How to Combat Mercury Emissions from Dental Clinics

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Metallic mercury released into aquatic environments is transformed into methyl mercury. This is accumulated in fish, often reaching hazardous levels in top predators such as sharks, tuna, northern pike and perch, thus requiring fish consumption advisories for populations at risk. Since sizable amounts of metallic mercury are released from dental offices each year into the waste water systems, many countries now require amalgam separators to be installed. In Sweden the efficiency of this environmental protection is supposed to be 98%, as stated by the manufacturers. Recent investigations, though, have pointed out that the efficiency of most commonly used amalgam separators of sedimentary type is far less. But there are ways to greatly improve the efficiency.

The extensive use of dental amalgam for tooth restorations in industrialized countries, especially during the last half-century, has resulted in a large stock of mercury in the population, in Western Europe alone estimated to about 2,000 tons (El, 2004). Despite esthetical and potential health aspects, 70 tons of mercury is used each year for tooth restorations in this region (Maxson 2004). In other countries, improved economic conditions have made it possible to restore instead of extract teeth, generally with dental amalgams for reasons of simplicity. A contributing factor is the intensified marketing in these countries by amalgam producers, as dental patients in industrialized countries are increasingly reluctant to use mercury-containing fillings. A third reason to the widespread use of amalgam fillings is the fact that environmental effects are seldom considered, and if they are considered, the cost for preventing pollution from dental amalgam is generally paid by the general tax payers and not by the dental patients receiving amalgam restorations. Therefore dental amalgam becomes an advantageous choice from a private-economical standpoint (Hylander & Goodsafe 2006). There are different approaches to reduce mercury emissions from dental clinics. The most widely employed approach is to have amalgam separators installed which are supposed to recover 95–99% of the mercury from the waste water of dental clinics. The aim of this study was to evaluate the true efficiency in actual operation of amalgam separators with a claimed efficiency of 99–%, installed at 12 dental clinics in the County of Uppsala, Sweden.

Method

The dental clinics studied were equipped with wet suction systems and amalgam separators of sedimentary type (SRAB 99™) preceded by a mesh (0.7 mm) at each chair collecting larger particles. The efficiency of the amalgam separators was initially determined under ordinary working conditions, and determined a second time after a thorough revision of each system, including a high pressure cleaning of the waste water system to remove and collect sediment deposited outside the separators, such as in pipes and buffer tanks. The mercury content in this sediment was also determined. In each collection period, all waste water leaving the amalgam separators was collected during four consecutive working days and analysed for the content of mercury with wet chemical methods and atomic absorption cold vapour technique (Urberg et al. 1989). The amount and type of dental work with amalgam was registered at all clinics.

Results

Most mercury entering the waste water system originated from the removal of old amalgam fillings, which was done at all clinics, ranging from 1.5 to 50 fillings per week per dentist at the studied clinics. The number of new amalgam fillings inserted ranged from 0 to 15 per week per dentist. Waste water leaving the dental chairs contained up to 85 mg mercury l⁻¹. Before revision, the mercury concentration in waste water leaving the clinics, after having passed through amalgam separators, ranged from less than 1 up to 74 mg l⁻¹, and was on average 15.8 mg l⁻¹ for 11 clinics. Extrapolating data to an annual basis with 220 working days per year, the discharge of mercury to the community waste water system ranged from 0.5 to 84 (average 14.5) grams of mercury per chair per year before revision of each system. After revision this figure was reduced to between 0.1 and 7.5 (average 1.7) grams of mercury per chair per year. The reduction of mercury emissions, thanks to revision and cleaning, was in total more than 500 grams of mercury per year from the eleven clinics, containing 45 active chairs (units). In the twelfth clinic, efficient cleaning could not be performed due to the design of the buffer tank. In an attempt to clean the tank, settled mercury was re-suspended and dispersed, resulting in higher mercury concentration in the waste water after cleaning, which was why this clinic was excluded from the calculations above.

