Reducing Mercury from the Environment: An Assessment of Dental Amalgam

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Introduction

As the prominence of global mercury pollution has increased, governments have realized that mercury from dental facilities is a severe problem that necessitates proper action. Regulations to address dental mercury discharges have existed in some European countries for decades. Currently, half of EU Member States have requirements for dental practices to install amalgam separators. In the United States, regulations to reduce dental mercury effluent began in the 1990s and now 12 States have mandatory program requirements for dental amalgam discharges. Progress on this issue has been steadfast in the U.S., as the Environmental Protection Agency is presently in the final stages of issuing national effluent guidelines and pretreatment standards for mercury discharges from dental facilities.

Realizing the lack of action to confront this issue in developing nations, The Global Mercury Partnership, a mechanism of the United Nations Environment Programme for immediate action on mercury reduction, established the East Africa Dental Amalgam Project in 2013. The project involves the installation of amalgam separators in facilities in Uganda, Kenya, and Tanzania to reduce the local impacts of mercury releases. The most significant development in tackling this universal contaminant has been the recent adoption of the Minamata Convention on Mercury, a global treaty to reduce the release of anthropogenic sources of mercury. Adopted in October 2013, the Convention has specific stipulations for dental amalgam.

These policy initiatives are indicative of the proactive measures being taken here and now to reduce mercury pollution from dental facilities but more must be done in the immediate future. Dentists must acknowledge their contribution to environmental damage and take the necessary measures to ensure that they no longer contribute to this global pollutant. Through the installation of amalgam separators and the implementation of best management practices for dental amalgam, dentists can effectively protect human health and the environment while incurring modest costs and changes to their practice of medicine. The harm being done through the release of dental mercury can easily be remedied: the solutions are available, readily adoptable and cost-effective.

The aim of this paper is to emphasize the necessity of tackling this specific source of mercury pollution and to underline the ease in which this can be done. This paper will offer a clinician's point of view to highlight the simplicity of adopting best management practices for dental amalgam and to urge all dentists to adopt environmental stewardship as an integral component to the practice of dentistry. The paper will go on to assess the political developments surrounding this issue and detail the cost of inaction in reducing mercury in the environment by analyzing the environmental, health, and economic impacts of mercury pollution. It will be clear by the end of this analysis, that any further delays in reducing dental mercury waste cannot be tolerated.

The Global Synopsis

Global anthropogenic emissions of mercury are compromised of both intentional and unintentional uses of mercury. Intentional uses include certain products and industrial processes, dental amalgam for fillings, and artisanal and small-scale gold mining. According to the latest UNEP report on mercury, artisanal and small-scale gold mining is currently the largest source of global mercury emissions, standing at 37% of total emissions (UNEP 2013). Emissions from the burning of fossil fuels are the second largest source of global mercury pollution, accounting for 25% of total emissions. Emissions from this process, as well as from the mining and smelting of ore are examples of unintentional uses of mercury, wherein mercury is released as a by-product (Pacyna et. al., 2010).

As a restorative material, dental amalgam has been used in teeth for over 150 years. Amalgam is a metallic alloy that is primarily made up of mercury, silver, copper and tin. Mercury comprises around 50% of the material. Amalgam is continually recommended as a restorative in dentistry because of its durability, high clinical success and relatively low cost. However, as it has come to light in recent years, current practices result in sizable quantities of mercury being released into the environment from dental clinics, contributing to the build up of this harmful toxin in the global environment. Mercury-containing amalgam waste enters the environment when new fillings are placed or old mercury-containing fillings are taken out, and the waste generated is then flushed into chair-side drains. Close to 340 tons of mercury is used per year in dentistry, of which about 70-100 tons (20-30%) enters the solid waste stream (UNEP, 2013).

The anthropogenic release of mercury to waters is of the highest concern because this source poses the greatest threat to human health. Global releases to water are at least 1000 tons per year (UNEP, 2013). Once mercury is released into the environment through discharges to oceans, rivers, and lakes, sulfate-reducing bacteria transform mercury into methylmercury (MeHg), a persistent, bioavailable, and bioaccumulative neurotoxin that, even in minute quantities, poses risks to human health, wildlife, and the environment. Once in lakes or other bodies of water, the mercury is taken up by aquatic plants. These are consumed by small fish who, in turn, are consumed by the larger fish which we then eat. This process of bioaccumulation means that the mercury becomes concentrated and levels increase as it moves up through the food chain (Benoit et al., 2003; Swartzendruber & Jaffe, 2012; Mergler et al., 2007). When this happens, the water from that source may be safe to drink, but the fish removed from it may not be safe to eat. A single pound of mercury may be enough to contaminate a 22 acre lake to the point where fish consumption should be carefully monitored.

