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"Assessing State and Local Regulations to Reduce Dental Mercury Emissions"

Introduction

Thank you, Chairman Kucinich and members of the Committee, for inviting me to testify about Massachusetts' efforts to reduce mercury pollution attributable to the dental sector. I am also pleased to share information with you about some of the programs underway in the other New England states to address this issue, which are being implemented under the New England Governors and Eastern Canadian Premiers Mercury Action Plan

As a scientist, a policy-maker, father and a fisherman I am very concerned about mercury pollution and its effects on our environment and on children's health. Throughout much of my professional career in the field of toxicology, in which I have a Ph.D. degree from Harvard University, and in environmental policy, in which I have a M.S. degree from the Harvard School of Public Health, I have been involved in mercury policy and research. I direct the Massachussetts Department of Environmental Protection's (MassDEP) multimedia mercury program, co-chair the New England Governors and Eastern Canadian Premiers (NEG-ECP) Regional Mercury Task Force (MTF); serve as the MA representative to the Quicksilver Caucus, a coalition of state environmental organizations focused on reducing mercury pollution; and serve as the northeast state representative to the Commission for Environmental Cooperation's North American Regional Action Plan for Mercury Task Force.

I am providing testimony at this hearing on behalf of MassDEP and the New England Governors Conference (NEGC). The NEGC, established by the Governors of the six New England states, coordinates regional policy programs in the areas of economic development, transportation, environment, energy and health. The NEGC also represents New England on the bi-national Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP).

Mercury Pollution in Massachusetts and the Northeast

Mercury pollution is a serious environmental and public health issue in MA and the across the country. The New England states and New York recently completed a regional total maximum daily load (TMDL) assessment for mercury that provides insight into the extent and

magnitude of mercury pollution in the northeast. TMDLs are required under the Clean Water Act. Simply put, a TMDL is a calculation of the maximum amount of a pollutant that a water body, or group of water bodies, can withstand and still meet applicable water quality standards, including fish that are safe to eat. A TMDL also includes an implementation plan to resolve the impairment.

The New England Interstate Water Pollution Control Commission coordinated the northeast (NE) mercury TMDL assessment, which covers the New England States and New York (see http://www.neiwpcc.org/mercury/MercuryTMDL.asp; accessed July 2008). This multistate regional TMDL was released for public review and comment in April 2007. Eight public informational meetings were then held throughout the region and a final document, reflecting public input, was submitted to USEPA in October 2007. The TMDL was approved by USEPA on December 20, 2007 (see http://www.neiwpcc.org/mercury/mercury-docs/FINAL%20Northeast%20Regional%20Mercury%20TMDL.pdf; accessed July 2008).

The NE regional mercury TMDL highlights the widespread and serious impacts of mercury pollution in our region, where over 10,000 lakes, ponds, and reservoirs, and over 46,000 river miles are listed as impaired for fish consumption due to mercury. In order to achieve the TMDL calculated in this assessment, anthropogenic mercury deposition to the region's freshwater bodies will need to be reduced by 87 - 98 percent. This will require reductions in mercury pollution from all preventable sources, including the dental sector, coal-fired utilities and other sectors. Furthermore, because mercury pollution can travel for long distances once released into the environment, no single state or region can solve this problem in isolation. Comprehensive and aggressive mercury pollution reductions on a national level are needed.

The New England Governors and Eastern Canadian Premiers Mercury Action Plan and the MA Zero Mercury Strategy

Taking a lead-by-example approach, MA and the other New England states are implementing an aggressive regional mercury reduction strategy. This initiative, the bi-national New England Governors/Eastern Canadian Premiers Mercury Action Plan (MAP), was

unanimously adopted by the Governors of the New England states and the Premiers of the Eastern Canadian Provinces in June of 1998 (http://mass.gov/dep/toxics/priorities/negecp.pdf; accessed July 2008). The MAP established a long-term goal of virtually eliminating anthropogenic sources of mercury pollution in the region. Interim goals of a 50% reduction by 2003 and 75% by 2010 compared to a 1998 baseline, were also adopted. MA is also implementing a statewide Zero Mercury Strategy (http://www.mass.gov/envir/Sustainable/resources/pdf/Resources_Hg_Strategy.pdf; accessed July 2008).

