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Mercury Contaminated Sites

Characterization, Risk Assessment and Remediation

With 171 Figures and 95 Tables

Springer

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Preface

Mercury is outstanding among the global environmental pollutants of continuing concern. Especially in the last decade of the 20th century, environmental scientists, legislators, politicians, and the public have become more aware of mercury pollution in the global environment. It has often been suggested that anthropogenic emissions are leading to a general increase in mercury on local, regional, and global scales. Numerous industrial activities, including the mining of gold, silver, and mercury itself, have caused mercury contamination of terrestrial and aquatic ecosystems. Mercury-contaminated sites are abundant worldwide. Mercury has been accumulated as an "industrial legacy" in the rocks, soils, and sediments at, and adjacent to, industrial sites and now may pose significant risks to human and ecological health. Direct inputs of mercury into the environment by industrial activities have generally decreased significantly in the Western world over the past three decades. However, sources such as coal combustion and the use of mercury in gold and silver mining continue to be of importance on a global scale. The same is true for diffuse sources such as terrestrial landscapes that have been impacted by mercury inputs from the atmosphere in the past. Soils (and vegetation) located close to large atmospheric mercury sources have clearly been sinks while these sources were active in the past. In the long run, however, these soils may have become important diffuse area sources after the original emissions were discontinued. Unlike other metals, which are generally not very volatile, mercury from contaminated sites can have a significant impact on remote ecosystems via the atmospheric pathway. Thus, mercury contamination is not only just a local issue but also has global dimensions.

This book summarizes, for the first time, information on the characterization, risk assessment, and remediation of mercury-contaminated sites on the European, Asian, and American continents. Review chapters are supplemented by detailed inernational case studies. Included are papers which were initially presented at the 4th International Conference on Mercury as a Global Pollutant held in Hamburg, Germany, August 4 - 8, 1996. The conference was organized jointly by GKSS Research Centre Geesthacht, Germany, and Oak Ridge National Laboratory, USA, and was attended by over 400 participants from 35 nations.

It was the decision of the technical advisory team to publish the Hamburg conference papers in the peer reviewed open literature. This has now been achieved through the preparation of five special journal issues and this book covering all topics from the conference. These publications contain about one-third of the

original presentations from the conference. Copies of the special issues can be obtained directly from the publishers as follows:

- Analytical Developments in the *Fresenius Journal of Analytical Chemistry*
- Atmospheric Cycling in the journal *Atmospheric Environment*
- Biogeochemical Cycling in the journal *Biogeochemistry*
- General Topics on Mercury in the journal *Science of the Total Environment*
- Human Health Issues in the journal *Water, Air and Soil Pollution*

The sixth special issue in this series is the present book that contains a number of submitted technical papers and invited overview papers.

In Chapter 1 Ebinghaus et al. review what is known about natural and anthropogenic emissions of mercury to the atmosphere and evaluate this information in the context of regional and global budgets. Ferrara (Chap. 2) describes mercury mining in Almaden (Spain), Idrija (Slovenia), and Mt. Amiata (Italy), contrasting environmental impacts at both active and inactive sites. Lacerda and Salomons (Chap. 3) consider the amalgamation technique for extraction of gold, noting that environmental impacts of this activity can be serious, but that little information is available on the long-term risks or on measures available to remediate contaminated sites. In Chapter 4, Turner and Southworth provide an overview of mercury-contaminated sites in North America and offer some "lessons learned" from experiences at these sites. Hempel and Thoeming review a number of remediation techniques for soil at contaminated sites, noting that wet classification remains the most common technique (Chap. 5). Mukherjee examines nine technologies for the removal of mercury in gases from metallurgical industries (Chap. 6). A brief overview and update on the situation at Minamata Bay in Japan are presented by Kudo and Turner (Chap. 7). The broad review chapters conclude with a discourse (Chap. 8) by da Costa on the behavior of mercury species in biological systems, and more specifically, on the surface chemistry of microbial cell walls.