The main source of human exposure to methylmercury is through the consumption of contaminated fish and seafood. Tuna, swordfish, pollock, shrimp, and cod are the most contaminated sources (Sunderland, 2007). "It is estimated that 95% of ingested MeHg is absorbed through the gastrointestinal tract, after which it quickly spreads to all parts of the body—including the brain. In pregnant women, MeHg is actively transferred from blood to placenta, and fetal levels of mercury are assumed to be an average of 70% higher than maternal levels "(Mergler et al., 2007).

Mercury has a wide-range of impacts on human health, especially on developing fetuses and young children. Neurological and behavioral disorders are a result of mercury toxicity. Symptoms from toxicity are tremors, insomnia, memory loss, neuromuscular effects, headaches, and cognitive and motor dysfunction. Links to cardiovascular disease have been noted in recent studies as well, with observed impacts on cardiovascular end points like acutemyocardial infarctions (AMIs), hypertension, and changes in heart rate variability (Mergler et al., 2007; McKelvey & Oken, 2012). In the most vulnerable of populations, young children, toxicity can cause irreversible neurological damage resulting in mental retardation, seizures, vision and hearing loss, delayed development, language disorders and memory loss. Children with higher levels of mercury contamination are also more likely to suffer from attention-deficit hyperactivity disorder (Boucher, et al. 2012).

Consumption of contaminated fish is highly disconcerting and problematic. In a 2010 assessment of world fisheries, the Food and Agriculture Organization noted that:

> Just over 100 million tons of fish are eaten worldwide each year, providing two and a half billion people with at least 20 per cent of their average per capita animal protein intake. This contribution is even more important in developing countries, especially small island states and in coastal regions, where frequently over 50 per cent of people's animal protein comes from fish. In some of the most food-insecure places – many parts of Asia and Africa, for instance – fish protein is absolutely essential, accounting for a large share of an already low level of animal protein consumption (FAO, 2010).

Certain subpopulations in the U.S. also consume fish in higher frequency. Presently, one of the largest-scale methlymercury issues is in the Arctic, where local communities are fragile due to high exposure from fish consumption in indigenous dietary sources (Hylander & Goodsite, 2006). In Quebec, the Inuit population has the highest levels of exposure to any population in the world due to their high fish diets (Mercury: Time To Act). In these contexts, mercury pollution has manifested into an environmental justice issue, adversely affecting the livelihoods of vulnerable populations who experience disproportionately higher exposure to mercury. Subsistence farmers, indigenous groups, and other individuals for whom eating fish is culturally or socioeconomically significant have unfairly suffered more from this global contaminant. Mercury has come to threaten the culture and ways of life of these groups of people.

A Clinician's Perspective

Recycling amalgam is necessary to prevent mercury waste from entering landfills, waste incinerators and water treatment works where they are subjected to either high heat or high alkalinity, both of which can cause a release of mercury from a formerly stable, and bound, amalgamated state. The exposure of amalgam to the oxidizing environment of a sewer or wastewater treatment facility can fracture the amalgam bonds, causing a release of mercury. As these treatment facilities cannot effectively remove this material, raw mercury is discharged back into the water supply. Additionally, if the sludge from these facilities is burned, mercury is released. Even if landfilled, mercury will leach out of amalgam from the conditions present deep inside the landfill and find its way into the ground, water, or air.

Scrap amalgam includes excess mix, carvings, empty capsules from pre-capsulated alloy, extracted teeth containing amalgam, in-line disposable traps and vacuum traps. These should all be placed in specially designed containers and sent for recycling. Amalgam separators are also employed to prevent the fine particulate amalgam waste, generated through the removal of old restorations, from entering the waste water stream. On average about 70% of the amalgam waste is captured by the in-line filters. The remaining 30% is removed by the amalgam separator. Other than simply not having a willingness to make a slight change to the way waste is handled in the office, or not wanting to spend a relatively small amount of money to ensure a better quality of public health, there is no conceivable reason why a dentist would not want to recycle this material.

