DENTIST THE MENACE?

The Uncontrolled Release of Dental Mercury

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Executive Summary

While there has been considerable public debate about the potential health effects of mercury fillings, little attention has been focused thus far on the disposal of waste dental mercury. Dental clinics remain largely unregulated for mercury disposal and extracted amalgam materials are often rinsed down the drain, usually to a municipal wastewater system (or septic system), deposited in biomedical waste containers destined for waste incineration, or placed in trash disposed in a municipal waste landfill or incinerator. By far, the largest single contributor of mercury to wastewater is from dental offices. While most other anthropogenic mercury uses—and their subsequent releases—have declined by 80 percent or more since the 1980s, this has not been the case in the dental sector. Today, dentists are the third largest user of mercury in the United States, consuming over 20 percent of the estimated 200 metric tons used in 2001—or over 40 metric tons of mercury—with most eventually released into the environment.

Mercury is a persistent, bioaccumulative toxin that poses a risk to human health, wildlife and the environment. While mercury is a naturally occurring metallic element, numerous human activities—including the use of dental fillings—contribute 70 percent of emissions into the environment. Levels of mercury in the environment have increased dramatically, with a twenty-fold increase over the past 270 years. Pregnant women and their developing fetuses, infants and young children are especially susceptible to the harmful neurological effects of mercury. A July 2000 National Academy of Sciences study found that at least 60,000 children are born at risk for adverse neurodevelopmental effects each year due to their mothers' exposure to methyl mercury. Further, data released from a Center for Disease Control and Prevention study in March 2001 indicates that at least one in ten women of childbearing age is exposed to mercury at levels above what is considered safe—translating into nearly 400,000 children born at risk of mercury exposure each year.

The change required in dental office practices is relatively straightforward and inexpensive. *For example, it costs less than $ 50.00 a month, slightly less than the cost of a single filling, for dentists in the Massachusetts Dental Society to remove and recycle mercury from amalgams.* However, only a small percentage of dentists nationwide have taken the steps necessary to reduce use and release of this dangerous toxin. Up until recently this lack of action may, at least in part, be a result of the general focus primarily on voluntary mercury reduction initiatives at dental clinics by government agencies over the past decade or so.

Another significant factor is that the influential American Dental Association (ADA), as well as many state dental associations, has refrained from promoting, and even opposed mercury reduction efforts. Following the lead of the ADA, the U.S. dental establishment has consistently resisted efforts to reduce releases of mercury and follow suit with the rest of the health care establishment. The ADA refuses to encourage its members to assume responsibility for curtailing dental mercury pollution, opting instead to obstruct initiatives at the state and local levels. Consistent with its position, the ADA is now advocating for the Food and Drug Administration to effectively preempt significant legislative advances made at the state level. In doing so, the ADA relies on questionable scientific assumptions that deny the serious impact of mercury releases and its build up in the environment.

Yet a growing number of governments now believe that dental mercury is a serious problem that needs to be addressed, and they are beginning to act. Many countries, especially in Western Europe and Canada—and a small, but growing number of local and state governments in the U.S—now recognize dental mercury waste as a serious environmental pollutant and are enacting both voluntary guidelines and stringent policies to curtail its release. State and local governments are now finding that the establishment of some enforceable requirements, in addition to voluntary incentives, are providing the necessary impetus for dentists to change practices in the classic "carrot and stick" approach which has proved very successful in many other applications.

Clearly, the time has come for U.S. dental associations—as other health care industry associations are already doing—to embrace the fundamental credo of "first do no harm," by taking responsibility to reduce amalgam use and mercury pollution. Environmentally responsible dental clinics reduce the use of mercury where feasible, employ best management practices and operate amalgam separators to get the highest capture rates of dental mercury. This approach protects human health and the environment while requiring only a modest, compact, and available shift in clinical practices and expenses.

Recommendations

1. Disposal of dental amalgam into all waste streams should be prohibited and all dental mercury should be trapped, collected and recycled.

2. The reduced use and release of dental mercury should be fostered through voluntary incentives, technical assistance and mandates to encourage and/or require dentists to:
   - adhere to stringent best management practices
   - install amalgam separators to reduce mercury discharge by 95 percent or more
   - clean and replace mercury-laden pipes and plumbing fixtures
   - manage quantities of excess elemental mercury properly
   - submit annual reports on dental mercury reduction initiatives, including the quantities of mercury used and recycled.

3. An investigation should be conducted to determine environmental impacts and potential liability implications of dental mercury released into septic systems.

4. Mercury reduction and sampling requirements should be phased in over time for all municipal wastewater treatment plants.

