

Review Article

Roadmap to mercury-free dentistry era: Are we prepared?

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ABSTRACT

From the perspectives of longevity, mechanical performance, and economics, amalgam has long been considered the material of choice, especially for certain types of restorations in posterior teeth, including replacement therapy for existing amalgam fillings. In spite of numerous advantages over other filling materials, its use has been decreasing in recent years and the alternative tooth-colored filling materials are increasingly used. There is a trend towards minimal interventional, adhesive, techniques in dentistry, which are based on adhesion to tooth structure by chemical interaction and/or micromechanical retention. At the same time, the quality and durability of alternative materials have improved. Mercury is the metallic element of concern used in dental amalgam. Mercury is a well-documented toxicant, with reasonably well-defined characteristics for the major forms of exposure, involving elemental mercury as well as organic and inorganic mercury compounds. Looking into the kind of practice and its popularity among dentists and the patients in India, even we have to comply with the use of amalgam by implementing the best possible ways to minimize the extent of damage to nature.

Key Words: “Dental amalgam”[MeSH], “harmful effect*”[MeSH], “Hazardous waste*”[MeSH], “mercury poisoning*”[MeSH] OR “Mercury toxicity”[tiab] OR “Amalgam toxicity”[tiab]

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INTRODUCTION

Most people who have encountered mercury have done so after breaking a thermometer. And no doubt we find it as one of the most appealing elements in the periodic table. Right!! We are talking about the most mysterious element-able to cure and to poison; able to bear the whole weight of the light, and being capable of shattering into a numerous uncountable particle in different directions.

HISTORIC PERVIEW

The first written record of mercury comes from Aristotle, who in the fourth century BC described the metal as “liquid silver.” In 380 BC Theophrastus of

Eresus was writing was is still the largest and most productive mercury mine in the world, at Almaden, Spain. In the first century AD Pling described the mine as “the most famous for the revenues of Roman nation.” Pling also mentioned that the mine was worked exclusively by Roman convicts and slaves, and wrote the hazards of poisoning.

LETHAL DOSE

To ask how poisonous is mercury is to ask “how high is up?” a lethal dose of mercury is less than the quarter of a gram. It would take 113 such doses to make up a single dose.

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MERCURY AND DENTISTRY

Mercury has been used in dental practice as amalgam for the last two centuries, as a dental restoration filling material. This material contains mercury in about 50% of its total mass and the remaining constituents are silver, tin, copper, zinc, and other trace metals.^[1]

According to Skinner, amalgam is a special type of alloy in which one of its constituents is mercury. In dentistry, it is common to use the term amalgam to mean dental amalgam.^[2]

Though the dental amalgam is widely used, however, injudicious handling consequently leads to human health risk, particularly associated with occupational exposure and environmental damage from mercury emission.

DIFFERENT FORMS OF MERCURY

1. Elemental
2. Organic
3. Inorganic.

EFFECTS ON HUMAN

Mercury is able to cause myriads of adverse effects including:

1. Neurotoxicity (elemental mercury, mercuric salts such as mercuric chloride)
2. Nephrotoxicity (elemental mercury, mercuric salts such as mercuric chloride)
3. Teratogenicity (methyl mercury)
4. Death (elemental mercury, methyl mercury).

Exposure to mercury has been associated with over 250 symptoms in humans, resulting in complications for proper diagnoses. Mercury can be quickly removed from the blood. From here it is transported and sequestered into various tissues; in other words, there may not be a direct correlation between blood mercury concentration and the gravity of mercury poisoning.^[3] Low-level exposure to vaporized metallic mercury can be inhaled, causing mercury poisoning. The principal toxic effects of this exposure include excitability, tremors, and gingivitis. Exposure to vaporized metallic mercury can also be toxic to the immune system, nervous system, kidneys, cardiovascular system, gastrointestinal system, lungs, muscle, liver, blood cell count, skin, and eyes [Figure 1].^[4] Human fetuses and small children who are exposed are more likely to have mercury concentrated in the brain and kidney.^[5]

EFFECTS OF PRENATAL MERCURY EXPOSURE

Mercury in its nonionized form crosses the lipid barriers in the membranes of the brain and placenta and is removed slowly after getting oxidized. Maternal amalgam restoration can expose the fetus to low levels of elemental mercury and even removal of this restoration cannot help to escape the mercury exposure. However, no evidence has been found regarding adverse pregnancy outcomes or health deterioration in the new borns.

