DIOXINS EMISSION FROM AN OPEN-BURNING-LIKE WASTE INCINERATION: SMALL INCINERATORS FOR HOUSEHOLD USE

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Introduction

Many municipalities in Japan once encouraged their citizens, by providing financial support in some cases, to use a small-scale incinerator to burn waste at their back yard to reduce waste which was destined to the municipalities' incineration plant or landfill site. As a result small incinerators for a household use have been widely purchased across the country, especially in the suburban cities or in rural area. As dioxins became at a big social issues in Japan, however, most municipalities has, in turn, discouraged to use such incinerators since those were regarded to be a potential source of dioxins in the environment as dioxins from other nominated stationary sources such as MSW incinerators was being regulated. This study was aimed to collect fundamental information on dioxin emission from such incinerators to evaluate scientifically their contribution on the level of dioxins in the environment.

Methods and Materials

Two typical incinerators were selected for this experiment. The size and the volume of furnace of them are nearly the same, one with 120 L in furnace volume and 1 m in height excluding chimney while the other with 130 L and 1.1 m, respectively. Both are equipped with a grate and an air inlet at the bottom of furnace. Waste is charged from a top of the furnace for one incinerator (Type A) while the other from a side of the furnace (Type B) as shown in Photo 1.

Combustion air and flue gas for those incinerators are highly dependent on natural draft, and thus are varied with air inlet area, a kind and amount of waste burnt, chimney height, weather and so on. In order to obtain a practical data on dioxin emission under various burning conditions that those incinerators might encounter while burning household waste, combustion air was controlled intentionally in this study. A mechanical draft attached to the outlet of chimney regulated combustion air at three levels, i.e. starved air condition, natural draft condition (without a mechanical draft), and excess air condition.

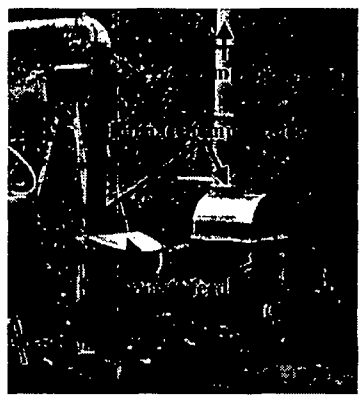

Photo 1. Incinerators used in this study.

Wastes were selected from components of general household waste that were apt to be burnt in those incinerators, i. e. newspaper, corrugated paper, copy paper, plastics (PVC, PE, PS), wood chip, and garden waste. Plastic wastes were mixed with corrugated paper at designated ratio, and garbage was excluded in this study because waste components with a high moisture content is seldom burnt in those incinerator. Corrugated papers soaked in NaCl solution of two different concentrations were also selected for a study to evaluate dioxins emission by burning inorganic chlorine containing waste.

