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Mercury emissions and energy consumption in used fluorescent tube treatment

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This study was to investigate the exposure to mercury vapor and mercury particles from an incinerator via ambient air using a simulation method. RAPTAD (Random-Puff Transport and Diffusion), the combination of the Lagrange-type model and the puff model, was used in the calculation of atmospheric diffusion. HOTMAC (Higher Order Turbulence Model for Atmospheric Circulation) was used as the weather model of the meso scale in the calculation. The 23 wards of Tokyo were set as a boundary of the calculation. Airborne concentration of mercury was the highest in the certain area, estimated as a factor of 10^{-5} lower than normal background level in the area where incineration sites were concentrated. In the case, mercury daily intake increased a factor of 10^{-5} to 10^{-6} compare to average daily intake. As a result, it was estimated that blood mercury concentrations could reach as high as a factor of 10^{-5} for the reported lowest observed adverse effect level (LOAEL) under the given conditions. These concentrations could primarily be attributed to the inhalation of airborne mercury. In addition, mercury emissions to the soil and water as well as the required energy consumption were discussed for used fluorescent tube treatment.

Key words: Mercury, Emission, Energy consumption, Fluorescent tube

1. INTRODUCTION

Given growing concerns over Risk Assessment in recent years, precautionary principles and risk reductions against environmental problems have been identified as a high-priority issue throughout the world, especially in the OECD. The European Commission has adopted a proposal for a Directive on Waste Electrical and Electronic Equipment (WEEE) and a proposal for a Directive on the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment. Along with these Directives, the use of certain hazardous substances including mercury during manufacture will be banned from 1st July, 2006.

One of the problems associated with the OECD ban of mercury is that it focuses only on occupational exposure and accidents. Due to the energy efficiency, mercury, however, is still used in fluorescent tubes for lighting. In addition, fluorescent bulbs (or known as compact self-ballasted fluorescent lamp) with high energy performance has been produced to substitute incandescent bulbs. Mercury substitution of lighting, however, may result in lower energy efficiency for usage. Thus resource collection of mercury fluorescent lamp is one of the possible solution, exist handling method demands larger amount of energy than landfilling directly.

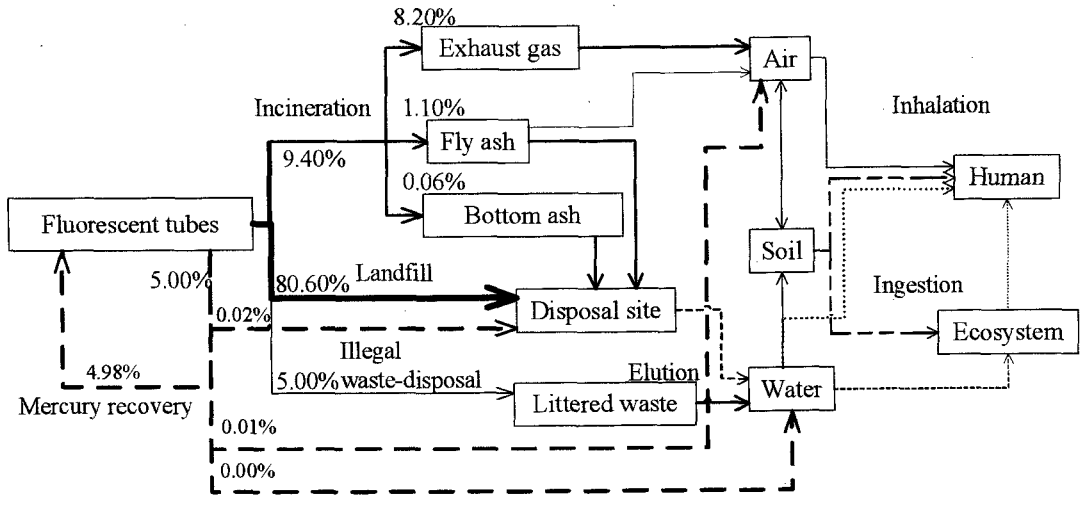


Fig.1: Material flow of mercury contained in fluorescent tube

Considering the above problems, the environmental emissions of mercury contained in used fluorescent tubes were calculated. In addition, energy consumption and waste amount were evaluated based on the modeled scenarios, which were set considering both resource collection and other conditions.

Table I: Settings of the scenario

Diffusion model	RAPTAD (Random-Puff Transport and Diffusion)
Weather model	HOTMAC (Higher Order Turbulence Model for Atmospheric Circulation)
Emission heights	Heights of incineration chimney
Emission source	Incineration plant of the 23 wards of Tokyo
Sampling site	6 points in Tokyo and 16 points in nearby area
Altitude	Concerned (digital map of 250m mesh, Geographical Survey Institute)
Land-use	Concerned (land use data, Geographical Survey Institute)

2. MATERIALS AND METHODS

In this study, fluorescent tubes used in Japan were investigated. The scope of this investigation was set to consider the used fluorescent tube lightings. The functional unit was defined as the handling of 1 kg of used fluorescent tube lightings per hour. Fig. 1 showed the mercury flow and the system boundary of this study. The details of four different scenarios with regard to energy analysis and analysis of the abandonment process were described in Table I.