5. The American Dental Association's efforts to obstruct state and local initiatives to reduce dental mercury releases should be strongly opposed, including recent efforts to convince the Food and Drug Administration to preempt state legislation in this area.

SECTION I

INTRODUCTION

Dental amalgam has been used extensively as a restorative material in teeth for over 150 years. Amalgam is a metallic alloy consisting primarily of four metals—mercury, silver, copper and tin—with mercury comprising around 50 percent of the amalgam materials.[1] Despite the existence of increasingly attractive non-mercury fillings, U.S. dental associations continue to recommend the use of amalgam, citing its "nearly fool-proof ease of use, high clinical success, relatively low cost, and known performance."[2] However, current practices result in significant quantities of mercury being released from dental clinics, contributing to the build up of this toxic heavy metal into the global environment.

Nationwide, the dental sector is now the third largest user of mercury. Approximately 100 million amalgams are placed in patients each year by 175,000 U.S. dentists,[3] and around 70 percent of these are replacement fillings, according to the American Dental Association. Historically, U.S. dentist clinics purchased 2,767 metric tons of mercury or approximately 55 metric tons per year between 1941 and 1990.[4] Since the 1980s, dental use of mercury has declined slightly due to the changeover from elemental mercury to prepackaged dental amalgam capsules and the increasing use of non-mercury fillings. Yet the percentage of total mercury used—and released—by dentists has increased significantly due to voluntary phase outs and the controls imposed on other industries. According to recent estimates, the dental sector used 41 metric tons of mercury in 1999[5] and 44 metric tons in 2001[6] (or 22 percent of the total 220 tons used last year) compared to 50 tons in 1985 (or 3 percent of the total 1,718 metric tons).[7]

Current projections anticipate that dental mercury use is expected to remain relatively stable, with perhaps a gradual decrease, in the coming years.[8] The table presented below provides consumption data on major mercury uses between 1985 and 2001. The data shown for dental mercury use before 1999 are thought to be low due to under-reporting.[9]

CONSUMPTION OF REFINED MERCURY BETWEEN 1985 AND 2001
(METAL VALUES ARE IN METRIC TONS[10])

	1985	1990	1992	1993	1994	1995	1996	2001[11]
Chloralkali	235	247	209	180	135	154	136	46
Paint	169	22	0					
Laboratory	14	32	18	26	24			
Other Chemical/Allied Products			18	18	25			
Electric Lighting	40	33	55	38	27	30	29	28
Wiring devicesand switches	95	70	69	83	79	84	49	60
Batteries	952	106	16	10	6	<0.5		
Measuringinstruments	79	108	52	65	53	43	41	22
Dental	**50**	**44**	**37**	**35**	**24**	**32**	**31**	**44**
Other Uses	84	58	148	103	110	93	86	
TOTAL	*1718*	*720*	*622*	*558*	*483*	*436*	*372*	*200*

SECTION II

Occurrence and Toxicity of Mercury

Mercury is a persistent, bioaccumulative toxin that even in minute quantities poses a risk to human health, wildlife and the environment. It is one of the most toxic non-radioactive elements[12] and is a volatile heavy metal that can be rapidly released into the atmosphere. A potent neurotoxin, mercury causes damage to the central nervous system, immune system, liver and kidneys of humans,[13] and is particularly dangerous for fetuses, infants and young children. Results from the first nationally representative sample of mercury in human blood and hair, taken in March 2001 by the Center for Disease Control and Prevention, indicate that at least one in ten women of childbearing age is exposed to mercury levels above which harm could occur.[14] This translates into 390,000 children born each year at risk for neurodevelopmental deficits due to maternal exposure to mercury. Numerous species of wildlife and fish are also at risk from the pervasive occurrence of this toxic substance in the environment.[15]

While mercury is a naturally occurring metallic element, anthropogenic uses account for approximately 70 percent of all mercury emissions into the environment. In the last 270 years, industrial practices have led to a twenty-fold increase in levels of mercury in the environment.[16] Elemental mercury and mercuric compounds are resistant to many of the natural environmental processes that otherwise break down, alter and dilute toxins.[17] As a result, mercury persists indefinitely in the environment and cycles between the air, freshwater and saltwater, and soil/sediments. In water and soil, mercury is transformed into its most toxic form, methyl mercury by the natural biochemical process of methylation.[18] Methyl mercury is highly soluble and therefore is mobile, incorporating easily into living tissues. Over time, methyl mercury bioaccumulates in the tissues of fish and wildlife, becoming increasingly concentrated in species higher on the food chain.[19]

