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Substance flow analysis for mercury emission in Poland

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Abstract. Substance Flow Analysis (SFA) is an approach showing main sources of emission and flows of pollution to the environment, which allows to define possible environmental risk. Total identified mercury emission to air, soil and water in Poland for year 2010 from anthropogenic sources was estimated as 18.0 Mg. Annual Hg emission to air from by-product sources was equal 13.5 Mg, with the highest share of emission from brown coal-fired power plants. Mercury contained in combustion residues and removed from flue gases is transferred to waste waters, disposed to landfills and used to a concrete production with unknown amounts. Annual mercury emission to air from the use of mercury-containing products (0.5 Mg) was estimated by authors based on model for distribution and emissions for batteries, light sources, other electrical and electronic equipment and also for measuring and control equipment. Emission to air from dental practice (0.3 Mg) was estimated for combustion of wastes containing dental amalgam and from bodies cremation. SFA for the use of mercury-containing products and dental practice presents significant load of 10.4 Mg mercury contained in hazardous wastes produced annually. It covers wastes of used products, dental amalgam wastes directly from clinics as well as stream from incineration of infectious dental wastes. In the paper mercury discharges to water from large and medium industrial facilities (2.9 Mg) and municipal waste-water treatment plants in large agglomerations (0.4 Mg) are presented. Smaller loads are generates by leachate transfer from municipal landfills to WWTPs and further to agriculture and also by releases from dental amalgam in buried bodies. The paper indicates lack of information in SFA which should be regarded, mainly concerning mercury releases from municipal landfills to water and soil and emissions from municipal WWTPs to air.

Key words: mercury, emission, inventory, air, water, soil, substance flow analysis

Introduction

Poland with brown and hard coal-fired power plants (90% of electricity generation) is one of a major mercury emitter to atmosphere in Europe. Anthropogenic mercury emission to air, water and soil in Poland in 2008 was estimated by Panasiuk et al. (2009) on level 25.7 Mg Hg per year.

In industry mercury load captured from flue gases (fly ash) is transfered to waste waters, bottom ash and gypsum. Landfilled municipal wastes with mercury-containing products are sources of mercury releases to ground waters and soil as well as leachate transfer to waste-water treatment plants. Thus the approach using Substance Flow Analysis (SFA) is necessary for a proper environmental policy.

Methods

For national project MERCPOL authors estimated mercury emission to air, soil and water for base year 2008 (Panasiuk and Glodek, 2012). Annual mercury emission to air from by-product sources, the use of mercury-containing products and dental practice in Poland was equal 17.7 Mg. Based on initial E-PRTR data for 2007 mercury emission to water was 3.0 Mg. Waste stream of mercury-containing products sold yearly and passed to municipal landfills was estimated on level 4.8 Mg Hg (with potential discharges to soil).

Currently the newest inventory of mercury by-product emission to air in Poland is available. The National Centre for Emission Management (KOBiZE, 2012) operating in institute IOS has prepared inventory of emission from industrial processes and fuel combustion in residential sector for years 2009-2010.

The biggest national problem is still emission from electricity and heat generation (8.6 Mg in 2009 and 8.8 Mg in 2010). However the share of hard and brown coal combustion in emission was verified due to new data on mercury content in Polish coals. For public power plants temporary emission factor 0.05 g/Mg was used for hard coal combustion and 0.10 g/Mg for lignite combustion. These factors were proposed by KOBiZE only on the basis of assumption of 50-60% mercury emission reduction, not measurements. Emission from remaining industrial sectors was estimated by KOBiZE (2012) on level 4.3 Mg for year 2010. Reported mercury emission from cement industry (1.6 Mg) can be overestimated. Based on the European Pollutant Release and Transfer Register (E-PRTR) data for year 2008 and extrapolation for remaining cement plants, Polish Cement Association estimated own mercury emission amount as 220 kg/year. Emission from non-industrial combustion processes (coal-fired commercial, institutional and residential installations) is reported by KOBiZE on level 1.5 Mg for 2009 and 1.8 Mg for 2010.

Mercury emission from the use of mercury-containing products was estimated by Panasiuk et al. (2009) based on model for distribution and emissions (Kindbom and Munthe, 2007) for batteries, measuring and control equipment, light sources as well as other electrical and electronic equipment. Consumption of mercury for production of mercury-containing products launched annually to Polish market (9.4 Mg Hg) was assessed on the basis of data for EU-25 presented by Maxson (2006). Majority of this mercury stream is disposed in municipal landfills. Detail assumptions are described by Panasiuk and Glodek (2010).

