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Knowledge for Clinical Practice

DENTAL AMALGAM:

STRATEGIES TO REDUCE ITS ENVIRONMENTAL IMPACT

By Fiona M. Collins, BDS, MBA, MA, FPFA

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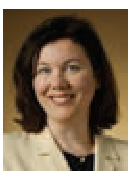
ABSTRACT

Dental amalgam has proved to be a durable restorative material. However, it also is a source, albeit a minor one, of the mercury released into the environment by human activity. Improper disposal of amalgam waste results in its ending up in landfills, wastewater sludge or incinerators. Additionally, publicly owned treatment works (POTW) cannot remove 100% of the mercury from wastewater. The American Dental Association released its Best Management Practices for Amalgam Waste several years ago, detailing how amalgam waste can be disposed of safely. The recent EPA Final Rule mandates the use of amalgam separators to segregate solid waste from evacuation lines before it leaves the office toward the POTW. In addition, new rules on evacuation line cleaners and on the disposal of amalgam waste apply. The Minamata Treaty also provides nine measures related to amalgam, of which signatories are intended to choose at least two: to reduce the use of amalgam in the long term and to reduce its environmental impact.

ABOUT THE AUTHOR



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EDUCATIONAL OBJECTIVES

The overall goal of this article is to provide dentists, dental hygienists, and dental assistants with information on requirements and best practices in the handling of amalgam. After completing this course, participants will be able to:

1. Describe how mercury reaches the environment and the impact of methylmercury
2. List and describe key elements of the EPA Final Rule and considerations for amalgam separators
3. Review best management practices for amalgam waste
4. Describe initiatives and options related to the future use of amalgam.

Introduction

Dental amalgam has proved over time to be a valuable material for direct restorations and core buildups.[1-4] It owes its origins to formulations in China.[5] A paste containing silver and somewhat similar to amalgams was reported as early as 659 CE in China,[5] and a compound containing largely tin, together with the remaining 10% consisting of a combination of mercury and silver, was reported there approximately 900 years later. Dr. Pierre Fauchard, after whom the Pierre Fauchard Academy is named, developed an amalgam containing lead in the early 18th century, and almost a century later another French dentist developed a silver direct restorative material that contained mercury. Numerous amalgams were subsequently developed in Europe and the United States during the 1800s, culminating later in the introduction of modern dental amalgams.[6]

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However, the potential impact on the environment of mercury released from human activities, and ultimately its impact on human and animal health, is also well-recognized.[7] Considerable efforts are now being made to reduce the impact of mercury-containing products, including dental amalgam, on the environment.[7] Recent developments include the availability of alternative direct dental restoratives, best practices in the handling of amalgam waste and the availability of efficient methods to reduce environmental exposure to amalgam by segregating it "at source" rather than its release into wastewater.[8,9] Before addressing these efforts, we will look at the issues related to mercury pollution in the environment and the role of amalgam waste in context with other sources of mercury and their environmental and potential health impacts.

Mercury Naturally Present in the Environment

Mercury is naturally present in the environment, released over time from rocks and soil through weathering by wind and water and as a result of volcanic activity.[10] There are three broad categories of mercury present[11] (Table 1). These include organic mercury, which is present when mercury combines with carbon. Inorganic mercury, also known as divalent mercury (Hg2+) and mercuric mercury, combines with other elements (e.g., chlorine, oxygen, or sulfur). Inorganic mercury includes mercuric sulfide, known as cinnabar. Organic mercury is mostly present as methylmercury (also known as monomethylmercury). Organic mercury also exists as dimethylmercury and phenylmercury. Elemental mercury (Hg0), also known as metallic mercury, is a metallic-looking liquid at room temperature. It is a second form of inorganic mercury and the type most frequently found in ambient air.[12] Elemental mercury can partially evaporate to form vapors, increasingly so as the ambient temperature increases. The levels of naturally occurring mercury present in the environment are generally low.

Human Activity and Mercury in the Environment

Mercury present due to human activity occurs predominantly as a result of burning fossil fuels, mining, incineration of waste, and smelting. Together, these account for about four-fifths of the total associated with human activity.[10] Of the remaining 20%, solid waste, fertilizers, and fungicides, as well as mercury released from wastewater, account for 75% and 25%, respectively[10] (Figure 1).

