

**EPA's Mercury Report To Congress:  
A Basis for Decision-Making?**

**Frank Ferraro**  
**Vice President, Environmental, Health and Safety Management**  
**Wheelabrator Technologies Inc.**  
**4 Liberty Lane West**  
**Hampton, NH 03842**

## **INTRODUCTION**

Section 112 (n)(1)(B) of the Clean Air Act Amendments of 1990 directed the US EPA to conduct and transmit to Congress by November 1994, a study of mercury emissions from electric utility steam generating units, municipal waste combustion (MWC) units, and other sources including area sources. The study was to consider the rate and mass of the emissions, the health and environmental effects of these emissions, technologies to control them, and the costs of the controls.

While the Report was intended to inform Congress concerning mercury emissions, it is also intended to serve as a basis for future Federal policy and regulatory decisions. The purpose of this paper is to review and assess the status of the Report and identify its weaknesses and deficiencies. It is the studied opinion of this author that the Report, in its current format, suffers from a number of "fatal flaws" which bring into question its usefulness both as an accurate information document for Congressional review, and as a basis for future policy and regulatory decisions.

The discussion below begins with a brief look at the history of the Report. Specific sections of the Report are identified where perhaps fatal flaws exist in the areas of sources, fate and transport models, and some of the controversy over mercury exposure, health effects, and the chosen reference dose. Some observations are incorporated concerning the Science Advisory Board's comments to EPA in a recent review panel. Finally, these comments address flaws in the current Report, but also identify and address flaws in the EPA Report preparation process.

## **MERCURY REPORT TO CONGRESS**

### **History**

For a number of years beginning around 1987, representatives of EPA's Offices of Air Quality Planning & Standards (OAQPS) and Research and Development (ORD) had been involved with collecting data on mercury emissions from MWCs under the Clean Air Act Section 111 New Source Performance Standards development activities. In gathering emissions data, these EPA representatives interacted with MWC owners and operators individually and through groups such as the Integrated Waste Services Association (the MWC industry trade association), the Conference of Mayors/Municipal Waste Management Association (MWMA), Solid Waste Association of North America (SWANA), and the American Society of Mechanical Engineers (ASME).

As part of this continuing effort and dialog, OAQPS held a two-day Public Meeting in February 1990, at their offices at Research Triangle Park, NC to review the status of their NSPS data collection activities for mercury from MWCs. This information and subsequent data eventually lead to promulgation of an emissions standard for new and existing MWCs (40 CFR 60.50b and 60.30b) in December 1995.

After the passage of the 1990 CAAA, EPA's OAQPS's Emission Factor and Inventory Group also began collecting various emissions information to prepare a series of reports on pollutant emissions, e.g., Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds. However, the individuals within this branch of OAQPS were not the same ones as those working on the MWC NSPS.

The MWC industry first became aware of EPA's work in preparing the Locating and Estimating Report in June 1993. The Integrated Waste Services Association (IWSA) provided comments to EPA on MWC

sources and emission rates of mercury. In September 1993, EPA issued the Locating and Estimating Mercury report, ignoring the majority of IWSA's work. Three months later, EPA issued a draft report entitled: National Emissions Inventory of Mercury and Mercury Compounds: Interim Final Report and solicited comments on selected sections of it. IWSA responded by referring the Agency to its previous detailed comments to the Locating and Estimating report.

Over the next year, there was no further communication from EPA on the Mercury reports. Then, in January 1995, EPA published a notice in the Federal Register that there would be a two-day Peer Review workshop to discuss the results of the draft Mercury Report to Congress. While the workshop was open to the public, EPA was not inclined to accept any public comments.

At the January meeting, it was learned that EPA had proceeded with the development of the Mercury Report to Congress, and while one of the major stakeholders, the electric utility industry, had been integrally involved in the preparation and review of the Report, the MWC industry was not even informed of the existence of a draft report until the Public Notice. In addition, no one from EPA's OAQPS or ORD that had been working for the past several years on the MWC NSPS and data collection had been involved in the preparation or review of the draft Report.