To date these efforts have been a great success. The region achieved a 54% reduction in mercury emissions by 2003 and is well on its way to the 2010 reduction target. In MA, mercury emissions have been reduced by greater than 70%. These reductions have been accomplished through the adoption and implementation of strict mercury reduction programs targeting all major sources of mercury pollution. These include: trash incinerators, for which MA and regional emission limits are 3-fold more stringent than required by the USEPA (see http://www.mass.gov/dep/air/laws/regulati.htm; accessed July 2008); coal-fired electric generating units, for which MA regulations require 85% emissions control in 2008 and 95% by 2012, much more stringent than the recently vacated Clean Air Mercury Rule (see http://www.mass.gov/dep/toxics/stypes/hgfact.doc; accessed July 2008); mercury-added products, where MA and other New England states have adopted legislation that phases-out unnecessary uses of mercury, requires manufacturer funded recycling programs, product labeling and product notification to a regional data-base of mercury-added products (see http://www.mass.gov/dep/toxics/stypes/hgres.htm#mma; accessed, July 2008); and the dental sector, which is discussed in greater detail below. These initiatives substantially exceed USEPA requirements and are being successfully implemented across the region.

Mercury Pollution Attributable to the Dental Sector

Mercury from the dental sector may be released to the environment in several forms including amalgam particulates, soluble mercury, and mercury vapor. Once released into the environment all of these forms of mercury may ultimately be converted into a chemical form of

mercury, methyl mercury, which is extremely toxic to the developing brain of the fetus. Methyl mercury is also strongly bioaccumulated in fish, often to levels that are unsafe for human consumption. As indicated in the regional mercury TMDL discussed previously, mercury contamination of fish is an extensive cause of water body impairment in MA and the northeast.

Dental mercury is disposed of into wastewater when amalgam fillings are installed, shaped or removed. Mercury from the dental sector has been estimated to account for a significant fraction of mercury loadings to municipal sewage. The Massachusetts Water Resources Authority (MWRA), which operates the largest sewage treatment facility in MA, estimated that mercury from the dental sector was responsible for 13% to 79%, with a midpoint estimate of 46%, of mercury loadings to its system in the 1990's, prior to MA state initiatives to address this source (*Mercury in Dental Facilities: Boston* (1997) http://www.mwra.state.ma.us/03sewer/html/dentsum.htm; accessed July 2008). Values of 40-50% are also supported by observations in other cities, where substantial reductions in mercury loadings have been reported following rules mandating the use of amalgam separator pollution controls. Sludge mercury levels in Toronto, Canada were reported to have decreased by more than 50% following the adoption of bylaws that required all dentists to meet stringent mercury discharge limits through the use of amalgam separators (*Toronto Sewer Use Bylaw*, Great Lakes Binational Toxics Strategy Mercury Workgroup presentation by Robert Krauel (2002) http://www.epa.gov/Region5/air/mercury/meetings/Krauel.pdf; accessed July 2008). In Minnesota, mercury reductions of 29% - 44% were reported at two wastewater treatment plants (WWTPs) when amalgam separators were installed at dental clinics (Anderson, 2001). Similar reductions have also been observed in Washington State and Massachusetts. These data indicate that efforts to control dental mercury discharges to wastewater at the source are an effective mechanism to reduce environmental releases of mercury attributable to municipal wastewater and bio-solids treatment and disposal.

The majority of dental mercury entering wastewater is in the form of relatively small particles of mercury amalgam. Larger pieces of mercury amalgam are can be captured by chair-side traps and vacuum filters and would thus not enter wastewater (unless the traps are cleaned in a sink). Although there is debate about the effectiveness of these traps and filters, a study

published by the *Journal of the Canadian Dental Association* (Adegbembo, et al., 2002) demonstrated that they remove about 40% of mercury amalgam. Although this is a substantial fraction, in this study close to 60% of the waste dental mercury was not captured and would thus have entered wastewater discharged from the dental office if secondary pollution controls (amalgam separators) were not in use.

Because the small amalgam particles not captured by chair-side traps and filters have a large surface area to volume ratio, mercury from this amalgam can more easily dissolve and volatilize to the air compared to intact fillings. Thus, although mercury in amalgam is less volatile and soluble than elemental or ionic mercury, it can be mobilized and become available for methylation if released to the environment. This conclusion is supported by experimental evidence that demonstrated that mercury levels in fish increased over 200-fold when they were exposed for only 28 days to representative samples of amalgam typically found in dental wastewater (Kennedy, 2002). Data from dental clinics also demonstrates that soluble mercury can be discharged directly in untreated dental wastewater and that the use of oxidizing cleaners (e.g. bleach) increases the amount of such soluble mercury (Batchu et al, 2006).

