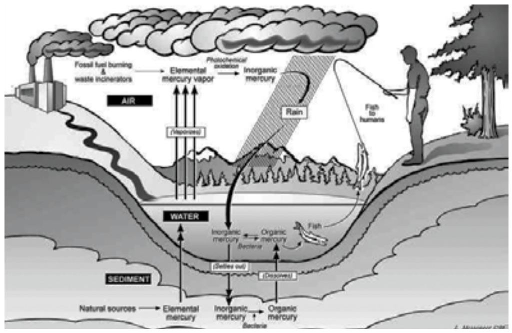
EXECUTIVE SUMMARY

WERF

WATER ENVIRONMENT RESEARCH FOUNDATION — BIOSOLIDS

Minimizing Mercury Emissions in Biosolids Incinerators

The U.S. EPA lists mercury compounds as one of the 33 air toxics of greatest concern in urban areas under Clean Air Act Section 112(k). This study surveyed facilities in the U.S. and identified practices and control technologies to cost effectively reduce mercury emissions from biosolids (sewage sludge) incinerators. The research helps utilities and regulators characterize, measure, and minimize mercury in publicly owned treatment works (POTWs) that practice biosolids incineration in the U.S.



The Mercury Biogeochemical Cycle.

For this study, the National Association of Clean Water Agencies (NACWA) helped WERF survey POTWs nationwide and determine analytical techniques employed for all matrices, biosolids incinerator design and operational parameters, testing frequency, and historical data. A comprehensive literature review assessed information on wastewater and other industries to summarize current understanding of mercury speciation in combustion gas. Speciation is a critical piece of information needed to develop any mercury minimization strategy. Only limited information is available on mercury speciation cycling through a biosolids incinerator facility. A more complete understanding of mercury speciation allows designers and operators to better control mercury.

Mass balance studies are important to understanding mercury cycling in biosolids incineration – this report provides guidance for mass balance study design and application (including two mass balance studies from full-scale facilities).

Air pollution control and capture devices and additional technologies applied to other mercury emission sources (i.e., coal-fired utilities, municipal waste combustors, medical waste incinerators, hazardous waste combustors, crematories, and industrial boilers) are also discussed in this report.

Biosolids Incinerators in the U.S. Represent a Very Minor Source of Mercury

This study found that the 234 biosolids incinerators located in the U.S. represent a very minor source of mercury. For example, conservative (high) estimates show these units collectively emit less than 0.9 metric tons (1 U.S. ton) of mercury to the atmosphere each year, which is roughly 0.5% of the total amount of mercury annually emitted to the atmosphere in North America. Relative to other sources of mercury emissions in the U.S., biosolids incinerators emit much lower quantities and are a minor source.

The study also recommended that POTWs that practice incineration should consider the following series of actions (and developed the guidance presented in the report to perform these):

- Conduct a mercury mass balance for their plants, including a specific mass balance around their incinerators, using standardized test methods and techniques.
- Determine the industrial and non-industrial sources of mercury entering their plant, which could include dental amalgams, other industrial discharges, or background concentration in soil, etc.
- Implement source control measures, through municipal/industrial pretreatment program modifications. These may include regulatory changes and implementation of best

BENEFITS

- Presents information regarding current analytical methods used by the wastewater industry to measure and monitor emissions from incinerators.
- Provides a detailed explanation of mercury speciation in combustion gases and how mercury speciation drives the efficacy of control technology.
- Evaluates control technology applied to related industries for mercury abatement.
- Surveys and evaluates next-generation methods for mercury monitoring in combustion gas.
- Provides step-by-step instructions for mass balance studies necessary to evaluate biosolids incinerators and identify likely control technology.
- Shows that relative to other sources of mercury emissions in the United States, biosolids incinerators emit much lower quantities and are a minor source.

RELATED PRODUCTS

Evaluating and Measuring Biosolids Incinerator Emissions (91ISP1)

Estimation of Mercury Bioaccumulation Potential from Wastewater Treatment Plants in Receiving Waters: Phase I (05WEM1CO)

Estimation of Mercury Bioaccumulation Potential from Wastewater Treatment Plants in Receiving Waters: Phase II (05WEM1COa)

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management practices for significant sources of mercury to the system (e.g., dentists and dental laboratories).

- Consider installing additional air pollution control devices (APCDs) if source control measures prove insufficient to reduce mercury emissions to the needed level. Systems include activated carbon injection systems with a baghouse and activated carbon polishing. Such systems are costly to procure, install, operate, and maintain.

Impacting Chemistry of Mercury in Exhaust Gases

It is not possible to predict mercury speciations on biosolids incinerator exhaust gases, because exhaust gas systems are rarely at equilibrium. Mercury in the exhaust gases from combustion sources are partitioned into three general species (forms): elemental (Hg^0), oxidized (Hg^{II}) (ionic), and particulate bound (Hg^P). Mercury (chemical) speciation depends on the following kinetic considerations:

- **Humidification** of exhaust gases can lower temperatures, but this high water content can inhibit mercury oxidation or mercury adsorption onto particulate material.
- Excess **oxygen** provided post-combustion pushes the system towards oxidative conditions. **Chlorine** influences the formation of metallic chlorides, and high chloride content drives production of $HgCl_2$.
- In the presence of **sulfur**, mercury can form stable compounds such as HgS or $HgSO_4$. This bonding of mercury with sulfur inhibits the formation of soluble mercury species through competition.
- **Carbon** in biosolids can inhibit mercury evolution during incineration, with higher carbon concentrations relating to lower mercury emissions; unburned carbon in ash can adsorb mercury.
- The presence of other chemicals can affect mercury emissions. For example, selenium reacts to form the stable compound HgSe.

Controlling Mercury Emissions

Mercury emission minimization strategies typically begin with the consideration of source control as the first measure to reduce mercury entering the process cycle. Source management programs focus on source identification, source reduction and segregation, infrastructure control and maintenance, and pretreatment systems. Mercury removal in APCDs depends largely on the method of operation of the APCDs and the physical properties of mercury species. For example:

- Elemental mercury (Hg^0) is a difficult species to capture and presents the greatest challenges for mercury control strategies. Oxidized mercury (Hg^{II}) is highly water-soluble, allowing removal in any type of wet scrubbing mechanism.
- Particulate-bound mercury (Hg^P) is also removed partially in the wet scrubbing mechanisms, whereas further reduction has been reported through the use of fabric filters and wet electrostatic precipitators.

Wide-ranging mercury removal rates are reported for all types of APCDs, primarily because of variable operational conditions as well as diverse chemical and physical composition of the feedstock. Speculation as to the actual ability of existing technologies to add co-benefit mercury removal needs to begin with solid understanding of speciation throughout the biosolids incinerator. To date, installation of mercury-specific control systems for biosolids incinerators has been limited to two POTWs that have only recently installed activated carbon-based APCDs for mercury control.

Conclusion

This study will help operators specify and design effective mercury minimization systems and processes. The background information includes a comprehensive literature review summarizing the current understanding of mercury speciation in combustion gas and guidance for mass balance study design and application.

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