TABLE 1. Naturally occurring mercury

Organic mercury	Methylmercury, dimethylmercury and phenylmercury
Inorganic mercury (Hg2+)	Mercuric sulfide (cinnabar), other metallic salts as white powders/crystals
Elemental mercury (Hg0)	Metallic-looking shiny liquid (pure mercury) at room temperature

Mercury Release into the Environment by Human Activity

Mercury vapor is released into the environment through incineration of waste containing mercury (including products), which can include sludge from wastewater treatment plants and solid waste, and from landfills (again including sludge).[13] Factories also release mercury vapor, and crematoria are recognized as releasing mercury vapor when individuals with dental amalgam fillings are cremated.[14] Clinics

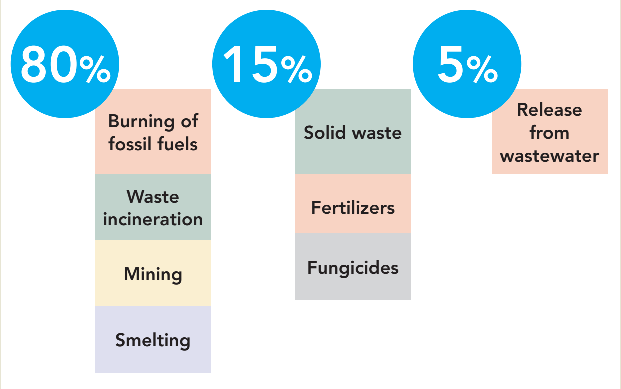

Figure 1. Sources of mercury present due to human activity

may also release mercury. From the atmosphere, mercury settles into water and onto land in all three categories (see Table 1). Mercury in landfills, from bodies in cemeteries, and other ground also leaches into the surrounding land and groundwater, and thereby reaches lakes, rivers, and deltas, and the sea (Figure 2).

Atmospheric mercury is mainly present as elemental mercury. In water, elemental mercury is known as dissolved gaseous mercury.[12] Inorganic (divalent) mercury usually accounts for <5% of atmospheric mercury, present as reactive gaseous mercury. It is an important factor in surface water, remains in air for less time than elemental mercury, and dissolves easily in water.[12]

Aqueous Ecosystems: Methylation and Human Health

Mercury in surface waters exists in numerous forms, including as dissolved gaseous mercury (elemental mercury), dissolved inorganic (divalent) mercury (also known as dissolved reactive mercury), and as organic mercury predominantly in the form of methylmercury.[15] Most mercury deposited in water initially arrives as inorganic (divalent) mercury.[16] This can be transformed into dissolved gaseous mercury.[17] Mercury in the surface water can evaporate from the surface, thereby re-entering the atmosphere. However, once entering the atmosphere, redeposition into water can occur. Mercury can also settle on and become buried in sediment under the water, and from there re-enter the water above or become suspended again.[16] Both methylation and demethylation of mercury can occur in water.

Methylation of mercury in water requires a series of steps (Figure 3). Non-methylated mercury present can undergo methylation through a complex series of steps. The mercury is first complexed, after which it enters bacteria present in the water, where it is transformed into methylmercury. Bacteria involved include sulfate-reducing bacteria. Sunlight photolysis reactions can also methylate mercury.[12] Methylation is greater in streams, rivers, wetlands, and lakes than in seawater.[12,17] Factors increasing the amount of methylation include a low aquatic pH environment and higher levels of dissolved organic carbon.[16] Other factors include sulfate levels and the amount of ultraviolet radiation and sunlight.[18] Demethylation can also occur through volatilization by sunlight, mediated by reactive oxygen species, and in deep water through degradation, mainly in the sea.[12,16] Demethylation may occur by algae in fresh water.[12]

Methylmercury and Health

Methylmercury bioaccumulates in the muscles and fatty tissues of fish and shellfish, and is the major type of mercury to do so. In this manner, it enters the food chain and ultimately humans ingest fish containing high levels of mercury.[19] The level of methylmercury in fish/shellfish can be millions