Emission to air from dental practice was estimated for combustion of wastes containing dental amalgam and from bodies cremation. Amount of mercury in dental materials launched annually to Polish market (10 Mg) was assessed according to estimates of the Polish Ministry of Health for 2005 (new data are not available). It was assumed that 2.2 Mg Hg is accumulated in society as new dental fillings. From 7.8 Mg Hg passed to solid wastes, the excess of prepared mixture (2.0 Mg Hg) is recollected as hazardous waste. Remaining amount of mercury in old amalgam wastes is half collected and treated as hazardous waste (2.9 Mg Hg) and half incinerated with infectious wastes. These wastes are incinerated with average 90% emission reduction (currently only in industrial plants, earlier also in hospital plants without proper equipment). Mercury emission to air from bodies cremation is reported by EC (2012) for assumptions of 9% of corpse cremated in Poland in 2011, number of 3 crematoria applying mercury removal techniques (with 50% Hg capture) and 10 crematoria not applying these techniques.

Data on mercury discharges to water was used from E-PRTR database for year 2009. Authors used also new estimates of mercury loads transfered in a leachate from municipal landfills to waste-water treatment plants and further transfered in a sewage sludge to agriculture in Poland (COHIBA, 2011). Mercury discharges to water and soil from dental amalgam in buried bodies was calculated on the basis of burial data, assuming that 20% of Hg is reaching groundwater and the rest is chemically bounded.

Substance flow analysis for mercury was provided in SOCOPSE (2009) for the EU-27 in year 2000. Based on this research and new data, Sundseth et al. (2012) prepared SFA diagrams for year 2005 as well as baseline and MFTR 2020 scenarios.

For Poland, Bojakowska and Sokolowska (2001) prepared mercury content balance in exploited coals and other mineral raw materials in 1997. They estimated amount of 28.8 Mg Hg in Polish hard coal and lignite (part of hard coal exported from Poland) and 13.7 Mg in copper ores, lead-zinc ores, ceramic and calcareous raw materials. Panasiuk et al. (2009) collected and estimated new data on national mercury emissions to air, water and soil. SFA for Poland in 2008 for industrial processes, fuel combustion, municipal landfills and waste-water treatment plants was made in COHIBA (2011). In this paper authors present the comprehensive SFA for Poland for 2010 covering also mercury streams from the use of mercury-containing products and dental practice.

Results

For year 2010 mercury by-product emission to air in Poland amount to 13.5 Mg, see figure 1. Emission from electricity and heat generation (8.8 Mg) results mainly from brown coal-fired power plants (5.6 Mg) and hard coal-fired plants (3.1 Mg) and additionally from wood co-combustion (0.1 Mg; KOBIZE, 2012). Verified mercury emission from remaining industrial sectors is 2.9 Mg and from households - 1.8 Mg.

Mercury emission to air from the use of mercury-containing products (initial and later within 10 years) was estimated on level 0.46 Mg Hg. Consecutive 2.90 Mg Hg contained in products is re-collected and stored safely. Waste stream of mercury-containg products passed to municipal landfills was estimated by authors on level 4.84 Mg Hg with potential releases to soil and waters. Remaining 1.20 Mg of mercury is still accumulated in products in society.

In dental practice incineration of 2.9 Mg Hg in infectious wastes causes emission to air 0.29 Mg Hg. Annual mercury emission for dental fillings from bodies cremation was equal 0.06 Mg. For year 2010, total annual anthropogenic mercury emission to air from industry, products and dental practice in Poland was equal 14.2 Mg Hg.

According to E-PRTR data, mercury discharge to water in 2009 was 3.32 Mg with majority of 2.92 Mg from Polish large and medium industrial facilities. In cause of municipal waste-water treatment plants in large agglomerations this discharge to water (from residential sector, hospitals and dental clinics as well as small industrial facilities) was 0.41 Mg. Load of mercury transfered to urban WWTPs in leachates from Polish

municipal landfills was estimated in COHIBA (2011) as 3 kg annually. Impact of sludge incineration in Poland has not be researched yet. Mercury stream in sewage sludges transfered from these WWTPs to agriculture amount to 0.31 Mg. Consecutive 0.16 Mg Hg can be discharged to soil from dental amalgam in buried bodies.

For year 2010, total identified anthropogenic mercury emission to the environment in Poland was 18.0 Mg Hg per year. Basing on EMEP data annual atmospheric deposition on Poland's area (including export and import of pollution) was estimated in COHIBA (2011) on level 7.8 Mg.

In industry, mercury contained in combustion residues and removed from flue gases is transfered to waste waters, disposed to landfills and used to a concrete production. Amount of mercury deposited in industrial wastes and construction materials is unknown. Based on national average mercury contents in coals (Wojnar and Wisz, 2006), from 19 Mg Hg contained in coals combusted annually for power and heat generation, ca 10 Mg is captured. Remaining hard coal is combusted in Polish industry and residential sector and it contains 3-4 Mg Hg. Other unknown mercury input to industry processes originates from non-ferrous ores and other mineral raw materials consumption and from biomass and wastes co-combustion.

Significant load of 10.4 Mg Hg is contained in safely stored hazardous wastes from the use of mercury-containing products and dental practice. It is amount to 2.9 Mg in wastes of batteries, measuring-control equipment, light sources, other electrical and electronic equipment, and 4.9 Mg in a stream directly from dental clinics as well as 2.6 Mg from incineration of infectious dental wastes.

