

Translation of
Quecksilberemissionen aus Zahnarztpraxen

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Mercury Emissions Generated In Dental Establishments

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A. Preface

Mercury is known as a extremely toxic element. Nowadays Mercury is found in ail water treatment facilities in Hessia. *One* source could be the dental office. The Federal Ministry of the Environment lists the consumption of amalgam in dental medicine as 26 tonnes per year. The common amalgam contains 50% Hg, 30% Ag, and 20% Sn. The project was initiated by studies in Sweden and *in* Hessla, where up to 1.5 kg of amalgam from one dental office was discharged into the sewer system.

The following aspects should be addressed during this project:

1. Establishing the amount of waste water and amalgam, looking at all amalgam contaminated drains in dental off ices.
2. To substantiate the Swedish test methods by means of real flndngs.
3. Developing a test method to determlne the efficiency of amalgam collectors.
4. Establishing a skeleton agreement for dental operations.
5. Looking into the feasibility to meet the limit of 0.05 mg/l with respect to available technology.

6. Test comparing the suitability of available amalgam collectors in accordance with above skeleton agreement.
7. Guide-line to control and maintain the devices.
8. Development of a suitable waste management program for the collected amalgam waste.

The double effect of waste reduction and re-collect raw materials is of utmost importance to this project.

B. Results

During this project the following results were obtained for each aspect.

1. Establishing the amount of waste water and amalgam, looking at all amalgam contaminated drains in dental offices.

in Hessa and North Rhein- Westfalia a total of 17 dental offices were selected for the investigation.

The criteria for selecting a dental office

- different makes of treatment units were present,
- water samples could be taken immediately after the treatment unit - without mixing with other (local waste water),
- the waste water of one day could be collected and
- different kinds and methods of treatments were available.

Before starting to take samples, all existing traps (sieves, filters etc) were emptied to reduce to a minimum the effects of the device type on the treatment unit. After the samples were taken, all traps were emptied again and the contents were added to the samples.

Representative mix-samples were taken from different samples collected during one day's operation and after homogenizing, were analysed for

- viscosity
- amount of settled substances
- determining the size of the particles and
- amount of Chrome, Cobalt and Nickel

For each particle size fraction

Fraction I: larger than 0.5 mm

Fraction ii: 0.1 mm to 0.5 mm

Fraction Iii: 0.025 mm to 0.1 mm

Fraction IV: smaller than 0.025 mm

the contents of Mercury and Silver were established.

The waste water per dental office amounted to between 8.5 and 63 liter per day. This amount depends proportional on the number of patients (10 - 20). These numbers do not apply to offices which use water-ring-pumps or water-jet-pumps for their suction system. Her-e the amount of water measured was 20 liter in 5 minutes.

The amount of Mercury per day fluctuated between 40 mg and 20.080 mg. The arithmetic average is 3.800 mg of Hg per day. On the basis of this factor and assuming that a dentists works only 4 days a week full time, the total freight is calculated by

$$\begin{aligned} & 3.8 \text{ g/d} \times 4 \text{ d/week} \times 48 \text{ weeks/y} \\ & = 729.6 \text{ g/y per treatment unit.} \end{aligned}$$

As each dentist has in general two treatment units, this means a total freight between 1-1.5 kg/y per dental office.

In conclusion it is pointed out that the established amounts do correspond with the real conditions at the site where the samples were taken. To avoid interfering with the daily routine while taking the samples, it was impossible to clean all drains and hoses before and after taking the samples to establish the real amounts. Nevertheless it can be considered as a fact that the established amounts do picture the real condition, as over time, due to sedimentation, a stream-technical favourable profile has developed in the pipes and hose connections.

