B－23 **Emission of volatile organic compounds from landfill site and their sources**
（廃棄物処分場の温度とVOCsの排出の関係）

Department of civil engineering, Tokyo Institute of technology ○Samerjai Panyosaranya, 浦瀬太郎

1. Introduction

Landfill plays a most important role in the framework of solid waste disposal. Various kinds of gases, landfill gases (CH_4 and CO_2) as well as some trace components like volatile organic compounds (VOCs), are generated inside landfill. Although VOCs account for small amount of emission, their adverse effects on environment and human health should not be overlooked. So far there are not many studies on VOC emission from landfill sites. This study aims to investigate the effect of temperature, time and types of materials on VOC production in order to identify the major sources of VOCs from landfill sites.

2. Materials and Methods

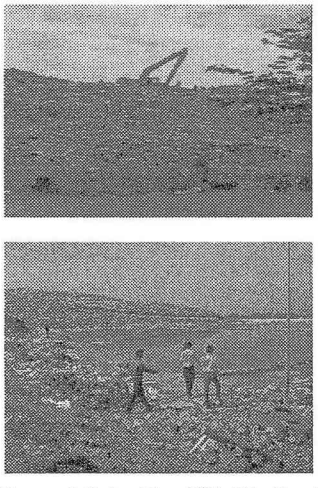

Figure 1 Sainoi landfill, Thailand.
(top) A pile of solid waste
(bottom) Leachate pond

2.1 Landfill survey in Thailand

In the present work, measurements of VOC emission were undertaken at Sainoi landfill in Nonthaburi Province, Thailand in November 2004, December 2004 and March 2005 for leachate and in January 2005 for gas. Sainoi landfill receives approximately 843 ton of waste per day (February 2003) from all over Nonthaburi Province. The major components of waste are food wastes and papers (58%), plastic (26%) and wood (13%). There is no waste separation or recycling system in this landfill site. Besides, the leachate has been sent directly to shallow pond and deep pond with no leachate treatment system.

Leachate samples were collected at a raw leachate pipe, a deep pond and a shallow pond. The 10-ml samples were added into 15-ml air tight vials and stored at 4°C before analysis by solid phase micro extraction (SPME) and Gas Chromatography Mass Spectrometry (GC-MS). An activated carbon adsorbent was used for air samplers and the samples were taken at landfill surface level and at 50, 100, and 150 cm depth below the surface. The extraction with carbon disulfide was needed for the absorbent before VOC analysis by GC-MS.

2.2 Experiment

15-ml vials were used for laboratory experiments for VOC production. In the first experiment, the vials containing leachates were kept for 4 days at 20°C and 110°C to see whether VOC is produced by heating leachate. The vials with pure water instead of leachates were prepared as blanks. In the second experiment, various kinds of materials, wood, soap bottle (HDPE) , bottle pump head (PP), beverage bottle (PET) and foam noodle cup (PS), were added into 10-ml water and 10-ml leachate and then stored under room temperature (20°C or 30°C) and 80°C for 1, 4, 7, 32, 85 day(s) before the analysis. In the last experiment, 10-ml pure water containing two kinds of PS products, foam noodle cup and food pack, were kept at room temperature (30C) and 80°C for 1 day and 5 days before the analysis. The VOC analysis was carried out by using SPME and GC-MS. After each VOC analysis, the added materials were washed with pure water and added to a new 10-ml

water vial before the next analysis A solid/liquid ratio of the added materials was 0.5-1, 1, 3, 4 and 10 percent by weight for PS, wood, PVC, PP and HDPE, and PET, respectively.

3. Results and discussions

3.1 Effect of temperature

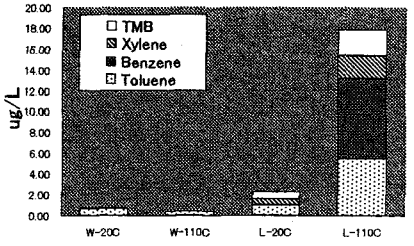

Figure 2. VOC concentration from water (W-20C, W-110C) and leachate (L-20C, L-110C) under 20°C and 110°C

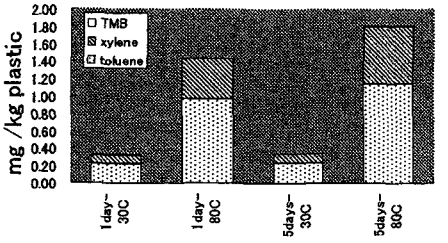

Figure 3. VOC concentration from water with added PS foam container at 1 day and 5 days

Figure 2 shows the concentration in leachate vials kept at 110°C increased significantly from 2.2 to 17.8 ㎍/L whereas heating pure water did not increase VOCs. Temperature was an important factor of VOC productions in leachate. The production of VOCs might be occurred bysome substances inside leachate under high temperature. Figure 3 presents VOC concentration in water with added PS foam container under 30°C and 80°C. The concentration in water under 30°C and 80°C was 0.32 and 0.14 mg VOC/kg material at 1 day and 0.34 and 1.81 mg VOC/kg material at 5 days respectively. The production of VOCs in water with added PS foam container kept at 80°C was greater than that at 30°C. Pyrolysis, degradation, desorption or combination of these under high temperature was suggested for possible mechanism of VOC production.

