Mercury in Waste Dental Amalgam: Why Is It Still a Problem?

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While eminently useful, mercury is also highly toxic. As tons of the silvery substance are used in thousands of products each year, more and more effort is put into keeping mercury out of the environment and preventing human exposure. In 2003, half of the state legislatures in the country as well as the United States Congress introduced bills to protect the public from mercury.[1]

Among products containing mercury, dental amalgam is a focus of concern. Relative to other sectors, dentists use large quantities of the metal in fillings, and they generate large amounts of mercury-containing waste. This waste is easy to capture; inexpensive collection systems can collect up to 99 percent of dental mercury. Yet, in the United States, relatively few dental offices use these systems.

Why not? What stands in the way of dentists implementing what seems—on the surface—to be a straightforward means of collecting mercury waste, preventing its release into the environment and furthering a widely-accepted social goal?

This paper looks at the issues from the perspective of King County's decade-long attempt to remove mercury-containing amalgam from dental wastewater. Starting with a voluntary program in 1994, King County instituted mandatory requirements in 2001. While this move proved successful in the case of King County, other jurisdictions—and organized dentistry—do not necessarily embrace it. This paper examines some of the reasons for this and proposes a solution.

Capturing Dental Mercury: Whose Job Is It?

Since the early 1990's, wastewater treatment plants have looked at dentists as potentially significant dischargers of mercury. A 1991 study in King County found that dentists accounted for an estimated 14 percent of the mercury load to the wastewater system.[2] A 2001 study by the Association of Metropolitan Sewerage Agencies looked at seven municipal wastewater treatment plants and found that dental offices were "by far" the greatest contributors of mercury to the sewer system. According to the report, dentists accounted for an estimated 40 percent of the mercury load—more than three times the next largest source.[3] More recent estimates in King County[4] are that 40 - 60 percent of mercury detected at the wastewater treatment plants—or 171 pounds per year—comes from dental offices.[5]

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[1] Reindl, John. June 26, 2003. Pers comm. (email). "Status of Local, State and Federal Mercury Product Legislation and Laws, 2003-2004 Legislative Sessions."
[2] Municipality of Metropolitan Seattle, 1991. Dental Office Waste Stream Characterization Study. Seattle, WA.
[3] Association of Metropolitan Sewerage Agencies, 2002 (March. Amended July 2002). "Mercury Source Control & Pollution Prevention Program Evaluation. Final Report." Prepared by Larry Walker Associates.
[4] Magnuson, Patricia. 2004. Pers. Comm. Estimates are based on 1996 influent loading data and a contribution of an estimated 250 mg Hg/dentist/day.
[5] Magnuson, Patricia. 2002. Regulating Dental Office Wastewater: Cost-effectivenss Analysis of Four Regulatory Options. Seattle, WA.

Based on these and other similar data, treatment plants needing to reduce the mercury entering their systems naturally looked to dentists. By 2001, King County and the Cities of Toronto and Montreal had required dentists to take steps to control mercury discharges, typically by installing amalgam separation equipment to remove mercury-containing amalgam particles. By mid-2003, the State of Maine passed a law requiring dental offices to install amalgam separators and the City of San Francisco made plans to take similar action. In fall 2003, a committee in the U.S. House of Representatives held hearings on mercury in dental wastewater.

To some in the dental profession, it appeared that regulators and lawmakers were unfairly targeting dental offices. The American Dental Association (ADA) set up the Task Force on Amalgam in Dental Office Wastewater in 2001 and hired a consulting firm, Environ International, to assess the environmental impact of amalgam in dental wastewater. Dr. Eugene Sekiguchi, then ADA president-elect and chair of the Task Force, summarized dentistry's view of the problem: "As dentistry is a science-based profession, the task force believed it was critical to base our approach on scientific knowledge, not speculation."[6]

Environ's (draft) study concluded that while the dental sector uses 35.2 tons of mercury each year and discharges about 29.7 tons of mercury into the wastewater system, only 0.4 ton of this mercury actually reaches surface waters in the United States.[7] Since mercury poses a risk to fish and those who eat them only when it is deposited *on* [from the air] or *in* surface waters, the ADA concluded that it was unreasonable—*unscientific*—for regulators to focus on the dental sector.

Instead, in fall 2002 the ADA adopted its own action plan for amalgam wastes. The centerpiece was a set of Best Management Practices describing how to recycle amalgam waste.[8] ADA President T. Howard Jones called upon dentists to cooperate, but also committed the ADA to helping local and state dental societies resist regulatory pressure (e.g., the mandating of amalgam separators.)