Increasingly, the dangers posed by mercury contamination to public health are prompting national, state and local authorities to warn people to avoid ingesting foods likely to contain mercury. In July 2000, a National Academy of Sciences study found that "…over 60,000 children are born each year at risk for adverse neurodevelopmental effects due to in utero exposure to MeHg (methyl mercury)."[20] Six months later, the Food and Drug Administration issued new fish consumption advisories for pregnant women not to eat certain ocean fish due to high levels of methyl mercury.[21] To date, public health advisories have been issued in 41 states warning people to limit their consumption of both freshwater and saltwater fish. Some states are cautioning pregnant women and children to avoid consuming certain fish altogether and at least ten states have issued statewide advisories recommending limits on the intake of fish obtained from *any* pond, lake or river within their borders due to extensive mercury contamination.[22]

SECTION III

Dental Mercury Disposal Routes

The largest single source of dental mercury released into the environment comes from the removal of existing amalgams from patients during dental procedures (replacement fillings, crowns, extractions, etc). Extracted amalgam materials are either rinsed down the drain—usually to a municipal wastewater system (or septic system) where it can build up in sewage sludge—deposited in biomedical waste containers destined for waste incineration or autoclaves, or placed in the trash that is later disposed in municipal waste landfills or incinerators. It is estimated when an amalgam is prepared for a filling, 10 percent[23] is leftover and is often simply discarded. The "overpack" portion is either drawn into the dental clinic's waste vacuum system or is expelled by the patient into a chairside cuspidor.[24] But the majority of dental mercury waste is discarded into wastewater systems.[25]

Dental Mercury Waste Disposal into Wastewater

Studies by EPA and numerous municipalities[26] document that most municipal wastewater treatment plants have high levels of mercury with significant contributions from dental clinics.[27] Recently, the Association of Metropolitan Sewerage Agencies (AMSA) evaluated seven major municipal wastewater treatment plants (WWTPs) to determine and quantify sources of mercury coming into these facilities. At all plants, dental uses were identified as "by far" the greatest contributors to the mercury-load, accounting on average for 40 percent of the load, more than three times the next largest source.[28]

DISCHARGE OF DENTAL MERCURY TO WASTE WATER SYSTEMS

City	Mercury load from dental offices
Duluth, Minnesota	36%[29]
Seattle, Washington	40-60%[30]
Palo Alto, California	83%[31]
Greater Boston Area, Massachusetts	13-76%[32]

While municipalities undertaking similar studies have found comparable percentages of mercury coming from dental offices, estimates of the tonnage of dental mercury discharge into wastewater vary greatly per year, according to the table below.

QUANTITIES OF DENTAL MERCURY ANNUALLY RELEASED INTO SEWERS

(Assuming 175,000 dentists in the U.S. and 250 workdays per year)

Study	Date	Tons Per Year
Cailas[33]	1994	23.5
Drummond[34]	1995	24.6
Arenholt-Bindslev And Larsen[35]	1996	12
Water Env. Fed.[36]	1999	12
Canadian[37]	2001	24.7[38]
AMSA[39]	2002	2.6

Yet there is little debate that municipal wastewater treatment systems are not designed to treat hazardous waste or reduce mercury loadings to the environment. Consequently, all mercury in the influent wastewater remains unattenuated in municipal treatment plants, and either settles out in the grit chamber or residuals (sludge, or "biosolids"), or passes through the system to be discharged into a downstream lake, river or ocean along with the "treated" effluent. Moreover, conditions at certain points within the wastewater treatment process are perhaps favorable for promoting methylation of mercury within the wastewater or sludge.[40] This has the effect of converting a portion of the influent mercury into its more toxic, organic form (methyl mercury), which is also highly soluble and able to pass through the facility to the receiving water body.

Mercury amalgam particles that drop out of wastewater in the grit chamber (the initial coarse settling chamber at the front end of a treatment plant), are most commonly landfilled along with all other filtered materials. The residual sludge, which is the primary byproduct of the treatment process, is frequently incinerated. Incineration releases the mercury directly into the atmosphere as mercury vapor. Studies conducted at the metropolitan wastewater treatment plant in Minneapolis-St. Paul indicate that as much as 95 percent of the mercury load to the treatment plants is released to the atmosphere during sludge incineration,[41] with the balance discharged to the Mississippi River.[42]

When not landfilled or incinerated, "biosolids" are used in fertilizers or other soil additives. Agricultural sludge application can lead to mercury contaminated soil and groundwater, as well as direct volatilization to the atmosphere. Regulations for land application of sludge in the U.S. are far less restrictive for mercury and other heavy metals than many other countries.[43] This practice has not been thoroughly studied and is further hindered by the fact that both state and federal agencies responsible for regulating sludge-spreading are also often responsible for promoting it.