2. To substantiate the Swedish test methods by means of real findings.

in Sweden, back in 1978, the amount of waste water in five dental offices without installed retrieval systems were established. The collected substances were analysed with regard to particle size.

in average the following sizes were established:

| | | |
|---------------|----------------------|---------|
| Fraction I: | larger than 0.5 mm | : 54.5% |
| Fraction II: | 0.1 mm to 0.5 mm | : 37.6% |
| Fraction III: | 0.025 mm to 0.1 mm | : 6.9% |
| Fraction IV: | 0.010 mm to 0.025 mm | : 1.0% |

Although these test results were available already in 1978, the selection of particle size for the standard sample of 10.0 g to establish the "Standard test of *Collection* Regulations for Mercury containing waste generated in dental establishments" were:

| | | |
|---------------|------------------------|---------------|
| Fraction I: | (2.0 mm to 1.0 mm) | : 5.0 g = 50% |
| Fraction II: | (1.0 mm to 0.35 mm) | : 2.5 g = 25% |
| Fraction III: | (0.35 mm to 0.044 mm) | : 1.5 g = 15% |
| Fraction IV: | (0.044 mm to 0.020 mm) | : 1.0 g = 10% |

During a discussion with the National Swedish Environmental Protection Board in Stockholm on November 27. 1984, it could not be explained why for the standard test a size selection, different from the test results, were granted.

A comparison between the samples taken in 'one day and the Swedish standard test shows no conformity. In contrast to the Swedish standard test, the majority of particles are found to be smaller than 0.1 mm.

As the size of the particles effects greatly the efficiency of presently used mechanical collecting methods of a collecting device, the efficiency with the day samples is drastically reduced compared with the Swedish standard test.

Therefore a new test method had to be developed.

3. Developing a test method to determine the efficiency of amalgam collectors.

To establish a test method, the effects of the parameter

- size of particle,
- speed of incoming water
- load and
- viscosity of carrier medium

was studied with respect to the efficiency of amalgam collectors.

The separation is accomplished by presently available devices according to the centrifuge principle or sedimentation/filtration.

Effect of particle size

The size of the particle effects greatly the centrifuge separation and the sedimentation. The larger the particles are, the better the devices work.

Effect of speed of incoming water

Especially with a sedimentation device the efficiency depends greatly upon the speed of water flushing through the system. This can also be explained, as particles which would settle with a lesser speed are flushed away with water coming in with a high speed.

Effect of load

The effect of the load is negligible with the sedimentation device, as the sedimentation speed to settle depends only on the viscosity of the carrier and the particle size.

Effect of viscosity of carrier medium

During the analysis of the samples, taken from dental offices? viscosity data were obtained, which varied only minimal from the viscosity data of the carrier medium (water) used during the tests. As it is not likely that, while using an amalgam collector, the viscosity will be much different, the effect of the efficiency due to a different viscosity was not investigated any further.

Selection of a tensid

The use of a tensid is necessary to bedew the amalgam. if not bedewed, the amalgam will clot or it will form a fine layer at the surface. A reproducible measurement is not possible in this condition.

Test method

Taking into consideration the above mentioned test results, a text for a standardized test method was drafted in close co-operation with Professor Rotgans, University Tuebingen and graduate engineer Stumpf from the Technical Testing Association in Essen (see encl 3). The method described therein to manufacture sample material (amalgam) was developed by Professor Rotgans.

4. Establishing a skeleton agreement for dental office operations.

The skeleton agreement contains general demands, for example place of installation, amount of waste water, used material, accessibility to take samples, control signals and special installation instructions for amalgam collectors.

Not listed are the of waste water sources, which have to be connected to an amalgam collector. In principle, besides the waste water of the treatment units, also the waste water originating from the hand basin in the office should be connected to an amalgam collector. The cleaning of amalgam contaminated devices in the basin will contaminate the waste water.

A general demand, to let the waste water from the hand basin flow through an amalgam collector, would mean for most establishments the installation of a separate amalgam collector at the basin. Considering the consequences, thought should be given, specially for existing installations, to regulate alternatively by means of administrative *rules*, the cleaning of amalgam contaminated devices in a dish sink to eliminate the problem of how to collect the amalgam from the hand basin.

5. Looking into the feasibility to meet the limit of 0.05 mg/l with respect to available technology.

As the reference point is defined differently, the measured concentration depends mainly on the amount of water, which varies greatly from location to location, behind the treatment unit, at the border of the office or at the point of connecting into the community sewer system.

Even a common reference point directly behind the treatment unit is questionable, because the flow and amount of water depends on the system and varies between a some liter and a few cubic meters per day.

