Annual Changes in Wet Deposition Fluxes of Trace Metals and Scavenging of Mercury by Precipitation in an Urban Area

Background

Risks caused by the intake of dietary toxic trace substances which are bioaccumulated through the food chain after their deposition to the ground, are important for the assessment of the human health risks related to atmospheric trace substances. For the evaluation of those risks, quantification of atmospheric deposition of trace substances is primarily required. Atmospheric deposition occurs through both wet and dry processes, which are due to the precipitation and the deposition of gases and particles, respectively. In Japan, deposition of trace substances including mercury has been not monitored over long periods. Hence, levels and annual changes in their deposition fluxes remain unclear.

Objectives

To clarify annual changes in wet deposition fluxes of mercury (Hg), cadmium (Cd), copper (Cu), manganese (Mn) and lead (Pb) and scavenging of mercury by precipitation on the basis of the observations for 4 years (2000 - 2003) in Komae City, Tokyo (Fig. 1).

Principal Results

1. Annual changes in wet deposition fluxes of trace metals and factors affecting their annual changes

Annual wet deposition fluxes of Hg, Cd, Pb and Zn showed a declining trend that corresponds to changes in atmospheric concentration. In particular, for Hg and Pb, a large reduction wet deposition flux was observed (Fig. 2). According to the previous studies based on lead isotope ratios and trace metal concentrations in the atmosphere, Hg, Cd, Pb and Zn in the atmosphere originate significantly if not predominantly from municipal solid waste (MSW) incinerators located around the study site. It was found that the emissions of Hg and particles from MSW incinerators in the Tokyo area (23 wards) have decreased annually (Fig. 3). Thus, the reduction in wet deposition fluxes of Hg, Cd, Pb and Zn is due to the decrease in their emissions from MSW incinerators by an improved flue gas control system in recent years *1.

2. Scavenging of particulate mercury and gaseous mercury by precipitation

The contribution of the scavenging of gaseous and particulate Hg by precipitation to the bulk Hg wet deposition flux was evaluated on the basis of scavenging ratios for trace metals (= concentration in precipitation/concentration in air)*2. The results indicated that approximately 30 - 60 % of the Hg scavenged by precipitation originated from particulate Hg, which is similar to the contribution from gaseous Hg (Table 1). This suggests that both the scavenging of atmospheric particulate and gaseous Hg by precipitation plays an important role in Hg wet deposition.

Future Developments

Bioaccumulation of trace metals such as Hg in fishes via the deposition to aquatic regions is an important pathway for the assessment of their human health risks. In future studies, wet and dry deposition of trace metals will be measured in Tokyo Bay, which is selected as a study aquatic region.

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Reference

M. Sakata and K. Marumoto, 2004, Annual changes in wet deposition fluxes of trace metals and scavenging of mercury by precipitation in an urban area, CRIEPI Report No. T03015 (in Japanese)

*1：Since MSW incinerators are not the major emission sources for Cu and Mn, the reduction in their emissions did not contribute significantly to the decrease in the atmospheric concentrations and wet deposition fluxes.

*2：Wet deposition flux of particulate Hg was calculated, assuming that the scavenging ratio of particulate Hg is same as the mean value of other trace metals which exist entirely in particulate form.

