INFLUENCE OF EXTREME HEAVY RAIN ON LEACHING CHARACTERISTICS OF LEACHATE FROM MUNICIPAL SOLID WASTE LANDFILLS

ホ, ニャット, リン

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氏　　名：　Ho Nhut Linh（ホ　ニャット　リン）

論 文 名：　Influence of extreme heavy rain on leaching characteristics of leachate from municipal solid waste landfills
（都市ごみ埋立地の浸出水流出特性に及ぼす極端豪雨の影響）

区　　分：　甲

論　文　内　容　の　要　旨

Landfill is the most widespread waste management process applied especially in developing countries. In developed countries, even thermal treatment is used to partly replace the landfill method, the incineration residues still need to be landfilled. Leachate from landfills with its high toxicity of organic and inorganic pollutants is a major threat to the environment. Landfill progress requires a long-term stabilization due to the complicated components of leachate. Understanding the leaching behavior of pollutants from landfill wastes is essential in order to provide more suitable solutions for landfill management. Among various internal and external factors, rainfall can be considered as one of the most crucial factors that strongly impacts on leachate quantity and quality. Nowadays, extreme weather events happen more frequently in many regions lead to the increase of rainwater amount infiltrated into landfill body. The impact of heavy rain on the leaching behavior of components in municipal solid waste incineration (MSWI) residues is attractive that needs to be clarified. However, it has not yet reported by previous studies.

Chapter 1 introduces the overview of MSW management including MSW definition, generation, composition, collection, treatment and disposal was reported firstly. Then, the landfilling of MSWI residues and related problems were emphasized; the current generation status and characteristics of MSWI residues, and the major contaminants in leachate. This chapter also introduces the factors that impacted leachate quantity and quality. Finally, the objectives and structures of the study were presented.

Chapter 2 investigates the actual conditions of landfills under the impacts of heavy rain through a national comprehensive survey at 13 landfills in Vietnam. The objectives of this chapter are to; 1) describe the landfill management situations in Vietnam, 2) report the actual incidents of landfill caused by heavy rain and understood their adaptive solutions to handle, and 3) apply the statistical analysis of collected leachate data to basically evaluate the correlation between heavy rain and leachate quality. The results revealed that Vietnam landfills were strongly impacted by heavy rain as a consequence of various incidents such as the overload of leachate, the change of leachate quality, and the damage of landfill retaining wall. The new landfill with age more than 10 years showed the decrease of COD concentration in leachate around 0.43 times while the new landfill with age less than 2 years showed the increase of COD and BOD_5 concentration to around 0.46 and 0.28 times, respectively after heavy rain compare to normal rain. The concentration of TN, NH_4-N and Cl- in leachate showed the weak correlation with heavy rain. The microorganism activity is considered to play an important role in the variation of leachate quality under heavy rain impacts from the new and old landfills.

Chapter 3 simulates the impact of heavy rain on the leaching behavior of MSWI bottom ash (BA) by using the percolation column experiment. This experiment was conducted by using three Plexiglass columns packed with MSWI BA to evaluate the impact of recurring heavy rain and normal rain on leaching behavior of total organic carbon (TOC) and four major ions (Cl^-, Na^+, K^+, and Ca^{2+}) in leachate under semi-aerobic landfill condition for 200 days. Additionally, pH values and the leachate quantity were also investigated. After heavy rain, pH of leachate increased to around 11 to 12 and it decreased to around 8 after normal rain. pH variations can be explained by the carbonation of leachate. The release amount of leachate components after supplying 1 kg of rain water was obtained for both heavy rain and normal rain. Results showed that heavy rain released from 0.4 to 0.67 times of TOC and ion amounts lower than in case of normal rain. Interestingly, the data showed that the release amount of pollutants in leachate was not much different under the change of heavy rain intensity. It indicated that the release of TOC and ion amount was not considerably affected by heavy rain intensities.

Chapter 4 clarifies the impact of heavy rain on the leaching of pollutants from MSWI residues by conducting the lysimeter experiment. Five lysimeters with 3.5 m in height and ϕ0.3 m in inner diameter were used to simulate the actual condition of Japanese landfill. In order to simulate a more realistic condition of Japan landfill than the conditions in Chapter 3, the watering condition was adjusted with the changing of three heavy rain characteristics (intensity, duration, and frequency), and the adding of chelating treated fly ash into waste samples. Among TOC and ions, the leaching of four heavy metals, including lead, copper, zinc, and iron were also evaluated. After 437 continuous days of conducting the experiment, pH value in leachate after normal rain was around 6.5 to 11 lower than the value of around 8 to 12 after heavy rain. These results in line with the results reported in Chapter 3. The release amount of TOC and ions in leachate collected after heavy rain was from 0.1 to 0.27 times lower than that after normal rain and it can be explained by the dilution mechanism. Heavy rain frequency and heavy rain duration do not impact on the leaching amount of pollutants. Under different heavy rain intensities, the release amount of TOC and ions was not much different. It is concluded that heavy rain intensities do not impact on the release amount of pollutants. By other words, heavy rain could not accelerate the landfill stabilization progress. Additionally, ions were easily washed out by water compared to TOC. Data showed the unclear tendency of leaching behavior of heavy metals under different rainfall patterns.

In Chapter 5, the water transfer model and the solute transfer model in unsaturated conditions of ash layer were developed to simulate the leachate quantity and leachate quality variations under both normal and heavy rain conditions. The water transfer model which provided results could favorably fit the experimental data of leachate generation amount from lysimeter experiments. However, the results of the solute transfer model need to be improved to receive a better fitting with the leachate quality data from the experiment. This model is important to manage and create the appropriate operating strategies to enhance landfill stabilization progress.

Finally, the conclusions derived from the whole study were summarized, and then the recommendations for future plans of this study were introduced in Chapter 6.