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Lab-experiment of incineration ash dispersion for control in MSW landfill.

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1. Introduction

In Japan where solid waste disposal is heavily depending on incineration, dioxin has been a big environmental concern. Most dioxin produced in incineration process are deposited in incineration residues, and consequently dumped in a landfill. If the residue is dispersed into atmosphere, it will be a serious threat to the environment. In this study, the possibility of dispersion of residues was studied by using lab-scale wind chamber, with moisture content as an main variable.

2. Method

2.1 Experimental Setting

A wind chamber, made of acrylic board, was used for the experiments. Figure 1 shows the configuration and size of the chamber. In order to simulate dumping residue in a landfill, air flow was generated by a blower, and ash samples are charged from side hole at IU in Figure 1. Air flow was fixed at 3m/s in this study. Dispersed ash was collected by cylindrical filter samplers which are set at 2m downward from the injection point.

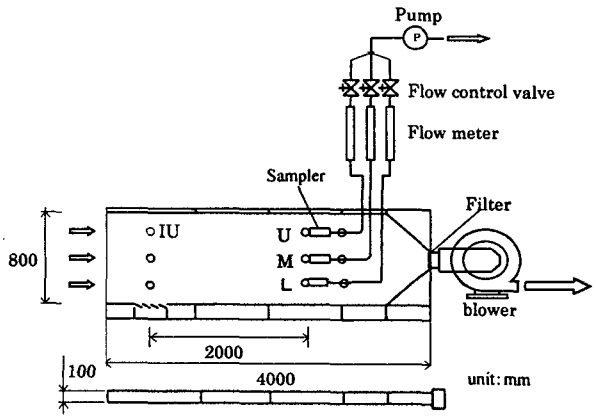

Figure 1 Schematic view of wind chamber

Three samplers, called U, M, and L, are set with an interval of 20cm each other, and aspirated at the same wind velocity as in the chamber. The amount of ash collected by samplers are very small, so in the following context, "dispersed amount" is estimated by multiplying the ratio of the cross sectional area of the chamber (0.03 m^2 for U and L, and 0.02 m^2 for M, see Figure 1) to that of sampler nozzle (1.67×10^{-4} m^2).

Particle size distribution was measured by a laser diffraction particle size analyzer (LDPA, Shimadzu SALD3000). In this method, sample is dispersed in ethanol solution, particle size (volume) is determined from the scattering spectra. For wet samples, optical microscope was used because coagulated particles with moisture will be disassembled in the solution when measured by LDPA. In the latter method, the number of particles are counted by diameter, so the volumetric distribution was calculated using a geometric average of each class in a histogram.

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Assuming constant density, volume fraction is supposed to be equivalent to weight fraction in this study.

2.2 Ash samples

Incineration ash (bottom ash) were sampled from three MSW incinerators in Sapporo, Japan. All the incinerators has a burning capacity of 600t/24h. The physical characteristics of samples are shown in Table 1. Particle density was measured by a picno-meter.

Table 1 Characteristics of ash samples

	moisture content*1 (%)	density*2 (g/cm^3)	Ignition Loss (%)	Incinerator
Ash-H	34.6 42.3	2.4 2.4	2.8	stoker type 300t/24h×2
Ash-S	22.4 28.4	2.3 2.5	1.7	stoker type 300t/24h×2
Ash-A	27.8 36.4	2.1 2.5	5.5	stoker type 300t/24h×2

*1 upper: as sampled in a incinerator
lower: water holding capacity (Maximum moisture content)
*2 upper: <125 μm
lower: 125-250 μm

Particle size distributions of dried ash are shown in Figure 2. Ash were separated with 2mm-mesh sieve, and particle size of 2mm-under sample was determined by LDPA. Among three samples, Ash-H contains smaller particles than other two ash samples, and higher moisture contents as received. Densities of particle are almost the same for all samples.