The draft Report was provided to the public, including IWSA, for the first time on the morning of the first day of the Workshop. The Public was asked to review and comment on the seven volume draft report on the same day they received it. IWSA was granted only an "observer" status and was offered ten minutes to present any comments at the Workshop.

While EPA was not inclined to accept any public comments on the draft Report, IWSA was subsequently allowed to submit a comment document which cited factual errors in data as well as errors and problems with many of EPA's assumptions in the report. One of the most fundamental flaws in the draft report was that the basic emissions data in the report had been drawn from the incorrect Locating and Estimating - Mercury Report. EPA had ignored the data submitted by IWSA, some of which was based upon testing conducted by EPA's OAQPS and ORD.

### **Problems with the Draft Report**

The draft Report contained inaccuracies and erroneous and ultraconservative assumptions which could lead a reader to believe that mercury emissions from MWCs were seriously impacting the environment and threatening human health. The three primary problem areas in the draft Report are: 1) Sources of mercury emissions, 2) Fate and Transport Models and Assumptions, and 3) Toxicologic information and assumptions.

**Sources.** As stated above, the branch of EPA that collected emissions data for the draft Mercury Report relied on old data. All of the actual stack test results of mercury emissions from MWCs that had been generated for State air permit compliance tests and by EPA/ORD and OAQPS for development of the MWC NSPS was ignored. These data were readily available and much of it had been provided to EPA by IWSA in comments on the Locating & Estimating and National Inventory reports.

Also, even though the draft report was released in January 1995, EPA based the source data in the Report on data as it existed in 1990. In the draft Mercury Report, EPA's estimate of mercury emissions from MWCs was 64 tons per year (tpy), even though in 1993, IWSA provided EPA with data demonstrating that 1993 emissions were no more than 44 tpy and that value was decreasing rapidly. The Agency's own most recent inventory estimate for MWCs for 1995 is **29 tpy**.

The 1995 draft Mercury Report states that MWCs account for 12% of the emissions inventory. However, in 1995, EPA issued a Fact Sheet along with the release of the MACT Emissions Standards for MWCs which stated that MWCs will represent only 3% of the total mercury emissions nationwide once the MACT standards are fully implemented. The inference here is that current MWC emissions are four times what they will be by December 2000. This is patently untrue as is clearly shown in the MWC emissions database that is maintained by EPA.

EPA also ignored other sources of mercury emissions, references for which were readily available in reports prepared by states such as New Jersey and Florida, and underestimated other sources even when they did include them. For example, EPA underestimated the potential mercury releases from fluorescent lights by an order of magnitude, totally ignored the potentially large source of mercury emissions from open field burning, and used inaccurate mercury speciation data in characterizing emissions from MWCs.

**Fate and Transport Models and Assumptions.** In the draft Mercury Report, EPA relied on series of equations and models to estimate the potential impact of emissions of mercury from U.S. sources. The two air quality models were a regional prediction model and a source specific model. The rudimentary multiple pathway model, IEM2, which is primarily a series of equations, was also used. Comments on the inadequacies of these models and the problems with the associated assumptions made by EPA were provided to EPA by IWSA. The following are some of the more critical points made by IWSA.

**RELMAP.** To predict regional concentrations of mercury from sources of mercury emissions, EPA used the Regional Lagrangian Model of Air Pollution (RELMAP), and attempted to verify the results of the RELMAP predictions by comparing them to specific observations and sampling events. However, the actual measured results prove the RELMAP-predicted values consistently overestimate actual wet deposition data by a factor of two. EPA states in the Report that actual results "agree well" with predictions, even though EPA's data proves this to be incorrect. For example, EPA states in the Report that at one location in Vermont, the observed measurements were 9.3 ug/m<sup>2</sup>, whereas the RELMAP model predicted up to 20 ug/m<sup>2</sup>. For another location, the RELMAP model predicted deposition at up to 10 ug/m<sup>2</sup> when actual deposition was 5.7 ug/m<sup>2</sup>.