EXPOSURE TO MERCURY IN DENTAL PERSONNEL

The mercury body burden of dental personnel is usually higher than in the general population. Mean urine mercury levels of 3–22 µg/L have been found in dental practitioner in contrary to general population group who have a range of 1–5 µg/L (Hörsted-Bindslev P. Amalgam toxicity-environmental and occupational hazards. *J Dent.* 2004 Jul; 32 (5):359-65). This increased level is due to dealing with dental amalgams whether it be mixing and placing the amalgam restoration or just removing the mercury amalgam filling.

MERCURY HEALTH EFFECTS

General effects

- Depend on form of Hg, dose, route of exposure, during foetal stage of development
- Tremors
- Impaired vision and hearing
- Paralysis
- Insomnia.

Neurological effects

- Emotional instability
- Developmental deficits during foetal development
- Attention deficit and developmental delays during childhood.

MERCURY CONTAINING HEALTHCARE PRODUCTS

- Thermometers
- Sphygmomanometers
- Gastro-intestinal devices (esophageal dilators,

- canter tubes, feeding tubes)
- Pharmaceutical products
- Dental filling
- Laboratory chemicals (fixatives, stains, reagents, preservatives)
- Fluorescent light tubes
- Batteries
- Boiler switch (including thermostats).

ENVIRONMENTAL IMPACT

- Health-care facilities are one of the main sources of the release of mercury into the atmosphere
- In 1991, the WHO confirmed that mercury contained in dental amalgam is the greatest source of mercury vapor in nonindustrialized settings
- A 1999 report targets health care facilities as responsible for 5% of mercury releases in wastewater.

MERCURY TRAVELS

- One gram of mercury is present in a normal thermometer
- Four grams of mercury are enough to adulterate a small lake thus affecting the fish and making them unsuitable for consumption by women of childbearing age.

OCCUPATIONAL IMPACT

- Healthcare workers work with mercury-based products on a routine basis and are in danger of inhaling toxic vapor when breakages or leakages happen
- Spilled mercury can also be tracked on footwear exposing other healthcare staff^[6]
- Expose already compromised patients.

PERMISSIBLE MERCURY VAPOUR EXPOSURE LIMITS

- OSHA Mercury^[7] (PEL) of 0.1 mg/m³ (8 h [TWA]). Some state OSHA mercury vapour limit of 0.05 mg/m³ (8 h TWA).
- ACGIH - recommends a guideline of 0.025 mg/m³.

MERCURY TOXICOLOGY

In general, the toxicology of mercury is highly dependent on the route of administration, the exposure conditions, and the speciation of mercury.

Mercury exposure through dental amalgam fillings may occur by mercury vapor inhalation released from the restorations in the mouth, released organic mercury ingestion, or swallowing small pieces of amalgam releasing mercury in the alimentary tract. The European Chemical Agency (ECHA) website indicates the following classification for mercury [Table 1] ([http:// apps. echa. eu/registered/ data/dossiers/ DISS 9d872986-171c 222a e044 00144f67d249/ AGGR 995f8d07 ac73 4081 8ad0 ed8b5616e7ee_DI SS 9d872986 171c 222ae044 00144f67d249.html](http://apps.echa.europa.eu/registered/data/dossiers/DISS_9d872986-171c_222a_e04400144f67d249/AGGR_995f8d07_ac73_4081_8ad0ed8b5616e7ee_DI_SS_9d872986_171c_222ae04400144f67d249.html)).

TOXICOKINETICS

Mercury vapor is lipophilic and can pass biological membranes, including the blood-brain barrier and placenta, thus resulting in deposition in the central nervous system, including the fetal brain. The vapor dissolved in the blood and tissues rapidly becomes oxidized due to catalase activity. Ionic Mercury becomes bound to some extent to metallothionein and accumulates in the kidneys. Excretion takes place via urine and to some extent through feces and sweat.

