MANAGEMENT OF MERCURY WASTE IN DENTAL CLINICS

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Introduction:

Dental amalgam is an alloy composed of a mixture of approximately equal parts of elemental liquid mercury and an alloy powder, containing powdered metals, silver, copper, zinc, and tin. The first use of amalgam was recorded in the Chinese literature in the year 659, and for the last 150 years, it has been the most popular and effective restorative material used in dentistry. This popularity of amalgam mainly arises from its excellent long term performance, ease of use and low cost.

However despite the long history and popularity of dental amalgam as a restorative material, one of its major components, mercury, is of particular concern due to its potential adverse effects on humans and the environment.[1-3] This has been the subject of a number of previous publications , expert panel meetings, national and international conferences.

The purpose of our paper is to review the current state of knowledge on dental amalgam with special emphasis on recognizing the potential sources of mercury contamination in the dental office. We review the current safety guidelines and mercury hygiene recommendations for judicious use of this restorative material.

Why should we be concerned about mercury?
Mercury and the environment.

Concern about the effects of mercury in the environment has increased over the years. Human beings are constantly exposed to mercury in the environments from a multitude of sources as a result of both natural emissions and human pollution. The exposure includes the breathed air, consumed water, ingested food, medical and dental products.

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Chemically, mercury exists in three major forms: elemental (valence 0), inorganic (valence +1 and +2) and organic (alkyl and aryl). These three forms are different in their physical and chemical properties, their rates of absorption, excretion, and their distribution patterns in tissues. *The chemical form of mercury, therefore, determines its toxicological profile.*

Elemental mercury is the most volatile of the three, and mercury vapor in air is the predominant form of elemental mercury. In dentistry, only the metallic form is available. Critical times are when metallic mercury exists in liquid/vapor form, rather than bound in a set amalgam. As a vapor, metallic mercury can be inhaled and absorbed through the alveoli in the lungs at 80% efficiency. After cellular absorption, this metallic mercury is converted into mercuric ions which can produce toxic effects.

Sources of mercury in drinking water and food are generally inorganic and organic mercury compounds, with organic compounds like methyl mercury being particularly associated with seafood[4].This is the form of mercury that humans and other animals ingest when they eat some types of fish. Methyl-mercury is particularly dangerous because it *bio-accumulates* in the environment. Though, we as dentists do not directly use this form of mercury, but improper disposal of amalgam waste products from dental offices, leads to mercury deposits in the water. Once mercury is deposited into lakes and streams, bacteria convert some of the mercury into the organic form, *methyl-mercury* .

The main sources of mercury from the dental office into the environment are: (Fig. 1)

- Mercury vapor in the air (elemental mercury)
- Amalgam waste products : solid trash, waste water sludge

If proper mercury disposal measures are not followed, the amalgam waste products can pollute the environment through the following main routes:

- **Mercury in medical waste incinerators**

  Mercury is a very volatile metal that evaporates easily. When a mercury containing product finds its way into a medical waste red bag and is incinerated, the mercury becomes gaseous and exits through smoke stacks into the air. The mercury then settles on land and in water where it can be changed into its organic form, methylmercury. It is very important to educate employees about the dangers of putting amalgam wastes in the red medical waste bags to prevent this contamination

- **Mercury in solid waste stream:**

  If waste amalgam is placed in the garbage, it could potentially be incinerated, and the mercury will volatilize and enter the atmosphere as described above. If the solid waste is sent to a landfill, the mercury may volatilize out with the methane gas that is released from the landfill.

- **Mercury in waste water stream**

  Mercury amalgam that is not captured by a trap in dental office will travel to the local wastewater treatment plant. Once mercury enters the wastewater treatment plant, most of it concentrates in wastewater bio-solids during treatment. Since most treatment plants dispose of generated solids by land spreading, mercury enters the terrestrial environment by this process. Some of this mercury spread on land may, over time, be volatilized to the atmosphere. This mercury may then be deposited into lakes and streams, methylated, and ingested by fish, eventually reaching wildlife and humans.