Mercury in Traps, Drains, and Sewer Pipes

Following years of use, the plumbing in dental offices can become significantly laden with dental amalgam. Studies show that high levels of mercury are accumulating in sewer pipes from dental offices, presenting potential liability concerns to land owners.[44] Amalgam particles trapped in dental office plumbing and drainage pipes have been found to provide a continuing source of dissolved mercury to wastewater over time.[45] The slow dissolution of mercury amalgam in dental office plumbing, as well as in the municipal sewer system, serves as a long-term source of mercury to the receiving facility and is eventually released to the environment.[46]

Mercury in Septic Systems

Where no publicly operated treatment works exist, dental clinics frequently rely on septic systems for wastewater disposal. Similar to municipal treatment plants, the potential for methylation exists in the anoxic environment of a septic tank,[47] which can lead to the production and discharge of methyl mercury at private disposal fields. At these locations, the mercury path to the environment is more direct and the soils and groundwater surrounding the drain fields of these systems can become contaminated with mercury.[48] Significant levels of mercury contamination have been detected both within septic tanks as well as adjacent to, and downgradient from, disposal fields receiving wastewater from dental clinics.[49] The drain fields of septic systems receiving dental wastewater have the potential to serve as point sources of mercury contamination to the underlying and adjacent soils and groundwater, and may potentially convey environmental liability on to the property owner, and/or wastewater generator.[50]

Other typical disposal routes for waste dental mercury

Solid Waste

Mercury-bearing scrap amalgam is often discarded into the trash and leaves the dental office by solid waste hauler and is either landfilled or incinerated. The mercury in amalgam disposed in a landfill may break down over time and co-mingle with landfill leachate. Depending on the landfill, mercury may enter groundwater, contaminate underlying soils, volatilize into the vapor phase and dissipate to the atmosphere or, when landfill leachate is sent to a wastewater treatment plant, be taken up in sewage sludge that is either re-landfilled or distributed. Also, formulation and release of methane gas from landfilled mercury may contribute to production of mercury emissions within the landfill.[51]

Biomedical waste/Incineration

Waste dental mercury is often disposed into the biomedical waste container. A recent survey found that 25 to 30 percent of dentists place their contact amalgam wastes into biomedical "red bags" that are often incinerated.[52] Medical waste is a special type of regulated waste due to the potential presence of bacteria and pathogens, which is separated and handled differently from other solid wastes. If any amalgam has come in contact with the mouth or has been removed from or with teeth, it is considered "contact amalgam" and is often discarded into biomedical waste. So-called "red-bag" waste is often sent to a medical waste incinerator, where the mercury is vaporized into the atmosphere. Some handlers of biomedical waste sterilize it with high temperature and pressure steam in a process known as "autoclaving." Oftentimes, these facilities operate with no emission controls or standards, which result in mercury vapor releases, and discharge of effluent to the local wastewater system

following sterilization. Ultimately the mercury-bearing residuals from this process are landfilled.[53]

Recycling

While actual numbers are hard to come by, a small but increasing number of dental clinics are beginning to have their mercury recycled. Where collection systems are in place, approximately 60 percent of all mercury-bearing amalgam waste is captured in coarse filters at chair side,[54] and 95 percent or more of the mercury can be cost-effectively captured when an amalgam separator is added to the system. These programs are, in general, effective and require only a modest shift in practices, and add a very minor increase in operating expense. According to recent estimates, an amalgam separator unit capable of removing both particulates and dissolved mercury can be operated for between $47.95-$100 per month.[55] Currently, there are many firms across the U.S. offering services to collect and recycle mercury from dental clinics. In addition, there are 11 amalgam separators available in the U.S. that were recently tested by American Dental Association and found to exceed testing standards.[56] Similarly, a recent study of several amalgam separators by the Minnesota Dental Association and the Metropolitan Council of Environmental Services reached similar conclusions.[57] Yet it is estimated that less than one percent of dentists have amalgam separator units in operation today.[58]

Storage

Prior to receiving pre-encapsulated amalgams, dentists used to make their own mercury fillings and some still have large stocks stored in their offices. (Few, if any dentists today make their own fillings.) While some states and locales have hosted "clean sweeps" to collect excess elemental mercury from dentists, based on the quantities collected thus far it is likely that large quantities of elemental dental mercury remain uncollected and represent a significant risk of being mismanaged or improperly disposed.