The Environ/ADA analysis of the situation differs from the regulators' analysis in two important respects. First, there is disagreement concerning the amount/percentage of mercury currently captured in dental offices using traditional traps and filters. Drawing on several studies, Environ calculates a 78 percent 'capture efficiency' for U.S. dental facilities. That is, across all dental facilities, Environ estimates that 78 percent of the mercury—or 23.2 tons a year—is already captured.[9] However, a 2002 study published in the *Journal of the Canadian Dental Association* finds that only 42 percent of mercury amalgam is captured in traps and filters (32 percent in chairside traps and an additional eight percent in pump filters).[10] This translates into 12.5 tons captured in dental offices—significantly less than the Environ estimate.

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[6] Berthold, M. 2003. "ADA's 'Best Management Practices of Amalgam Waste' offered." *ADA News Today* at www.ada.org/prof/pubs/daily/

[7] Environ International Corp. 2003 (Aug) Draft. "Assessment of Mercury in the Form of Amalgam in Dental Wastewater in the United States." Prepared for the American Dental Assoc., Chicago, IL. Page 17.

[8] Berthold, M. 2003. "ADA's 'Best Management Practices of Amalgam Waste' offered." *ADA News Today* at www.ada.org/prof/pubs/daily/

[9] Environ International Corp. 2003 (Aug). "Assessment of Mercury in the Form of Amalgam in Dental Wastewater in the United States." Prepared for the American Dental Assoc., Chicago, IL

[10] Adegbembo, A., Watson, P., and Lugowski, S. 2002 "The weight of wastes generated by removal of dental amalgam restorations and the concentration of mercury in dental wastewater. *Journal of the Canadian Dental Association*, 68(9). And Watson, P. 2002. Presentation at the Binational Toxics Strategy Mercury Workgroup on Dental Mercury. Dec. 2002. Chicago, IL.

Second, contrary to assumptions implicit in the Environ report, 'captured' mercury—whether in dental offices or treatment plants—is not necessarily sequestered from the environment. A 2000 study found that more than three-quarters of King County, Washington, dental offices did *not* reclaim or sequester mercury-bearing waste captured in chairside traps or pump filters. Rather, they put it in the garbage, mixed it with medical waste, stored it onsite or put down the drain.[11] Most medical waste is incinerated or heat-treated, and so is garbage in many locales. Heating this waste has the potential to release mercury directly into the air. (Mercury air emissions are problematic because air deposition on water bodies can lead to contamination of fish and wildlife and ultimately, harm to humans.) Landfilling garbage is not necessarily safe either: recent studies have documented methyl mercury in gases emitted from landfills.[12]

Similarly, wastewater treatment plants are *not* designed to sequester or recycle captured mercury (or other heavy metals). Wastewater utilities invest in pre-treatment programs to keep these substances from entering the system. If mercury solids enter a treatment plant, they eventually wind up in the grit and/or the sludge, or biosolids. Treatment plant grit is typically landfilled, leading to possible problems with leaching and/or volatilization (mentioned above). Nationwide, biosolids are either burned (22 percent of the nation's biosolids), landfilled (17 percent)[13] or applied to land as fertilizer or compost. In the latter case, wastewater utilities are interested in continuously improving the quality of these biosolids to maintain marketability.

In summary, mercury waste from dental offices is difficult to control—once it leaves. While the Environ study may represent organized dentistry's perspective that most mercury is collected using the systems already in place, this 'capture' is temporary. From the perspective of landfill operators and wastewater utilities, the only way to really sequester mercury is *before* it leaves the dental office, using office-based amalgam separators. This principle, known as source control, is the basis of effective pre-treatment programs.

Most pre-treatment programs have relied on the voluntary capture of mercury by dental offices. Amalgam separators are rarely mandated. Reasons range from a preference on everyone's part for voluntary and collaborative arrangements to the fact that mandatory regulations, such as numerical discharge limits, present enforcement difficulties for local utilities. These issues are discussed in the remainder of this paper.

'Voluntary Compliance:' Does It Work?

Both organized dentistry and regulators prefer to control mercury discharges from dental offices by seeking action/compliance on a voluntary basis. For example, the Minnesota State Dental Association and the Metropolitan Council Environmental Services (Minneapolis-St. Paul) jointly sponsor the Voluntary Dental Office Amalgam Separator Program in which dental offices voluntarily pledge to install amalgam separators. In Washington State, the Washington State Dental Association and the State Department of

[11] Local Hazardous Waste Management Program in King County, 2000. "Management of hazardous dental wastes in King County, 1991-2000." King County Dept. of Natural Resources, Seattle, WA.

