AMALGAM SEPARATION: WHY?
1. What is amalgam?

1.1. Dental amalgam

Amalgam is an alloy of mercury with one or more other metals, such as silver, zinc, copper, gold, platinum, indium, or palladium. In differing mixtures amalgam has been used for dental fillings for more than 150 years.

Mixing ratios of dental amalgams vary. The German Federal Institute for Drugs and Medical Devices (= Bundesinstitut für Arzneimittel und Medizinprodukte) recommends the use of so-called “gamma-2-free” amalgams, which consist of “min. 40% silver, max. 32% tin, max. 30% copper, max. 5% indium, max. 3% mercury and max. 2% zinc”. This alloy powder is then mixed with pure, liquid mercury, which results in an overall mercury level of approx. 50%.

On their website the American Dental Association stated that amalgam „is considered a safe, affordable and durable material that has been used to restore the teeth of more than 100 million Americans. […] Dental amalgam has been studied and reviewed extensively, and has established a record of safety and effectiveness“.

1.2. Mercury occurrences in the environment

Mercury is an element that occurs in various ores in the earth crust or in connection with volcanic action, “although cinnabar (mercury sulphide) is in practice the only ore from which mercury is extracted as the principal product“.

In order to retrieve liquid mercury, “crushed cinnabar ore is roasted in rotary furnaces. Pure mercury separates from sulfur in this process and easily evaporates.” Mercury is the only pure metal which is liquid at room temperature. Its chemical sign is Hg.

While the amount of newly extracted mercury constantly decreases, “recycled mercury constitutes an increasing share of the market“.

1.3. Amount of mercury in dentistry

Amalgam waste deriving from dentistry is mainly generated by amalgam fillings placed and extracted. One mainly distinguishes between contact and non-contact amalgam waste. “Non-contact amalgam (scrap) is excess mix leftover at the end of a dental procedure. Many recyclers will buy this clean scrap. […] 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“ and amalgam separators.

The amount of mercury used in dentistry is difficult to name because figures vary greatly. In his “Overview: Mercury Releases from Amalgam to the Environment: Air, Water and Soil” Peter Maxson estimates that in 2005 the dental profession required “240-300 tonnes of mercury”. Of this amount, the European Union requires ≈ 125 t of mercury (including 10-30% mercury carved away as waste)” per year.

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1 Bundesinstitut für Arzneimittel und Medizinprodukte 6.
2 ibid. 6
4 “Mass Flow Analyses of Mercury 2001.” Danish Environmental Protection Agency
5 “Cinnabar.” Wikipedia: The Free Encyclopedia
6 “Mass Flow Analyses of Mercury 2001.” Danish Environmental Protection Agency
9 ibid. 5.
10 ibid. 10.
1.4. Amalgam waste in water

In her study “Mercury in Waste Dental Amalgam: Why Is It Still a Problem?” Gail Savina estimates that “dentists in the United States alone discharge an estimated 51 tons of mercury each year.” 11

A Canadian study, carried out by O’Connor Associates Environmental Inc. in 2000, “estimated that [Canadian] dentists release 686 kg (or 125 mg per dentist per day) of mercury into waste water annually, 85% of which enters municipal sewage treatment plants”. 12 Another Canadian study carried out by CC Doiron & Associates in the same year estimates that even more mercury, namely 781 kg per year (or 131 mg per dentist per day), enter the sewerage system. 13

In 1995 the Canadian Mercury Network indicated that the total release of mercury from all sources in Ontario was 1,587 kg. Assuming that this value represents current production, then dentistry may have contributed 27% (430.89/1,587 kg) of this loading. 14

Studies in King County, Washington impressively illustrate the impact of amalgam separation on the reduction of mercury in waste water and biosolids. After the introduction of a compliance program, hand in hand with intensive information campaigns, the amount of mercury in biosolids could be reduced by 50 percent.

![Annual median mercury concentration in biosolids](chart.png)

Fig. 3 - Mercury levels in King County - biosolids

2. How does dental amalgam get dangerous?

2.1. Methylmercury

Once mercury is released into the environment it is converted into methylmercury by bacteria and microorganisms. Methylmercury is the form of mercury that humans and other animals ingest when they eat some types of fish.