Human Wastes

Amalgam have been determined to be the primary source of mercury in human waste.[59] After releases from dental offices, human wastes are the next greatest contributor of dental mercury to waste waster treatment plants (WWTPs).[60] In addition, amalgam fillings are responsible for additional environmental releases of mercury at the end of life. Each cremation in the U.S. accounts for, on average, one gram of mercury, due to vaporization of mercury contained in dental amalgam fillings.[61]

SECTION IV

Challenges to Reducing Dental Mercury Releases

Numerous opportunities are now available for dental clinics to reduce overall mercury use, as well as contain and capture waste amalgam prior to discharging it into the wastewater system. Some local governments have successfully worked with their dental community to foster effective voluntary mercury reduction initiatives, yet these cases remain the exception rather than the rule. To date, dental mercury waste mismanagement is primarily due to the following:

- lack of general awareness among dentists that their waste mercury is a serious pollutant that should be managed properly;
- lack of the regulatory control by most government agencies;
- lack of support from the American Dental Association (ADA) and state dental associations for dentists to take the necessary steps to reduce mercury releases; and
- lack of governmental resources for the level of staff outreach to the dental community that voluntary initiatives require in order to be effective.

Lack of Regulatory Control for Dental Mercury Releases

Currently, there are few regulations governing the use, control or discharge of mercury from dental uses. Once amalgam materials are delivered to dental clinics, there are no recording or manifest requirements designed to record the quantities of mercury used and recycled, or to track disposal routes.

The problem with mercury in wastewater was first identified when municipal WWTPs experienced mercury spikes in samples of their treated effluent. This contaminated effluent was failing discharge limits for mercury established by the National Pollution Discharge Elimination System (NPDES). A NPDES permit includes discharge limits for individual environmental contaminants that are based on the human health criteria for each contaminant, and the characteristics of the receiving waters into which the treated effluent is released. As such, it is up to the municipal sewer authority to keep track of industries and commercial enterprises that discharge wastewater into their systems to ensure that a commercial entity is in compliance with the discharge limits. Yet municipal wastewater authorities often lack effective enforcement mechanisms and few have chosen to regulate dental mercury under NPDES or any other requirements. Currently less than 10 percent of major WWTP facilities even have a mercury sampling requirement in their NPDES permits.[62] An even smaller percentage of the 63,000 minor WWTPs (serving less than 1 million population) have a mercury limit in their discharge permits.

Voluntary Approaches to Reducing Dental Mercury Releases

Much information now exists on how to operate an environmentally responsible dental office, and this information, including Best Management Practices (BMPs), has been distributed in many states. BMPs are designed to be economically achievable measures and/or actions to control and reduce or eliminate the discharge of pollutants to the environment.

BMPs have been developed by individual state waste management or pollution prevention authorities or nongovernmental organizations in conjunction with the state dental association and, to this point, are generally voluntary, rather than mandatory.[63] These guidelines outline sound methods for collection and proper management of mercury and other wastes, and provide information on resources, techniques and equipment. Voluntary approaches for reducing dental mercury releases usually begins with employment of BMPs, and are then followed by other steps, including the installation of amalgam separators. Chairside traps, vacuum filters, and air-water separators are readily available and all can be used to more effectively limit the uncontrolled discharge of mercury amalgam.[64]

In certain locales, government-initiated voluntarily programs for dental clinics to reduce pollution have resulted in documented reductions of mercury releases. Yet, throughout the Nation, government resources for sustained staff outreach and assistance are generally not available for successfully promoting voluntary initiatives to the local dental community.

ADA's Lack of Support for Reducing Dental Mercury Releases

Perhaps the biggest hurdle to removing mercury from dental waste streams is to obtain the cooperation of both individual state dental associations and the American Dental Association (ADA).[65] Despite overwhelming evidence to the contrary, the ADA presents conflicting and often contradictory statements about the nature of amalgams, at times claiming that their members make only a "small contribution to mercury in dental wastewater,"[66] but other times remaining completely silent on the question of environmental impacts, such as in its *Statement on Dental Amalgam*.[67]

The ADA's unwillingness to acknowledge the extent of the mercury problem within the dental industry is also reflected at the state levels. Although state level dental associations have at times appeared ready to support the dental mercury reforms, they have also frequently rejected the potency of the issue. In Seattle, for instance, dentists questioned the environmental impact of amalgam, and claimed amalgam separators were "untested, expensive and not readily available,"[68] although they have been widely tested, and even according to ADA's testing, are cost effective and readily available.[69] In its most recent statement on the issue, the ADA pledged support for a Food & Drug Administration initiative to preempt or override any and all state laws intended to regulate the dental industry and reduce its use of mercury.[70]