The RELMAP model predicted local maximum values for mercury wet deposition as 60 ug/m<sup>2</sup>, while EPA cites the highest measured value of actual data as 30 ug/m<sup>2</sup> in the Florida Everglades. As shown by the data in EPA's report, predicted impacts using RELMAP are approximately twice the actual measurements in every case. In the Report, the Agency even admits that the RELMAP results were "significantly larger" than the measured values. However, no attempt to adjust the RELMAP results were made.

While a factor of two may not seem large enough to be of concern, the impact of the RELMAP predicted values *is* significant on the overall assessment of potential risk. In EPA's hypothetical risk assessment, RELMAP results contribute to a mercury concentration in fish of 0.5 ppm, *one-half* the FDA action level. Consequently, a factor of two becomes very significant, dropping the regional contribution to 0.25 ppm in fish.

**COMPMERC.** To estimate the impact from specific sources of mercury emissions, EPA used COMPMERC, a modified version of a dispersion and deposition model called COMPDEP. Air quality models are usually developed for or by OAQPS's Air Modeling branch in Research Triangle Park, NC (RTP). The COMPDEP model, however, was developed by EPA's Environmental Assessment office in

Washington, D.C. The DC office, recognizing that COMPDEP had not been validated nor peer reviewed asked the RTP modeling group to refine COMPDEP. The RTP office had been developing and was about to promulgate the next version of their dispersion model, ISC3, which had been peer reviewed and was more sophisticated than COMPDEP. The RTP group was unable to refine nor validate the wet deposition algorithms in COMPDEP and, in an effort to respond to the request from the Environmental Assessment group, the Modeling group added the wet deposition portion of COMPDEP to the ISC3 model which also included a dry deposition component. The ISC3 model with the COMPDEP wet deposition algorithms was released to the public by EPA along with the caveat that anyone using the wet deposition portion of ISC3 does so "*at their own risk*" and that the wet deposition portion of ISC3 "*should not be used for regulatory purposes*", e.g., risk assessment or permitting (Personal communication, OAQPS, Sept. 1996).

It is puzzling as to why EPA's Environmental Assessment group chose to use COMPDEP for the Mercury Report. COMPDEP suffers from many flaws, such as lack of source depletion and poor handling of wet and dry deposition. EPA's Science Advisory Board criticized EPA in February 1996 for use of unvalidated modeling, including COMPDEP and IEM2, saying that the models "**violate a fundamental scientific principal, i.e., conservation of mass**" and provide "**little grounding of reality of the overall methodology.**"

While EPA's newer model, ISC3, is not a perfect model, it contains a number of improvements over the COMPDEP model, including a plume depletion algorithm designed to conserve mass. Unfortunately, the wet deposition algorithms in ISC3 are the COMPDEP algorithms that have still not received the validation necessary to allow its use as a regulatory tool.

The wet deposition portion of COMPDEP is seriously flawed. For modeling of wet deposition, COMPDEP estimates the maximum wet flux rate and assumes that this occurs at the same point as the maximum dry deposition. It is well known that wet deposition flux rates drop off quickly with distance from the stack, and maximum impacts typically occur within several hundred meters of the stack. The maximum dry deposition impact point, however, occurs much further away from the stack. The wet flux rates can decrease by more than an order of magnitude within a few kilometers of the maximum point. The maximum wet flux rate may be more than 100 times higher than the average flux rate across a 10-km modeled area. Use of the maximum impact point wet flux rate will overestimate long term risks by up to two orders of magnitude.