Methylmercury is particularly dangerous because it bioaccumulates in the environment. Bioaccumulation describes “the increase in concentration of a substance in an organism over time”. 15 Fig. 4 illustrates this cycle. It shows the absorption of methylmercury and how it is passed on through the food chain. From small organisms of the aquatic ecosystem (e.g. plankton) it is transferred to larger one until it reaches the human body. Nowadays, almost all fish contain traces of methylmercury. Evidence of bioaccumulation is that “larger fish that have lived longer have the highest levels of methylmercury because they’ve had more time to accumulate it. These large fish (swordfish, shark, king mackerel and tilefish) pose the greatest risk.” 16

The WHO (World Health Organisation) has issued the following limitation of the tolerable intake of methylmercury per kg per week: 17

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Tolerable intake and other toxicological recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylmercury</td>
<td>Provisional tolerable weekly intake (PTWI) of 1.6 µg/kg bw</td>
</tr>
</tbody>
</table>

In connection with the above figures, several institutions have issued

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13 cf. ibid. 759e.
14 cf. Adegbembo and Watson. 759e.
17 “Mercury Programme” United Nations Environment Programme: Chemicals
advises on the recommended maximum intake of certain types of fish. “The Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) are advising women who may become pregnant, pregnant women, nursing mothers, and young children to avoid some types of fish and eat fish and shellfish that are lower in mercury”, and not to eat more than “12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury”.

2.2. Mercury in water and its effects

As already mentioned, methylmercury, the most harmful type of mercury for humans, mainly enters the human body via food. One of the primary sources is fish and seafood. Methylmercury is lipophilic, which means that it dissolves in fat. It is transported into the brain via the blood circle and “affects the immune system, alters genetic and enzyme systems, and damages the nervous system, including coordination and the senses of touch, taste, and sight”. In milder cases “adults complain of reductions in motor skills and dulled senses of touch, taste, and sight. These milder effects are generally reversible if exposure to mercury is halted”.

Methylmercury is furthermore especially harmful for unborn babies, because research has shown that they tolerate far lower levels of mercury. Since methylmercury has the potential to affect growth and development of embryos and foet, pregnant and nursing mothers have to be especially careful, as already mentioned.

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18 “What You Need to Know about Mercury in Fish and Shellfish.” U.S. Environmental Protection Agency

19 ibid.

20 “Mercury Contamination of Aquatic Ecosystems.” U.S. Geological Survey

21 ibid.

3. Solution to the problem – Amalgam separation

Amalgam separation and the careful collection and disposal of dental waste are the only solutions to prevent dental mercury from entering the public water system and consequently harming mankind!

While fairly ineffective measures to prevent mercury from entering the public sewage system (e.g. chair side traps or vacuum filters) only manage to “remove 40 to 80 percent of the amalgam particles from the waste”24 amalgam separators are able to separate almost 99 percent of the mercury. After having seen the effects of mercury on the human body, the impact of hindering every tenth of a percent of mercury from entering the public water system becomes evident.

In their article “Estimated Quantity of Mercury in Amalgam Water Residue Released by Dentists into the Sewerage System in Ontario, Canada” Adegbembo and Watson estimate that “the use of ISO-certified amalgam particle separators by all dentists could dramatically reduce dentistry’s share of mercury in Ontario’s municipal sewage treatment plants to barely 0.54%.”25 If you compare these figures with the 20–60 percent of mercury that entered the Canadian sewage system as stated earlier, the necessity of amalgam separation becomes evident.

When dealing with the topic of amalgam separation one inevitably comes across METASYS. Already in the early 1980s Bruno Pregenzer invented the first amalgam separator. The company METASYS was founded in 1988 and within a few years it became the world’s leading producer of amalgam separators. Nowadays, many of the most famous manufacturers of dental units fit METASYS amalgam separators into their dental units ex works.

3.1. Types of amalgam separators

The basic problem in separating amalgam particles is that they can range from “0.45 micrometers to larger than 3 mm. To remove these various sized particles from waste discharge, amalgam separators can use a range of techniques, alone or in combination.”26 Here are the four main methods of separation: centrifugation, ion exchange, filtration and sedimentation.