3.2 Effect of materials

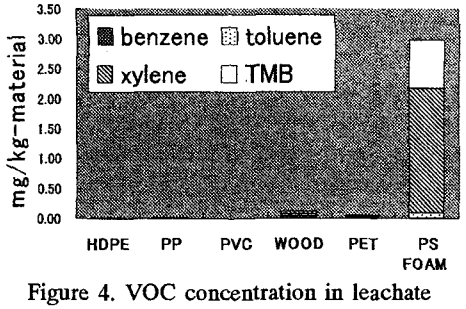

Figure 4. VOC concentration in leachate with added various kinds of materials kept at 80°C

Figure 4 demonstrates VOC concentration in leachate vials with added several kinds of materials, which was kept under 80°C and analyzed at 4 days. In this study six types of materials, HDPE, PP, PVC, wood, PET and PS, were used. The concentration in leachate with added each material was 0.017, 0.015, 0.0018, 0.11, 0.051 and 3.0 mg/kg-material respectively. This result clearly indicated that PS foam container gave outstandingly high VOC production among other kinds of materials. PS, which is widely used for packing materials, might be one of the sources of VOC production in landfill site.

3.3 Time-dependent VOC production

Figure 5 shows VOC concentration with time in water with added PET and PS under 80°C. As time elapsed, the concentration had decreased exponentially. The VOC adsorption at plastic surface might bring about this high concentration during the first period. However, high VOC concentration was obtained in water with added PS at 32 days. This extremely high concentration might be occurred by the remained VOC adsorbed in the inner part of plastic.

3.4 Comparison of VOC compositions

Figure 6 represents VOC compositions from various kinds of sources: (a) raw leachate (b) deep pond (c)

shallow pond (d) leachate kept at 110°C (e) air at 150cm depth below landfill surface (f) water with added PS foam container under 80°C at 1 day (g) water with added PS foam container under 80°C at 5 days (h) water with added PS food pack under 80°C at 1 day and (i) water with added PS food pack under 80°C at 5 days. Xylene is the sum of m,p,o-xylene and ethylbenzene and TMB is the sum of ethyltoluene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene and 1,2,3-trimethylbenzene. Four compounds, benzene, toluene, xylene and TMB, were mostly found in raw leachate, leachate from deep pond and shallow pond, leachate kept at 110°C and air inside landfill. Xylene presents as the main component in raw leachate with toluene/xylene ratio=1:1.5, whereas toluene is predominant in leachate from deep pond and air at 150 cm depth below landfill surface. The toluene/xylene ratio was 1:0.25 and 1:0.16 respectively. Toluene and xylene concentrations in the shallow pond were more or less same amount. However, benzene was the largest component in leachate kept at 110°C. In addition, two compounds, toluene and xylene, were the main compositions detected in the cases of PS foam container and PS food pack while very small amount of TMB was obtained. The sources of TMB will be a subject of future study.

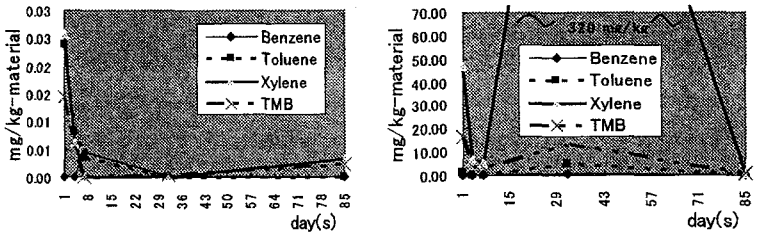

Figure 5. VOC concentration with time in water with added PET (left) and PS (right) kept at 80°C

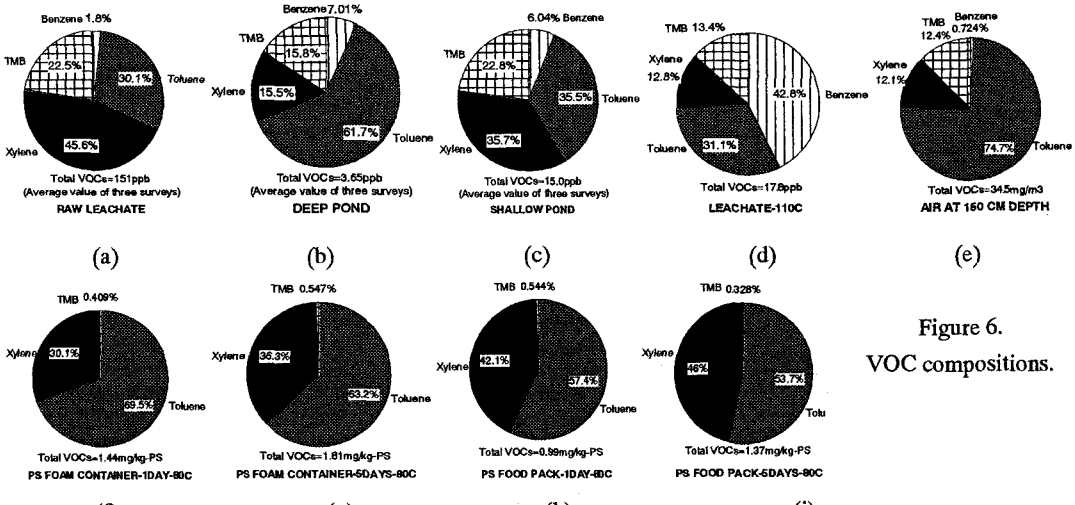

Figure 6. VOC compositions.

4. Conclusions

The production of VOCs was found in the heated leachate and heated vials containing materials under high temperature. Among several kinds of materials, PS gave the highest VOC concentration. Moreover, as time elapsed, the production rate seemed to become smaller. This indicates that a part of VOCs originated from the desorption at the material surface. Toluene and xylene were the main compounds in leachate and water containing PS. PS might be one of the sources of VOCs in landfill site. However, TMB was not originated from PS, though it is widely detected in leachates. The source of TMB has to be investigated.