

Study the sources of mercury vapor in atmosphere as a threatening factor for human health and bio-filtering methods for removal of toxic pollution

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Abstract: A global atmospheric transport model is used to calculate mercury concentrations in the atmosphere. In this study, a comprehensive analysis was made to describe the environmental behavior and pollution status of mercury (Hg). The most important aim in this study is to show mercury pollution sources and to introduce some new technologies for removing this dangerous material from air. In this paper, some bio technologies such as bio filtering method and bio adsorbent such as leaves of trees was introduced. The capacity and application of biotrickling filters for the removal of mercury vapor from simulated flue gases was expressed. It was resulted from paper that the most prominent source of mercury is the east of Asia and the southeast of Asia. The lowest source is concerned Australia. In this investigation it was found that activated carbon can be one of the best tools for removal of mercury vapor. The adsorbent uniquely combines a chelating ligand with an ionizing surface nano-layer on a mesoporous substrate was the other consequences of this study which can be as a suitable adsorbent for omitting this pollutant from atmosphere.

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1. Introduction:

The industrial activities of human have resulted in the pollution of soil, water, and atmosphere with heavy metals. Heavy metals are the most prominent dangerous groups of anthropogenic environmental pollutants with high toxicity and persistence in the environment. Independent of the origin of the source, heavy metals can accumulate in crops or plants and may lead to the damage and alteration of animal or human physiological functions through the food chain [1]. Vegetation is an effective indicator of the impact of a contamination source in its vicinity, because most plants have the capacity to accumulate these pollutions therefore their concentrations are much higher than those in the air [2]. For example, Mercury and its compounds are included in the Title III listing of hazardous air pollutants (HAP) by US EPA due to their potential impact on human health. As a result, they are subject to standards and regulations such as clean air mercury rule issued in 2005 [3]. For another example, Arsenic and selenium have been linked to harmful toxicological impacts despite the fact that these elements are essential trace elements for mans and animals. These are among the toxic air pollutants addressed in the 1990 Clean Air Act Amendments.

Coal-fired plants for electricity generation are one of the anthropogenic sources of emissions of arsenic and selenium [4]. Lead (Pb) is the other prominent pollutant in marine environments. Before the implementation of antipollution policies on automotive Pb >60% of its anthropogenic discharge into the atmosphere originated from alkyl-lead additives in gasolines [5]. Although these groups of metals are present in soils, contamination comes from local sources, mostly industry (mainly non-ferrous industries, but also power plants, iron and steel and chemical industries), agriculture (irrigation with polluted waters, use of fertilizers, especially phosphates, contaminated manure, sewage sludge and pesticides containing heavy metals), waste incineration, combustion of fossil fuels and road traffic [6]. In the present study we report the results of the measurements of air mercury pollution and our effort is to show the best ways for removal of this contaminant.

2. Mercury Determination and Removal from Atmosphere:

Using H₂S and an activated carbon as adsorbent, the removal of Hg⁰ in simulated coal combustion flue gases was examined in one study

which has been done in Japan at 2005. The following consequences were obtained from this investigation: in the presence of both H_2S and SO_2 , mercury removal was favored at lower temperatures (80–100 °C). At 150 °C, presence of O_2 was indispensable for Hg^0 removal from H_2S – SO_2 flue gas system. The partial oxidation of H_2S with O_2 to elemental sulfur and the Claus reaction may contribute to the Hg^0 removal over activated carbon by the following reaction: $S_{ad}+Hg=HgS$. The formation of elemental sulfur on the activated carbon was confirmed by a visual observation [6]. In the other investigation, The science men have shown that in the spring summer period the western Russian Arctic is under, the influence of regional and far continental anthropogenic sources of atmospheric mercury emissions. The concentrations of mercury in Murmansk, and over Kola and Moto sky Bays were associated with a primary direction of near surface winds from the nearest sources of mercury emission located in the Kola Peninsula region. The mercury concentrations are two-fold lower than the concentrations that are typical of the near surface air of the inner continental reserve territories (background areas), and are comparable to the concentrations measured in the air of the other Arctic regions [7]. Estimates of the global consumption of mercury by application and region in 2005 are shown in Figure 1. Two groups of anthropogenic sources of mercury might be distinguished: primary anthropogenic sources and secondary anthropogenic sources. Primary anthropogenic sources are those where mercury of geological origin is mobilized and released to the environment. The two main source categories in this group are mining (both for mercury and for other minerals) and extraction and burning of fossil fuels which contain mercury as a trace contaminant. Secondary anthropogenic sources are those where emissions occur from the intentional use of mercury, including mercury use in industrial processes, in products, in dental applications, or in artisanal and small-scale gold mining (ASGM) operations. Emissions to the environment from both primary and secondary sources can occur via direct discharge of exhaust gases and effluents, and through the generation of mercury-containing wastes [8]. For example, the regional mercury budget from anthropogenic and natural sources in Chongqing, an important industrial region in southwest China has been investigated [9].