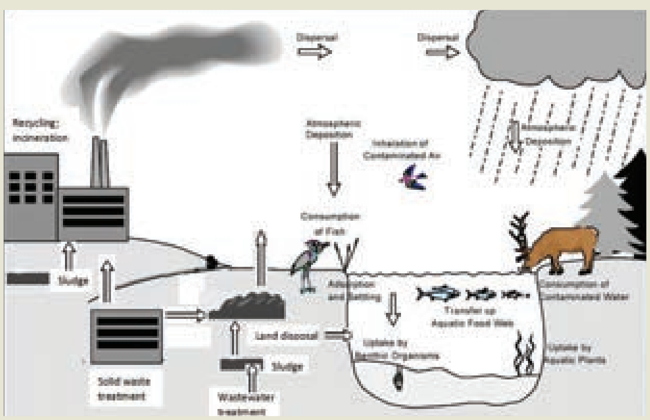

Figure 2. Release of mercury into the environment

Source: Adapted from EPA diagram

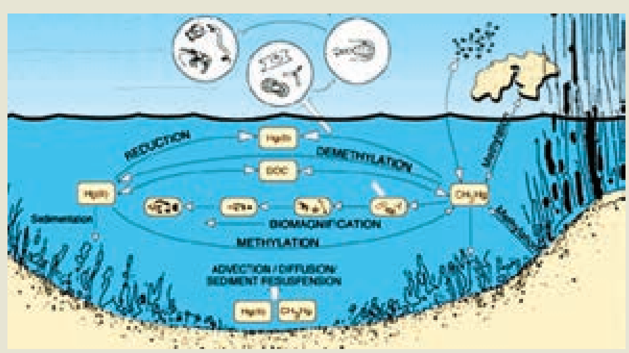

Figure 3. Methylation of mercury

Source: United States Geological Survey

TABLE 2. Signs and symptoms of methylmercury exposure
Impaired vision and taste
Auditory disturbances
Numbness
Impaired motor coordination and abnormal reflexes
Headaches
Poor memory and concentration
Immune system impairment
Changes to enzyme and genetic systems
Developmental defects
Severe convulsions (extremely high levels of methylmercury)
Coma (extremely high levels of methylmercury)
Death (extremely high levels of methylmercury)

of times greater than the surrounding aquatic environment. Bioaccumulation is greater for larger than smaller fish, and methylmercury levels in fish biomagnify when predator fish eat smaller fish, increasing the amount of methylmercury present. Methylmercury is of more concern for human health than other forms of mercury and it is the most toxic. It impairs the immune system, changes enzyme and genetic systems, is especially detrimental for the central nervous system and results in the degradation of myelin.[16] Signs and symptoms of methylmercury poisoning include tremors, impaired vision and taste, auditory disturbances, numbness, headaches, abnormal reflexes, impaired motor coordination, and poor memory and concentration.[16,20] Further, developing embryos are five to 10 times more sensitive than adults.[16] As observed in Minamata Bay, Japan, patients with extremely high levels of methylmercury poisoning suffer from severe convulsions, coma and death[21] (Table 2).

The Role of Dental Amalgam

Dental amalgam accounts for around 20% of all mercury used in products.[23]

An estimated 270 to 341 metric tons of mercury in 2010, accounting for 10% of mercury used, has been attributed to mercury in dental amalgam.[24] Overall, <1% of mercury released into the environment was estimated to be from dentistry.[25] Chairside traps and vacuum pump filters alone are estimated to remove up to 80% of contact amalgam waste in wastewater.[26]

Amalgam waste in wastewater going to POTW and inappropriate disposal of contact amalgam waste and non-contact amalgam waste are all contributing factors to mercury pollution.[8,9] Further, while POTW are effective in removing solid and dissolved mercury contained in wastewater, one study found that 10% remained when the water was released.[26]

Global Collaboration

The United Nations Minamata Convention on Mercury ("Minamata Treaty") was developed to reduce mercury pollution, and was adopted in 2013.[7] It is named after Minamata Bay, Japan, where the consequences of acute methylmercury poisoning were experienced by the local population. This Treaty, under Article 1, has as its objective "to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds."[7]

In order to achieve this objective, a number of strategies and measures were developed for global implementation. These addressed manufacturing, exports, imports, and a proposed reduction over time (phasing down) in the use of mercury across industries. As part of this initiative, the contribution of mercury from dental amalgam was addressed, with seven measures developed that were focused on reduced use of dental mercury and two addressing the management of mercury to reduce its environmental impact by decreasing mercury release. Each country party to the Treaty could choose two or more measures for implementation. Measure 9 refers to "Promoting the use of best envi-

Existing discharger with amalgam separator

- **Grandfathered in for 10 years provided amalgam separator is functioning properly**
- **Compliance report by October 12, 2020**

Existing discharger (no amalgam separator)

- **Must be in compliance by July 14, 2020**
- **Compliance report by October 12, 2020**

New discharger

- **Install and use**
- **Must be in compliance immediately**
- **Compliance report within 90 days of first discharge**

Figure 4. Compliance with the EPA Final Rule

ronmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land." In the context of dental amalgam, this refers to best practices in the management and handling of amalgam waste. A key initiative in best practices is the incorporation of amalgam separators in dental offices.