MERCURY WASTE MANAGEMENT

The World Health Organization confirmed that decreasing the use of dental amalgam is not only important in reducing human exposure, but also to lessen the considerable amount of mercury that is estimated to be released into the environment from this source. The use of dental amalgam and its applications, such as illegal sales and use in ASGM, improper waste management, or even through cremation, is contributing to the problem of global mercury pollution.^[4]

Dental amalgams off-gas mercury vapor. The newer high copper amalgams are less stable and create a much greater release of mercury vapour.

DENTAL AMALGAM AND SEWAGE SLUDGE

In a 2016 document titled, “Dental Amalgam and Mercury Regulation,” the European Federation of National Associations of Water Services advocated for a ban on dental amalgam to decrease mercury in the sludge from the wastewater treatment plants.^[8]

Nationally, dentists discharge about 5.1 tons of mercury into publicly owned treatment works,

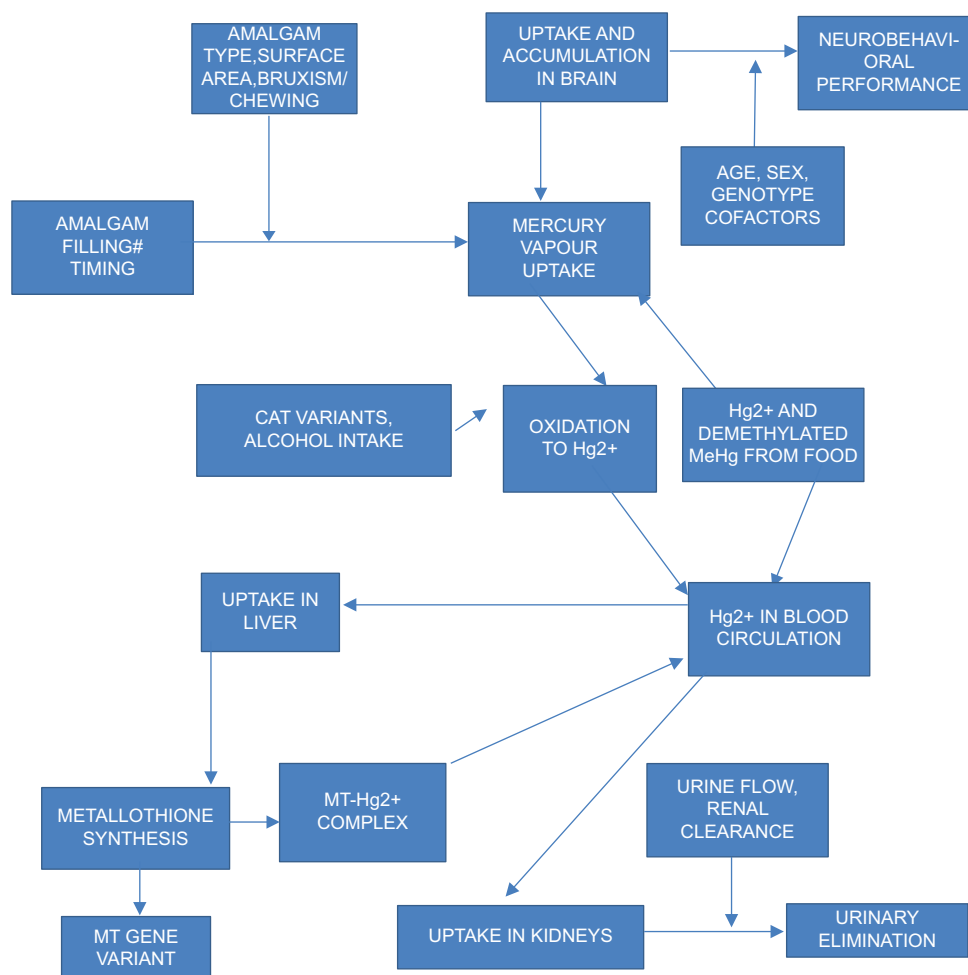


Figure 1: Fate of inorganic mercury and potential effects, Source: Philippe Grandjean.