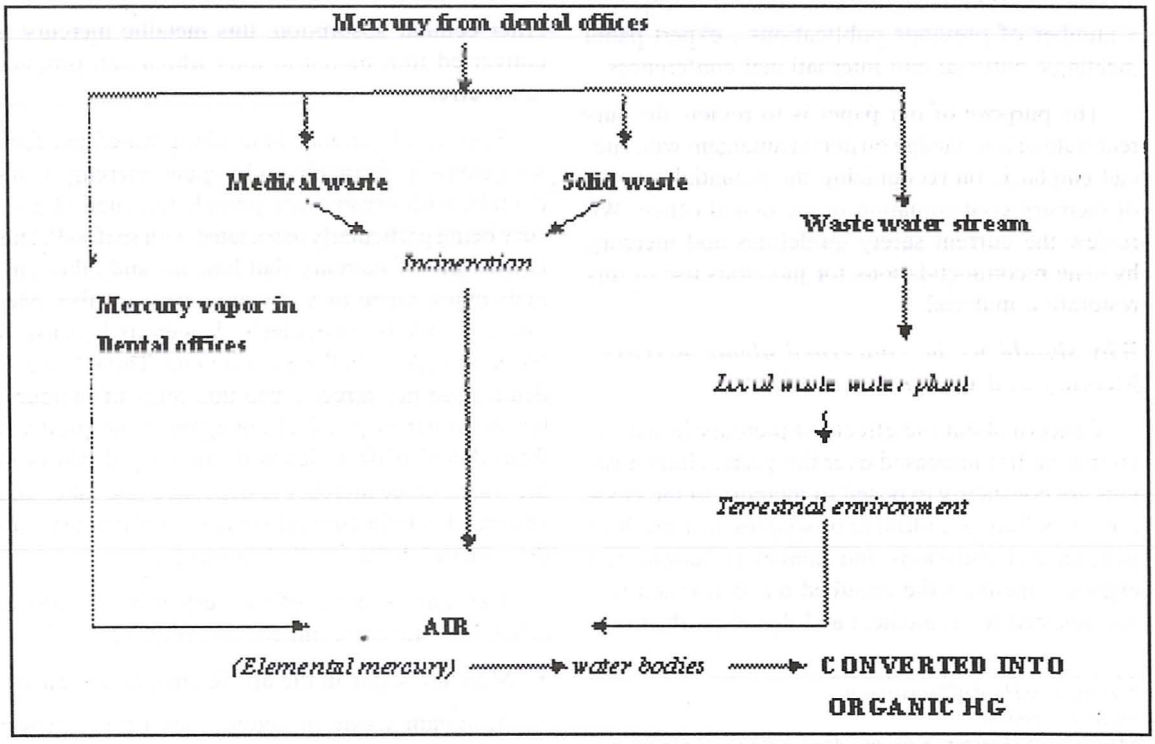


Figure 1: Sources of mercury into environment from dental office.

- **Mercury cycle in dentistry**

The primary challenge in dentistry for the continued use of amalgam as restorative material is therefore management of mercury waste. The path of dental mercury from the purchase of the amalgam product to the end of the clinical lifetime of a restoration has been monitored[5]. (Fig. 2)

- The types of amalgam waste created hence may be listed as the following types:
- **Major amalgam particles:** (> 100μm)
  - **Non contact amalgam (scrap):** this constitutes the surplus of triturated amalgam
  - **Contact amalgam:** is amalgam that has been in contact with the patient. Examples are extracted teeth with amalgam restorations, carving scrap collected at chair side, and amalgam captured by chair side traps, filters or screens
- **Minor amalgam particles:** (< 100μm)
  - **Amalgam sludge** is the mixture of liquid and solid material collected within vacuum pump filters or other amalgam capture devices.
  - **Empty amalgam capsules** are the individually dosed containers left over after mixing pre-capsulated dental amalgam.

***Who is affected*? Safety concerns regarding dental amalgam:**

Having recognized that chronic exposure to high levels of mercury vapor generated during dental procedures can be a potential health hazard, we need to know at what levels we can be affected. The adverse health effects of mercury used in dental offices can mainly affect the following three groups:

- Dental patients
- Dental professionals in the dental operatory environment
- Environmental pollution

