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Amalgam waste management

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Dental amalgam has been extensively used as a tooth filling material for many decades and has beyond doubt saved millions of teeth that otherwise would have needed to be extracted. The release of amalgam particles into dental office wastewater is a matter of particular concern as amalgam particles could then be discharged into the environment. Amalgam waste discharges contribute to mercury in the environment through direct wastewater discharge, incineration, land-filling and sewage sludge incineration, although the discharge from dentistry is probably responsible for less than 1% of the total mercury discharged annually into the environment as a result of human activities. Nevertheless, dentists, by being producers of amalgam waste, have a responsibility and a duty of care for the proper management of this waste within their practices. Appropriate measures should be taken to minimise the amount of waste where possible or take action to ensure that all generated waste is disposed of in accordance with environmental legislation.

Key words: Amalgam waste, dentistry, mercury

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Dental amalgam has been extensively used as a tooth filling material for many decades and has beyond doubt saved millions of teeth that otherwise would have needed to be extracted. Several surveys indicate that its use is declining, at least in the developed countries, for different reasons.

Both the placement and the replacement of dental amalgam restorations produce amalgam waste. Various categories of amalgam waste can be identified (*Table 1*), and best management practices for these waste products should be adopted by dental offices. The release of amalgam particles into the dental office wastewater is a matter of particular concern as amalgam particles could then be discharged into the environment. The particle sizes of amalgam in wastewater range from large visible particles to a sub-micron colloidal suspension. There is no doubt that the mercury content of the wastewater generated from dental clinics contributes to the total mercury load to local wastewater treatment facilities, although there is controversy regarding how much[1].

Amalgam waste discharges contribute to mercury in the environment through direct wastewater discharge, incineration, land-filling and sewage sludge incineration, although the discharge from dentistry is probably responsible for less than 1% of the total mercury discharged annually into the environment as a result of human activities[2,3]. However, dentists, by being producers of amalgam waste, have a responsibility and a duty of care for the proper management of this waste within their practices. Appropriate measures should be taken to minimise the amount of waste where possible or take action to ensure that all generated waste is disposed of in accordance with environmental legislation. Taking voluntary action demonstrates that dentists want to do their share to make their offices more environmentally friendly. One excellent example of initiative is the Canadian Dental Association who by working proactively developed, in agreement with the Canadian Council of Ministers of the Environment, a Canada-wide standard on mercury for dental amalgam waste (http://www.ccme.ca/assets/pdf/cws_merc_amalgam_e.pdf). The ultimate goal in managing amalgam waste should be to minimise the amount discharged into the environment, which is best achieved by minimising the amount generated and recycling as much as is practicable.

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Table 1 Definitions of amalgam waste types

A.	Non-contact amalgam	Amalgam waste that has not been in contact with a patient.
A1	Used amalgam capsules	Used amalgam capsules contain trace amounts of amalgam alloy and mercury. The used capsules can be recycled.
A2.	Amalgam scraps (non-contact amalgam)	Excess amalgam that is not used in placing a restoration and has not been in contact with a patient. Amalgam scrap can be recycled.
B.	Contact amalgam	Amalgam waste that has been in contact with a patient.
B1.	Amalgam in chairside traps (contact amalgam)	Amalgam in wastewater that is retained by chairside traps (using a nominal hole size 0.7mm retains about 2/3 of all amalgam particles). It can be recycled as contact amalgam
B2.	Amalgam in vacuum pump filters	Amalgam in wastewater that is NOT retained by chairside traps is retained by vacuum pump filters. It can be recycled as contact amalgam.
B3.	Amalgam in wastewater	About 4/5th of the amalgam in wastewater is retained by chairside traps and vacuum pump filters while the remaining is discharged past the vacuum pumps.
B4.	Extracted teeth with amalgam restoration (contact amalgam)	Extracted teeth with amalgam restorations can be disinfected e.g. in 96% ethanol and recycled with other types of contact amalgam.

Table 2 Questionnaire, FDI Science commission project

In your country:

1. Are there any regulatory requirements regarding storage and/or proper disposal of amalgam waste?
2. Are there regulatory requirements associated with amalgam separators?
3. Are there any national agencies that maintain lists of "approved" amalgam separators and vendors?
4. Do amalgam separator manufacturers or distributors offer recycling programmes as part of their service? (i.e. allows spent or full cartridges/separators to be shipped to recycling facilities).
5. Are there any national agencies that regulate licences to recollection companies?
6. Do any other independent recollection companies have a licence to recollect spent or full cartridges/separators to be shipped to recycling facilities?
7. Do you know what happens to the recollected amalgam scrap?

Waste identification, risk assessment and risk handling

The American Dental Association (ADA) recently developed a guideline for best management practices for amalgam waste, available on the ADA's website (www.ada.org/prof/prac/issues/topics/amalgam.html). In brief, the guidelines describe the types of amalgam waste and the steps required for recycling it. The guidelines also provide best management practices (BMP) for amalgam waste handling and a guide for integrating these BMPs into the dental office.