Moreover it should be mentioned that it is not feasible to control the limits. The thought to take samples from ca. 30.000 dental offices a few times a year seems, considering the needed man power, utopian.

The amount of amalgam produced varies tremendously over time and that would make it necessary to take a day's sample.

It is not possible to take a representative sample with respect to amount and time, because it is not guaranteed that all dentists will be treated the same. During the period of taking the samples it was noticed that in one office amalgam fillings were removed in one patient after another which automatically would result in a very high Mercury content in the waste water, whereas in another office only extractions, prosthetic and medical treatment was given without the disposal of amalgam and Mercury into the waste water.

Due to above explanations it is established, that the limit for Mercury of 0.05 mg/l as per regulations can not be applied to dental offices nor dental clinics. It can only be applied to industry and trade.

On the other hand for dental establishments and dental clinics the following regulations are suggested.

1. Beginning with 1988 all newly established dental offices and dental clinics must be equipped with certified amalgam collectors. This regulation is also applicable to re-designed single treatment units within an office and clinic which are equipped with several treatment units.

2. Existing dental establishments as well as dental clinics must install certified amalgam collectors on all treatment units by 31. 12. 1989 at the latest.

This suggestion is modelled on guide lines, which were made mandatory in Sweden. This regulation was, suggested by Sweden, adopted by the Helsinki Commission of the BALTIC MARINE ENVIRONMENT - PROTECTION COMMISSION.

6. Test comparing the suitability of available amalgam collectors in accordance with above skeleton agreement.

Up until the dead line nine amalgam collectors were submitted for testing of their efficiency. Those are products of six different companies. For determining the efficiency of these devices, the under point 3 mentioned testing method was used. The standard curve has to be considered as temporary, because the available data were few. The final curve should be based upon a better statistic.

For the testing standard mixtures, produced by the University of Tuebingen in co-operation with the University of Stuttgart, were used. The samples were numbered in order being used. The corresponding numbers are found in the testing protocols.

I point out that with respect to the efficiency there does exist an uncertainty, because pure tap water was used as a carrier during the testing. In reality the contamination of the water through cotton balls, dust as well as organic substances could possibly reduce the efficiency.

The established figures show a broad spectrum between 54.9% and 96.3%. Let it be mentioned that those figures were derived from *new* devices. At the present time, with respect to the efficiency over a longer period of time, no evaluation is possible. To establish these figures, more testing would be necessary after the units were in use for a longer period of time.

7. Guide-line to control and maintain the devices.

The goal of the guide line is to lay out

- what specifications in the manual with respect to maintenance and time periods are expected
- what is demanded with respect to handling of the collected amalgam

1. Maintenance and control

The intervals and the extent of the maintenance are to be defined by the manufacturer in a way that the devices are kept functional.

a) Dynamic collectors

Dynamic collectors are devices which are powered mechanically or electrically. Usually they use the principle of a centrifuge.

b) Static collectors

Static collectors use the principle of sedimentation or filtration.

2. Demands with respect to handling of the collected amalgam

The collector should be designed in a way that the collected amalgam sludge can be safely and easily removed.

8. Development of a suitable waste management program for the collected amalgam waste.

The amalgam waste in amalgam collectors can only be managed through a comprehensive waste management system for all kind of waste, which are generated in the dental office.

The following wastes are generated in the dental praxis:

X-rays

Solutions used for x-ray development

Teeth with amalgam fillings

Amalgam residues from amalgam collectors

Used sieves with amalgam residues

Amalgam left overs

Used needles and cannulas

Medicine and their left overs

Old x-ray films, lead foils

As the proper waste management of these residues is difficult for the dentists to handle due to time involved and required licencing, it is suggested that the dental associations enter into a skeleton agreement with waste management companies to manage the waste in dental offices. The dentist can join these agreements.

For each waste special waste management is set forth.

The demands for waste management companies as well as administrative regulations will be disclosed in detail.

The cost involved to manage the waste can only be estimated, as the cost for collection and transportation depend on local circumstances and do effect the total amount.

Conservatively estimated the cost involved are ca. 40 - 50 DM per dental office per month.