[12] Lindberg, S.E.; D. Wallschlager; E.M. Prestbo; N.S. Bloom; J. Price and D. Reinhart. 2001. "Methylated mercury species in municipal waste landfill gas sampled in Florida, USA." *Atmospheric Environment*, 35:23 (4011-4015). Lindberg, S. 2003 (Aug.) Pers. Comm. (Email) re: methylated mercury in Washington State landfills.

[13] US EPA, 1999 (Sept). Biosolids Generation, Use and Disposal in the United States. EPA530-R-99-099.

Ecology signed a Memorandum of Understanding in 2003 specifying essentially the same thing.[14] Whether these voluntary programs prove effective without regulatory back up remains to be seen.

In February 2003, the American Dental Association released "Best Management Practices for Dental Amalgam," a set of guidelines about recycling amalgam wastes.[15] While the guidelines stress recycling of amalgam collected in chairside traps and pump filters, they make no mention of installing amalgam separators to remove amalgam particles from wastewater. On the other hand, the *Journal of the American Dental Association* published a special report titled "Purchasing, installing and operating dental amalgam separators" in August 2003.[16] The effectiveness of these efforts in persuading member dentists to install amalgam separators, again, remains to be seen.

Data suggest that the majority of dental offices will not install separators until required to do so. Even though amalgam separation equipment is effective (removing 95-99 percent of mercury in the wastewater)[17] and relatively inexpensive (especially compared to pollution prevention machinery required of small businesses like dry cleaners and autobody painters), dentists have historically resisted installing separators until required to take action.

For example, during the seven-year period 1994-2000, dentists in King County were encouraged to voluntarily purchase and install amalgam separators through a joint program run by the County and the local dental association. The County offered cash rebates to dentists that purchased separators, spending an estimated $250,000 on the outreach and rebate program.[18] By 2001, 24 out of a projected 900 offices (or less than 3 percent) had installed amalgam separators.[19]

The County then decided to enforce wastewater discharge limits on dental offices. In most cases compliance meant installing a separator. By 2003, two years after being warned that limits would be actively enforced, 779 offices—more than 80 percent of the projected total—had installed the equipment.[20]

Similar scenarios have occurred in Toronto, Montreal and Victoria, jurisdictions that led the way in mandating amalgam separators. In 2000, the City of Toronto enacted a By-law requiring, among other things, installation of amalgam separators by dental offices. Two years later, 60 percent of the 1500 dental offices had complied.[21] Montreal passed a similar By-law in the same year. As of October 2003, *all* of Montreal's 850 subject dental offices had submitted paperwork describing the type of amalgam separator installed (inspections had not yet started).[22] Finally, in British Columbia's Capital Regional District

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[14] 2003 (Aug.) "Memorandum of Understanding: Washington State Department of Ecology and Washington State Dental Association" at www.ecy.wa.gov/programs/eap/pbt/documents/mou-ecy-wsda.pdf .
[15] American Dental Association, 2003 (Feb.) "Best Management Practices for Amalgam Waste."
[16] McManus, K. and P.L. Fan, 2003 (Aug.) "Purchasing, installing and operating dental amalgam separators." *Journal of the American Dental Association,* 134:1054-65.
[17] Ibid.
[18] Savina, Gail. 2003. Managing Dental Amalgam Waste, King County Case Study (slide show). Quicksilver Caucus Mercury Workshop St. Louis, MO.
[19] Local Hazardous Waste Management Program in King County, 2000. "Management of hazardous dental wastes in King County, 1991-2000." King County Dept. of Natural Resources, Seattle, WA.
[20] Local Hazardous Waste Management Program in King County. 2003.
[21] Shaw, Martin. 2003 (Sept) Pers Comm. (phone). City of Toronto.
[22] LeFloch, A. 2003 (Oct). Pers Comm (phone). City of Montreal.

(including Victoria and Sydney), all dental offices inspected by mid-2003 (about half the total) had installed separators per a 2001 Bylaw requiring this.[23]

Where amalgam separators aren't required, they remain an anomaly. One manufacturer tallies its separator sales in those states that don't require them: Wisconsin – 2; Texas –1; New York – 2; and New Jersey - 0.[24] Its sales in Connecticut—which *does* require them—exceed 600. The Northeast Ohio Regional Sewer District, itself under the gun to reduce mercury discharges to Lake Erie and the Cuyahoga River, asked dentists to submit mercury discharge minimization plans and to implement the plans. According to one local official, "Only a handful—in the single digits" had installed amalgam separators. [25]

Despite the fact that most dentists, in the words of the American Dental Association, "share the concern we all have for the environment in which we all live,"[26] the large majority do not *voluntarily* purchase and install amalgam separators. Subject to an array of regulations designed to protect human health and the environment, dentists spend their time and money doing what they are required to do.