Air Quality Model Input Parameter Assumptions. EPA also made many assumptions in using the RELMAP and COMPDEP models. The base-case mercury speciation profiles for MWCs were contradictory and without reference. For the RELMAP modeling of MWCs, one table in the Report indicated a base case speciation of 15% elemental, 85% ionic, and 20% particle bound, while another table had the base-case speciation for the same source listed as 20% elemental, 60% ionic, and, 20% particle bound. For the COMPDEP modeling of MWCs, the speciation was assumed to be 15% elemental, 85% ionic, with no particle bound mercury. Thus, three different base-case speciations are listed for the same plant type, all without reference.

The mercury speciation assumed in the draft Report of 15% elemental and 85% ionic for MWCs is also inconsistent with other published data. According to work completed in 1991 by Dr. Nicolas Bloom at the Stanislaus, California waste-to-energy plant, a more accurate percentage is 70% elemental and 30% ionic for an MWC with a scrubber and fabric filter baghouse.



Within the next two to three years, most MWCs will be injecting powdered activated carbon into the flue gas as a mercury emission control method to comply with the 1995 MACT standard. Results of testing conducted by EPA and others show that powdered activated carbon is extremely effective in capturing ionic mercury. Actual results using carbon to control mercury emissions demonstrate at least 90% removal of mercury from MWC flue gases. After MACT controls reduce total mercury emission rates by 90% or greater, the remaining species will be between 70%-90% elemental mercury and between 10%-30% ionic mercury. Therefore, the use of elemental to ionic ratios of less than 70:30 is misleading.

EPA did acknowledge that **"due to the high degree of uncertainty regarding the emission speciation and possible rapid chemical and physical transformations immediately after emission, it is recommended that these maximum simulated deposition values should be considered highly uncertain until further research is conducted to reduce these uncertainties."** Despite this acknowledged "high degree of uncertainty," EPA continued to use speciation values without reference when, in fact, actual field data is available.

Using unvalidated air models and models that consistently over predict along with invalid assumptions can yield projected impact results from specific sources that are orders of magnitude higher than they really are.

**Water Quality and Terrestrial Models.** The model used to predict concentrations in the aquatic and terrestrial compartments, the Indirect Exposure Methodology (IEM2) model, is based on a series of equations initially developed for organic chemicals and is not directly transferable to inorganic mercury compounds. In addition, there are errors in the equations that were used in IEM2. For example, the equation used to predict the gas phase mass transfer coefficient was derived for surface spills of organic liquids and is determined based on the area of the spilled material. This equation is not appropriate for mercury, especially in the case of an ionic species such as Hg(II) or monomethylmercury.

The diffusion of mercury from air to the ground surface or water should be governed by a concentration gradient, but the IEM2 model does not address this factor. The IEM2 model equations also do not address any chemical transformations affecting mercury in soil, water or sediments (oxidation, reduction, methylation, demethylation), nor do they address physicochemical properties important to inorganic chemicals (complex equilibrium, dissolution, precipitation). The chemistry of mercury is complex and dynamic and must be accounted for if a reasonably accurate picture is to be developed concerning mercury's behavior in the environment.

EPA also notes that the model "cannot be used to predict response to reduction or elimination of loadings." Thus, the IEM2 model treats lakes like a bathtub without a drain. If a source reduces its emission or stops emitting altogether, there is no decrease in deposition over time. This is an obvious critical flaw in the model. This disconnect between reality and the IEM2 modeling methodology results in an inaccurate depiction of the potential impacts of mercury.

In addition, the models used to predict sediment concentrations have not been validated, and are likely to produce unrealistic results. Based upon the above, it is estimated that EPA's use of IEM2 and the associated assumptions result in a one to two orders of magnitude overestimation of mercury impacts.