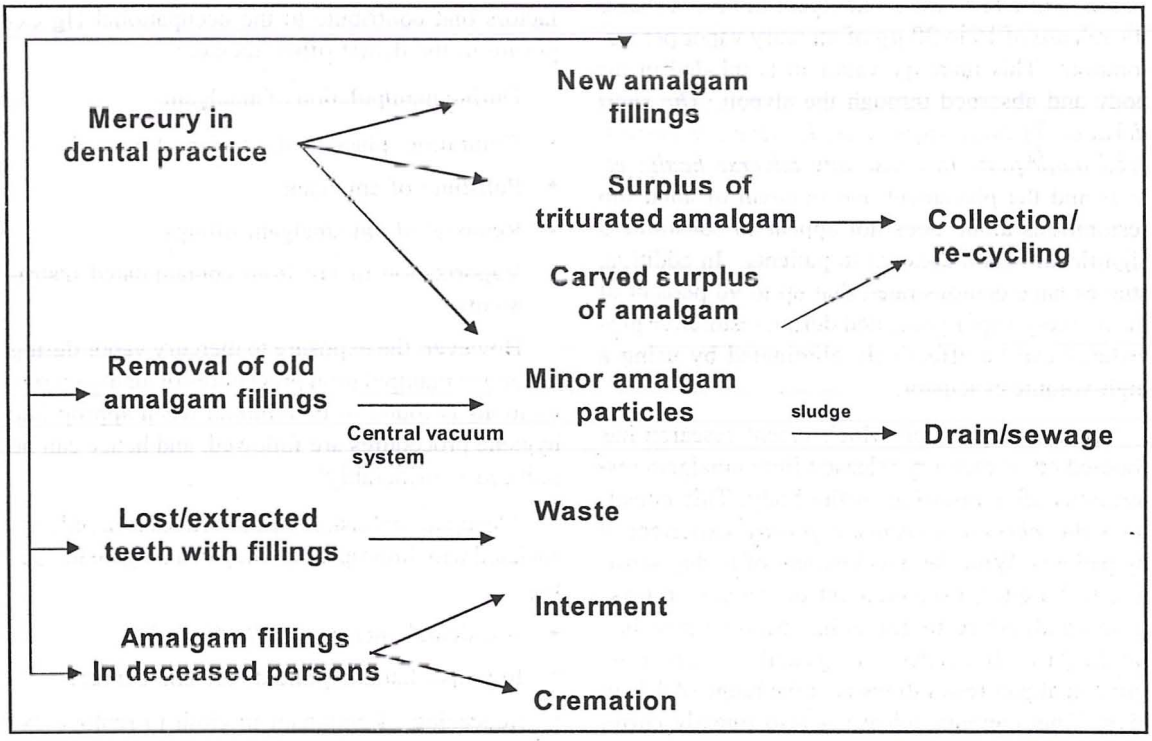


Figure 2: Mercury cycle in dentistry.

***Dental patients* and exposure to Hg from amalgam:**

Dental patients are believed to be exposed to the mercury vapor through the following routes:

- During all amalgam manipulation procedures
- From the existing mercury levels in the environment.
- Chronic mercury exposure from existing amalgam restorations in mouth.

During the amalgam procedures, both the placement and removal of amalgam restorations can result in significant levels of intraoral mercury vapor.[6] An early study using copper amalgam and procedures reported that intraoral mercury vapor can reach up to 388 µg/m3 of air during the insertion of an amalgam restoration[7]. Other studies have shown that dry polishing of amalgam restorations resulted in the release of 44 µg of mercury vapor per restoration, while removal of amalgam in vivo initiated the release of 15 to 20 µg of mercury vapor per restoration[6]. This mercury vapor in is inhaled in the body and absorbed through the alveoli. *The short duration of these exposures, however, is considered inadequate to cause any adverse health effects* and the placement and removal of amalgam restorations alone does not appear to constitute a significant health concern to patients. In addition, studies have demonstrated that up to 90 percent of the mercury vapor generated during restorative procedures can be effectively eliminated by using a high-volume evacuator.

Another aspect, on which recent research has focused on, is mercury released from amalgam restorations after insertion in the body. This constitutes the *chronic mercury exposure* experienced by patients. With the development of highly sensitive techniques, measurement of mercury release from amalgam restorations has become possible. Studies have shown that average daily mercury dose from amalgam restorations is in the range of 4.5 µg /day[9]. This mercury release is also linearly correlated to time and the surface area of restorations. There still is considerable controversy regarding the *extent to which mercury from amalgam contributes to our total daily exposure to mercury*. Further refinement of measurement techniques, appropriate experimental design and judicious data analyses will aid in reaching a consensus on this issue.

Another significant question is *whether mercury released from dental amalgam results in significant adverse health effects,* as mere exposure is not synonymous with ill effects to health. Hence, it is of considerable importance that we emphasize on carefully designed research required to investigate potential biological effects resulting from **low level** Hg.

Dental professionals and exposure to mercury in dental office: *occupational exposure*

Chronic exposure to mercury vapor owing to inappropriate handling of dental amalgam can be a potential health hazard in the work place. The main factors that contribute to the occupational Hg exposure in the dental office include:

During manipulation of amalgam:

- Trituration, placement, condensation
- Polishing of amalgam
- Removal of old amalgam fillings
- Vaporization of Hg from contaminated instruments

However, the exposure to mercury vapor during the above manipulation procedures of amalgam restorations is found to be minimal when appropriate hygiene procedures are followed, and hence can be reduced considerably[8].