and most of this mercury will end up in the environment.^[9] Once the amalgam waste has gone through the sewage treatment plant, the remaining amalgam waste becomes sewage sludge. This sewage sludge is then disposed of in landfills, incinerated, or sold as fertilizer for agriculture purposes. These pathways of disposal of sewage sludge release mercury into groundwater or air.^[10] Dentists typically dispose of excess amalgam into specific medical waste containers, however, if this waste is incorrectly disposed of, the amalgam may be incinerated, causing the mercury to enter the air where it will eventually end up in the water or on land.^[11]

DENTAL AMALGAM AND CREMATION

A substantial source of mercury pollution comes from cremation. Estimations of the amount of mercury released via this pathway vary considerably, due to the large number of dental restorations.^[12] Cremation emissions add to both environmental pollution in

areas close to the source and also countrywide emissions due to atmospheric transport. These emissions are deposited primarily through rain. Mercury is persistent and can change in the environment into methylmercury, which is extremely toxic.^[13] During cremation, mercury will enter the process, since it is not only from dental amalgam in teeth but also due to bioaccumulation of mercury in the body.^[14]

Crematoriums have many risk factors, not just to the funeral workers, but also to the population in surrounding neighborhoods. Living near these environmental toxic exposures can have negative health effects, particularly in vulnerable subpopulations.^[15]

The World Health Organization, the US EPA, and other public health experts consider any level, no matter how low, of emissions of mercury, dioxins, furans, and particulate matter from incineration to be a threat to human health. Vulnerable populations

Table 1: European chemical agency classification of mercury

Hazard statements	Risk phrases	Safety phrases
H330: Fatal if inhaled	R26: Very toxic by inhalation	S45: In case of accident or if you feel unwell, seek medical advice immediately
H360: May damage fertility or the unborn child	R61: May cause harm to unborn child	S53: Avoid exposure - obtain special instructions before use
H372: Causes damage to organs	R48/23: Toxic: Danger of serious damage to health by prolonged exposure through inhalation R50/53: - Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment	S60: This material and its container must be disposed of as hazardous waste S61: Avoid release to the environment

Table 2: National objectives for minimizing amalgam use

Objectives	Ways of implementing
1. Set national objectives for minimizing amalgam use	Setting national objectives aiming at minimizing its use
2. Promote mercury-free dental restorations, including raising public awareness of amalgam's mercury content	Promoting the usage of mercury-free alternatives for restoring tooth that are cost worthy and clinically potent too Each party shall, within its capabilities, promote and facilitate... provision to the public of available information on technically and economically viable alternatives to mercury-added products
3. Update dental school curricula to promote mercury-free dentistry	The dental schools and professional organizations should motivate their dental professionals along with the students to make use of mercury-free dental restorations as alternatives thus advancing their dental practices
4. Modify insurance and government programs to favor mercury-free dentistry	Suppressing those insurance programs and policies which promote the use of dental amalgam fillings instead mercury-free dentistry
5. End amalgam use in children and pregnant women	Promoting the use of cost-effective and clinically effective mercury-free alternatives for dental amalgam

such as babies, children, women of childbearing age, and the elderly are particularly at risk from exposure to these toxins. Employees who work in these environments, as well as those populations who live near the source, are exposed to higher levels of these pollutants.^[4,16,17] The effects of mercury vapor exposure can last long after the exposure has ended. While typical symptoms and signs, such as tremors, gingivitis, and salivation may quickly disappear after exposure has stopped,

mechanisms of long-lasting or remote effects have not been investigated.^[4]

ARTISANAL SMALL SCALE GOLD MINING

According to Esdaile and Chalker,^[18] the approximate amount of mercury released through ASGM is between 410 and 1400 tons annually, which is about 37% of total global mercury emissions. Easy access to mercury, along with its low cost and the soaring price of gold make this a sustainable livelihood for miners.