The Environmental Protection Agency Final Rule

The Environmental Protection Agency (EPA) Final Rule was signed into law on June 14, 2017, and became effective on July 14, 2017.[8] Under this, use of an amalgam separator certified to be ISO 11143-compliant is required and specified best practices must be followed[27-28]. The amalgam separator must be tested and certified that it meets the requirement of being at least 95% efficiency. Under the Final Rule, dental offices that place and/or remove amalgam (and thereby release amalgam into wastewater flowing from the dental unit) are referred to as "dischargers." "Dental amalgam" is defined it as "an alloy of elemental mercury and other metal(s) that is used in the practice of dentistry." Requirements for compliance and one-time compliance reports are provided for dental facilities already discharging wastewater to POTW (existing dischargers) and for new dischargers.[8] Depending on a dental office's location, local regulations and requirements for amalgam separators and cleaners may be more stringent that the EPA requirements, which are the minimum.

Facilities that are new dischargers after the Final Rule came into effect must install and use an ISO 11143-compliant amalgam separator at the time the facility becomes a new discharger. They must be in compliance immediately and a one-time compliance report must be submitted within 90 days of the first discharge to a POTW. Facilities that were dischargers prior to July 14, 2017 (one month after the Final Rule came into effect), i.e., existing dischargers, must be in compliance within 3 years (i.e., by July 14, 2020). A third category of dischargers – existing dischargers that had already installed an amalgam separator prior to the Final Rule coming into effect – were grandfathered in for 10 years until June 14, 2027, provided the amalgam separator is still functioning properly. A compliance report must be filed by October 12, 2020, for facilities that were existing dischargers.[8]

Several categories of dental facilities are exempt. As noted in the EPA's Frequently Asked Questions issued subsequent to the Final Rule, dental offices that have a wastewater retaining tank technology that collects all amalgam process wastewater and that as a result do not discharge amalgam process wastewater to a POTW are exempt. In addition, offices using a different technology that is as efficient as amalgam separators are exempt (Table 3). Note that it is important to check state, municipal, and local regulations in these regards.

Understanding and Selection of Amalgam Separators

Amalgam separators remove and segregate solids from dental unit evacuation lines and flowing through chairside traps prior to the wastewater being discharged to POTWs.

The solids can then be recycled. Some amalgam separators are >99% efficient, exceeding the required efficiency of 95% under ISO-11143. Amalgam separators work through sedimentation, filtration, ion exchange, centrifuging, or a combination of these methods (Figure 5). Sedimentation relies upon particles settling out in a settling tank before wastewater goes to the POTW, with the separators slowing the flow of water to enable settling out. In some filtration devices, dissolved mercury can be filtered out in addition to particles.[25] Centrifugation results in particles settling out on the sides of the chamber due to the centrifugal forces within the amalgam separator.[25] In the case of ion exchange systems, particles separate out and end up in the bottom of the separator, including very small particles. They benefit from the binding of dissolved mercury with chemicals resulting in these bound compounds also separating out.[25] Devices using a combination of methods, or several layers of filtration, are particularly efficient at removing solids consisting of both smaller and larger particles. Several brands of amalgam separators currently on the market are >99% efficient.