Indeed, ADA and the greater dental industry insist on obscuring substantiated scientific evidence in order to advance their objection to reforming the use of mercury in dental applications, floating a host of flawed arguments designed to reject outright the possibility of regulation. The ADA, for example, asserts that incineration is the only means by which mercury is released to the environment, thus categorically denying evidence of the presence of mercury in wastewater. It argues that mercury is stable while in the general waste stream, and only emits mercury to the environment when burned as sludge or solid waste. This reasoning is then used as the primary justification for recommending only the prevention of amalgam waste incineration, relegating further evaluation of minimization of the amalgam-derived mercury discharged from vacuum systems to secondary consideration.[71] The ADA goes so far as to argue that amalgamated mercury waste poses no environmental risk, asserting that it is a "scientific fact that mercury in dental amalgam chemically combines with other ingredients, including silver, to form a biologically inactive substance."[72] ADA maintains that mercury in dental amalgam does not leach under toxicity characteristic leaching procedure (TCLP) testing and therefore, it should not be considered a hazardous waste under federal regulations.[73] Finally, ADA, state dental associations and their members consistently refer to amalgams as "silver fillings" even though, on average, the silver actually only comprises 25 percent of an amalgam filling.[74]

All of these contentions, arguments, and positions by the ADA and state dental associations are designed to undermine and discourage legislative and regulatory efforts to control mercury discharge limits for the dental industry, even though scientifically the positions are largely unfounded. Non-mercury alternatives have been viable and readily available for some time,[75] and for many applications are already used extensively in the U.S. and other countries. However, potentially higher costs, especially in the case of gold or gold alloys, and the possibility of other problems such as shorter lifespan—as some believe is the case with composites[76]—make the dental industry wary of accepting responsibility for the transition away from mercury amalgams and for reducing their mercury releases. But clearly, the inconvenience of using non-mercury fillings wherever feasible, and the small additional charges associated with utilizing new technologies for the capture and recycling of mercury, is far outweighed by the environmental benefits.

SECTION V

A Broader Perspective

While dental mercury use and release continues relatively unabated in this country, there are a growing number of new initiatives in the U.S.—and especially abroad—to reduce dental mercury pollution. As described below, voluntary guidelines by themselves are oftentimes not as effective without the addition of some regulatory "teeth."

The Case for Coupling Voluntary Initiatives With Dental Mercury Regulations

Based on the case studies presented below, it appears that a combination of voluntary and mandatory initiatives have been most successful in convincing dentists to take the necessary steps to reduce their mercury pollution.

Seattle, Washington

In 1990, Seattle began to quantify the dental contribution of mercury in wastewater entering their treatment plants. By 1994, enough information had been collected to justify proposing a rule requiring the installation of amalgam separators in all dental offices. In response to intense opposition by dentists, this rule was tabled in 1995 in favor of aggressive educational outreach with the goal of changing the prevailing practices and spurring voluntary adoption of amalgam separation technology.[77] After five years of intensive outreach and cash incentives, and more than 400 office visits by both county and dental society officials, less than 3% of dental offices had purchased amalgam separators, and less than 40% of dentists collected and recycled mercury-bearing wastes.[78] After a decade, the voluntary approach was deemed unsuccessful and regulatory intervention was determined necessary. This involved requirements for installation of amalgam separators, with a phase-in period that extends to July of 2003. In the most recent phase of the project, city officials have encountered little resistance from the local dental society.[79]

Wichita, Kansas

The City Pretreatment Staff has worked with the dental community to develop BMPs for managing mercury discharges. Implemented in June 1, 2001, phase 1 of the program required use of a technology greater than the traditional chairside trap and vacuum filter—at minimum, a modified chairside trap with either decreased pore size or a modified design that allows for some sedimentation. If mercury levels have not decreased significantly after completion of Phase 1, then Phase 2 will be implemented, requiring Best Available Technology to reduce mercury levels by 90% or more by June 1, 2003. Although initially the program is voluntary, dentists who do not comply will be fined $2000 with additional fees for quarterly sampling and fines for exceeding a discharge limit of 0.0007 mg/L.[80]

Boston, Massachusetts

In 1995, Greater Boston area hospitals were responsible for contributing 22 pounds of mercury to the WWTP. Yet by the year 2001 their contribution was one pound— primarily due to Massachusetts Water Resources Authority regulation and enforcement. However, during that same time period, dental facilities escaped environmental regulation. In 1995, their load to the WWTP was approximately 36 pounds and in the year 2001 their contribution of mercury to the WWTP was still around 36 pounds per year—no reduction! Clearly, this creates an unlevel playing field between the hospitals forced to comply with the regulations and the dental facilities who are not.[81]

Billerica, Massachusetts

A review was undertaken by Solmetex, an amalgam separator manufacturer, in 2000 at a dental clinic to determine the average amount of mercury discharged per day with and without an amalgam separator in a clinic housing four dentists and six hygienists. At the beginning of the study, the dental clinic had no chairside traps, leaving only the screen mesh pump filter to remove mercury particles. Influent and effluent samples were taken over 74 days from February 2000 to September 2000. Prior to separator installation, each dentist discharged an average of 570 mg/day. After an amalgam separator was installed, tests indicated a 99% removal rate.