Before the State of New Jersey enacted their recycling regulation, an impact study was conducted. Three main points of that study are worth noting. First is the impact on agriculture. Pre-treating the dental office wastewater by installing an amalgam separator meant that the water entering the treatment facilities was virtually free of amalgam, as greater than 99.5% of the amalgam was removed at the source. The bio-solids in the residual sludge of the facility could then be beneficially reused as fertilizer. The second impact was social and quite obvious. By decreasing the release of mercury into the air and water, mercury levels in the food chain were reduced, leading to a healthier food supply. Lastly, the study looked at the economic impact for dentists in mandating amalgam recycling. They concluded that in an average practice of about 750 patients, it would cost about $0.87 per patient per year to recycle all amalgam waste. This seems to be an incredibly insignificant amount to spend. We should all, as clinicians, be concerned about the proper handling of the wastes our practices generate. Besides, most dentists live in the community where they practice and so should thus be good stewards of that community and its environment.

A simple unwillingness to change is also responsible for the lack of widespread adoption of amalgam recycling. We are a society which has become accustomed to simply throwing away that which is used, empty, or no longer of use to us. Behaviors can be difficult to change. This is no different with the dental community than it is with the general public. If we have done something the same way for years, we are often slow to change our behavior as we "perceive" that the way we are doing things is just fine. In these situations people are often refractory to change and so we see the importance of having an educational model for waste management, similar to that which has been done with infection control training or the training of clinicians in the proper handling and disposal of medical waste. By explaining the environmental problems associated with mercury disposal and showing the dentist how important and easy recycling is, regulations will look less onerous and greater compliance will be achieved as the dentists will come to view themselves as a part of the effort to improve overall health.

The last major regulatory change affecting dentistry in the U.S. was the 1970 mandate by the Occupational Safety and Health Administration (OSHA) regarding the wearing of gloves. Many dentists ignored this mandate until 1984 when a tipping point in glove-wearing behavior was reached. In 1984 the cause of AIDS was found to be the blood-borne transmission of HIV. Once this was known, dentists who ignored the long standing OSHA mandate changed their thinking and behavior overnight.

In some countries amalgam recycling is not yet mandatory. The time to act is now. The issue of mercury and dental amalgam is not going away. With Europe regulating recycling, many States in the U.S. doing the same, the U.S. EPA in the process of regulating the rest, and an international treaty on the horizon, the tide has turned. These wastes must not be incinerated or treated as regular trash or medical waste. Further, they must not be discharged into a sewer or septic system without first passing through an amalgam separator. With the ease and relatively low cost of recycling, and with the major impact of improved health, regulation must be sooner rather than later.

For any country there is an enormous benefit to dealing with this issue now. Recycling this material ultimately keeps it from finding its way into the water, soil and air. This leads to a healthier food supply and concomitantly to a healthier population. When you think in these terms, you see a decreased pressure on limited health care resources and their associated costs as less people will require treatment for health issues associated with mercury ingestion.

Economic Impacts of Mercury Pollution

Quantifying the total damage wrought by mercury pollution is exceedingly difficult given the pervasive nature of this contaminant. Existing studies have been able to quantify economic impacts in relation to IQ loss in children but these studies have been primarily focused in the U.S., making it difficult to extrapolate figures globally. Other uncertainties exist in quantifying the precise economic impact, including the cost of treating ailments resulting from mercury toxicity, like cardiovascular disease, immune system effects, cognitive dysfunction, and premature death. Another problematic element in assessing the extent of mercury pollution damage is the unquantifiable cost to the livelihoods and cultures of vulnerable populations who consume a disproportionate amount of fish, and are therefore exposed to higher levels of mercury toxicity.