Figure 5. Amalgam separators

TABLE 3. Facilities exempt from the EPA Final Rule
Oral pathology offices
Oral and maxillofacial radiology offices
Periodontal offices
Prosthodontic offices
Orthodontic offices
Mobile dental units providing care at multiple locations
Facilities where amalgam is not placed and where amalgam is only removed in unplanned or emergency situations
Facilities that only provide dental hygiene treatments (do not place or remove amalgam)
Facilities that have a wastewater retaining tank technology that collects all amalgam process wastewater
Facilities using a different technology that is as efficient as amalgam separators

Considerations in Selecting an Amalgam Separator

A number of factors should be considered when determining which amalgam separator(s) to use. These include efficiency, regulations, and requirements specific to your office's location, compatibility, pump preservation, capacity, costs, footprint, handling and disposal of solids, ease of installation, maintenance requirements, warranties, and company support.[25,29]

First, the amalgam separator must meet or exceed the ISO 11143 standard of at least 95% efficiency. However, it is crucial to check state, municipal and local regulations as these may include specific requirements that are more stringent. Many locations require an efficiency of >99% capture. The amalgam separator must be compatible with your system, whether it is a wet or dry vacuum system, and it must have sufficient capacity for your needs. Make sure the amalgam separator will not negatively impact your vacuum pump. In offices placing a greater number of amalgams, consideration should be given to a larger amalgam separator that will not require as frequent changing out of canisters (containers) as would a smaller device.

Assess the amalgam separator's footprint (size) and available space, and determine whether you want a central amalgam separator to service several operatories, or whether individual amalgam separators are preferable. In an office with multiple operatories, using one central amalgam separator can simplify replacement of canisters and maintenance. Current capacity requirements and any projected future capacity needs must be assessed, based on the number of chairs and flow rate. Depending on your facility, installation of a central amalgam separator may necessitate replumbing of the lines. If you have multiple operatories and choose individual amalgam separators for each operatory, operatories that are strictly dedicated to dental hygiene procedures are not required to have these installed[25,29] (Table 4).

Vendors can assist with these determinations and recommend suitable amalgam separators. When comparing costs, the initial cost and ongoing costs must be factored in. Check whether your proposed vendor can offer installation, maintenance, and services.

TABLE 4. Factors in selecting amalgam separators and vendor
ISO 11143 compliance, efficiency and ratings
Federal, state, and local regulations and requirements
Compatibility – wet or dry vacuum system, pump
Capacity and flow rate – consider current and future needs
Footprint – size, central/individual separators, available space
Ease of installation
Costs – initial and ongoing
Handling and disposal of solids, recycling of containers
Maintenance – requirements and ease of maintenance
Warranties
Company (vendor) support – initial and ongoing (e.g., help with waste disposal and recycling)

Handling and Replacing Canisters

Canisters must be replaced when they have reached the maximum fill level. To protect the operator handling the canisters, personal protective equipment including a surgical face mask, protective eyewear, and gloves must be worn and contact with the canister's contents avoided. In accordance with the EPA regulations, the amalgam separator manufacturer's guidelines must be followed for replacement of the canister. In addition, canisters should be replaced at 12 months, even if they are only partially filled, because ISO 11143 certification is based on canister replacement at a maximum of 12 months to help ensure proper functioning of the amalgam separator. The EPA recommends that a backup canister is kept on site and that amalgam separators be monitored monthly.

The EPA regulates the disposal of mercury-containing hazardous waste, and the solids collected in the amalgam separator must be handled in accordance with federal, state, and local regulations. The canisters must be recycled appropriately by an approved recycler of amalgam waste. Canisters must never be rinsed, and they must never be disposed of in the office in the trash or in hazardous waste bags.

Your amalgam separator vendor may offer a convenient service with pickup of used canisters or arrange for them to be shipped using prepaid return labels provided when you received new canisters and which can be affixed to the original protective box containing a used canister for return shipment. Delivery of new canisters can also be automated

Figure 6. Disposable traps

on a prearranged schedule. The use of an approved amalgam recycler is mandated by the EPA. Approved recyclers separate mercury from other metals in dental amalgam and recycle the mercury, keeping it out of the environment. The dental office is responsible for ensuring that all amalgam waste is going to an approved amalgam recycler. Records must be maintained verifying disposal and appropriate recycling of amalgam waste, including from amalgam separators.[29] Recyclers will send a certificate of recycling to your office, or this may be forwarded by your amalgam separator vendor as a service. This can be received by mail or email and must be kept on file. Upon request, you must make this certificate available to authorities in the future for inspection.

Evacuation Line Cleaners and the Final Rule

Evacuation line cleaners must have a pH of between 6 and 8. In addition, the use of evacuation line cleaners containing oxidizers is prohibited under the EPA Final Rule as these can solubilize bound mercury, releasing it into wastewater going to the POTW. The EPA FAQ further clarifies the language in the Final Rule, noting that the prohibition on the use of oxidizing or acidic cleaners is specific to lines that feed dental unit wastewater through the system and ultimately to POTWs. It does not apply to dental unit waterline cleaners used to help ensure the safe delivery of patient care.