State of New Hampshire

In May 2002, the New Hampshire legislature passed first-in-the-nation legislation requiring state rules "for dental offices relative to the use of environmentally appropriate disposal equipment or methods" to trap dental mercury—despite opposition from the ADA.[82] The New Hampshire Department of Environmental Services supported the legislation, calling "…for better management of mercury amalgam waste, promoting the increased use of alternative fillings and phasing out the use of amalgam over time."[83] Similar to a law adopted in Maine in 2001, the New Hampshire law also requires dental offices to provide information "…regarding the risks and benefits of dental mercury, including mercury amalgams." It also requires the health department to "provide information …about the risks and benefits of dental restorative materials including the use of amalgam in children under the age of 6."[84]

State of Connecticut

Legislation passed by the Connecticut legislature in 2002 requires vocational dental education or training schools to develop and implement a plan approved by the environmental commissioner that assures best management practices are used to prevent discharge of mercury into the environment, and to properly manage and recycle elemental mercury and amalgam. The law also requires the plan to provide for an education program for dental students regarding the hazards of mercury and best management practices."[85]

Dental Mercury Reduction Initiatives in Other Countries

Over the past decade or so, many other countries have taken concrete steps to reduce dental mercury use and pollution. For example, the fact that sludge with elevated mercury content had to be treated as a hazardous waste led several European governments to ban certain types of amalgam disposal and require dental pollution prevention practices. In Scandinavia in the early 1980s, publicly owned treatment facility sludge used for fertilizer by farmers was found to have extremely high levels of mercury. Consequently, the farmers discontinued using the pellets, which forced facilities to trace the source of mercury and eliminate it from their influent. Subsequent research uncovered that the largest generators and dischargers of mercury were dental clinics.

Starting in 1992, Scandinavian countries, as well as Germany, Switzerland, Austria and Holland, either required the use of advanced amalgam separation equipment, or regulated dental mercury in some manner.[86] Today most regulations in Europe require 95 percent removal (by mass) of waste amalgam prior to discharge, with this standard applied downstream from the initial filters that easily remove the largest particles.

The table on the following page illustrates the steps that many countries have taken to reduce dental mercury use and pollution. The information comes primarily from a compilation by the United Nations Environment Program for their draft *Global Mercury Assessment*.[87]

OTHER COUNTRIES' DENTAL MERCURY REDUCTION INITIATIVES

Country	Regulation/Initiative
The Netherlands	For several years, there has been an agreement between the national organization of dental surgery and the public authorities to collect amalgam separately from the sewage system with at least 95% efficiency.[88]
Sweden	A voluntary agreement since 1979 requires that all dental clinics are equipped with amalgam separators.[89] Between 1990 and 1995, the concentration of mercury in the city of Stockholm's WWTP sludge decreased by 33%,[90] which is approaching the percentage of mercury believed by Swedish authorities to originate from dental clinics (50%). Beginning in January 1999 the Swedish Parliament abolished compensation for amalgam fillings with the ultimate aim of a total ban of the use of dental amalgam, in part, to reduce environmental release.[91]
Canada	A recently adopted Canada-wide Standard is the application of "best management practices" to achieve a 95% national reduction in dental mercury releases to the environment by 2005, from a base year of 2000. Best management practices are defined as including the use of an ISO certified amalgam trap, ,or equivalent, and appropriate management of waste so that mercury does not enter the environment.[92] The Sewer Use Bylaw in Victoria, BC requires installation of amalgam separators in all dental offices by July 1, 2001. If dentists do not comply, they are required to collect and transport the wastewater from the dental operation for off-site management.[93] Victoria's BMPs include guidelines for collection, storage and recycling of mercury. In addition, Montreal and Toronto have imposed stricter new emissions standards to reduce dental mercury releases by 90 percent or more. As a result of recent initiatives, more amalgam separators are being installed in Canada than in the U.S.,[94] even though Canada's population is much smaller than the U.S.
Denmark	Results from wastewater sludge studies in Denmark indicate a dramatic reduction in mercury (50 - 80%) following mandatory installation of amalgam separators in dental clinics.[95] Dental amalgam is allowed only in molar teeth, where the filling is worn, until further notice, thereby significantly reducing both mercury use and, over time, releases. Denmark is ready to ban the remaining use of dental amalgam, whenever the Danish National Board of Health is satisfied that the non-mercury alternatives have full substitution capabilities.[96]
France	1998 regulations regarding elimination of amalgam waste from the dental sector is complemented by a 2000 decision by the Agence Francaise de Securite Sanitaire et des Produits de sante that imposes the use of predosed capsules of amalgam. In addition, an amalgam separator is required and waste water pipes should be cleaned when the equipment is installed. Finally, an agreement is required for disposal of amalgam waste in an appropriate facility.[97]
New Zealand	In 2001 the New Zealand Dental Board adopted guidelines on dental amalgam waste and wastewater discharges. The guide describes a code of practice for the use, storage, collection and disposal of mercury. It recommends that amalgam scrap should be collected, stored and sent for recycling. The guidelines state that amalgam scrap should not be disposed of in any medical waste to be incinerated, systems to reduce amalgam discharge to wastewater should be installed, and by regulation, amalgam separators meeting the ISO 11143 standard (an established stringent standard for dental mercury reduction) should be installed.[98]
Switzerland	According to the Swiss government, because of increasingly popular non-mercury alternatives, use of amalgam tooth fillings has been strongly reduced. There is also reportedly an increased use of mercury separators in dentists' offices.[99]