Discussion

Contrary to what may be expected, the major part of mercury in the waste water of dental practices does not originate from placing amalgam fillings but from the removal of old fillings. At insertion, the losses of mercury are generally less than 20% of the mercury used for the filling, and most of these losses are disposed of as dry waste, or hazardous waste when such a handling system is available, thereby reducing the amounts of mercury entering the waste water system. However, at the removal of fillings, drilling will always turn a portion of the filling into fine particles entering the waste water.

On the other hand, amalgam fillings in the teeth will cause a continuous emission of mercury due to abrasion from everyday chewing. These emissions total about 0.1 tons per year and, hence, are of the same size as the mercury loss from dental clinics in Sweden.

In addition to mercury emissions from dental clinics and the daily wear from chewing, there is a third important pathway of mercury loss from amalgam fillings: cremation. This is presently the largest point source of mercury in Sweden. Cremation will result in the complete release of mercury from amalgam fillings left in the mouth after death. It is possible to partly recover these emissions, but the costs are high and recovering is not at 100%. In our opinion the cost for flue gas cleaning at crematoria should be added to the patient.

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**Fig. 1**: Schematic design of a waste water system at a dental clinic with amalgam separators, coupled to a suction system of a so-called wet type.

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**Vacuum bypass pipe Ø 25 mm**

**To vacuum pump for evacuation Ø 50 mm**

**Air separation tank**

**Buffer tank**

**Electrically maneuvered on/off valve to avoid back suction**

**Non-return valve**

**Drain to community waste water system**
fee for amalgam restorations and not by members of the church, as is the present case. Mercury loss due to abrasion from chewing cannot be avoided in any other way than by replacing amalgam fillings with mercury-free ones. One may therefore question why one would insert amalgam fillings since this practice will result in large mercury emissions, even if the best available techniques are used to reduce the emissions.

The mercury emissions from dental amalgam most easy to limit are those from dental clinics. However, waste water leaving the clinics always contained more than 0.07 mg l⁻¹ in our investigation. This demonstrates that separators employing sedimentation as a means of recovery of mercury do not meet the limit concentration of 0.0002 mg l⁻¹ waste water, a value based on the permitted level in sludge used for agricultural production in a sustainable society (Lunds kommun 2002).

There was poor recovery of mercury at most clinics before revision, which partly was caused by full amalgam separators, although they had been changed on a yearly basis according to a fixed maintenance system. After cleaning and revision, which included insertion of new amalgam separators, the recovery of mercury increased markedly. This demonstrates the importance of professional installation and regular maintenance of amalgam separators for optimal function. Even with such conditions, the studied amalgam separators of sedimentary type, never exceeded 85% recovery at operation in practice, which is markedly lower than the 99% recovery obtained in laboratory tests and claimed to be the efficiency when marketing the amalgam separators.

The laws of physics make it impossible for this type of amalgam separator to perform better when fed waste water from dental clinics, which holds a larger portion fine particles than used in standardized laboratory tests. Recently, an amalgam separator using pine bark treated with a metal binding agent has been developed. The waste water is passing through this bark filter, which resembles a big espresso coffee brewer, and recovers both small and large amalgam particles as well as dissolved mercury-ions, which are specifically adsorbed to the complexing agent on the bark surfaces. Ideally, the filter is coupled in series with a traditional sedimentary type amalgam separator. In this way, the operation period of the bark filter is prolonged before it needs to be changed or reconditioned.

Conclusion
The major part of mercury in the waste water from dental clinics originates from removing old fillings in populations where dental amalgam has been used for an extended period of time. Presently, amalgam separators of the sedimentary type cannot reduce the mercury content to levels needed to combat pollution in a society based on criteria for sustainability. However, there are techniques available that meet these requirements. These techniques should be compulsory and the costs be incorporated into the patient fee for insertion of amalgam fillings.

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