Regulatory situation globally

The current perceptions of the environmental significance of mercury set forth by WHO in 1991[4] has relatively rapidly lead to mandatory wastewater treatment requirements in several countries worldwide. For example, according to the Council of European Communities directive 84/156/EEC, the mercury limit for sewage is 0.05mg/l (= 250nmol/l) effluent, while similar rigorous limits are also being set in other countries. Many sanitary districts have difficulties complying with existing, or anticipated requirements of their discharge levels concerning priority pollutants such as mercury. It is in this context that unregulated small quantity generators, such as dental clinics, have been identified as one of the sources that may be causing these compliance problems. There is therefore a growing perception in many countries that in order to reach their goals, amalgam separators needs to be installed in dental offices. Several studies have identified large reductions of mercury output into wastewater treatment plants following installation of amalgam particle separators[5-8]. However, the impact of amalgam separator installation on the mercury concentration of wastewater treatment plant effluent is not well documented.

In view of this emerging situation, 80 national dental associations received a questionnaire in 2003 from the FDI science committee requesting information about the regulatory requirement and situation regarding amalgam waste (*Table 2*). Replies were received from 23 associations (28% response rate). A synopsis of the answers is presented in *Table 3*. About half of the respondents reported that amalgam separators were now mandatory equipment in dental offices.

Table 3 Answers from national dental associations (n=23) to questionnaire regarding amalgam waste situation. Detailed answers can be requested from the FDI Head Office.

National or regional regulatory requirements regarding storage and/or proper disposal of amalgam waste?					
National regulations for storage/disposal		Regional regulations for storage/disposal		National regulations for storage/disposal	
1.	Bahrain	16.	Germany	18.	Australia
2.	Belarus	17.	USA	19.	Greece
3.	Canada			20.	Senegal
4.	Czechia			21.	Serbia
5.	Denmark			22.	South Africa
6.	Estonia			23.	Turkey
7.	Finland				
8.	Iceland				
9.	Italy				
10.	Japan				
11.	The Netherlands				
12.	Poland				
13.	Slovakia				
14.	Slovenia				
15.	Spain				
Are there regulatory requirements associated with amalgam separators?					
Yes		Regional variations		No	
1.	Bahrain	12.	Australia	14.	Estonia
2.	Belarus	13.	USA	15.	Greece
3.	Canada			16.	Italy
4.	Czechia			17.	Japan
5.	Denmark			18.	Poland
6.	Finland			19.	Senegal
7.	Germany			20.	Serbia
8.	Iceland			21.	South Africa
9.	The Netherlands			22.	Spain
10.	Slovakia			23.	Turkey
11.	Slovenia				
National agency that maintains lists of approved amalgam separators and vendors?					
Yes				No	
1.	Czechia			5.	Australia
2.	Germany			6.	Bahrain
3.	Iceland			7.	Belarus
4.	Italy			8.	Canada
				9.	Denmark
				10.	Estonia
				11.	Finland
				12.	Greece
				13.	Japan
				14.	The Netherlands
				15.	Poland
				16.	Senegal
				17.	Serbia
				18.	Slovakia

***Table 3** continued over...*

Table 3 *continued...*

National agency that maintains lists of approved amalgam separators and vendors? *(continued..)*			
Yes		No	
		19.	Slovenia
		20.	South Africa
		21.	Spain
		22.	Turkey
		23.	USA
Amalgam separator manufacturers or distributors that offer recycling programmes as part of their service?			
Yes		No	
1.	Australia	14.	Bahrain
2.	Canada	15.	Belarus
3.	Czechia	16.	Estonia
4.	Denmark	17.	Greece
5.	Finland	18.	Poland
6.	Germany	19.	Senegal
7.	Iceland	20.	Serbia
8.	Italy	21.	South Africa
9.	Japan	22.	Spain
10.	The Netherlands (only some)	23.	Turkey
11.	Slovakia		
12.	Slovenia		
13.	USA (only some)		
National agency that regulates licences to recollection companies?			
Yes		No	
1.	Australia	19.	Belarus
2.	Bahrain	20.	Senegal
3.	Canada	21.	Serbia
4.	Czechia	22.	South Africa
5.	Denmark	23.	Turkey
6.	Estonia		
7.	Finland		
8.	Germany		
9.	Greece		
10.	Iceland		
11.	Italy		
12.	Japan		
13.	The Netherlands (only some)		
14.	Poland		
15.	Slovakia		
16.	Slovenia		
17.	Spain		
18.	USA (recyclers / not collectors)		

Table 3 *continued over...*

***Table 3** continued...*

Independent recollection companies with licences to recollect spent or full cartridges/separators to be shipped to recycling facilities?			
Yes		No	
1.	Bahrain	16.	Australia
2.	Belarus	17.	Iceland
3.	Canada	18.	The Netherlands
4.	Czechia	19.	Poland
5.	Denmark	20.	Senegal
6.	Estonia	21.	South Africa
7.	Finland	22.	Turkey
8.	Germany		
9.	Greece		
10.	Italy	No answer:	
11.	Serbia	Japan	
12.	Slovakia		
13.	Slovenia		
14.	Spain		
15.	USA		