Wastewater Limits Are Difficult to Enforce

Governmental agencies may shy away from requiring dental offices to control mercury discharges because the regulatory (numeric) limits on mercury in wastewater can be difficult, both technically and financially, to measure and enforce. These difficulties in determining mercury concentrations in dental wastewater are due to daily, even hourly, fluctuations in the constituents of process wastewater; confusion about where to take samples; logistical difficulties in sampling; and costs of testing.

The problem has been addressed in some places by allowing businesses to meet local discharge limits *de facto*—that is, by installing and properly maintaining approved separators. This 'best available technology' approach avoids the problems incurred in measuring compliance with numeric standards.

Wastewater Limits Are Difficult to Meet

Another reason for government's hesitance in making dental offices meet numeric limits for mercury is that the dentists, in many cases, *can't* meet these limits—no matter what they do. As a result, jurisdictions facing stringent mercury standards don't necessarily impose numeric requirements on dental offices. In some cases, they don't require amalgam separators either.

This is how it works.

The federal permitting system sets standards for effluent discharged into open water. This puts pressure on treatment plants to monitor—and perhaps regulate—wastewater received from dischargers like dentists. For example, King County sets a mercury limit of 0.2 parts per million in wastewater discharged to its system—a concentration that most untreated dental wastewater exceeds. However, by installing separation equipment, most dental offices can meet King County's mercury discharge limit, and King County, as noted above, now enforces this.

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[23] Barnhart, Ron. 2003 (Sept). Pers Comm. (phone). Capitol Regional District, Environmental Programs, Victoria, B.C.
[24] Dube, Al. Aug. 4, 2003. Pers. Comm. Solmetex, Boston, MA.
[25] Linn, Keith. 2003 (Sept.) Pers comm. (phone). Northeast Ohio Regional Sewer District, Cleveland.
[26] Berthold, M. 2003. "ADA's 'Best Management Practices of Amalgam Waste' offered." *ADA News Today* at www.ada.org/prof/pubs/daily/

Water quality standards for effluent discharged into some waters, such as the Great Lakes and San Francisco Bay, are exceedingly stringent—1.3 parts per trillion mercury for the Great Lakes drainage basin, for example. This can put treatment plants discharging to these waters in a bind. For example, the Northeast Ohio Regional Sewer District (including Cleveland), which discharges to Lake Erie and the Cuyahoga River, exceeds the 1.3 ppt standard due to background mercury in household wastewater and other undifferentiated sources—even before mercury from dental offices is factored in.[27]

A similar situation exists with the sewer utilities that discharge into San Francisco Bay.

Responses to this conundrum vary. Palo Alto negotiated a permit with the State of California that exempts Palo Alto from meeting a numerical limit provided all dental office dischargers install amalgam separators.[28]

In the case of NEORSD, the same driver produced a different result. Because NEORSD, like Palo Alto, was not able to meet its stringent mercury standard even before calculating dental mercury, it set no numerical limit for mercury in dental wastewater. Rather, NEORSD set a narrative requirement for dentists "to minimize mercury through use of best management practices."[29] Unlike Palo Alto, however, these best management practices did not include installation of amalgam separators.

Regulations Are Piecemeal

Mercury assumes various forms (metal, liquid, gas), each regulated by a different agency or agencies. But despite this array of media-specific agencies and regulations, mercury often manages to fall through the cracks.

Mercury in dental office wastewater is a good example. While state hazardous waste or toxics agencies regulate the disposal of "dangerous wastes," it is not clear whether dental office wastewater designates as dangerous waste or not. Designation is site- and sample-specific. The historical regulators, wastewater agencies, are under the thumb of the federal permitting system and set mercury limits for wastewater entering the treatment plants. But, as noted in the preceding section, enforcement is difficult. In addition, most of the mercury entering a treatment plant remains there, in the grit and solids. In those places where solids are incinerated, mercury is discharged to air and is regulated by air quality agencies. Air regulations address immediate health risks (from inhalation), not the long-term bioaccumulation of mercury deposited on distant water bodies over time.

The net result is that the 50 tons of mercury discharged by dental offices in the United States each year may fall within the purview of many agencies, each approaching the problem through its particular regulatory lens. Each agency can, regulation-wise, move the mercury to a different media and a different set of regulations (without removing it from the environment). No one agency addresses the cumulative long term effects of mercury discharges, and there is no assurance that the mercury is ever effectively sequestered.