**Impacts on Fish.** The methodology used to calculate concentrations of mercury in water does not adequately address the complex nature of the mercury biogeochemical cycle in the aquatic environment. The EPA model structure is overly simplified, with the soil-water partition coefficient assuming

inordinate importance in predicting mercury behavior. Many other equally or more important factors and reactions affecting mercury behavior in reality are not addressed in the model, including acid-base reactions, oxidation-reduction reactions, methylation, complexation, water temperature, pH and dissolved organic carbon. Models that incorporate the factors affecting the behavior of mercury are important adjuncts to predicting bioaccumulation. EPA, however, rejected the use of more refined approaches such as the mercury cycling model (MCM) outlined in Hudson et al. (1994), choosing instead "to accept that considerable variation exists in mercury bioaccumulation in fish". The result of these decisions is a low degree of confidence in the results from the IEM2 model. Numerous alternative aquatic models (e.g., REDEOL, WATE02, MINEOL, MEXAMS) exist that can be used to deal with the equilibria of mercury in aquatic systems. These models incorporate pH effects, redox chemistry, precipitation, surface adsorption, ligand exchange and formation of ternary complexes.

The methodology that EPA used to address mercury bioaccumulation in fish also suffers from uncertainty. The Agency notes in the draft Report that there is a "substantial level of uncertainty" in the bioaccumulation values for the two trophic levels of fish studied, and shows that both the derived bioaccumulation factor values and the bioaccumulation factor values based on estimates derived from the literature vary by *more than two orders of magnitude*. The Agency nevertheless uses point estimates for bioaccumulation factors to predict deterministic exposures in the Report without ever analyzing the precise level of uncertainty.

## CONGRESS and FEDERAL AGENCIES

Voicing concern over the conclusions in the draft Report, several federal agencies, including the Food and Drug Administration and the Departments of Agriculture, Commerce and Energy, requested that they be allowed to review the Report before it was released (Environment Reporter, April 1996).

One of the primary concerns expressed was how little mention there was in the Report of the National Institute of Environmental Health Sciences (NIEHS)-funded study of the Seychelles Islands. This comprehensive multi-year study was an attempt to overcome the problems of all of the other epidemiologic studies of the health impacts of mercury exposure. EPA based its human health impact analyses in large part upon the results of the study of the mercury contaminated grain episode in Iraq in 1971. The Iraqi study, which was after-the-fact and anecdotal, indicated that fetal exposure to very low levels of mercury would lead to developmental problems. However, many researchers, including the researchers that conducted the Iraqi study have cautioned that the Iraqi study should not be used to derive toxicological assumptions for mercury. EPA also reviewed other mercury-related human health studies, but in most of these case studies, there were limitations and/or confounding factors.

The Seychelles' study is being conducted by a team from the University of Rochester and includes members of the team that conducted the Iraqi study. According to NIEHS, the Seychelles Islands study, "a study of children of heavy, daily fish consumers, demonstrated no developmental damage from the same levels of mercury exposure that was found in the Iraqi study." (NIEHS Press Release, 1996.)

Subsequent to the release of the 1995 draft Report, EPA did make some changes in the Report which did address some of IWSA's comments. For example, EPA included three mercury emission speciation scenarios for MWCs: the original speciation assumption and two assumptions which more closely relate to actual measured data from MWCs. The modeling results using these alternative scenarios, which showed insignificant impacts, were not discussed in the Executive Summary nor the Summary and

Conclusions of the revised Report. These speciation scenarios are found on one page of text and three tables in the middle of the 100-plus page Volume III of the revised draft Report.

## SCIENCE ADVISORY BOARD

Concerned that EPA might complete the Mercury Report before the important Seychelles work was published, a bipartisan group of Senators and members of Congress asked EPA to delay finalizing the Report until the Seychelles study was released and could be incorporated into the EPA Report. This group also asked EPA to submit the draft Report to EPA's Science Advisory Board (SAB) for review. On June 18, 1996, EPA announced that it was delaying the release of the Report and had sent the revised draft Mercury Report to the SAB to begin its review.