However we have no knowledge about other mercury flows: from old municipal landfills to ground waters and soil and from municipal WWTPs to air. Share of dental clinics, small industry and population in mercury burden of WWTPs in Poland is also unknown.

Conclusion

Annual mercury emission in 2010 from power and heat generation, remaining industrial sectors and fuel combustion in residential sector in Poland is 13.5 Mg to air and 3.3 Mg to water. Mercury contained in combustion residues and removed from flue gases is disposed to landfills and used to gypsum and concrete production. These streams should be also estimated.

Substance flow analysis of mercury in Poland shows lack of knowledge on this pollution flows between activity sectors, waste storage and environmental elements.

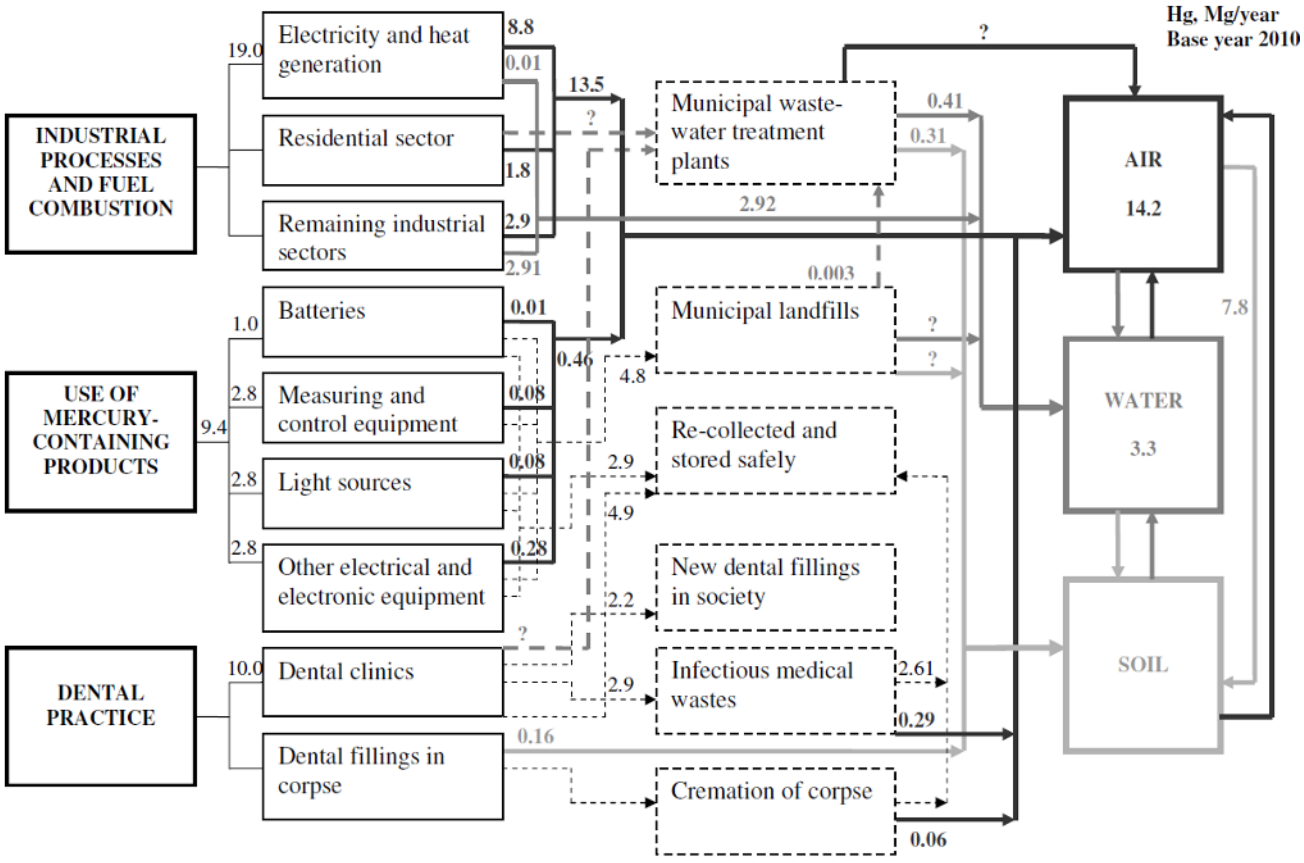

Fig. 1. SFA diagram for mercury for Poland in year 2010.

Proper management of hazardous wastes from the use of mercury-containing products and dental practice can decrease pressure on the environment and impact on human health. Studies on amount of mercury in dental materials launched annually to Polish market and streams of dental amalgam in clinics should be first step. The next unknow is direct release from municipal landfills to ground waters.

Currently identified mercury emission to air, soil and water in Poland in 2010 (18 Mg annually) is only part of pollution flows in the environment. Load of mercury deposited in Polish soils in the past and release factors should complete SFA.

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