SECTION VI

Summary

Amalgam use and release by the dental establishment is a significant and persistent source of mercury pollution in the U.S. and must be curtailed. Many other industries, sectors, institutions and government agencies have been actively pursuing ways to reduce their reliance on mercury. In 1998, for example, the American Hospital Association entered into an agreement with EPA committing to the virtual elimination of mercury from hospital waste streams by 2005. In so doing, the health care industry recognized that its fundamental credo of "first do no harm" must extend to the toxic materials and contaminants used in treatments and equipment.

But U.S. dental associations, following the lead of the American Dental Association, have consistently resisted efforts to reduce releases of mercury and follow suit with the rest of the health care establishment. The ADA refuses to encourage its members to assume responsibility for curtailing dental mercury pollution, opting instead to obstruct initiatives at the state and local levels. Consistent with its position, the ADA is now currently supporting a regulatory effort by the Food & Drug Administration that would effectively preempt and reverse significant legislative advances made at the state level. In doing so, the ADA relies on questionable scientific assumptions that deny the serious impact from mercury used and eventually released into the environment, despite a preponderance of evidence contradicting these claims.

Yet in instances where dentists have showed a willingness to support mercury reduction initiatives—both abroad as well as within a growing number of local communities across the U.S—they have clearly demonstrated the relative ease and low expense with which effective pollution prevention practices and technology can be applied to existing practices. Environmentally responsible dental clinics employ best management practices together with amalgam separators to get the highest capture rates of dental mercury. This approach is economical, compact in design, available, and protective of human health and the environment. For example, it costs Massachusetts Dental Society members only $50 per month[100] to operate the amalgam separator equipment needed to trap and collect waste mercury, a price that is redeemed exponentially by the long term benefits to human health, wildlife and the environment.

SECTION VII

Recommendations

1. Disposal of dental amalgam into all waste streams should be prohibited and all dental mercury should be trapped, collected and recycled.

2. Policies should be adopted to foster the reduced use and release of dental mercury through a combination of voluntary incentives, technical assistance and mandatory requirements to encourage dentists to:
   - Adhere to stringent best management practices to control discharge of mercury.
   - Install amalgam separators to reduce discharge of amalgam particles (and in some cases dissolved mercury) by 95 percent or more, and follow strict protocols to ensure units are maintained to manufacturer's specifications.
   - Clean and, as needed, replace mercury-laden pipes and plumbing fixtures.
   - Properly manage significant quantities of excess elemental mercury.
   - Submit annual reports on quantities of mercury used and recycled, and an evaluation of the performance of BMPs, amalgam separators and removal of mercury in discharge pipes.

3. An investigation should be conducted to determine environmental impacts and potential liability implications of dental mercury released into private septic systems.

4. Major municipal wastewater treatment plants (WWTPs) should have mercury reduction and sampling requirements in their National Pollution Discharge Elimination System permits. Similar requirements for minor WWTPs should be phased in.

5. The American Dental Association's efforts to obstruct state and local initiatives to reduce dental mercury releases should be strongly opposed, including recent efforts to convince the Food and Drug Administration to preempt state legislation in this area.

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