- Sedimentation based separators have baffles or tanks that reduce the speed of the waste water flow allowing amalgam particles to settle out of the waste.
- Centrifuge based units spin waste water and draw the amalgam particles to the sides of the unit [at the bottom of the tank].
- Ion-exchange units take advantage of the tendencies of certain chemicals to bind with dissolved mercury causing the particles to separate from the solution and rest at the bottom of the separator.
- Filtration is often used in combination. Some separators, for example, use sedimentation followed by filtration and ion exchange, with the aim of removing smaller amalgam particles not removed by sedimentation as well as dissolved mercury particles.27

In order to meet legal requirements, amalgam separators need to be ISO-certified. ISO (= International Organization for Standardization) is the world’s largest organisation that develops standards, its main field being technical standards.28 ISO has also published standards for amalgam separators.29 To be ISO 11143-certified the amalgam separators needs to “have a minimum removal efficiency of 95% if installed prior to March 20, 2003 or 98% if installed after March 20, 2003.”30

Besides the different methods of separation one can furthermore distinguish two main types of amalgam separators – chair side and central amalgam separators. As the name already indicates, chair side separators are installed right inside the dental unit. The main advantage of this type of separator is that the dangerous materials are removed at source. This way the amalgam sludge does not travel through the pipe system and has the opportunity to sediment there.

Besides separators which are placed inside the dental unit, there is also the possibility of installing a central amalgam separator next to the central suction system. Although this system is cheaper compared to individual separators, it bears the disadvantage that the whole amalgam sludge travels through the practice’s pipe system before it is separated. This means that it is less hygienic. Another problem is that it is more difficult to maintain the separator and that a failure of this separator means that work in the whole practice is out of order. The failure of one chair side separator only means that work on one dental unit is out of order.

METASYS believes in separation by means of centrifugation and sedimentation. Our product line includes the chair side models MULTI SYSTEM TYPE 1 and COMPACT Dynamic as well as various central solutions.

Besides the EXCOM hybrid 1, METASYS also offers central suction systems for 2 to 3 or up to 5 dental units.

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23 Batchu, Hanu. “Evaluating amalgam separators using international standard” 999
24 Adegbembo and Watson 759e.
25 “Amalgam Separators.” British Dental Association 2
26 McManus, Kevin R. „Purchasing, installing and operating dental amalgam separators: Practical Issues“ 1055
27 cf “Overview of the ISO system” ISO Online
28 “Subpart 374-4: Standards For The Management of Elemental Mercury and Dental Amalgam Waste At Dental Facilities“ Department of Environmental Conversation
29 “Purchasing an Amalgam Separator” Department of Environmental Protection: Bureau of Land & Water Quality
3.2. Method of separation

In order to understand the method of separation a little better, here a very basic description on the method of operation of our MULTI SYSTEM TYPE 1.

The separator works on the basis of under pressure, pressing the air through the whole system. Air (yellow) and contaminated water (blue=water, red=mercury, blood, etc.) enter the amalgam separator (top right). Air is separated (6.2) and leaves the system towards the suction motor (6.3). Fluids and residues are forced into the collection container, where the first step of the amalgam separation takes place (6.4). Since residues and precious metals are heavier than water, they sink to the bottom of the container. This means that here separation by sedimentation takes place.

Before the pre-cleaned water is forced through into the centrifuge (6.6) it has to bypass a filter drawer which holds back coarse parts. Waste water coming from the cuspidor is also directed into the centrifuge (6.7). Here, the second step of the amalgam separation takes place – the centrifugation. During the rotation of the centrifuge coarse particles are flung to the walls of the inner centrifuge chamber while the clean water is forced over the edge of the outer chamber wall and then fed into the drain (6.8). After a short pause the pump motor (6.9) comes into operation again and pumps the residues, together with the remaining water, into the collection container (6.4).

This cycle is repeated until the fluid level drops below the level of installed probes, then the electrical contact is broken. The centrifuge continues to rotate for a short time before it comes to an abrupt halt. The further rotating water column rinses the debris off the walls of the centrifuge and into the bottom of the chamber.

Following a short pause the pump motor (6.9) starts to work again, pumping particles and remaining water into the collection container (6.4).

4. What other measures need to be taken?

It needs to be stressed that the whole process of separation is of no use if the residues in the collection container are not disposed of thoughtfully. With DENTAL ECO SERVICE, the subsidiary company of METASYS, we are able to provide a comprehensive recycling solution. Since the early 90s DENTAL ECO SERVICE has built up a world-wide collection system of amalgam containers.

ECOTRANSFORM comprises the collection and recycling of amalgam for dentists in an easy and cost-effective way. The system operates world-wide (for details of our collection points see list below). Dentists send their full amalgam containers to their national collection point – this often happens by post in a special type-tested packaging. In some countries our partners organize the collection from the dental practice directly.

