Estimation of Mercury Emissions Due to Combustion of Fossil Fuels in Slovenia

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Abstract: Combustion of fossil fuels is most important anthropogenic source of Hg to in the global atmosphere. Most important industrial Hg sources in republic of Slovenia are fossil fuels burning thermal power plants (TPP Šoštanj, TPP Ljubljana, TPP Trbovlje). Mass balance calculations for TPP Šoštanj showed that between 300 to 400 kg of Hg is released to the atmosphere yearly. Total Hg emissions from Slovenian power plants are estimated to be around 450 kg yearly. Small industry and private houses contribute only 7 % of that amount. Hg emissions due to oil and gasoline consumption are much lover, estimated to be only 2.7 kg yearly.

Key words: power plants, Hg emissions, fossil fuel combustion

INTRODUCTION

Fossil fuels combustion is the greatest source of anthropogenic emissions of mercury into the environment. Present-day worldwide fossil fuel combustion was estimated to produce emissions of Hg of about $0.7\text{-}3.8 \times 10^3$ ton/yr (NRIAGU AND PACYNA, 1988; PACYNA, 1996). Most important source are thermal power plants that combust coal, liquid or gaseous fossil fuels.). Due to high combustion temperatures mercury become volatile and it is emitted into the atmosphere via flue gases. Mercury that is released from power plants can be in different oxidation states (i.e., elemental (Hg^0) or oxidized (Hg^{2+})). The proportion between them depends upon coal type and composition, combustion and flue gas conditions, and flue gas cleaning technologies. This has significance for several reasons. The chemical form of the Hg may affect the degree of its removal, as well as its atmospheric fate, health effects and risk assessment.

In the atmosphere Hg undergoes various physical and chemical transformations, and finally is removed from the air by wet or dry deposition. After it is deposited into aquatic environment Hg undergoes transformations such as: methylation, demethylation, reduction, oxidation, diffusion, settling and burial, evaporation, etc.

In Slovenia there are four important thermal power plants Power Plant Šoštanj (775 MW, Power Plant Trbovlje (125 MW), Power Plant Ljubljana (175 MW) and Power Plant Brestanica (228 MW). First three power plants use lignite or brown coal for electricity or heat production. PP Brestanica use natural gas or oil as a fuel.

Fossil fuel combustion in individual heating systems and in small industry contribute smaller part of total Hg emissions.

Results and discussion

According to data from International Energetic Agency (1996), the majority of coal in Slovenia is burned in power plants, mostly lignite from Velenje coal mine (4,340,000 t/y) following by brown coal (1,540,000). After closure of Zasavje coal mines most brown coal is imported. Only 17,000 t of black coal is burned yearly in Slovenia, mostly by industry.

Šoštanj power plant is the biggest energetic system in Slovenia, which produce more that one third of Slovenian electricity. It uses lignite from near mine in Velenje. Average Hg content in burnt lignite is 82 – 99 ng/g (dry weight) (Kotnik et al., 2000). Mass balance calculations showed that it emitted into environment about 356 kg Hg yearly. From that amount 42 kg Hg are deposited on fly ash landfill. About 314 kg of Hg is emitted into the atmosphere by flue gases. Most emitted

Hg is in elemental form (80 %), and the remaing is divalent mercury.

Power Plants Trbovlje and Ljubljana use brown coal from different coal mines in the world. Average Hg content in brown coal is 53 ng/g (Baker, 1994). Both power plants burn up about 1,540,000 tones of coal. Taking into account, that more than 90 % of Hg is emitted into the atmosphere, yearly Hg emission to atmosphere would be 73 kg. From that amount Trbovlje Power Plant contributes 30.4 kg Hg yearly and Ljubljana Power Plant about 42.6 kg Hg per year. The data about natural gas consumption in Brestanica Power Plant were not available, but from data given by Chu and Porcella (1995) we assumed that yearly emission is less than 10 kg of Hg per year. Locations and yearly emissions from Slovenian power plants are presented on Figure 1. Due to coal combustion Hg emissions in Slovenia are around 416 kg. Slovenian emissions due to coal combustion are shown in Table 1.
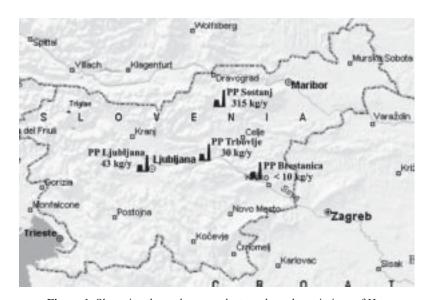

Figure 1. Slovenian thermal power plants and yearly emissions of Hg.

Table 1. Yearly Hg emissions due to coal combustion in Slovenia (in kg/year).

	Lignite		Brown coal		Black coal		Total
	Consumption (×1000 ton)	Emission (kg Hg/y)	Consumption (×1000 ton)	Emission (kgHg/y)	Consumption (×1000 ton)	Emission (kg Hg/y)	Emission (kg Hg/y)
Thermal power plants	4095	332	1129	53.9	0	0	386
Industry	66	5.3	57	2.7	17	1,3	9.3
Households	179	14.5	142	6.8	0	0	21.3
Total	4340	351.5	1328	63.3	17	1,3	**416**

Similar calculations as for coal have been also done for oil and its products. In calculations data from CHU AND PORCELLA (1995) and LIAN ET AL. (1996) have been applied. For oil they obtained average Hg content between 2 and 8 ng/g and for natural gas 20 ng Hg/m^3 or 0,56 ng Hg/MJ. LIAN ET AL. (1996) reports average Hg content in gasoline bought in Slovenia to be 1,2 ng/g. We assumed that 100 % of Hg is emitted to atmosphere.

Most Hg emissions from oil derivates have been found to be due to combustion of petroleum spirit in small Power plants. The yearly Hg emissions do not exceed 1,2 kg Hg. Transportation contribute another 1,4 kg of Hg mostly combusted in gasoline engines (64 %). Total Slovenian emissions from oil and its derivates consumption was estimated to be around 2,7 kg/Hg per year. Atmospheric Hg emissions due to oil and its derivates combustion in Slovenia are shown in table 2.

Table 2. Hg emissions to atmosphere due to oil and its derivates consumption in Slovenia (in kg Hg/year).

	Oil		Petroleum spirit		Gasoline		Total
	Consumption (×1000 ton)	Emission (kg Hg/y)	Consumption (×1000 ton)	Emission (kg Hg/y)	Consumption (×1000 ton)	Emission (kg Hg/y)	Emission (kg Hg/y)
Small thermal power plants	N/A		155	0.2			0.2
Industry	N/A		184	0.3			0.3
Transport	353	0.5	N/A		765	0.9	1.4
Households	56	0.1	446	0.7			0.8
Total	409	0.6	785	1.2	765	0.9	**2.7**

CONCLUSIONS

Slovenian contribution of mercury to the global atmosphere due to fossil fuel combustion is les than 0.02 % (approximately 420 kg) (of which 99 % of Hg originates from coal. Most Hg is released by three thermal power plants (386 kg of Hg) that use lignite or brown coal as a source of thermal energy. Households and other industries represent minor source of Hg to the total Slovenian Hg emissions. References

Acknowledgement

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