A closed bottle technique (CB) and an intraoral flow (IOF) technique are two in vitro mercury vapor collection techniques. Both techniques indicated mercury vapor release was dependent on volume. The largest bottle, 500 ml, yielded a

significantly greater amount of mercury vapor within the CB systems. In the IOF technique, the addition of air flow over the restoration demonstrated a significant increase in mercury vapor released compared to the sealed IOF technique [10]. In the IOF technique readings are initially higher but level off and remain relatively constant after about 24 h. The largest release of mercury vapor was reported in the first

Global mercury consumption by application and by region in 2005
(note: East and Southeast Asia bar is split)

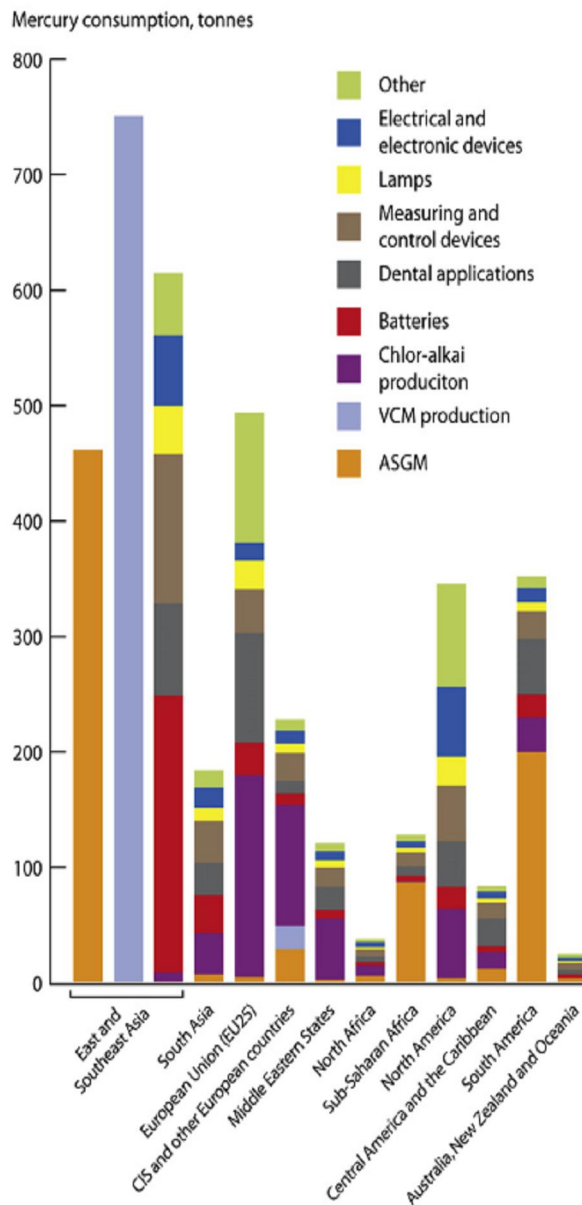


Figure 1. The global consumption of mercury by application and region in 2005 [8]

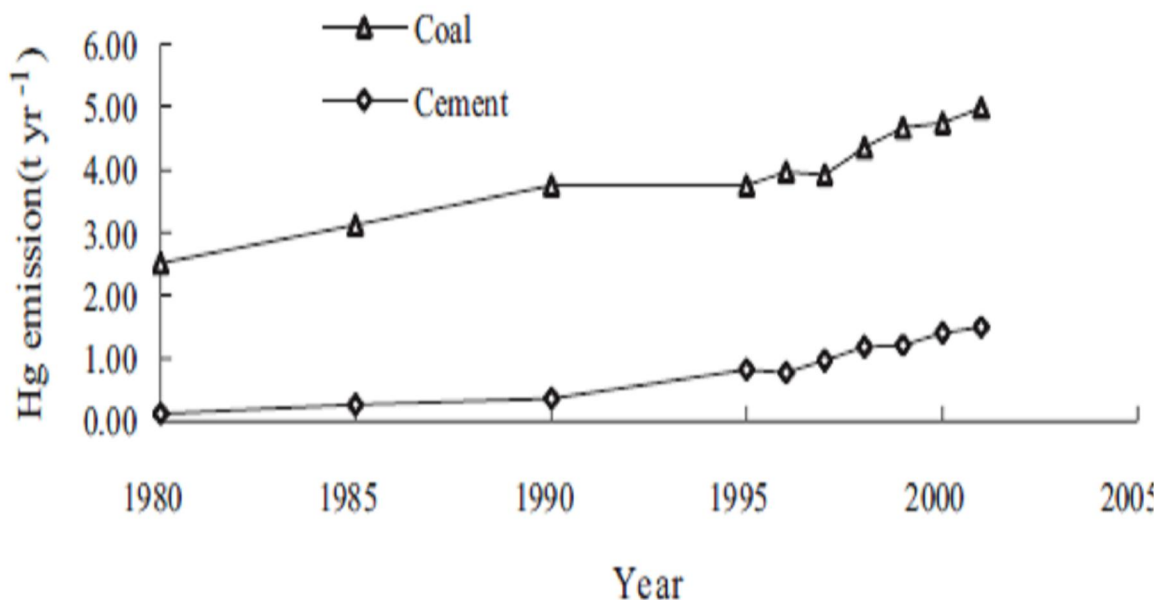


Figure 2. Trends of mercury emissions to the air from coal combustion and cement manufacturing in Chongqing [9]