All of the collection containers are ultimately sent to our company’s headquarter in Rum bei Innsbruck, Austria. In our own recycling plant we are able to fully process the material and recover mercury and precious metals. It is particularly geared to the specific characteristics of amalgam waste and fulfills all necessary European guidelines. This way, approx. 1.500 kg of pure mercury can be retrieved from amalgam waste every year and therefore prevented from harming mankind.
Here an overview of the whole recycling cycle:

4.1. International collection points

Currently ECO TRANSFORM operates in these countries (www.metasys.com/collection_centers):

- Australia
- Austria
- Canada
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Hungary
- Italy
- Latvia
- Netherlands
- Norway
- Poland
- Slovenia
- Switzerland
- United Kingdom
- United States
In Austria and Germany DENTAL ECO SERVICE provides an all-inclusive recycling cycle not only collecting amalgam containers but also all other types of dental waste.

We provide typed-tested packaging for various kinds of dental waste, such as amalgam scrap, contaminated needles, extracted teeth, etc. Once a container is full it is collected and replaced by our staff.

5. Legal regulations

Many countries are aware of the dangers of dental mercury in public waste water and have thus passed laws and regulations regarding amalgam separation.

In 2013 The International Convention on Mercury (Minamata Convention) recognized the dangers of mercury and has set out regulations for the use of various mercury-containing products (e.g. dental amalgams).

The Minamata Convention aims at restricting mercury-containing products. The Minamata Convention has been implemented in the European legislation by the EU Regulation 2017/852. The regulation bans to use mercury-containing fillings for children and teenagers younger than 15 years.

It is furthermore no longer allowed to place dental amalgam filling for pregnant and breastfeeding women. As of January 1, 2019 only pre-capsuled dental amalgam is to be used. Furthermore, the installation of an ISO-certified amalgam becomes mandatory. If the use of mercury in dentistry will be banned generally is currently discussed by the EU-parliament.

In the USA comparable actions are taking place. In 2013 US EPA has passed the Amalgam Separator Rule, which became effective as of July 14, 2017. By July 14, 2020 most US dental practices need to comply with the regulation by using an amalgam separator. The rule also set out how arising dental amalgam wastes (e.g. filters, traps) must be treated.

6. Conclusions

Undoubtedly, dental mercury entering the public water system poses an extreme harm to environment and humans. Besides its fatal effects on people’s health, methylmercury also causes permanent damage to the aquatic ecosystem. It has been shown that even very small amounts of mercury cause severe problems.

The installation of an amalgam separator is the only solution to the problem. No other measure prevents almost all mercury from entering the public water system.

With a fairly small investment, dentists are able protect environment, our health and the health of future generations.
7. Sources

7.1. Images

Fig. 1 - Lauer, Reinhard. „Diagnose und Therapie der chronischen Quecksilbervergiftung“ Amalgam Informationen. Updated 23 June 2007. Retrieved 10 July 2007 http://www.amalgam.homepage.t-online.de/diag_ther.htm


Fig. 3 - “Mercury Levels in King County Biosolids.” King County. Updated 8 May 2007. Retrieved 25 July 2007 dnr.metrokc.gov/wlr/indwaste/amalgdiff.pdf - 2007-05-08


Fig. 6 - Container “MULTI SYSTEM TYP 1” METASYS

Fig. 7 - “Method of Operation (MST 1)” METASYS

Fig. 8 - “Amalgam collection container in parcel for dispatch by post” - METASYS

Fig. 9 - Various Collection Containers for Dental Wastes – METASYS

7.2. Bibliography


“Amalgam Separators.” British Dental Association Advice Note 57 (2005)


http://en.wikipedia.org/wiki/Cinnabar


http://www.zeromercury.org/EU_developments/070525_EEB_Dental_Amalgam_conference.html


http://www.usgs.gov/themes/factsheet/146-00/


• Amalgam separation
• Hygienic compressed air
• Suction
• Water decontamination
• Infection control
• Recycling

METASYS Medizintechnik GmbH
Florianstraße 3, 6063 Rum bei Innsbruck, Austria
☎ +43 512 205420 | ✉ +43 512 205420 7
www.metasys.com | info@metasys.com

GERMANY
+49 8823 938 44 33
info@metasys.com

FRANCE
+33 4 37 90 22 15
info@metasys.fr

ITALY
+39 045 981 4477
desitalia@metasys.com