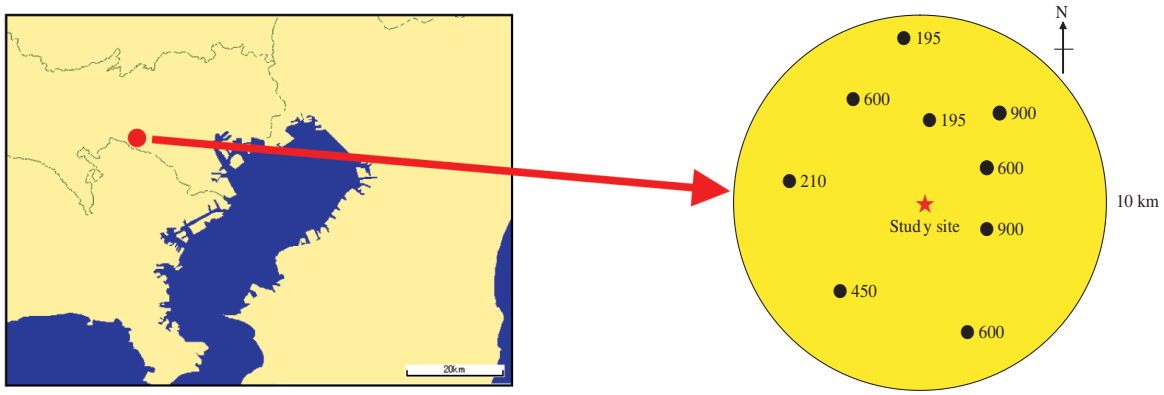


Fig.1 Location of Komae City, Tokyo and municipal solid waste (MSW) incinerators within 10 km of the study site (Number: capacity (tons d^{-1}) of each incinerator)
Many large MSW incinerators are located around the study site (9 sites within 10 km).

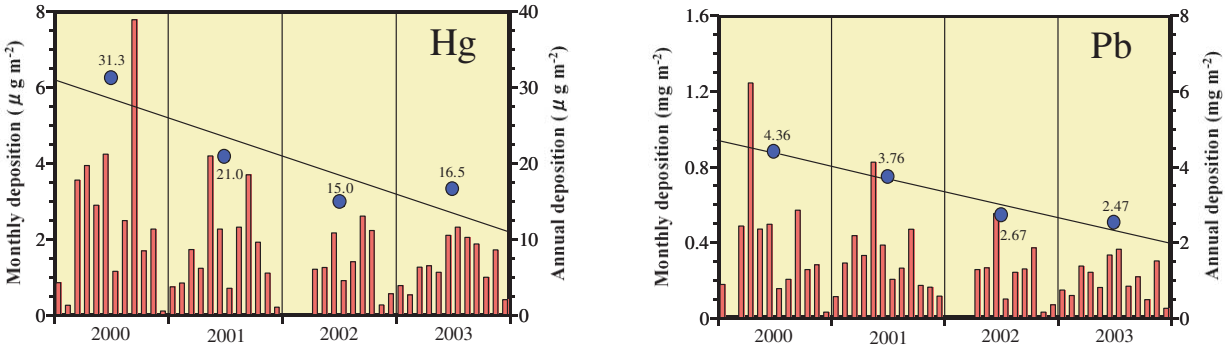
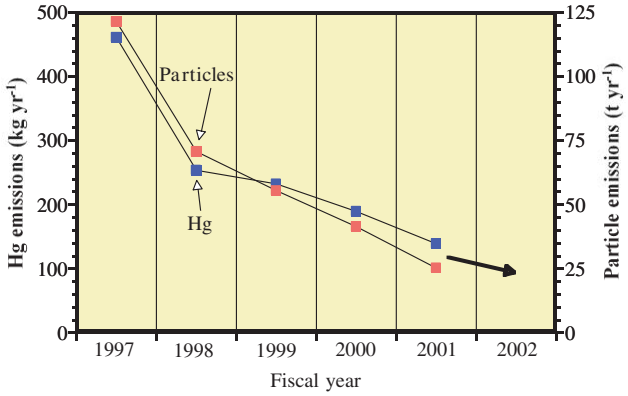


Fig.2 Changes in monthly and annual wet deposition fluxes of mercury and lead
Wet deposition fluxes of Hg and Pb showed an annually declining trend, repeating a seasonal change that wet deposition fluxes decrease during winter when the precipitation amount decreases. Annual reduction rates of wet deposition fluxes from 2000 to 2003 were 16 % for both metals.



Total emissions of Hg and particles from MSW incinerators (17 – 20 facilities) in Tokyo area were estimated on the basis of the published annual average concentrations in flue gases. The emissions of Hg and particles in 2001 decreased to approximately 1/3 and 1/5 of those in 1997, respectively.

Fig.3 Annual changes in emissions of Hg and particles from municipal solid waste incinerators in the Tokyo area (23 wards) in the fiscal years of 1997 – 2002

Table1 Contribution of the scavenging of particulate Hg (Hg(p)) by precipitation to the bulk Hg deposition

Year	Scavenging ratios of trace metals	Wet deposition of Hg(p), μgm^{-2}	Contribution of Hg(p), %
2000	112 ± 32	12.8	48
2002	170 ± 49	7.3	58
2003	122 ± 15	4.5	32

The scavenging ratios of tracemetals except for Hg are similar to each other. The wet deposition flux of Hg(p) calculated using their scavenging ratios corresponds to approximately 32 – 58 % of the bulk Hg wet deposition flux measured.