Much of the mercury amalgam discharged from dental offices is concentrated into WWTP sludge and can subsequently be released to the biosphere if this material is incinerated or beneficially reused. Sewage sludge incinerators (SSI) do not typically have air pollution controls specifically designed to control mercury. Data on mercury emissions from SSI are sparse and national emission estimates are very uncertain. Based on limited stack test data, Massachusetts' SSI were estimated to emit about 150 pounds of mercury per year prior to regional and state efforts to reduce mercury wastewater discharges (*Mercury in Massachusetts*, MassDEP (1996) http://www.mass.gov/dep/toxics/stypes/hgtoc.htm; accessed July 2008). In the northeast, SSI were more recently estimated to be the region's third largest point source category of mercury emissions accounting for about 12% of the region's total (*Inventory of Anthropogenic Mercury Emissions in the Northeast*, Northeast States for Coordinated Air Use Management (2005) http://www.nescaum.org/documents/inventory-of-anthropogenic-mercury-emissions-in-the-northeast/; accessed July 2008). The inventory did not estimate direct wastewater discharges attributable to WWTP, septic systems, and sewer overflow events nor the amount of mercury

entering the environment from the land application of treated biosolids (sludge). These pathways would considerably increase the total.

The mercury present in sewage biosolids that are beneficially reused contributes to environmental releases of mercury. Mobilization of significant amounts of mercury from land-applied sludge has been documented and was accelerated by exposure to sunlight (Carpi et al., 1997a). Methyl mercury levels in surface soils amended with sewage sludge were also increased (Carpi et al., 1997b). Carpi et al. estimated a total flux of approximately 10,000 pounds of mercury to the air from land applied municipal sewage sludge per year in the US and Europe (Carpi et al., 1997a). Although there is no specific data on the rate at which mercury is mobilized from mercury amalgam particulates in land-applied biosolids, it is likely, given the relatively small sizes of the amalgam particulates in the material as well as its long-term exposure to variable environmental conditions including acid rain, sunlight and temperature, that a significant fraction of such mercury would be mobilized and become available for methylation over time.

In addition to SSI emissions and releases from land-applied sludge, a smaller amount of mercury derived from dental sector discharges will be directly released to surface or ground waters in WWTP effluent. Direct releases of dental mercury from sewers to waterways may also occur via combined sewer overflows during storm events that exceed a treatments system's capacity. High flows during such events are likely to "scour" settled mercury amalgam out of sewer lines resulting in direct discharges. Disposal into septic systems presents another pathway for mercury releases. Because of their high density, mercury amalgam particles will primarily settle out in a septic system's holding tank. Although much of this mercury amalgam would likely be pumped out and disposed of to WWTPs, direct impacts to groundwater, as well as the potential production of methyl mercury within septic systems, may occur.

Best management practices (BMPs) for waste amalgam specify that it be disposed of as a hazard waste or, preferably, recycled. Although the majority of dentists follow BMPs regarding the disposal of waste mercury and mercury amalgam, the available data suggest that some may not, resulting in dental mercury entering the trash or medical waste. Such disposal will result in

releases during handling and transport, potential releases at medical waste sterilization units, and will contribute to municipal solid waste incinerator emissions and landfill releases in leachate and landfill gases.

A 1995 audit of dental practices by the Western Lake Superior Dental Waste Management Program revealed that mercury amalgam was being disposed of in incinerated waste streams (infectious waste and solid waste) (*Western Lake Superior Dental Waste Management Program* http://www.epa.gov/Region5/air/mercury/meetings/tuominen.htm; accessed July 2008). A study by Kings County, WA also documented that mercury amalgam wastes were being disposed of into solid waste (*Mercury in Waste Dental Amalgam: Why Is It Still a Problem?* (2003) Local Hazardous Waste Management Program in King County; http://www.govlink.org/hazwaste/publications/WasteAmalgamProblems_03.pdf; accessed July 2008). Compliance audits in MA have also revealed instances where dental offices or their contractors inappropriately disposed of amalgam waste (see below). Further outreach and compliance assistance to dental offices is needed to help minimize inappropriate handling and disposal of dental mercury wastes.