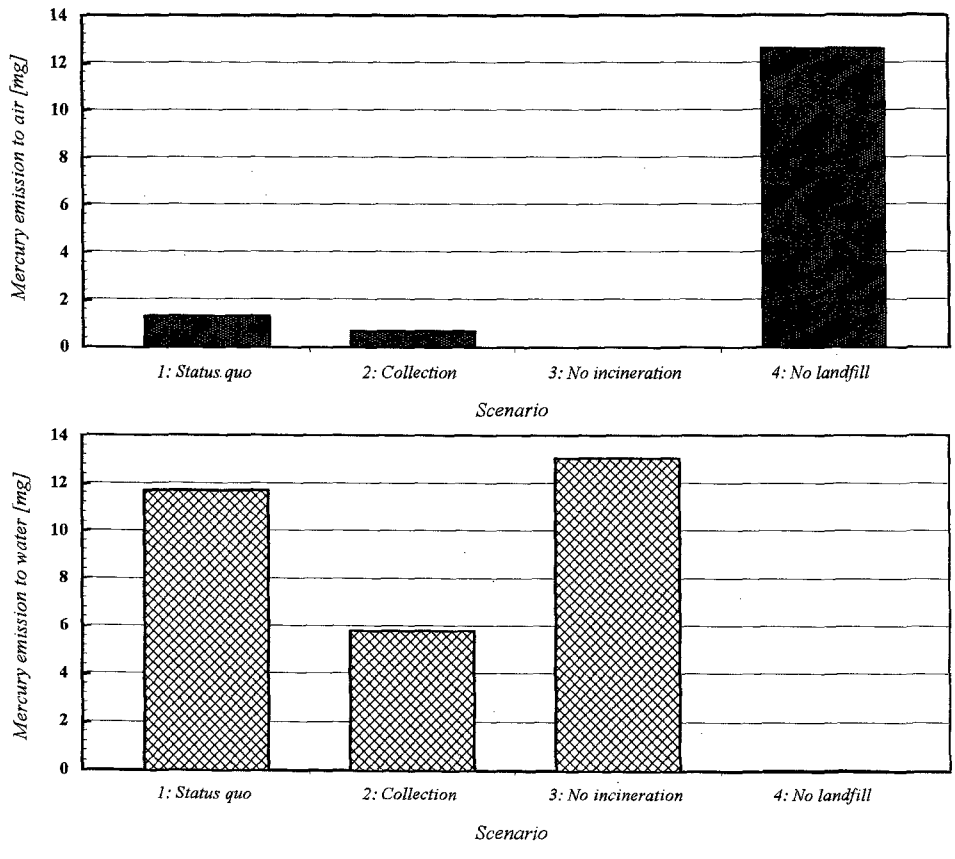
The rise in atmospheric mercury concentrations and in blood mercury levels caused by the diffusion and inhalation of mercury were also calculated using two models (RAPTAD and HOTMAC) [1]. The RAPTAD used in this research was an advection diffusion model based on the Monte Carlo Method. The details of calculation condition were described in Table II. The obtained data was then used for exposure calculations for inhalation of mercury.

Table II: Detailed data for the calculations

	Scenario 1 (Status quo)	Scenario2 (Collecting)	Scenario3 (Not incinerating)	Scenario4 (Not landfilling)
Incineration	9.36%	4.68%	0.00%	90.00%
Landfill	80.64%	40.32%	90.00%	0.00%
Collection	5.00%	50.00%	5.00%	5.00%
Litter	4.95%	4.95%	4.95%	4.95%
Illegal incineration	0.05%	0.05%	0.05%	0.05%

3. RESULTS AND DISCUSSION

Fig.2 showed the results of the abandonment-process analysis with respect to mercury emissions to the atmosphere, mercury emissions to water, the amount of solid waste, and energy consumption, respectively. Both of the environmental mercury emissions in Scenario 2 were about 50 % lower than that of Scenario 1. Separation regulation for incineration or landfill was not effective for reduce environmental mercury emission. The effective method to reduce solid waste was collection. The energy consumption in Scenario 2 was about 20 % higher than that in Scenario 1. This difference occurred because the mercury collection process included transportation to Hokkaido and heating mercury sludge in furnace. Therefore, future collection practice should increase the ratio of resource-collection and energy efficiency in order to reduce total energy