The second portion of the book is devoted to international case studies and includes papers from the 1996 Hamburg conference under the general topics: Industrial Sites, Mining, Emissions and Atmospheric Dispersion, Remediation, and Mercury Contamination in Aquatic Systems. Under *Industrial Sites* the various chapter authors provide an example of a site where mercury compounds were used to treat wood (Schöndorf et al.) and three examples (1) where mercury contamination of a marine system originated from an industrial area in Brazil without major point sources of mercury (Marins et al.), (2) where the contribution of electrical lamp (fluorescent) manufacturing plants to total emissions in the CIS was evaluated (Yanin et al.) and (3) where mercury in oil and gas deposits of the former Soviet Union has been characterized with respect to geological origin, geographic distribution, and relationship to other constituents (Ozerova et al.).

Under *Mining* are five chapters related to mercury mining and two chapters covering the use or association of mercury to gold and silver mining. Ferrara et al. summarize mercury emission estimates and ambient air concentrations for one of the closed mercury mines near Mt. Amiata, Italy, using LIDAR remote sensing

and point measurements. Miklavčič reports mercury concentrations in air, lichens, carrots, and beans in the town of Idrija (Slovenia), while Kobal et al. examine whether urinary mercury concentration in Idrija miners is a valid indicator of individual internal doses received during intermittent exposure to elemental mercury. Gnamus and Horvat evaluate the degree of contamination with mercury and its transfer in terrestrial food webs in the active mercury mining area of Idrija. Banasova describes changes in plant communities around an Hg mine and smelter in Slovakia, noting that observed changes are due to the combined emissions of sulfur dioxide, mercury, and copper. Lechler found that mercury still generally occurs in the same elemental form in which it was used in the 19th century to mine for gold in two areas in the western United States. The last chapter (Laperdina et al.) in this section summarizes mercury concentrations in environmental media in the gold mining districts of Siberia and points out the irreversible ecological degradation which has accompanied placer mining in these districts.

The section on *Emissions and Atmospheric Dispersion* begins with a chapter by Krüger et al. which describes determination of mercury emissions from a major industrial site in Germany occupied by both closed and still-operating facilities (chloralkali and acetaldehyde). Petzoldt et al. describe the use of modified zeolites to remove merucry from various industrial gas streams. Špirič and Hraste share practical experiences with a sulfur-impregnated activated carbon system designed to remove mercury from natural gas. Analytical techniques for the speciation of mercury emissions from a Municipal Solid Waste Incinerator (MSWI) are described by Wang et al.

Under the topic of *Remediation* the book includes papers by Matsuyama, who describes a novel low temperature thermal process for the treatment of Hg-contaminated soils involving addition of iron chloride (Matsuyama), and by Thoeming et al., who describe a hydrometallurgical technique (electroleaching of both mercury and gold) applicable to mercury-contaminated soils from the Brazilian gold mining areas. Finally, Meschede and Vogelsberger describe the demolition and decontamination of a chloralkali plant in Alexandria, Egypt.

The book concludes with four chapters describing *Mercury Contamination in Aquatic Systems*. Glass et al. examined mercury concentrations as a function of depth in sediments in six reservoirs on the lower St Louis River, a major tributary to Lake Superior. Patel et al. found mercury and other metals in sediments to be largely derived from mineral- and coal-rich regions in India. Probst et al. describe studies of mercury partitioning among water, suspended matter, and bottom sediments of the Ill-Thur river system in France, noting the presence of temporal and spatial gradients. Finally, Pandit et al. describe results of sampling and analysis for total and methylmercury in a tidal creek ecosystem near Bombay, India.

The various chapters clearly show that each contaminated site has its own history of pollution and, furthermore, that the risks associated with mercury depend on site-specific biogeochemical conditions. No universal treatment procedure is available and the selection of the most effective one should be made on a site by site evaluation.

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