Mercury also produces negative health effects at an ecosystem level – additional costs that elude precise quantification. Toxic effects targeting nervous, immune, and reproductive systems have been documented in wildlife containing higher concentrations of mercury. Fish can experience reproductive effects even at low levels of mercury exposure (Depew et al., 2012). In the Arctic, many species surpass concentrations of methylmercury that are said to lead to biological effects (including polar bears, and some species of whales, seals, fish, and birds) (Dietz et al., 2013). Certain types of birds in North America, like loons, eagles, and songbirds are also thought to be vulnerable to the toxicological effects from methylmercury (Evers et al., 2008). The subsequent economic impact of biodiversity loss, contaminated fish stocks and possible reduction in ecotourism from this environmental damage are also unaccounted for in economic assessments of mercury pollution. The numerous uncertainties surrounding the extent of mercury pollution are worrisome and warrant further inquiry. In the absence of a full understanding of the scope of this problem, the tenets of the precautionary principle must be employed to limit this source of pollution.

When assessing the extent of damage inflicted upon humans from this harmful contaminant, the figures in the U.S. are startling. A study conducted by the National Academy of Sciences in 2000 found that at least 60,000 children in utero are born at risk for neurodevelopmental effects each year as a result of their mother's exposure to methylmercury. An additional study by the Center for Disease Control and Prevention in

2001 found that one in ten women of childbearing age is exposed to unsafe levels of mercury, meaning that close to 400,000 children born in the U.S. each year are at risk of mercury exposure (Bender, 2002). Cord blood levels of mercury above acceptable limits in children are associated with loss of intelligence, which causes diminished economic productivity that persists over the entire lifetime of these children. This cost of toxicity is calculated at US$8.7 billion per year in the U.S alone (Hyland & Goodsite, 2006). In Greenland, where nearly 3/4 of children born have over the acceptable limit of cord blood mercury levels, the associated cost of lost IQ due to mercury toxicity is US$59.1 million per year. Nearly all mercury contamination in Greenland originates from outside the territory, attesting to the devastating transboundary nature of this contaminant (Hyland & Goodsite, 2006).

Minamata, a small fishing village in Japan, was the site of the worst mercury poisoning in history and its legacy has brought widespread attention to the devastating impacts of mercury toxicity. From 1932 to 1968, Chisso Corporation, a chemical factory, released industrial wastewater contaminated with high levels of methylmercury into Minamata Bay. Over 100 people in the region died as a direct result of methylmercury poisoning and tens of thousands of others were diagnosed with brain and nervous system damage (Hylander & Goodsite, 2006). The price paid for this contamination was not limited to human suffering. In the early 1990s, the cost of damage caused by Minamata disease was calculated at $73,915,474 per year in health damage compensations, $41,153,574 per year in expenditure for dredging work in Minamata Bay and $6,640,132 per year for fishery compensations (Mercury: Time to Act).

These preliminary economic assessments demonstrate that the damage imposed by mercury pollution is both immediate and long-term, and yet, not fully understood. These lessons serve as a stark warning against further inaction on reducing this global toxin. Immediate action must be taken to limit the release of this pollutant into the environment.

Dental Amalgam: The U.S. Context

Throughout the United States, States and municipal wastewater treatment plants, known as publicly owned treatments works (POTWs), aim to limit discharges of mercury to POTWs. Under the Clean Water Act, the U.S. Environmental Protection Agency (EPA) establishes national regulations to limit these discharges of mercury to surface waters and POTWs. The problem of mercury in wastewater was noted when municipal treatment plants observed mercury spikes in samples of their treated effluent in the 1990s (Bender, 2002). The contaminated effluent was failing standards set forth by the National Pollution Discharge Elimination System. A 2002 report prepared for the National Association of Clean Water Agencies (NACWA) found that dental clinics are the main source of mercury discharges to POTWs in the United States (U.S. EPA, 2008).

The majority of dental facilities in the U.S. are connected to sewerage systems and their wastewater is primarily received by POTWs. A study funded by the American Dental Association determined that 50% of mercury entering POTWs could be attributed to discharges from dental facilities (Vandeven & McGinnis, 2005). The greatest danger posed by this is that concentrations of methylmercury in dental wastewater have been detected that are orders of magnitude higher than background methylmercury concentrations in environmental samples in open oceans and lakes (U.S. EPA, 2008). The amount of mercury discharged from dental offices is important to POTWs because it can impact the ability of the POTW to remove overall mercury from influent wastewater.