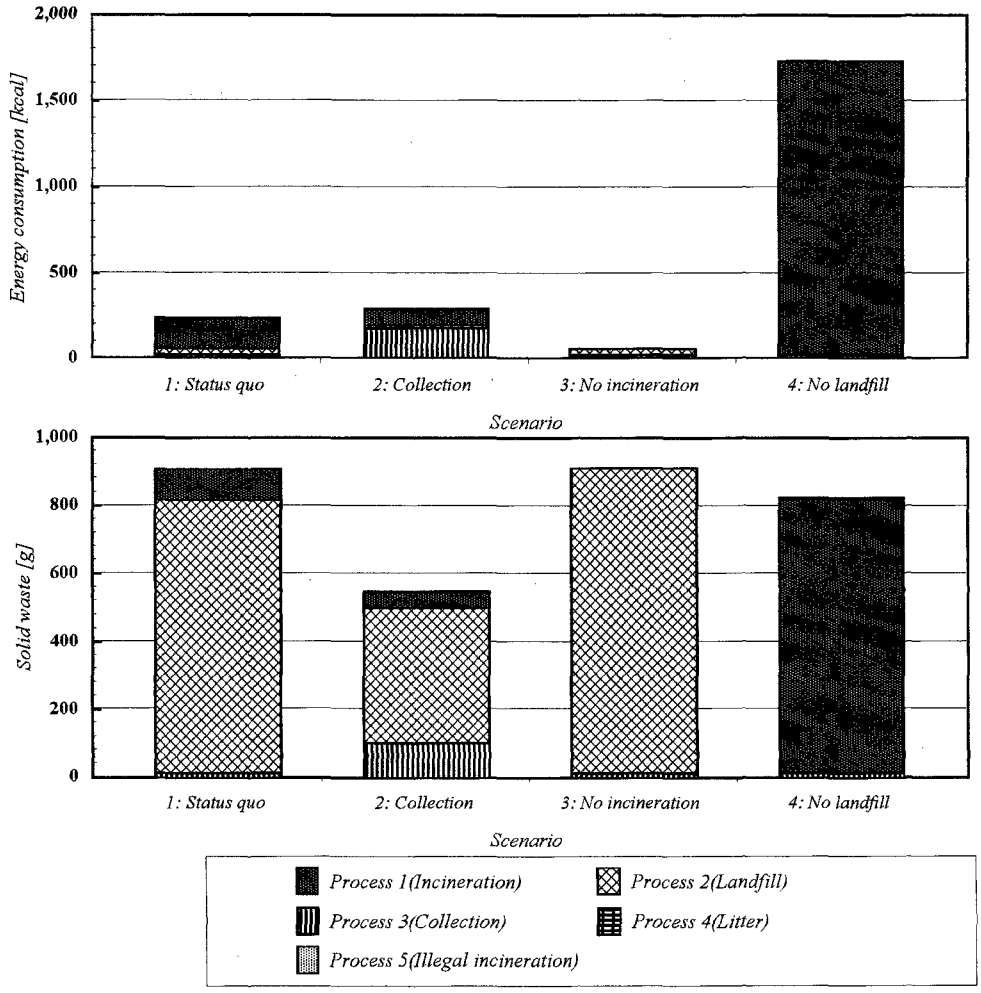


Fig.2: Results of the abandonment-process analysis

consumption and save landfill area. Fig.3 showed the simulation results for airborne mercury concentrations by diffusion. The values for the mercury levels reached a maximum of 2.1×10^{-13}g/m^3 at Shibuya, where the point sources were concentrated. In Chiba City (located to the east) and Kawagoe City (located to the north), mercury levels were observed as a factor of 10^2 and 10 lower than those at Shibuya, respectively.

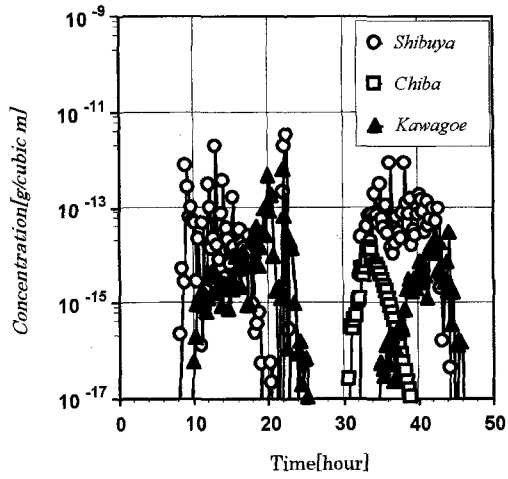


Fig.3: The simulation results

By incorporating an appropriate treatment procedure with collection process, the risk of mercury exposure and the energy consumption of mercury treatment could be reduced at the same time.

4. CONCLUSION

i) Using this method, airborne concentration of toxic metals emitted from substance and energy consumption on disposal stage for certain products would be predictable.

ii) This method would be helpful to make concern and decision making for policies and manufacture process.

In addition, more sensitive and reliable prediction would be possible if more detailed data such as population distribution, landfill or ecosystem information is available.

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Reference

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