Handling and Disposing of Amalgam Waste

The American National Standards Institute/American Dental Association (ANSI/ADA) Standard No. 109 has defined amalgam waste "as including amalgam (scrap), chairside trap filters containing amalgam vacuum pump filters containing, amalgam, saliva ejectors if used in dental procedures involving amalgam, used amalgam capsules, extracted teeth with amalgam restorations, and waste items that are contaminated with amalgam."[30] All amalgam waste must be handled and disposed of in accordance with federal, state, and local regulations and requirements (including the EPA Final Rule). The American Dental Association provides information on the handling of amalgam waste in its brochure "Best management practices for amalgam waste," which can be found on the ADA website.[31]

One of the nine initiatives in the Minamata Treaty is "Restricting the use of dental amalgam to its encapsulated form." In addition, the ADA recommends using the smallest amalgam capsule required for a restoration to help minimize amalgam waste.

Contact Amalgam Waste

Contact amalgam waste consists of any amalgam waste that has been in contact with the patient, both new amalgam and old amalgam from restorations. Loose amalgam in a cuspidor can be placed directly in an approved container. The requirements for amalgam separator waste are addressed above. Placement of contact and non-contact amalgam waste in approved containers is also known as "grey bagging."

Traps and Filters

The use of disposable chairside amalgam traps and filters is recommended. Amalgam in all traps and filters must be placed in an approved air-tight container as contact amalgam waste. When discarding disposable traps used in operatories where amalgam is placed and/or removed, these must also be placed in the approved container as contact amalgam waste (Figure 6). It is generally recommended that disposable traps be replaced at least weekly. Reusable traps can be disinfected but must never be rinsed under the tap. To comply with the EPA Final Rule, the disinfectant must have a pH of between 6 and 8. Chlorine, bleach, and other oxidizing agents must not be used.

Filters should be replaced at regular intervals, as recommended by the manufacturer. The used filter should be sealed with its lid on and sent for approved recycling.

Extracted teeth containing amalgam must also be disposed of as contact amalgam waste. If they are disinfected first, the disinfectant requirements noted above apply. In addition, extracted teeth must never be "red bagged" as medical waste.

Non-contact amalgam waste

Non-contact amalgam waste is any that did not at any time contact the patient. This includes scrap left over and used capsules – whether or not they contain scrap amalgam. These must all be placed in an approved airtight container.

Recycling

Amalgam waste must be recycled by an approved recycler. In selecting a recycler, consider whether they accept all types of contact and non-contact amalgam waste, used filters, and amalgam separator canisters, or only certain types of amalgam waste. Check on containers and/or packaging, and whether the recycler will provide these, as well as whether full containers will be collected or need to be shipped. The recycler must be compliant with all regulations. Make sure to receive a certificate of recycling each time your amalgam waste is recycled.

Current and Future Use of Amalgam

The Minamata Treaty calls for the phasing down of use of dental amalgam globally. Seven of the nine measures related to dental amalgam address methods of phasing down amalgam use through policy, prevention, education and training, and the use of alternatives (Table 5).

National policies on prevention reduce the need for any type of restoration, while the remaining measures help to promote the use of alternatives. The Treaty has, however, been criticized for its voluntary nature and lack of mandated deadlines, targets, or implementation.[32]

TABLE 5. Seven measures related to the proposed phasing down/reduction in amalgam used
(i) Setting national objectives aiming at dental caries prevention and health promotion, thereby minimizing the need for dental restoration
(ii) Setting national objectives aiming at minimizing its use
(iii) Promoting the use of cost–effective and clinically effective mercury-free alternatives for dental restoration
(iv) Promoting research and development of quality mercury-free materials for dental restoration
(v) Encouraging representative professional organizations and dental schools to educate and train dental professionals and students on the use of mercury-free dental restoration alternatives and on promoting best management practices
(vi) Discouraging insurance policies and programs that favor dental amalgam use over mercury-free dental restoration
(vii) Encouraging insurance policies and programs that favor the use of quality alternatives to dental amalgam for dental restoration

Source: Minamata Convention on Mercury, 2013. Part II:p41.