It is estimated that in the United States, the dental industry uses close to 35.2 tons of mercury in the form of amalgam each year. Of those 35.2 tons, approximately 29.7 tons are discharged into the internal wastewater systems of dental facilities. Based on the capture efficiency rate of existing technology in dental practices, it is estimated that chair-side traps and vacuum filters capture roughly 23.2 tons of mercury in the form of amalgam. Thus, nearly 6.5 tons of mercury is discharged into POTWs from dental facilities in the United States. This figure corresponds to approximately half of the estimated total mercury load to POTWs in the U.S. (Vandeven & McGinnis, 2005). With an average capture efficiency rate of 95% at POTWs, approximately 0.3 tons of mercury in the form of amalgam are discharged to surface waters.

Currently, only 12 States have mandatory program requirements for amalgam discharges from dental facilities, all of which require the installation of amalgam separators. The installation of amalgam separators is the key to successfully addressing dental mercury discharges. Capture efficiency rates for mercury by amalgam separators range between 95-99%. If amalgam separators were ubiquitously installed in dental practices across the U.S., the estimated discharge of 6.5 tons of mercury to POTWs in the U.S. would be reduced to approximately 0.3 tons (Vandeven & McGinnis, 2005). These results were supported in a 2008 report from the EPA. In an assessment of potential reductions of mercury to POTWs from mandatory installation of amalgam separators in 100% of U.S. practices, it was found that only 0.29 tons of discharge would enter POTWs, resulting in 0.029 tons of discharges into receiving streams after treatment (U.S. EPA, 2008). These studies attest to the efficacy of amalgam separators in reducing dental mercury discharges and the tangible outcomes that result from their installation.

Regulations that mandate the installation of amalgam separator technology in dental facilities is the most pragmatic approach to achieving compliance on this public health issue. The failures of voluntary initiatives are plentiful. By 1994 in Seattle, WA, there was ample information about the mercury loads from dental offices to justify legislation to regulate this source. Strong pushback from the dental community resulted in a compromise of intense educational outreach to spur the adoption of volunteer programs to install amalgam separation technology. After five years of outreach and financial incentives for adoption, less than 3% of dental offices had purchased separators and less than 40% of dentists collected and recycled any mercury waste. After 10 years, a regulatory intervention was deemed necessary (Bender, 2002).

Furthermore, in its 2008 Health Services Industry Report, the EPA assessed 9 local mandatory and voluntary programs for dental discharges of mercury to wastewater in an effort to evaluate the effectiveness of these programs. Localities in WA, CA, OH, WI, RI, and CO were assessed. Though each locality had a range of requirements, most required the adoption of best management practices to reduce the amount of mercury waste generated at the practice and the installation of amalgam separator technology to capture and recycle the mercury waste produced. The results of the study found that participation rates in voluntary programs were highly variable, ranging from 100% of dentists in a community to as low as 20% (U.S. EPA, 2008). The highest rate of participation was seen for voluntary programs that included the threat of a mandatory program. These results were confirmed in another study conducted by the NACWA in 2002, which found voluntary program participation rates to fall between 100% and 38%. In their findings, the NACWA noted that during the first year of implementation, regulatory programs have higher participation rates than voluntary programs. All of these outcomes support the notion that regulation is an essential component to having dental facilities properly capture and manage their amalgam waste.

A lack of regulatory control by most government agencies is behind the lack of widespread adoption of best management practices for dental amalgam. Though some local governments have successfully worked with dental organizations to produce mercury reduction initiatives, this has been the exception rather than the rule, attesting to the notion that regulation is a key driver to reducing mercury waste from dental facilities. Fortunately, the U.S. Environmental Protection Agency is in the final stages of issuing national effluent guidelines and pretreatment standards for mercury discharges from dental offices. The rule will focus on best management practices and the use of amalgam separators as a regulatory requirement. The Office of Management and Budget has recently approved the rule and is set to publish it in the Federal Registry in the coming months. The rule is anticipated to be fully implemented in the U.S. within 2-3 years.