State Initiatives to Reduce Mercury Pollution from the Dental Sector

The dental sector has been identified as a significant source of controllable mercury releases by many states. The Quicksilver Caucus (QSC), a coalition of state organizations seeking to reduce mercury pollution, recently published a review of state initiatives across the country addressing this source of mercury release (see http://www.ecos.org/files/3148_image_Corrected_Final_Dental_Amalgam_White_Paper_April_2008.pdf ; accessed July, 2008). This report was designed to help inform and assist states developing dental pollution reduction programs. The QSC report concluded that mercury from dental amalgam is a major source of controllable mercury released to the environment and likely will remain a significant concern into the future.

Overall, state initiatives have focused on increasing the use of amalgam separator control technologies and other best management practices to reduce mercury discharges to wastewater

and disposal into other waste-streams. Amalgam separators are relatively inexpensive technologies designed to capture mercury containing amalgam particulates, and in some cases soluble mercury as well, from dental office wastewater. Compliant units can reduce mercury discharges by a significant degree, typically greater than 95 - 99% based on the International Organization for Standardization (ISO) 11143 test protocol. Additional BMPs are primarily designed to ensure the safe handling and storage of waste mercury and to minimize inappropriate disposal.

According to the information compiled by the QSC, eleven states and numerous municipalities have adopted mandatory programs requiring the use of dental mercury amalgam separators to reduce mercury levels in wastewater from dental offices. Multistate regional efforts are also being implemented.

State and Municipal Approaches: Voluntary vs. Mandatory Programs

States and municipalities have used several approaches to increase the use of amalgam separators. Several of the programs considered in depth in the QSC report started with voluntary efforts to encourage the use of amalgam separators and other best management practices (BMPs). All of these programs ultimately transitioned to mandatory requirements either through legislation, regulation or enforcement of wastewater discharge permits.

For example, from 1994-2000, King County, Washington implemented a program to encourage the voluntarily installation of amalgam separators. Extensive outreach was conducted in collaboration with the local dental association and rebates were offered to defray the purchase cost of separators. By 2001, only 3% of the estimated 900 offices in the county had installed amalgam separators. The County then announced that mercury wastewater discharge limits would be enforced. Within 2 years over 80% of dental offices installed separators (see http://www.govlink.org/hazwaste/publications/WasteAmalgamProblems_03.pdf; accessed July 2008). A statewide voluntary program in Washington State achieved only 40% participation, prompting the adoption of mandatory requirements under the state's hazardous waste regulations. In MA, initial efforts to voluntarily increase amalgam separator use also did not

achieve high participation rates. Excellent participation occurred when the state announced a timeline for the adoption of regulations requiring separator use and provided an incentive-based voluntary early compliance program.

Regional Coordination Under the New England Under the NEG-ECP Mercury Action Plan

In order to reduce regional mercury emissions from sewage sludge incinerators and releases attributable to other pathways, the NEG-ECP adopted, in August 2005, a goal that 75% of dentists who generate amalgam mercury containing wastewater in the New England States and Eastern Canadian Provinces should have amalgam separator pollution controls installed by the end of 2007, and 95% by 2010. The Mercury Task Force (MTF) coordinating the MAP recommended this action because, by addressing mercury inputs to wastewater at the source, all subsequent release pathways would be reduced including incinerator emissions, releases associated with biosolids reuse and or disposal, and WWTP and other wastewater discharges.

By 2007 all states in the New England region had adopted legislation and/or regulations requiring the use of amalgam separators and other best management practices to reduce mercury amalgam discharge and disposal. Currently the states estimate that over 91% of dentists who generate mercury waste are now using amalgam separators. These programs are estimated to have reduced mercury entering the region's sewage by many hundreds of pounds each year.

This regional approach has facilitated progress and efficiency by leveling the playing field, providing mechanisms to share outreach materials, and facilitating coordination regarding regulatory and reporting requirements.

Massachusetts Efforts to Reduce Mercury Pollution from the Dental Sector

In MA, regulatory agencies including MassDEP and the Massachusetts Water Resources Authority (MWRA) have worked collaboratively with the Massachusetts Dental Society (MDS) to reduce mercury releases from the dental sector for many years. In the late 1990's the MWRA worked with the MDS on outreach efforts to increase the use of BMPs and amalgam separators

in the greater Boston area in order to reduce mercury levels in treated sludge. Building off of these efforts, in 2001, a joint Memorandum of Understanding (MOU) was adopted between state agencies and the MDS to formalize co-operation on outreach and communication efforts. Outreach efforts included the production and distribution of a BMP placard; inclusion of information on the MDS website; and presentations at state and regional dental conferences. As part of this initiative the MA Innovative Technology program also funded an independent assessment of amalgam separators by the University of Massachusetts to help address MDS member concerns about the efficacy of these units. The study concluded that amalgam separators were effective in reducing mercury discharges (*Development, Evaluation and Implementation of a Testing Protocol for Evaluation of Technologies for Removal of Mercury from Dental Facilities (2003);* see http://www.mass.gov/envir/lean_green/documents/other/removal_mercury_from_dental_facilities_part1.pdf; accessed July 2008).