C. Future

It is expected that every dental office generates the amount of 1 kg to 1.5 kg of Mercury per year, which accumulates in undissolved form in amalgam residues. By developing a test method to determine the efficiency of amalgam collectors, a basis was created to have all existing and future amalgam collectors examined according to standard with regard to efficiency.

By testing nine devices during the project, as well as three other devices separately with efficiency ratings from 86.1 % to 92.1 %, I suggest to licence for installation only amalgam collectors with a rating of more than 90%. They also should have a licence with respect to design.

at least 95%! (correction Mr. Bosse)

To allow enough preparation time for the dentists and the manufacturers to adjust their products, I suggest the following regulation:

- Beginning January 01, 1988 all newly designed dental offices and dental clinics have to be equipped with licenced amalgam collectors. They must have a 95% rating of at least 90% at a water flow of at least 6 l/min according to the established test method. The testing protocol has to be presented.
- Existing dental offices and dental clinics must install an equivalent amalgam collector by December 31, 1989.
- The removal or cleaning of amalgam contaminated trap systems (sieves, filters etc.) of the unit in the hand basin or toilet is prohibited once amalgam collectors are installed. This procedure is permitted only in the spittoon of the unit.

By realizing these suggestions the following relief for environment and industry is accomplished::

1. Relief of water treatment facilities in the Federal Republic of Germany by retrieving of at least 28.5 tonnes of Mercury per year (at 28.500 dental offices).
2. Eventually better chances to use the sludge from the water treatment facilities by reducing Mercury and other heavy metals.
3. By retrieving Mercury and Silver preservation of natural resources.

Originally it was assumed that the Mercury in dental offices was only generated in undissolved form. In connection with the project it was discovered at a few samples that the Mercury and other heavy metals were present in dissolved form. Therefore it is aimed to investigate this phenomenon in more detail in a final examination, in particular with respect to certain dental procedures (polishing of old amalgam fillings) and the use of certain dental instruments (turbine, drills, disinfectants).

Translation of paragraphs from report of water treatment plant of the City of Zuerich, Switzerland

Page 2, para. 4

Effect of mercury pollution in sewage water resulting from dental offices.

In two cases sewage water was examined before and after a dental office.

- 1) Schulzahnklinik Schwamendingen, Ahornstrasse 9
mercury before building: 6.9 mg Hg/ kg TS
after 143 mg Hg/ kg TS
- 2) Zahnaerztliches Universitaetsinstitut
mercury before building: 260 mg Hg/ Kg TS *
after 2300 mg Hg/ Kg TS

* data strongly raised due to university hospital (200 meters distance 5300 mg Hg/kg TS)

TS means Trockensubstanz (dry substance)

The amount of mercury in the sewage water is increasing extremely in the catchment area of a dental office.

page 2, para. 5

Relative Importance of dental offices in regards mercury in sewage water

Seven dental offices were examined. The samples were taken in the nearest- suitable manhole. Following amounts of mercury could be found in the sewage water:

| Dental offices | mercury (mg/kg TS) | distance to manhole |
|----------------------------------|--------------------|---------------------|
| <u>private offices:</u> | | |
| Ohmstreet 14 | 245 | 30 m |
| Schwamendingenstreet 5 | 398 | 20 m |
| <u>schooling clinics:</u> | | |
| Ahornstreet 9 | 143 | 70 m |
| Parkring 4 | 267 | 50 m |
| Goldbrunnenstreet 78 | 380 | 30 m |
| Altstetter Street | 54 | 150 m |
| <u>university dental clinic:</u> | | |
| Plattenstreet 11 | | |
| average level | ca. 20 | |

cont. page 2, para. 5

The results show that dental offices discharge a very large portion of mercury into the sewage water, although it is too early to make transport statements. Also it is important to consider the distance from the manhole to the discharge place. (page 3, para. 5) Nevertheless, the dental office can be considered as one of the major mercury dischargers.

page 3, para. 7.

Further action (suggestion)

Dental offices and the hospitals could be informed of the problem of mercury pollution by means of a letter. By internal improvements of work methods and separation of amalgam the Hg freight can be decisively reduced. However, these improvements will take effect after appr. one year, as the Hg-mud *has* mainly settled in the mains and only through rinsing they will enter the public sewage system and water treatment plants.