What happens to the recollected amalgam scrap?					
Disposal		Recycling		Unknown	
1.	Canada	4.	Australia	11.	Bahrain
2.	Poland	5.	Denmark	12.	Belarus
3.	Senegal	6.	Iceland	13.	Czechia
		7.	Italy	14.	Estonia
		8.	Japan	15.	Finland
		9.	The Netherlands	16.	Germany
		10.	USA	17.	Greece
				18.	Serbia
				19.	Slovakia
				20.	Slovenia
				21.	South Africa
				22.	Spain
				23.	Turkey

Amalgam separators

During placement or removal of amalgam, amalgam particles are generated and discharged into dental office wastewater through the suction system. The sizes of these particles range from over 3mm to less than 0.01mm. The fate of amalgam in wastewater has been described in a scientific assessment conducted in the United States[9]. Using a mass-balance approach, the study estimated that 68% of the amalgam particles in dental office wastewater are retained by chairside traps. A further 13% are retained by vacuum pump filters, and part or all of the amalgam particles past the vacuum pump are discharged from the office into the sewer. Of the amalgam particles that reach wastewater treatment plants, 95% are retained in grit chambers or biosolids (sludge)[9]. In an attempt to reduce the amount of amalgam in dental office wastewater reaching the treatment plants, amalgam separators are gradually being installed in dental offices worldwide.

Types of amalgam separators

There are three basic methods to separate the mercury laden amalgam particles from the dental wastewater stream: filtration, centrifugation and sedimentation.

Centrifugal separators function on a batch processing mode. The dental wastewater flows into the unit and once a sufficient volume of water fills the chamber, the separation process begins. The separated amalgam is collected in a tray. This technology is becoming less popular compared to the sedimentation devices, which collect the wastewater, allows it to settle and then, slowly, using a low volume pump decants the liquid out of the

container leaving the particles behind. Some sedimentation units also contain a filter and some even a chemical removal column for ion exchange[10] (*Table 4*).

Testing the separator according to ISO standard

Amalgam separators are tested in accordance with standard defined by the international organisation for standardisation (ISO). These are specified in ISO Standard number 11143[11]. One focus of ISO11143 is to assess the removal efficiencies in terms of their potential to reduce the number of amalgam particles entering the sewer system. The standard is based on a simulated specimen with a particle size distribution resembling an actual clinical specimen[12]. A standard 10g test sample is composed of ground triturated dental amalgam with the following distribution characteristics: 3g of particles with sizes between 0.5 and 3.15mm, 1g with sizes 0.1mm and 0.5mm, and 6g with particle sizes less than 0.1mm. To pass the standard, the efficiency of the amalgam separator is required to be at least 95% (mass fraction) removal of all particles.

There is some dispute regarding the validity of the ISO standard since it has been demonstrated that the efficiency of amalgam separators is influenced by the initial concentration of the dental wastewater, the physical setup of the discharge system before the dental wastewater reaches the separators, and the addition of chemicals to the dental wastewater. In addition, it is likely that assessment of efficiency based on particle removal by weight may not be as effective as removal based on concentration[13]. Also, external sources may cause performance variability, such as the length of the discharge path and the use of disinfectants. Nevertheless, it is likely that amalgam separators will decrease the amount of amalgam into the sanitary sewer system[14].

Purchasing a separator

Before purchasing or installing an amalgam separator, dentists should consider factors specific to the available models, including size and maintenance requirements[15]. Several factors need to be considered when considering a purchase of an amalgam separator:

- Space and utility requirements
- Amalgam separator models by technology
- Amalgam separator buyer's checklist
- Dental office/building constraints
- Regulatory issues
- Questions to ask your amalgam recycler
- Ease of maintenance and replacement
- Effect on suction equipment
- Cost.

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Table 4 Amalgam separators sorted according to filtration principle. This list should not be regarded as complete.

Principle	Producer	Model
Filtration	Avprox Inc.	Asdex
Sedimentation	Air Techniques Inc	Guardian Amalgam Collector A1000
	Metasys (In USA: Pure Water Development)	ECOII: Economy System Type II
	R&D Services	Amalgam Collector models CH9 & CH12, models CE15, CE18 & CE24
	Rebec Simple Solutions	REB models 1000, 5000, 7000 & 9000, RME model 2000
Sedimentation + Filtration	American Dental Accessories	Avprox AS-9
	Dental Recycling North America	BullfroHg
	Maximum Separation Systems Inc	MSS model 1000, model 2000
Sedimentation + Filtration + Ion Exchange	AB Dental Trends	Rasch models 890 -1000, -4000 & -6000
	Bio-Sym Medical	Merc II
	Dental Recycling North America	MRU models 100v & 10c
	Hygenitek	ARU-10
	SolmeteX Inc.	Hg separator models Hg5 & Hg10

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