Alternative materials include glass ionomers, resin-based composites, and other tooth-colored restorations (direct and indirect). However, dental amalgam remains a mainstay of restorative dentistry in many locations and settings. Although it is not an esthetic solution, dental amalgam is durable, easy to use, moisture tolerant, technique-forgiving, and relatively inexpensive. It is therefore globally still a restorative material of choice in appropriate situations (unless banned or limited by national or regional policy). One-quarter of pediatric dentists in one U.S. survey and 29% of general dentists reported that they currently placed amalgams frequently. Based on this survey, individuals placing amalgams frequently and those believing amalgam to be unsafe were also in favor of mandatory use of amalgam separators.[34]

Conclusions

Dental amalgam has been used as an effective, durable, and tolerant restorative material for many decades. In recent years, concern over mercury release into the environment by human activity has greatly increased. The majority of such mercury release is related to mining, waste incineration, smelting, and the burning of fossil fuels, other sources include solid waste and wastewater. While dental amalgam is a minor contributor, it can be managed to help prevent the inadvertent release of mercury into the environment. The EPA Final Rule has mandated the use of amalgam separators. It has also mandated the appropriate disposal of amalgam canisters, addresses amalgam waste, and has regulated the types of evacuation line cleaners that may be used. There are numerous considerations in selecting amalgam separators, depending on the office. Further, all federal, state, and local regulations related to amalgam separators, evacuation line cleaners, and disposal of amalgam must be followed if these are more stringent than the requirements of the EPA Final Rule. All amalgam waste must be stored, disposed and recycled in accordance with the regulations. The use of alternative materials and prevention programs that reduce the need for restorative care also contribute by reducing the use of amalgam. Preventing the release of mercury from dental amalgam contributes to protection of the environment, and helps to safeguard the health of humans and other species.

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1. ________________ developed an amalgam containing lead in the early 18th century.
- a. The Crawcours brothers
- b. Pierre Fauchard
- c. John McMillan
- d. GV Black

2. Mercury is naturally present in the environment, released over time ________________.
- a. from rocks and soil through weathering by wind
- b. from rocks and soil through weathering by water
- c. as a result of volcanic activity
- d. all of the above

3. Organic mercury is mostly present as ________________ governs the autonomic and motor response to pain.
- a. cinnabar
- b. dissolved mercury
- c. methylmercury
- d. dimethylmercury

4. Mercury present as a result of ________________ is one of the main sources of mercury in the environment due to human activity.
- a. burning of fossil fuels
- b. wastewater
- c. solid waste
- d. fungicides and fertilizers

5. Most mercury deposited in water initially arrives as inorganic (divalent) mercury.
- a. True
- b. False

6. Mercury in the environment can ________________.
- a. mix with carbon to form mercuric mercury
- b. evaporate from the surface, re-entering the atmosphere
- c. be reduced to elemental mercury
- d. dissipate and degrade when present in high quantities

7. The bacteria involved in methylation of mercury include ________________.
- a. manganate-reducing bacteria
- b. manganate-reducing fungi
- c. sulfate-reducing bacteria
- d. sulfate-reducing fungi

8. Methylmercury bioaccumulates in the ________________ of fish and shellfish.
- a. bones and cartilage
- b. skin
- c. muscles and fatty tissues
- d. all of the above

9. Methylmercury levels in fish ________________ when predator fish eat smaller fish.
- a. bioaccumulate
- b. biomagnify
- c. bioconcentrate
- d. biotransform

10. Patients with extremely high levels of methylmercury poisoning suffer from severe convulsions, coma, and death.
- a. True
- b. False

11. Overall, ________________of mercury released into the environment was estimated to be from dentistry.
- a.<0.5%
- b. <1%
- c. <5%
- c. >10%

12. Chairside traps and vacuum pump filters alone are estimated to remove up to ________________ of contact amalgam waste from dental unit wastewater.
- a. 20%
- b. 40%
- c. 60%
- d. 80%

13. POTW are effective in removing ________________ of solid and dissolved mercury contained in wastewater.
- a. 60%
- b. 70%
- c. 80%
- d. 90%

14. The objective of the Minamata Convention on Mercury is "to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds."
- a. True
- b. False

15. Under the EPA Final Rule, an amalgam separator must be certified to be ____________, with an efficiency of at least __________________.
a. ISO 11134-compliant; 95%
b. ISO 11143-compliant; 95%
c. ISO 11134-compliant; 99%
d. ISO 11143-compliant; 99%