Dental Amalgam: The European Context

Regulations to address dental mercury discharges have existed in some European countries for decades. In Sweden, a voluntary agreement has been in place since 1979 that requires dental practices to install amalgam separators. This voluntary program, unlike many in the U.S., has proven to be effective in reducing mercury loads to waste water treatment plants. Between 1990 and 1995, the concentration of mercury in Stockholm's treatment plant sludge was reduced by 33% (Bender, 2002). As of 1995, amalgam use is illegal in Sweden, due to the issues surrounding environmental release. Following regulations in Denmark that required dental practices to install amalgam separators, mercury reduction in wastewater sludge in the country was reduced 50-80% when assessed in 2002 (UNEP, 2002). In France, a rule established in 2000 requires the installation of amalgam separators in dental facilities, the cleaning of waste water pipes before equipment installation, and the proper disposal of amalgam waste at appropriate recycling facilities (Bender, 2002). Mandatory installation of amalgam separators are also required in Austria, Belgium, Czech Republic, Germany, Finland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, and the United Kingdom (BIO Intelligence Service, 2012).

A 2010 report from the European Commission estimated mercury demand for dentistry in the European Union at around 75 tons per year (range 55–95 t/y). Close to 45 tons of this ends up in dental surgery effluents annually. Only part of this is captured and treated as hazardous waste in compliance with EU legislation. According to the report, dental mercury waste constitutes up to 9–13% of overall EU emissions to surface waters (UNEP Technical Report, 2013). This is the case because in only half of EU Member States does there exist national legislation specifically obliging dental facilities to equip amalgam separators. In the absence of specific stipulations for amalgam separator installations, dental practices in the EU have neglected to equip their practices. As of 2012, nearly 25% of EU dental facilities were not equipped with the technology. A further issue among EU dental practices is that currently installed amalgam separators are not properly maintained, inhibiting the ability of these separators to properly capture mercury. According to the 2012 European Commission study sited above, existing separators in the EU only have an efficiency rate of 70%, significantly below the 95% rate of separators that are adequately maintained. Stronger enforcement of EU waste legislation is needed to ensure that future and existing separators are properly maintained so that at least 95% of amalgam particles are captured.

Without further policy action, the number of dental facilities equipped with amalgam separators will only rise steadily. This slow rate of increase is in line with the replacement rate for old dental chairs. New chairs are now typically equipped with amalgam separators (BIO Intelligence Services, 2012).

Working Towards A Global Solution

The beginning of international efforts to confront global mercury issues began in 2001 when the Governing Council of the United Nations Environment Programme (UNEP) invited the Executive Director of UNEP to initiate a global assessment of mercury, including its chemistry and health effects, sources, transboundary nature, as well as methods for its prevention and control (Minamata Convention: Text and Annexes). After the assessment was complete in 2003, the Governing Council deemed that the mercury problem was a significant issue that warranted international action. UNEP encouraged governments to adopt goals to reduce mercury emissions and releases into the environment and provided technical assistance and capacity building activities to implement these goals (Minamata Convention: Text and Annexes). Decisions of the Governing Council in 2005 and 2007 established a mercury program in order to tackle this global contaminant. The 2007 decision called for enhanced voluntary measures and a review of new and existing international legal instruments to progress action on the global mercury problem. Two years later, the Governing Council noted that these voluntary measures were insufficient to address this issue and called for the preparation of a globally legally binding instrument. An Intergovernmental Negotiating Committee (INC) was created to spearhead the efforts of drafting a legally binding treaty.

In January of 2013, the INC concluded its fifth session by agreeing to the text of the Minamata Convention on Mercury (Minamata Convention: Text and Annexes). The main provisions of the treaty include measures to control the supply and trade of mercury, incorporating limitations on certain sources of mercury, like primary mining. Control measures on mercury-added products and manufacturing processes are also included, as well as specific controls for artisan and small-scale gold mining. Measures also include provisions for the environmentally sound storage of mercury waste and for contaminated sites. Financial and technical support for developing countries is included through the establishment of a financial mechanism (Minamata Convention: Text and Annexes). The Convention was adopted and opened for signature in October 2013. Currently, there are 102 signatories to the Convention. Only 1 country, the United States, has ratified it. The Convention will enter into force 90 days after it has been ratified by 50 nations.

As is germane to the scope of this paper, the Minamata Convention has specific provisions for dental amalgam, listed in Annex A, Part II of the Convention. The most significant of the provisions is (ix): "Promoting the use of best environmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land." It is this provision that can be most readily implemented through the installation of amalgam separator technology in dental facilities. Regardless of the additional provisions that aim to reduce the use of dental amalgam and that encourage the adoption of alternative restoratives, the fact remains that dental amalgam is highly used today, and that in the interim, the most productive and efficient way to reduce the environmental impact of this material is through the installation of amalgam separators in dental facilities across the globe.