Although the MOU helped to raise awareness of the environmental impacts of dental mercury wastewater discharges, amalgam separator sales were reported to have increased only modestly in MA.

In 2004, to level the playing field and speed up the use of separator technologies, MassDEP initiated a follow-up two-phase program. At the start of this initiative, MassDEP indicated that it would develop and adopt regulations in 2006 requiring the use of amalgam separators, among other provisions. To achieve faster mercury pollution reductions while the regulations were being developed and implemented, the agency also initiated an incentive-based voluntary early compliance program. This program was devised in collaboration with MDS (*Dental Amalgam/Mercury Recycling: About the Voluntary Program (2004)* http://mass.gov/dep/service/about08.htm; accessed July 2008).

Incentives were provided to encourage dentists to participate in this voluntary early compliance program. Those participating before March 1, 2005 were exempted from permit fees and amalgam separator systems achieving 95% amalgam removal efficiency were grandfathered until February 1, 2010. Dentists who certified participation after February 28, 2005, but before

February 1, 2006, were exempted from permit fees and grandfathered for a shorter period, until February 1, 2007.

This incentive-based early compliance program was very successful. About 75% of MA dentists participated in the first year of the program. Regulations requiring the use of amalgam separators and BMPs were subsequently adopted in April of 2006 (*310 CMR 73.00: Amalgam Wastewater and Recycling Regulations for Dental Facilities* (2006) http://mass.gov/dep/service/regulations/310cmr73.pdf; accessed July 2008). These were developed with the assistance of a stakeholder workgroup including individual dentists, MDS representatives, sewerage authorities, and environmental groups.

The regulations require dental practices and facilities to certify to MassDEP every five years that:

- They have installed an amalgam separator system(s) demonstrated to remove at least 98 percent of mercury amalgam waste based on the International Organization for Standardization (ISO) 11143 protocol or an equivalent method acceptable to MassDEP;
- Every dental chair in the practice or facility where waste amalgam is generated and all wastewater that contains waste amalgam (including wastewater from chairs and cuspidors), is serviced by an installed separator(s);
- Installed separator units are sized appropriately to accommodate the facility's maximum amalgam wastewater flow;
- The amalgam separator system is maintained and operated according to manufacturer specifications;
- They use only non-corrosive and biodegradable vacuum system line cleaners;
- All amalgam waste containing mercury is appropriately recycled;
- Facility staff are informed about procedures for handling waste amalgam, and that at least one employee is familiar with procedures for operating and maintaining the installed amalgam separator system;
- They keep records to document that the program requirements are being met.

Facilities that participated in the voluntary program were allowed to continue using their 95 percent efficient amalgam separators but when the separators need to be replaced, units that meet the 98 percent removal efficiency standard are required.

Further details regarding compliance and filing deadlines, acceptable amalgam separators, companies that provide amalgam mercury recycling services, and recommended practices for handling amalgam and mercury wastes are available at http://www.mass.gov/dep/service/dentists.htm#regs; accessed July 2008).

Both the early compliance program and the final regulations relied on self-certification of compliance with the stipulated requirements. In order to simplify certification filings and database management, an electronic form and submission system were developed. Because not all dental practices were internet capable, hard copy submissions were accepted as necessary.