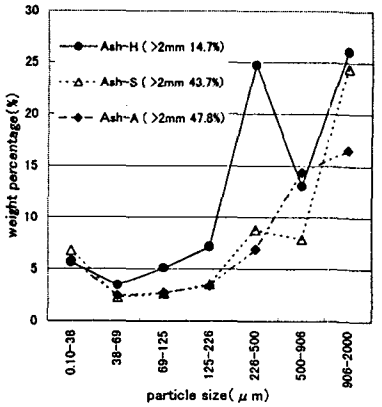

Figure 2 Particle size distribution of ash samples

3. Experiment with dry samples

3.1 Experimental condition

Ash samples were dried up in an oven at 65℃. Such dry condition will never happen in reality because incineration ash is cooled down with water in a incinerator, so ash has high moisture contents as in Table 1 when they are dumped in a landfill. In this study, dry sample is used as an reference to evaluate the influence of wetting, and to understand the dispersion behavior (because particle size is easily determined when sample is dry). Ash samples were charged into the wind chamber. Pre-sorting to remove large particles was not done to simulate actual condition of dumping at a landfill. The sample of about 850g was manually charged into the chamber continuously bit by bit for 15 to 17 minute. Particle size distribution of collected ash was determined by LDPA.

3.2 Results

Collected amount and calculated "dispersed amount" are shown in Table 2. Experiments were done twice for Ash-H. In Figure 3, dispersed amount are shown by a class of particle size, as the ratio to total charged amount. In a lower sampler, larger particle were collected because larger particle fall by gravity while flowing in the chamber. Size distribution are similar among all ash samples. Difference of

Table 2 Dispersed collected amount of ash sample by air samples (dry samples)
See Figure 1 for the sampler location

sample	Injected ash amount (g)	Dispersed amount (collected amount by sampler) at U(g)	at M(g)	at L(g)
Ash-H1	837.4	8.28 (0.0461)	21.72 (0.1814)	29.86 (0.1662)
Ash-H2	869.4	13.17 (0.0733)	26.80 (0.2238)	39.38 (0.2192)
Ash-S	852.4	26.53 (0.1016)	35.02 (0.2924)	30.56 (0.1701)
Ash-A	864.5	25.76 (0.1434)	50.79 (0.4241)	49.63 (0.2763)

dispersed amount between two duplicated tests for Ash-H are considered experimental error.

Particle size distribution in Figure 3 doesn't indicate dispersibility of each size of particle because charged ash has uneven or biased particle distribution. So, "dispersed rate" of each particle size, the ratio of dispersed and charged amount, was calculated, and shown in Figure 4. Though peak height varies among samples, peak size for each sampler is found consistent: under 70 μ m for U, 69-125 μ m for M, and 125-275 μ m for L. If Stoke's law is assumed, particle of 65 μ m and 90 μ m will just reach to sampler M and L, respectively. The discrepancy is caused by turbulent diffusion in the chamber.

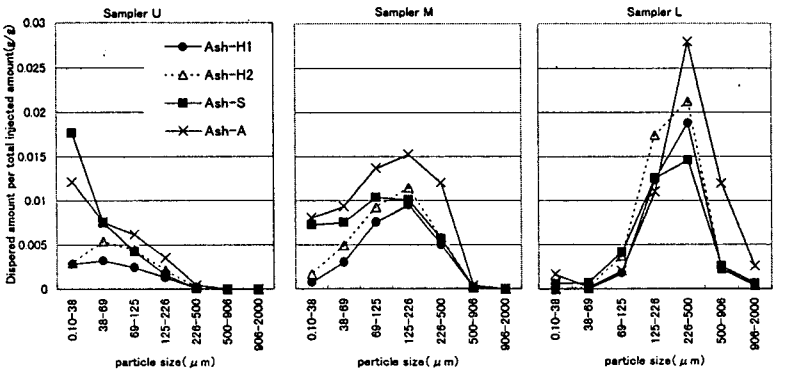

Figure 3 Dispersed amount of particle size group in the ratio to total injected amount (Dry sample)