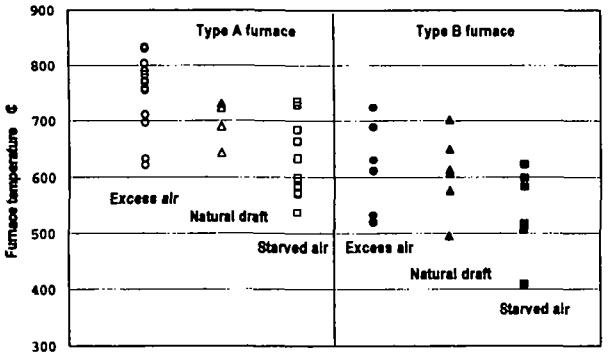

Figure 1. Furnace exit temperature

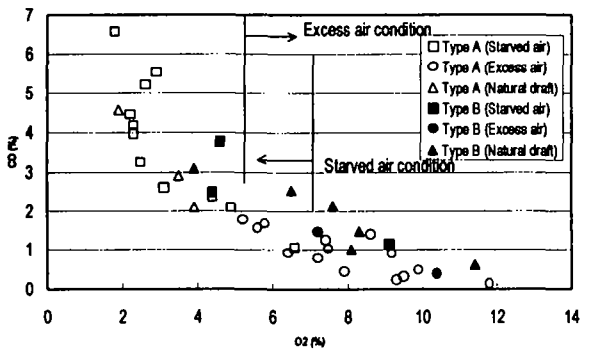

Figure 2. Relationship between CO and O2

After filling waste loosely in the furnace (1/5 - 1/10 of total volume of each waste) at the beginning of each run, fire was set, and after confirming self-burning, waste feed door was closed and gas sampling and monitoring were started. When a flare was lean next batch of waste was fed step by step until total waste (10 kg of waste) was burnt completely. At the end of each run bottom ash was removed to weigh, and inside of furnace was cleaned.

Flue gas was sampled at the sampling port located on the chimney, 1 m above of furnace exit for a measurement of temperature, O_2, CO, CO_2, HCl, and PCDDs/DFs. Furnace exit temperature was also monitored.

Results and Discussion

Combustion time for each run was mostly 20-40 min., and increased as air supply became less as far as amount of waste was nearly the same. Furnace exit temperature, mostly 500-800 C, increased above 800 C in cases of corrugated paper and its mixture with plastic wastes under some air supply condition. Furnace exit temperature of Type A had tendency of relatively higher value thanthat of Type B as shown in Figure 1 in the same air supply condition. Furthermore as air was supplied excessively furnace temperature increased. Furnace temperature together with O_2, CO_2, and CO varied distinctively in such manner as furnace temperature and CO_2 increases while O_2 and CO decreases after feeding waste. Temperature variation in Type A was relatively less compared to Type B furnace.

Figure 2 shows a relationship between O_2 and CO in flue gas. Bounded by 5-7% of O_2 lines data measured under starved air condition distribute in the range of lower O_2 and of higher CO, while under excess air condition in the range of higher O_2 and of lower CO. In natural draft condition O_2 was recorded between 2 and 11 %. In most cases combustion of this study was seemed to be under higher load condition as far as CO and O_2 concern.

Level of dioxins in flue gas ranged widely, from 0.3 ng-TEQ/Nm^3 to 4500 ng-TEQ/Nm^3, reflecting a kind of waste and a combustion condition (see Figure 3). Especially corrugated paper mixed with polyvinyl chloride (PVC) recorded higher value, more than 100 ng-TEQ/Nm^3 while corrugated paper mixed with polyethylene (PE) and polystyrene (PS) accounted dioxins level below 50 ng-TEQ/Nm^3, as similar as in the cases of wood chip, newspaper, and garden waste.

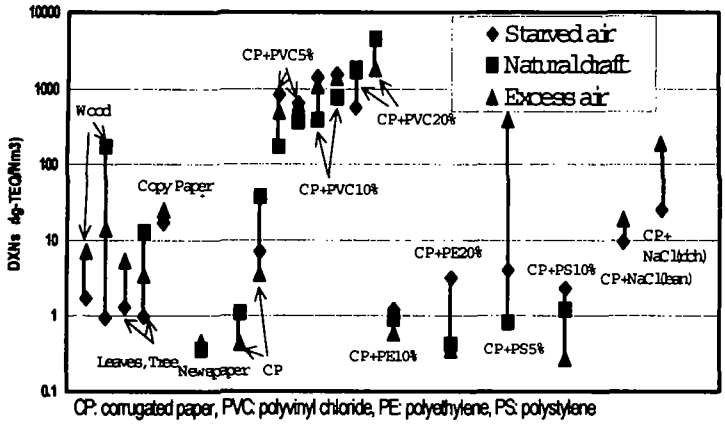

Figure 3. Dioxins in flue gas of two incinerators for a household use under different air supply

Although furnace temperature hiked as air supply was increased no significant differences was observed in dioxins level as air supply. Dried corrugated paper that had been soaked in NaCl solution showed relatively higher dioxins level in flue gas, increasing as NaCl concentration was high. Figure 4 illustrates dioxins level in flue gas in combustion of corrugated papers mixed with PVC orNaCl. As shown dioxins level increases as chlorine concentration in waste increases irrespective with the type of chlorine, i.e. organic or inorganic chlorine. This may imply that garbage burned in those furnace results in an increase of dioxins level in flue gas up to ~10^2 ng-TEQ/Nm^3 even if no PVC is contained in the waste. As far as chlorine in waste was below 1 % (wet basis), dioxins level was nearly identical for both type of chlorine.