Occupational risk in dental offices is mainly associated with improper handling of amalgam including:

- Accidental *mercury spills* (Fig. 3)
- Improper handling and direct skin contact
- Squeezing of amalgam in cloth to remove excess mercury.

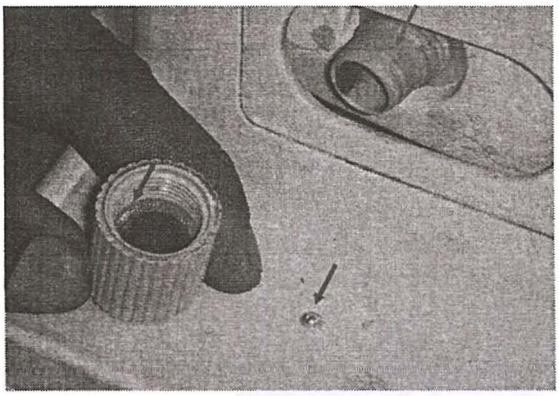


Figure 3: Accidental Mercury spill in dental office around amalgamator.

- Malfunctioning amalgamator
- Leaky amalgam capsules
- Malfunctioning bulk Hg dispenser

It is important to note that all sources of mercury are likely to affect the dentist. Also, *the exposure of the dentist is long standing and chronic.* Many studies have shown that dental professionals can minimize unnecessary exposure to elemental mercury simply by following recommended mercury hygiene procedures e.g. according to one study, mercury vapor in the breathing zone of the dentist was found to be minimal (1 to 2 µg/m3) when the high volume evacuator was used; without high-volume evacuation, however, mercury vapor levels were two to 15 times higher than the TLV as defined by WHO[6]. The generally accepted threshold limit value (TLV) for exposure to mercury vapor for a 40 hour work week is 50µg/cubic m.[10]

Hence, the importance of practicing proper mercury hygiene measures cannot be stressed upon more.

Mercury hygiene measures

From the above discussion, we can conclude that the most important issue to be dealt with regarding mercury hazard in dentistry is the emphasis on *judicious use of amalgam* rather than its use as a whole.

The hazards from mercury can be significantly reduced and brought well within the recommended TLV levels if proper mercury hygiene measures are employed. These measures include:

- **Trained dental personnel :**

  Train all personnel involved in the handling of mercury and dental amalgam regarding the potential hazards of mercury vapor and the necessity of observing good mercury hygiene practices
- **Office engineering**
- **Hygiene measures during manipulation of mercury**
- **Filtration**
- **Storage**
- **Re-cycling**

Office engineering:

During designing of the dental offices, the following steps should be kept in mind to create healthier working atmosphere and reduce the amount of mercury vapor.

Dental clinics should be designed such that they are well-ventilated, with fresh air exchanges and outside exhaust. If the work areas are air-conditioned, the air-conditioning filters should be replaced periodically.

Work area should be properly designed to facilitate spill containment and cleanup. Floor coverings should be nonabsorbent, seamless and easy to clean. Use of carpeting in operatories, where an accidental mercury spill might occur, is not recommended. Chemical decontamination of carpeting is not effective, as mercury droplets can seep through the carpet and remain inaccessible to the decontaminant. Removal of the contaminated carpet is the only way to ensure decontamination.

Periodically check the dental operatory atmosphere for mercury vapor. This may be done using dosimeter badges or through the use of mercury vapor analyzers for rapid assessment after any mercury spill or cleanup procedure.

Hg hygiene during manipulation:

- Use only pre-capsulated amalgam alloys. It is recommended against the use of bulk alloy and bulk elemental mercury, also referred to as liquid or raw mercury, in the dental office.
- Use an amalgamator with a completely enclosed arm.
- If possible, recap single-use capsules after use, store them in a closed container and recycle them.
- Use care when handling amalgam. Avoid skin contact with mercury or freshly mixed amalgam.
- Use high-volume evacuation systems (fitted with traps or filters) when finishing or removing amalgam.

In case of an accidental mercury spill:

- Never use a vacuum cleaner of any type to clean up the mercury.
- Never use household cleaning products to clean up the spill, particularly those containing ammonia or chlorine.
- Never pour mercury, or allow it to go, down the drain.
- Never use a broom or a paintbrush to clean up the mercury.
- Never allow people whose shoes may be contaminated with mercury to walk around or leave the spill area until the mercury-contaminated items have been removed.