Artisanal small-scale gold mining is the largest source of mercury emissions worldwide. Around 15 million people are estimated to be working in this sector and about 5 million are women and children. Artisanal small-scale gold mining has devastating effects not only on the local inhabitants but also on the environment, especially rivers, due to mining locations. Research shows that populations in these areas, as well as those downstream, eat fish that are highly mercury toxic. These communities are also subjected to tremendously harmful levels of mercury vapor, causing neurological, kidney, and possibly immunotoxic/autoimmune effects from mercury exposure.^[19]

MERCURY-FREE ALTERNATIVES IN ARTISANAL SMALL-SCALE GOLD MINING

An alternative to mercury in ASGM is the borax method. Gold is gravitationally separated by sluicing and panning, with iron shavings possibly removed by a magnet, then gold concentrates are mixed with an equal mass of borax. This mixture is heated and the gold solidifies in a relatively pure form when cooled. The borax complexes to silicate and oxide impurities.^[19]

NATIONAL OBJECTIVES FOR MINIMIZING AMALGAM USE

The set national objectives and the effective methods for minimising amalgam use has been documented in Table 2.

- Promote mercury-free dental restorations, including raising public awareness of amalgam's mercury
- Update dental school curricula to promote mercury dentistry
- Modify insurance and government programs to favor free dentistry
- End amalgam use in children and pregnant women.

TRUE ALTERNATIVES TO DENTAL AMALGAM:

Atraumatic restorative treatment

This is a nonmercury dental filling technique, that was developed in the 1980s in Tanzania as a minimally invasive way to fill teeth. Using atraumatic restorative treatment saves teeth that would have otherwise been extracted due to decay.

Advantages

Atraumatic restorative treatment requires no electricity, water, or conventional dental equipment. Only hand instruments are needed to clean the decay and a high viscosity glass-ionomer is then placed in the tooth.

Glass ionomer cement

Glass ionomer cements have organic acids like eugenol and bases like zinc oxide, and may also contain acrylic resins. Glass ionomer also have glass filler like some composite resins that release fluoride with time.

Advantage

- Tooth-colored restorative material
- Ease of use and appearance.

Disadvantage

- They are limited to use in small restorations.

Composite resin fillings

These restorations are the most common alternatives to dental amalgam and are referred as “tooth-coloured” or “white” fillings due to their color. Composites are acrylic resins reinforced with powdered glass filler. The color (shade) of composite resins can be customized to closely match surrounding teeth. These restorations are either self-cured or light-cured in layers using “blue light.”

Advantages

- Blend in with surrounding teeth
- High strength
- Require minimal removal of healthy tooth structure for placement.

Disadvantages

- More difficult to place than dental amalgam
- May be less durable than dental amalgam and may need to be replaced more frequently
- Higher cost of placement.

TECHNICAL ADVANTAGES OF MERCURY-FREE DENTISTRY

1. Mercury-free fillings are more minimally-invasive than amalgam

2. Mercury-free fillings can last as long– or longer– than amalgam
3. Mercury-free fillings can be placed as fast as amalgam
4. Mercury-free fillings can help prevent caries, unlike amalgam
5. Mercury-free fillings can be repaired more easily than amalgam
6. Mercury-free fillings are safer than amalgam
7. Mercury-free fillings are safer for the environment.

CONCLUSION

Dentistry is most outstandingly and foremost a healing vocation.^[1] Today it has become very crucial to adopt eco-friendly approach in every aspect of our lives including dentistry. Dental practice not only has a huge impact on the environment due to metallic unwanted waste generated in various procedures but also due to excessive use of water and electricity which has altogether accentuated the move towards “Green dentistry”. Green dentistry is a nature-friendly perspective that reduces the environmental impact of dentistry and creates an amiable surrounding. It deploys the model of four R, i.e., rethink, reduce, reuse, and recycle. Eventually, one gets the best and pocket-friendly quality treatment. Green dental practice focuses on preserving water and energy, reduction of waste, and minimizing the use of hazardous toxins that have a detrimental effect on patients as well as the environment, and promote the user friendly “Green” products.

Being an ingenious environmentally friendly tool, green dentistry has proven to save money and time along with energy conservation and reduction in pollution with the use of the latest techniques and procedures. Green or holistic dentistry, therefore, protects the environment and humanity from the hazards of rapid urbanization, especially in developing countries like India. To conclude, we quote *Ray Kroc* “As long you are green, you are growing. As soon you are ripe, you start to rot.” So let us go green today and save Mother Earth from biohazards for a better tomorrow.

