liquid solution was kept fully in columns. Unsaturated condition means liquid was passed thoroughly from the top to the bottom of columns by time. With the same rate flow, $CuSO_4$ solution was pumped into column A and B, de-ionized water was supplied into column C and D. The main differences of columns and conditions are given in **Table 1**. Leachate samples were collected every 6 hours and analyzed by Total Organic Carbon (TOC) analysis method. The variation of TOC between A and C, B and D is supposed to be the amounts of TOC decompose by biological dissolution (by bacteria).

Table 1. Experimental groups design

Column	A	B	C	D
Experimental conditions	Saturated	Unsaturated	Saturated	Unsaturated
Flows (25 ml/hr)	$CuSO_4$ 10 mg/L	$CuSO_4$ 10 mg/L	De-ionized water	De-ionized water
Dissolution group	Physicochemical dissolution		Biological hydrolysis dissolution	

3. Results and discussion

Firstly, by looking at the color of leachate samples presented in **Fig. 3**, it could be said that organic carbon content in saturated condition A, C at initial time were almost higher than unsaturated condition B, D, respectively. The green color in column A was from the mixture of organic leachate (in yellow) and $CuSO_4$ solution (in blue) while column B was only in blue. It showed the organic carbon content in case A was higher than in case B. Similarly, organic carbon content in column C (in yellow) was higher than in column D (in light yellow). Besides, the TOC results in **Fig. 4** and **Fig. 5** also gave the same remark. The TOC of case A was around 4000-1000 mg/L, higher than 500-1200 mg/L of case B, case C was around 7000-2000 mg/L, higher than 1500-5000 mg/L of case D. It could be explained that because in saturated condition, organic waste particles had been completely contacted with liquid solution while in unsaturated condition, parts of solid waste particle could contact with. And the physical force of effluent in saturated condition which was collected every 6 hours was stronger than in unsaturated one. These reasons led to the physical dissolution in saturated condition occurred rapid and earlier.

Secondly, because there were various common points and in order to easily compare the contribution of biological and physical dissolution processes, the TOC results of saturated condition A and C were compared together (Fig. 4); unsaturated condition B and D were group together (Fig. 5). In case A and C, the TOC both reduced, while, TOC values in case B, D both increased. The reasons in the first discussion could be used to explain this point as well.

Moreover, if comparing the case using $CuSO_4$ A to the case using deionized water C, B compared with D, the concentration of organic carbon in case A was totally lower than in case C. Similarly, TOC value in case B was totally lower than case D. That is because case A, B only included the physicochemical dissolution. While, case C, D accounted for both physicochemical dissolution and biological hydrolysis dissolution.

Thirdly, in order to quantify the contribution of each process, considering both physicochemical and biological dissolution process as 100%, the percentage of the contribution of physicochemical dissolution changing by time was shown in **Fig. 6**. The leftover percentage was the contribution of biological hydrolysis dissolution. In saturated condition, physical dissolution became a majority in dissolution process with the average over 50%. However, in unsaturated condition, enzymactic hydrolysis was a major contribution of dissolution processes. It could be expained that due to the physical force of solution in saturated condition was much than in unsaturated condition leads to these results.

4. Conclusions

In conclusion, using antimicrobial agent $CuSO_4$ could clarify the motivation of biological hydrolysis and physicochemical dissolution processes. Dissolved organic carbon of physicochemical dissolution was always smaller than of total two processes. In detailed, the average contribution of physicochemical dissolution in saturated condition was 68%, higher than it was in unsaturated condition only 31%. Besides, the experimental results verified that decomposition in saturated condition was higher than in unsaturated one. It means the physical dissolution in saturated condition has stronger motivation than in unsaturated condition.

References

1) Shimaoka et al. "Numerical Simulation of Self-Purification Capacity in a Recirculatory Semi-Aerobic Landfill Layer with Solid Waste" J. of the Japan Society of Waste Management Experts, Vol. 7, No. 5, 234-243, 1996.

2) Nguyen et al. "Quantification of Dissolution Coefficient and Equilibrium Concentration of Organic Carbon with Different Solid Waste Compositions" Proc. of the Japan Society of Civil Engineers Conference, FY 2011.

Fig. 2 Experimental columns design

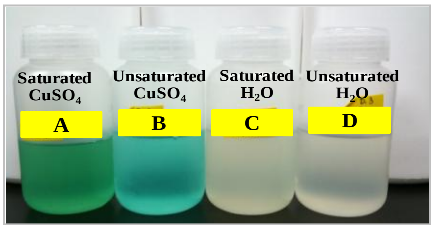

Fig. 3 Leachate samples

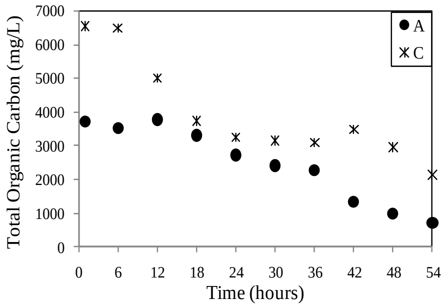

Fig. 4 TOC values of saturated condition

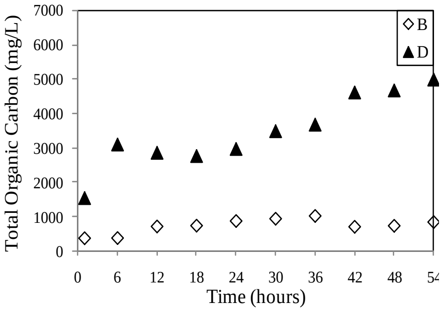

Fig. 5 TOC values of unsaturated condition

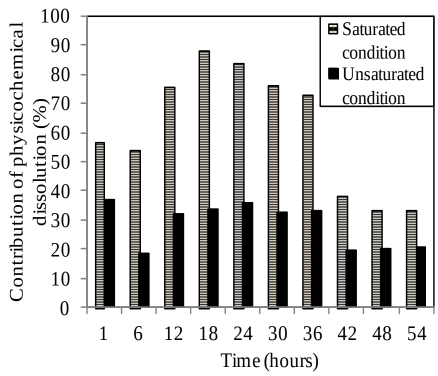

Fig. 6 Contribution of physicochemical dissolution