Table 1 summarizes dioxins production per unit weight of waste calculated by dioxins level in flue gas and total flue gas generated during each run. This indicates that considerable amount of dioxins are likely to generate in burning household wastes using a small incinerators exclusively designed for a household use. Values are generally varied in one or two order of magnitude depending on combustion conditions, i.e. types of furnace and combustion air in this study. Especially, mixed with PVC corrugated paper generates dioxins in the same order of or more than that of open burning of agricultural PVC that was estimated by us[1].

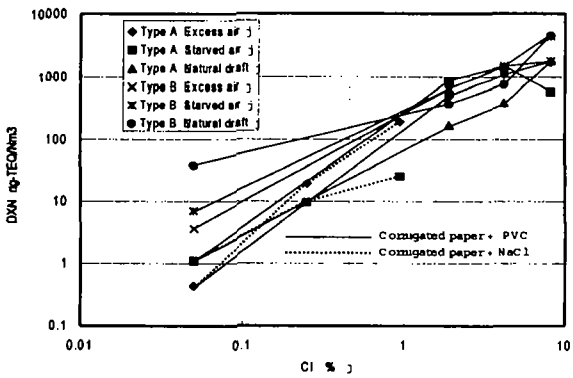

Figure 4. Dioxins in flue gas vs. chlorine in wastes

Conclusion

Using two typical small scale incinerators for a household use dioxins emission was evaluated for a various components of household waste under three different condition of air supply, i.e. excess air condition, natural draft condition, and starved air condition. Followings are drawn from this study.

(1) Combustion of this study was generally under lower O_2 and higher CO levels, and dioxins in flue gas showed wide variety of values, ranging from 0.3 to 4500 ng-TEQ/Nm^3. Corrugated paper containing PVC generates dioxins

Table 1. Dioxins production from household waste incinerators by wastes

Waste	DXN (ng-TEQ/kg wet)	No.of sample
Wood chip	14 200	5
Garden waste	5 140	5
Copy paper	200 210	2
Newspaper	400 420	2
Corrugated paper	6 420	6
Corrugated paper+PVC (5%)	1,670 11,500	6
Corrugated paper+PVC (10%)	4,000 17,000	6
Corrugated paper+PVC (20%)	6,100 28,000	6
Corrugated paper+PE (10%)	10	2
Corrugated paper+PE (20%)	3 40	2
Corrugated paper+PS (5%)	40	1
Corrugated paper+PS (10%)	3 30	2
Corrugated paper+NaCl lean	70 260	2
Corrugated paper+NaCl rich	190 2,040	2

in higher levels.

(2) Furnace temperature ranged between 500-800 C, and CO ranged widely from 200 ppm to 3 %, dioxins concentration in flue gas varied by a kinds of waste rather than by combustion conditions.

(3) Dioxins level in flue gas increased as the content of chlorine in corrugated paper as far as chlorine content was below 10 % (wet basis). Inorganic chlorine generated dioxins in the same order of magnitude as organic chlorine at least in the range of chlorine content of below 1 %.

(4) Dioxins production per unit weight of waste, although ranged in one or two order of magnitude depending on furnace types and combustion air, are significant when compared with values of open burning simulation obtained by us[1], especially in the case of mixture of corrugated paper and PVC.

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References

1. Ikeguchi T. and Tanaka M. (1999) Experimental study on dioxins emission from open burning simulation of selected wastes, Proceedings of the 19th International Symposium on Halogenated Environmental Organic Pollutants and POPs, Vol.47, September 12-17, 1999, Venice, Italy, pp.507-510.