The annual trends in mercury emission to atmosphere from this source are also presented in Figure 2. The amount of mercury vapor released drops by more than half after 5 h from trituration, which is in agreement with similar findings by other studies. [10].

The feasibility of using biotrickling filters for the removal of mercury vapor from simulated flue gases was evaluated by Indian Institute of Technology at 2007. In this study, early results on the control of mercury vapors in biotrickling filters were presented and discussed. The results highlight the highly complex nature of the mechanisms involved in mercury capture in biotrickling filters. At the same time, the potential of novel biosystems for the control of mercury vapor from flue gases is resulted. Further process optimization and detailed engineering of the best way to integrate the proposed mercury vapor control with existing or novel flue gas treatment are required. For the initial experiment, the gas stream consisted of mercury vapor ($300\text{--}650 \mu\text{g m}^{-3}$) in air which was treated in the reactor containing sulfur oxidizing bacteria and operated at room temperature. Under these conditions, the biotrickling filter exhibited complete removal of mercury vapor at an initial empty bed residence times of 70 s. Subsequently, the gas residence time was gradually reduced to 35 s, 20 s and to 6 s which is seen in Figure 3 [11].

A novel adsorbent for the capture of mercuric chloride vapor from flue gases has been developed in the investigation which has been done

in USA at 2004. The adsorbent uniquely combines a chelating ligand with an ionizing surface nano-layer on a mesoporous substrate. This enables selective, multi-dentate adsorption of mercury directly from the gas phase. A novel chelating adsorbent for the removal of gaseous mercuric chloride directly from flue gases has been developed.

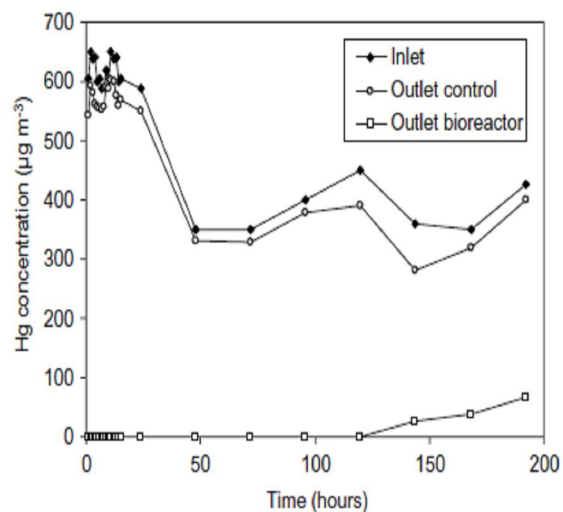


Figure 3. Inlet and outlet concentrations of mercury vapor in the SOB packed biotrickling filter and in the cell-free control [11]

The adsorbent is composed of a structured active nanolayer on a mesoporous silica substrate. Chelation is achieved through the use of a molten salt

coating on an immobilized chelating group. Elemental analyses indicate that the theoretical adsorption capacity for mercury is very high, approximately 33 mg/g. The adsorbent is suited for use in the lowtemperature end of the flue-gas treatment train, with a maximum operational temperature of 135 °C. Evaluation of the dynamic adsorbent capacity for mercuric chloride showed very efficient uptake and a minimum operating capacity of 12 mg Hg²⁺/g. Finally, the formation of chelating complex between HgCl₂ captured and cysteine ligands was confirmed using Far-FTIR [12].

3. Conclusion

In this paper the most important is to introduce the various sources of mercury vapor which can pollute the atmosphere. By investigating the other studies in this field it is clear that Asia is the most prominent of these sources. The two main source categories in this group are mining (both for mercury and for other minerals) and extraction and burning of fossil fuels which contain mercury as a trace contaminant. Secondary anthropogenic sources are those where emissions occur from the intentional use of mercury, including mercury use in industrial processes, in products, in dental applications, or in artisanal and small-scale gold mining (ASGM) operations. The best result that can be achieved from this investigation is that bio technologies can be low cost method for eliminating these pollutants. Biofiltration and activated carbons can be the best adsorbent for removal of mercury vapor. These adsorbent can remove with high efficiency which was shown in Figure 3.

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