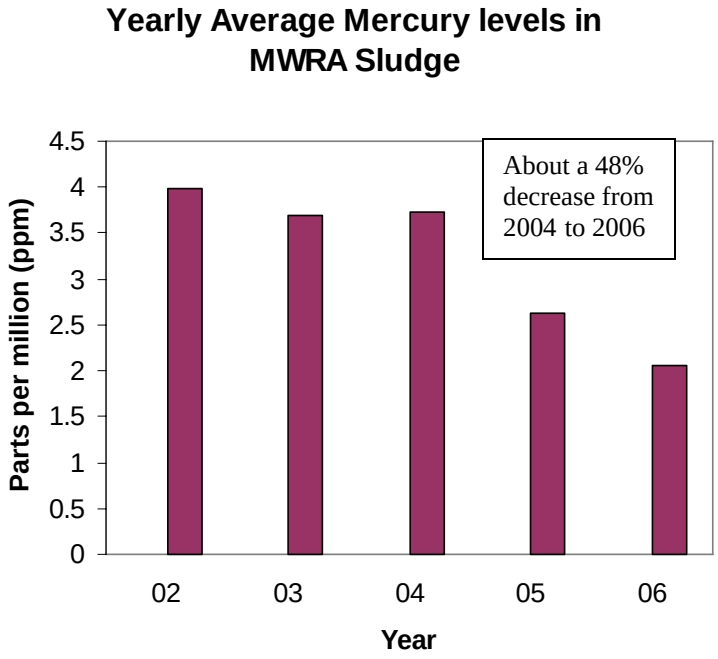
Compliance is being evaluated using audits and site visits to a statistically based sample of dental offices. Initial site inspections of 56 facilities, conducted in 2007, demonstrated excellent compliance with the amalgam separator installation requirements. All facilities had appropriate amalgam separators on-site although at one office the unit had not yet been installed. All installed separators were noted as being operated and maintained appropriately with about one third of the offices using a service provider and the remainder doing the work themselves. The audits did, however, reveal some areas for improvement. About 20% of facilities were not keeping adequate records. Confusion regarding appropriate recycling of amalgam waste was also evident, with close to 20% disposing of some mercury waste to “red bags” (infectious waste) and close to 10% not sending any mercury waste to an approved recycling facility.

On a related issue, MassDEP is investigating a dental amalgam “recycling” service that allegedly charged dentists to recycle waste amalgam, but then treated the amalgam to recover silver and illegally disposed of the residual mercury material into the sewer. Sampling of a sewer drain reportedly used for the illegal disposal contained mercury levels so high that, even with a 1000-fold dilution, the material grossly contaminated an agency mercury analyzer.

Taken together, these results indicate that dental offices and regulatory agencies need to pay close attention to the ultimate fate of collected waste mercury to ensure it is properly recycled or disposed of.

Environmental Results

Despite the compliance issued noted above, the overall effectiveness of the MA dental initiative is supported by data from the Massachusetts Water Resources Authority (MWRA), MA's largest sewage treatment facility, which services close to 2.5 million people. MWRA carefully monitors mercury levels in its treated sludge, almost all of which is beneficially reused as a soil amendment. As indicated in the Figure below, over the 2004 – 2006 period, when amalgam separator use increased to over 75% in MA, mercury levels in MWRA sludge decreased by about 48%.



Similar reductions have been reported in Washington State, Montreal, Toronto, and the Minneapolis-St. Paul area.

Conclusions

1. Substantial data indicate that the dental sector has been a significant source of mercury discharges to wastewater, which ultimately results in environmental releases attributable to sludge incineration, sludge reuse and wastewater discharge.
2. Substantial data also indicate that the use of amalgam separators and related best management practices can significantly reduce such releases.
3. State experiences to date indicate that collaborative initiatives with state dental organizations, which in the case of MA and other New England states have been very supportive of efforts to reduce mercury pollution from their profession, can help to raise awareness about amalgam separators and BMPs.
4. Regional and state goals with timelines for use of amalgam separators and BMPs provide benchmarks for assessing progress, help focus attention and motivate action.
5. In MA and Washington state, purely voluntary efforts to encourage the use of amalgam separators and BMPs did not reach participation levels sufficient to achieve environmental goals. Near complete compliance was quickly achieved when the states transitioned to mandatory programs.
6. The incentive-based early compliance program implemented by MA during the development and finalization of state regulations was highly effective in spurring the early use of amalgam separators and BMPs, rewarded environmentally conscious, proactive dental practices and achieved substantially quicker reductions in mercury discharges.
7. Follow-up compliance checks indicate that continued outreach and communication with dental practices is necessary to ensure that collected mercury wastes are properly recycled.

In summary, the successful experiences of MA and other states in reducing mercury pollution from the dental sector support further national action in this area. Programs that include outreach and education to the dental community, quantifiable goals and mandatory deadlines for

the use of amalgam separators and other BMPs have been demonstrated to be achievable and effective.

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