On February 26 and 27, 1997, the Mercury Subcommittee of the SAB held a Public Meeting to review their findings and receive comments from the public on the draft Report. According to published accounts (Daily Environment Report, February 1997) the Subcommittee strongly criticized the computer risk assessment models used by EPA as inadequate and unable to predict impacts from specific sources, and that EPA should not imply that the models are capable of accurately predicting impacts on humans, wildlife or aquatic life. The SAB panel pointed to EPA's own admission that the models are incapable of predicting the change in impacts on human health or wildlife due to decreases in any particular source.

The panel also reiterated EPA's own statements that the report and the estimates of risk are based on **qualitative** and not **quantitative** analyses. The panel suggested that EPA either remove the predictive models altogether from the report or make improvements and rerun the models with the qualifier that the results are still qualitative and should not be used for regulatory or risk assessment purposes.

The Subcommittee also pointed out that there is a large amount of mercury in the environment today that is the result of historic practices as well as ongoing activities such as gold and copper mining in South America and Asia that the U.S. has little ability to control. As this reservoir of mercury is re-emitted into the environment, it may equal the total current anthropogenic emissions. Therefore, additional controls on current mercury emissions in the U.S. may have little impact on the amount of mercury deposited in the U.S.

The Subcommittee nonetheless endorsed the Report's overall conclusion that exposure to methylmercury is harmful even at relatively low doses based upon the Iraqi and other studies cited in the draft Report. The Seychelles' studies included a small number of outlier results which the Seychelles' researchers felt could justifiably be removed from the evaluation. Without these outliers, the Seychelles' study showed no health impacts at the low levels reported in the previous studies. With the outliers, the results were unclear. The Panel believed that there was insufficient justification for discarding the outliers, and that meaningful results from Seychelles studies were still two years off.

The Panel found that EPA's current reference dose (Rfd), based on the Iraqi study, was within an order of magnitude of that suggested by the other studies EPA reviewed and the Seychelles' study, and that this is within an acceptable margin of safety. Therefore, the Panel determined that EPA should not revise its Rfd.



## SUMMARY

There are so many errors and questionable assumptions in the draft Mercury Report to Congress that it would take many more pages to discuss them all in detail than can be done so here. Some of the errors don't even pass a logic test, e.g., in the Report, EPA predicted that a single large municipal waste combustor could cause a mercury concentration of 26 ug/g in fish in a nearby lake, and yet, the highest concentration of mercury in fish in EPA's database is 8.9 ug/g. No fish sampled near an operating MWC have ever yielded a mercury level of even approaching 8 ug/g.

In many parts of the report, EPA states that there is substantial uncertainty or variability inherent in the modeling input parameters, such as the deposition flux rate or the fish bioaccumulation factor and fish ingestion rates. However, these caveats are not adequately carried through to the results of the analysis and therefore do not allow the reader to place the information into a reasonable context.

EPA has taken the approach of speculating on the worst case, hypothetical, potential impact that might ever occur using the most rudimentary and convenient models and assumptions. The failure to carry acknowledged uncertainties through into the main body of the analysis will lead to misinterpretation of results. These errors and assumptions can result in overestimating predictions of potential risk by several orders of magnitude.

The EPA Science Advisory Board Mercury Subcommittee has criticized EPA for many of the same reasons that others have, e.g., that characterizing the risk to human health and wildlife cannot be done in a quantitative fashion since the various models do not have the ability to accurately predict the health impacts of anthropogenic source emissions and their indirect exposure pathways. However, the SAB did not suggest that EPA increase the Rfd based upon the results of the Seychelles study. The studies that EPA relied upon were flawed and contain confounding factors which make it difficult to specifically attribute a cause/effect relationship to mercury. Even though the results of the Seychelles study show that the Rfd is within an order of magnitude of the one proposed by EPA, the Rfd for mercury should still be increased since it is based upon a series of studies with questionable results.

Nevertheless, EPA now must address the errors in the Report before a final version is released to Congress and the public.

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