16. Dental offices that have a wastewater retaining tank technology that collects at least 75% of amalgam process wastewater are exempts from the requirement to have an amalgam separator.
a. True
b. False

17. Which of the following is exempt from the EPA Final Rule?
a. A facility with a mix of general dentists and hygienists where amalgam is placed
b. Pediatric dentist offices
c. Prosthodontist offices
d. Endodontist offices

18. Sedimentation relies upon __________________.
a. centrifugal forces
b. particles settling out
c. partial ion exchange and particles settling out
d. centrifugal forces and particles settling out

19. All amalgam separators are compatible with dry and wet vacuum systems.
a. True
b. False

20. For offices with chairs where amalgam is routinely used/removed and that also have dedicated dental hygiene chairs, ________________.
a. a central amalgam separator must be used that covers all chairs
b. individual amalgam separators must be used for each chair
c. a mix of individual separators and a central amalgam separator for the dental chairs is required
d. a central separator or individual amalgam separator is not required for dedicated dental hygiene chairs

21. Canisters should be replaced __________________.
a. at 6 months even if they are only partially filled
b. at 12 months if they are full
c. at 12 months whether partially filled or full
d. by 18 months

22. Solids in canisters need to be recycled __________________.
a. separately by the dental office
b. by the amalgam separator vendor
c. by a waste metal recycler
d. by an approved recycler of amalgam waste

23. The dental office is responsible for __________________.
a. maintaining records of disposal of amalgam waste
b. maintaining records of amalgam separator efficiency
c. maintaining records verifying appropriate recycling of amalgam waste
d. a and c

24. Evacuation line cleaners must have a pH of between 6 and 8. In addition, the use of evacuation line cleaners containing oxidizers is prohibited under the EPA Final Rule.
a. True
b. False

25. Which of the following is not contact amalgam waste?
a. Amalgam in extracted teeth
b. Amalgam from old restorations
c. Amalgam left over in capsules
d. Amalgam in the evacuation lines

26. When discarding disposable traps used in operatories where amalgam is placed and/or removed, __________________.
a. the amalgam in them should be disposed of as contact amalgam waste and the traps disposed of in the trash
b. the amalgam in them should be disposed of as contact amalgam waste and the traps can be disinfected
c. the amalgam in them and the disposable traps should both be disposed of as contact amalgam waste
d. it is better to use reusable traps

27. Reusable traps __________________.
a. can be rinsed under running water
b. should be rinsed with water and detergent
c. can be treated with chlorine
d. can be treated with a disinfectant with a pH of between 6 and 8.

28. Extracted teeth containing amalgam can be "red bagged" if they have a tissue tag attached to them.
a. True
b. False

29. In one survey, __________________ were in favor of mandatory use of amalgam separators.
a. individuals placing amalgams frequently
b. individuals believing amalgam to be unsafe
c. individuals who did not place amalgams
d. a and b

30. Preventing the release of mercury from dental amalgam contributes to protection of __________________.
a. the environment
b. human health
c. animal health
d. all of the above

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EDUCATIONAL OBJECTIVES

- Describe how mercury reaches the environment and the impact of methylmercury
- List and describe key elements of the EPA Final Rule and considerations for amalgam separators
- Review best management practices for amalgam waste
- Describe initiatives and options related to the future use of amalgam.

COURSE EVALUATION

Please evaluate this course using a scale of 5 to 1, where 5 is excellent and 1 is poor.

1. Clarity of objectives .... ⑤ ④ ③ ② ①
2. Usefulness of content .... ⑤ ④ ③ ② ①
3. Benefit to your clinical practice.................... ⑤ ④ ③ ② ①
4. Usefulness of the references...................... ⑤ ④ ③ ② ①
5. Quality of written presentation.................... ⑤ ④ ③ ② ①
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8. Relevance of quiz questions .... ⑤ ④ ③ ② ①
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10. Did this lesson achieve its educational objectives? ◯Yes ◯No
11. Are there any other topics you would like to see presented in the future? ______________________
12. Overall administration of the program.............. ⑤ ④ ③ ② ①

QUIZ ANSWERS

Fill in the circle of the appropriate answer that corresponds to the question on previous pages.

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	16.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	17.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	18.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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