“THE FOOD YOU EAT CAN BE EITHER THE SAFEST AND MOST POWERFUL FORM OF MEDICINE OR THE SLOWEST FORM OF POISON.”

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Damle SG. Eco-friendly green dentistry: The future of dentistry? *Contemp Clin Dent* 2016;7:423-5.
2. Phillips MS, Ralph W. *Skinner Science of Dental Material*. Saunders; 9th edition 1993.
3. World Health Organization. *International Programme on Chemical Safety: Ten Chemicals of Major Public Health Concern*. Geneva, Switzerland: World Health Organization; 2019.
4. Mercury Contamination from Dental Amalgam. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6555253/>. [Last accessed on 2021 Jan 30].
5. Clower R, Clower N, Cutchins D, Ford D, Simpson E. *Conclusions of Grinnell Community Residents Studying Mercury Emissions from Crematoria*. Mountain View, CA: Google Sites; 2009.
6. Mercury in Healthcare Presenter: Marsha. Available from: <https://docplayer.net/amp/58310969-Mercury-in-healthcare-p-r-e-s-e-n-t-e-r-m-a-r-s-h-a-a-n-n-p-a-l-m-e-r-m-o-h-j-a-m-a-i-c-a.html>. [Last accessed on 2021 Jan 30].
7. Petersen PE. *Future Use of Materials for Dental Restoration: Report of the Meeting Convened at WHO HQ*. Geneva, Switzerland: World Health Organization; 2009.
8. Dental amalgam and the mercury regulation [Internet] Brussels, Belgium: EurEau; 2016;p. 6. Available from: <http://www.eureau.org/resources/position-papers/120-dental-amalgam-june-2016/file>. [Google Scholar] [Last accessed on 2019 Aug 15].
9. US Environmental Protection Agency; 2017. Mercury Regulation. Vol. 13: EurEau; 2016.
10. Mercury in Dental Amalgam. Washington, D.C.: US Environmental Protection Agency; <https://www.epa.gov/sites/default/files/2015-06/documents/dental-amalgam-study-2008.pdf> [Last accessed on 2019 Sep 20].
11. Health Services Industry Detailed Study: Dental Amalgam. Washington, D.C.: US Environmental Protection Agency; 2008. p. 76. <https://www.epa.gov/sites/default/files/2015-06/documents/dental-amalgam-study-2008.pdf> [Last accessed on 2019 Sep 22].
12. Reindl J. *Summary of References on Mercury Emissions from Crematoria*. Philadelphia, PA: Energy Justice Network; 2012. p. 44.
13. Gillespie C. *Mercury Abatement within the Crematoria Sector*. Scotland: Scottish Environment Protection Agency.p. 16.
14. Mercury in our mouth: an estimation of mercury usage and release from the dental sector in India [Internet] New Delhi, India: Toxic Link; 2012;p. 36. Available from: http://toxicslink.org/docs/Mercury_in_Our_Mouth.pdf. [Last accessed on 2019 Sep 29] [Google Scholar].
15. Brender JD, Maantay JA, Chakraborty J. Residential proximity to environmental hazards and adverse health outcomes. *Am J Public Health* 2011;101 Suppl 1:S37-52.
16. Mari M, Domingo JL. Toxic emissions from crematories: A review. *Environ Int* 2010;36:131-7.
17. No safe levels of exposure...[Internet] Moore Park, Toronto: Crematorium Working Group; 2013;p. 6. Available from: <https://www.toronto.ca/legdocs/mmis/2013/pg/comm/communicationfile-34847.pdf>. [Last accessed on 2019 Sep 29] [Google Scholar].
18. Esdaile LJ, Chalker JM. The Mercury Problem in Artisanal and Small-Scale Gold Mining. *Chemistry* 2018;24:6905-16.
19. Gibb H, O'Leary KG. Mercury exposure and health impacts among individuals in the artisanal and small-scale gold mining community: A comprehensive review. *Environ Health Perspect* 2014;122:667-72.