Efforts are being taken by parties to implement the provisions of the Minamata Convention in the interim period until its entry into force. As mandated in the resolution on arrangements in the interim period adopted by the Conference of Plenipotentiaries on the Convention, the INC will intermittently meet as is necessary to facilitate the rapid entry into force of the Convention and its effective implementation upon its entry into force. The sixth session of the intergovernmental negotiating committee on mercury (INC6) is scheduled to take place November 2014 in Bangkok, Thailand. Additionally, sub-regional conferences among the Forum of Ministers of Environment for Latin America and the Caribbean and Francophone Africa were held in March and July 2014, respectively, in support of early implementation of the Convention.

Acting Now

It is imperative that immediate action is taken to reduce anthropogenic sources of mercury in the environment. The output of mercury into the environment is unsustainable at current levels and continued unregulated disposal will only prolong the devastating affects created by this global toxin:

> It is likely to be years or decades before reductions in anthropogenic emissions and releases of mercury have a demonstrable effect on mercury levels throughout the environment and in the fish and marine mammals which are part of the human food-chain. This only reinforces the need to act now to continue and strengthen international efforts to reduce current mercury emissions and releases. Delays in action now will inevitably lead to slower recovery of the world's ecosystems in future from mercury contamination, leaving an even greater legacy of pollution for future generations (UNEP, 2013).

From sources where emissions can be readily controlled, as is the case with dental amalgam, it is all the more important to take immediate action to limit mercury emissions. As the World Health Organization has deemed, there are no safe levels of mercury, reinforcing the notion that any quantity in the environment is unacceptable, especially in the face of viable solutions to reduce it from specific sources.

As highlighted in a 2002 Minnesota Report in a cost-effectiveness analysis of mercury pollution reduction options, tackling mercury pollution further down in its pathway to the environment becomes increasingly more cost prohibitive: "The highest cost option identified was capturing soluble mercury at a wastewater treatment plant using best available technology, which was estimated to cost roughly US$5.5 million per pound" (Jackson et al., 2000). This figure highlights a very important notion: that if mercury waste is not addressed at its source, which in the dental context is through the installation of amalgam separators, at a nominal cost, the efforts needed to contain this pollutant become exceedingly more expensive.

Mercury emissions circulate in the global environment through several pathways and travel long distance to areas far from production or use. Because of the nature of this far-spreading, transboundary pollutant, actions need to be taken at the source whenever possible (Mercury: Time to Act). The transboundary nature of pollution makes individual regulations insufficient in addressing this mercury issue. Sweeping adoptions need to be implemented to ensure the elimination of this pollutant at its source. Once released into the environment, its effects know no boundaries, needlessly harming human livelihood (Jackson et al., 2002). As noted earlier, nearly all mercury contamination in Greenland originates from outside the territory. In Minamata as well, health effects were not restricted to Minamata Bay and around the Minamata River, but were extended to the major part of the population living around the inland Sea of Shairanui at the height of this public health crisis (Hylander & Goodsite, 2006).

There are many time-lag effects associated with mercury pollution. One that is specific to the dental amalgam issue is the buildup of amalgam in the sewer pipes from dental offices. Particles that are trapped in dental office plumbing and draining pipes have been identified as a continuing source of dissolved mercury to wastewater facilities over time (Bender, 2002). When amalgam is not properly captured before it enters the waste stream, it serves a consistent long-term source of pollution. For this reason and the numerous already stated, it is imperative that dental amalgam is prevented from ever entering the waste stream through the implementation of amalgam separator technology.

Given everything that has been highlighted in this paper, all efforts possible within existing political and economic realities should be made to reduce anthropogenic sources of mercury pollution into the environment. The case for dental amalgam pollution is simple: a cost-effective, readily adaptable, and easily implemented solution exists that stops mercury pollution at its source - the most effective means to tackle any form of pollution. The framework exists for a simple remedy to this particular mercury issue. There is simply no reason for delay in the implementation of amalgam separator technology in dental practices across the world.

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