Filtration: ***Capturing amalgam and mercury wastes*** **(Fig. 4)**

In order to reduce the amount of mercury from amalgam particles entering the sewer system or landfill, it is recommended that you use an amalgam trap. There are several filtration devices available to capture amalgam at the source of generation. These include:

- **Chair side traps** capture amalgam waste during amalgam placement or removal procedures (traps from dental units dedicated strictly to hygiene may be placed in the regular garbage). First, disinfect the trap for 24 hours using a minimum amount of disinfectant. Then, remove all visible amalgam and store it in an airtight container, labeled "WASTE AMALGAM." The disinfected trap can then be reused. Recycle the waste amalgam as outlined for the scrap amalgam.

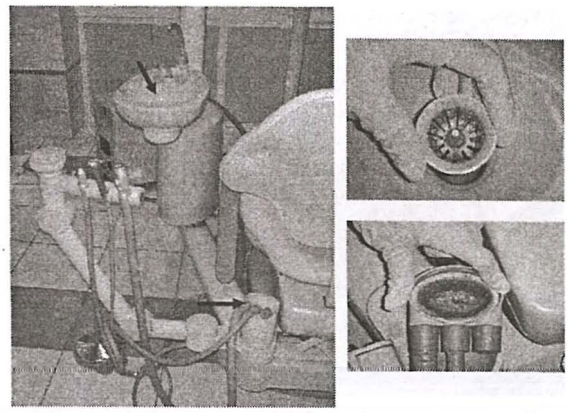


Figure 4: Filtration devices in dental unit.

- **Vacuum pump filters** or traps contain amalgam sludge and water. Some recyclers will accept whole filters, while others will require special handling of this material. Change these filters at least once a month, or more frequently if needed. DO NOT dispose of the filters as regulated medical waste. Place facial tissue or towels inside to absorb the liquid.
- **Amalgam separators:** Chair-side traps and vacuum pump filters generally remove 40 to 80 percent of the amalgam particles from the wastewater stream; however, some amalgam waste particles still enter the sewer system (11). Amalgam separators are devices designed to remove amalgam waste particles in dental office discharge. Amalgam particles in dental office wastewater can range in size from colloidal particles (smaller than 0.45 micrometers) to those larger than 3 millimeters. To remove these various-sized particles from waste discharge, amalgam separator units can use several separation

techniques, alone or in combination: sedimentation, filtration, centrifugation or ion exchange.

Storage:

Mercury in liquid or gaseous form is very mobile and has high diffusion rate. This allows it to penetrate through fine spaces. Mercury containing products hence should not be stored in open but in closets/cabinets. Storage locations should be near a vent that exhausts air out of the building.

Excess amalgam remaining at the end of a procedure should be stored in an air-tight container labeled "SCRAP AMALGAM.". The container should be filled till the brim with spent fixer or under water. At one time only a small bottle should be present in the clinic. This scrap amalgam should then be carefully packaged and sent for re-cycling.

Re-cycling

The stored waste amalgam can be re-used and hence should be carefully packaged and sent for re-cycling. Extracted teeth with amalgam restorations are mixed with body fluids such as saliva, blood, or other potentially infectious material. These should be first chemically disinfected and then packaged for re-cycling.

CONCLUSION

So is amalgam safe? For a material to be safe it is required, that it has a low incidence of adverse reactions or significant side effects when used according to adequate warnings and directions. Inherent in this definition are considerations of the risk-vs.-benefit relationship of the material. In relation to mercury exposure from dental amalgam, available data have not identified any significant side effect(s), other than the rare allergic reaction, after more than 150 years of use. Based on this overwhelming body of scientific data supporting the safety and efficacy of dental amalgam, and the absence of any similar database attesting to the safety and efficacy of an alternative material, there appears to be no justification for discontinuing the use of amalgam. **The issue of prime importance is to promote judicious use of amalgam and proper amalgam waste disposal.** We need to take prudential steps in the following direction:

- Laying down clear guidelines and educating professionals about the same for observing proper mercury hygiene measures in the dental offices and proper mercury disposals.
- Set up of proper mercury re-cycle plants which can collect mercury from all sources and re-use it.
- Further refinement of measurement techniques, appropriate experimental design are required to give an accurate idea of how much mercury is exposed to the air from dental practices.
- Carefully designed research required to investigate potential biological effects resulting from **low level** Hg.

***How can we help?* Educate and implement**

- Recommend strict mercury hygiene measures in our set-ups
- Encourage the development and use of mercury amalgam alternatives
- Seminars, continuing education courses on mercury hygiene
- Participate in a bulk mercury collection program
- Develop and distribute a pamphlet on amalgam waste reduction and recycling
- Form a Dental Task Force on Mercury Minimization

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