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[27] Linn, Keith. 2003 (Sept.) Pers comm. (phone). Northeast Ohio Regional Sewer District, Cleveland.
[28] Hughes, Stephanie. 2003 (Sept.) Pers comm. (phone) City of Palo Alto.
[29] Linn, Keith, 2004 (Jan). Pers comm (email). Northeast Ohio Regional Sewer District, Cleveland.

. . . and Regulations Are Patchwork

As noted above, wastewater treatment agencies were the first to address mercury discharges by dentists. By definition, these agencies have limited jurisdiction, and their regulatory mechanisms vary. Some (City of Toronto) adopted new Bylaws specifically addressing the issue. Others (King County, City of San Francisco) relied on enforcing limits already in place. Others (Palo Alto) negotiated special 'narrative' limits for dental offices. (These consist of a set of practices rather than numerical results.) Most have done little, or nothing, on this issue. The resulting patchwork system means that dentists living in one county or city may be required to act differently than those in the adjoining jurisdiction.

While the dental sector is organized hierarchically, with state and national organizations tackling this issue legally, politically and financially, treatment plants operate in loose confederations and develop situation-specific solutions. As noted above, enforcement models vary from place to place. Regulatory approaches used (or not used) often depend on local considerations—rules, limits, environmental impacts, values, politics and personalities.

This is beginning to change. In Ontario, the prospect of a 'patchwork' of " . . . potentially different by-laws in each of the 432 municipalities"[30] prompted the Royal College of Dental Surgeons of Ontario to propose a province-wide regulation mandating amalgam separators. It passed in May 2003. In the United States, the states of Maine, Connecticut and New Hampshire now require all of their dental offices to implement best management practices for amalgam, including the use of amalgam separators.

Conclusions

Dentists in the United States alone discharge an estimated 51 tons of mercury each year. This is easily and economically captured at the dental office. Given that mercury is a priority pollutant nationally and internationally, there is no good reason for governments to continue to avoid this issue.

While the dental community may not agree with environmentalists and/or regulators on the environmental significance of their mercury discharges, they are willing to comply with regulations, once asked. The experiences of King County, Toronto, Montreal, Connecticut and other jurisdictions bear this out. With little fuss, dentists have purchased and installed separators. A regulation concerning amalgam separators or alternative compliance procedures puts them on notice about what is required: there is a clear expectation, a definite time frame, and a method for measuring compliance. Decision-making is simplified.

Widespread installation of amalgam separators should make a difference in the quantity of mercury ultimately reaching the environment. If dentists contribute at least 40 percent of mercury entering wastewater treatment systems, and if amalgam separators remove 90-95 percent of this at the dental office, then jurisdictions requiring the installation of separators will find less mercury at the treatment plant and in its by-products.

Preliminary data from the City of Toronto and other places corroborate this.[31] The City of Toronto, which required installation of separators by January 1, 2002, showed a 58 percent reduction of mercury in

[30] Dispatch, 2003 (July/August). "College's New Regulation for Amalgam Waste Disposal Approved by Government Sets Benchmark for Canada," pp 10, 11 and 29.

[31] Krauel, Robt. 2002 Toronto, Ontario Sewer Use By-Law. Tuominen, Tim. 2002. Western Lake Superior Sanitary Sewer District. Presentations at the Binational Toxics Strategy Mercury Workgroup on Dental

treatment plant sludge in 2002 compared to 2001.[32] There was an 18 percent reduction in soluble mercury in treatment plant influent.[33] The Association of Metropolitan Sewerage Agencies is currently studying the effect of amalgam separators on mercury levels in effluent at eight United States wastewater treatment plants.

The current patchwork system of regulations regarding capture of dental amalgam serves neither the environment nor the dental community. This system—or rather, *non*-system—is a relic from a period when the problem was ill-defined and inadequately measured, the solutions untested, and the regulatory framework exclusively local. Regulations deal with mercury by compartmentalizing it within media (air, water and sediment) and reducing pollution only within that media. It is time for a new system—one that connects the dots, ensuring that remedial action in one media, such as water, does not exacerbate problems in the others.

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Mercury. Dec 2002. Chicago, IL. Arenholt-Bindslev, D. "Environmental Aspects of Dental Restorative Materials: A Review of the Danish Situation."

[32] Boyd, Owen. 2004 (Jan.) SolmeteX and Toronto Works & Emergency Services, Water & Wastewater Division, Quality Control and Planning. Pers Comm.

[33] Ibid.