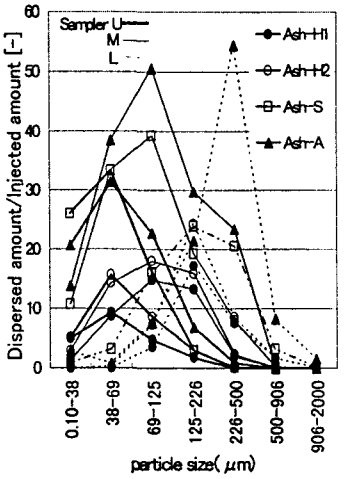

Figure 4 Dispersed rate of each particle size group

4. Experiment with wet samples

4.1 Experimental method

Ash samples with different moisture contents were prepared by drying as-received ash an oven at 65℃. Every 1 or 2 hours sample weight was measured and sample was mixed to have uniform drying condition. When pre-selected moisture content was attained, sample was taken out from the oven. Moisture content was determined using a part of the sample. Experimental condition is the same as for dried ash, and dispersed amounts are shown in Table 3.

Table 3 Dispersed amount of sample (wet samples)

sample	Moisture content (%)	Injected ash amount (g)	Dispersed amount at U (g)	at M (g)	at L (g)
Ash-S	0	852.4	18.3	35	30.6
	6.42	862.3	4.2	12.5	19.3
	9.19	844.7	1.5	2.5	9.9
Ash-A	0	864.5	25.8	50.8	49.6
	7.53	754.8	2.3	4.7	16.9
	9.43	718.8	0.5	1.3	5.4
	16.3	905.3	0.4	0.7	1.6
	23.16	851.6	0	0.3	0.6

4.2 Influence of moisture content

In Figure 5, dispersed amounts for sampler U and M were drawn against moisture content. As the moisture content increase, the dispersed amount decreases sharply. Only minor wetting of ash could efficiently reduce the dispersion. However, Ash-H shows the different behavior from other two samples: less dispersion at W=0, and it doesn't decrease until high moisture content. Ash-I (from a incinerator of 60t/16h x 2, data is not shown in the figure) has almost the same

correlation with moisture as Ash-A and Ash-S, so Ash-H has somewhat unique characteristics. The reason has not known yet.

As a result from Figure 5, moisture content should be kept higher than some critical value in order to prevent incineration ash from dispersing in a landfill. Since moisture content as received at landfill are enough high (see Table 1), dispersion is unlikely occur when they are dumped.

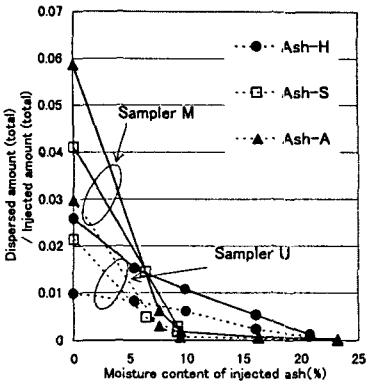

Figure 5 Dispersed amount (total) at different moisture content of ash

4.3 Particle size distribution of wet ash sample

As shown in Figure 4, only particle of smaller than around 100 μ m can disperse horizontally in the chamber while larger particles fall. Aggregation of fine particles by moisture is considered the reason of moisture effect to reduce dispersion in Figure 5. Particle size of ash samples were determined by micro-scope, then weight fraction of small particle was calculated to give Figure 6. Large particle over 125 μ m were weighed and excluded for LDPA examination. More than 3000 particles were counted to determine size distribution. Figure 6 shows the good correlation with Figure 5 as expected. "Dispersed rate" of each particle size were calculated like in Figure 4, but strong conclusion could not be obtained because of wide variation.

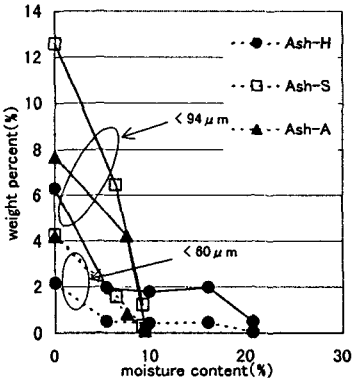

Figure 6 weight percent of small particles of injected ash

5. Conclusion

Particle size and moisture content are found to be key factors for dispersion of incineration ash. It can be concluded that common practice of moistening of bottom ash in an incinerator is safe enough to prevent dispersion. Fly ash has much higher concentration of dioxin than bottom ash, so solidification treatment should be applied before landfilling. Solidified fly ash have only negligible fraction of fine particle to be feared for dispersion(data will be shown in future).

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