Purves Environmental, Inc.

Since 1993

Dental Office Study

Reduction of Mercury Discharge from a Dental Office

Introduction

The mercury discharge from a dental office can range from <100 ng/L to >1,000,000 ng/L[1](ng/L= Parts per Trillion). The national discharge limit for POTWs (Public Owned Treatment Works) is 12 ng/L and 1.3 ng/L for the Great Lakes region. The regulation 40 CFR 441.50, commonly known as the Dental Rule has established guidelines for the reduction of mercury waste generated by the average dental office. This rule suggests ways to reduce the discharge by using a combination of Best Management Practices (BMPs) and the amalgam separator.

Purves Environmental has studied this issue since 2003. From the studies and data accumulated by the company, a significant concentration of mercury continues to be discharged by dental offices. Mercury concentrations from some dental office are high enough that POTWs are negatively impacted by the discharge. In some cases, the impact causes a violation of the POTW's NPDES permit limit for mercury discharge for which penalties can be significant. This case study demonstrates that the use of Best Management Practices (BMP) and Best Available Technology (BAT) can significantly reduce the mercury discharge from a dental office and help the POTW meet their mercury discharge limit.

The issue of dissolved mercury coming from the amalgam was discussed in the writing of the rule. William Purves of Purves Environmental, Inc. provided data supporting the idea that dissolved mercury could remain a serious issue when resolving the mercury discharge levels from a dental office (December 10, 2014 USEPA public comment meeting). This study helps resolve both the solid amalgam problem and some reduction of the dissolved mercury problem.

Scope

The study was conducted to examine not only the use of BMP and BAT but also look at the cost. Phase 1 was to assess the level of discharge and all areas that contributed to the discharge. Phase 2 was the plan to implement the changes required by the POTW. Phase 3 was implementing the BMP suggested by Purves Environmental. Phase 4 was implementing the BAT by using new technology to reduce the impact of amalgam on the waste stream.

The Practice

The practice is a small office with one operatory and two hygiene chairs. There is no amalgam separator. The Dentist remove amalgams and only places composites. The practice is part time operation four days per week. It has been at the same location for over 30 years.

1. Data accumulated since 2003 by actual analysis from manholes where dental offices discharge.

Initial Assessment

The initial study began when the local POTW was having issues meeting their discharge limit for mercury. The pretreatment assessment indicated that one dental office was the primary source. The sample taken at the office indicated high levels of mercury >100,000 ng/L. The local POTW required several steps to be taken by the practice to reduce the level of mercury entering the POTW. The initial steps were as follows:

Remove contaminated plumbing in the practice.

Line the discharge pipe going to the manhole to encapsulate any amalgam solids in the line.

The cost of the changes was nearly $20,000; this did not resolve the problem. The analysis of the discharge was still greater than 100,000 ng/L and the discharge was primarily dissolved mercury.

Phase 1

The Doctor was initially interviewed and found that he was following maintenance procedures as prescribed by the dental representative. He was also only removing amalgams and not placing them. His chairs were standard setup with cuspidors. His vacuum system was a standard wet vacuum system and he maintained the vacuum as required by the manufacturer. The doctor was doing everything required under the prescribed operating conditions.

Purves Environmental used their mercury vapor analyzer (Ohio Lumex RA915+) to survey the office. The RA915+ is used by the USEPA and many cities for the detection of mercury. The survey found that none of his chair side cuspidors or traps were a source of mercury. Examination of the plumbing and discharge to the POTW were also not at issue. It did reveal that one sink and a floor drain in the basement of the facility where water was being discharged by the wet vacuum pump was highly contaminated. The vacuum pump floor drain did not discharge to the same location as the other plumbing. These were the two primary sources that were discharging to the waste water system. Samples were taken at the pump filter screen and the pump discharge.

Phase 2

The initial plan was to remove the contaminated sink and rerouted the vacuum pump discharge to an enclosed sump where the water could be diverted to sewer that was lined. The other floor drain was to be capped and never used again. Before that phase was started, the practice was requested to use line cleaner (Clean LINZ) for eight days to clean all vacuum lines of biofilm as per manufacturer's instructions. Water samples were taken before and after the cleaning.

The levels were still very high, but the cleaning had a positive impact.

Table 1

	Mercury Concentration
Before Clean LINZ	6,700,000 ng/L
After Clean LINZ	4,100,000 ng/L

Phase 3

The practice continued to maintain the vacuum lines by daily cleaning with another cleaner (Power LINZ). The changes in the plumbing as suggested in phase 1 was implemented and an amalgam separator was added. The separator being used is the Liberty Boss by MARS Bio-med. This unit was chosen because it used a media that would adsorb dissolved mercury as well as solid amalgam. The water sample taken after the separator was installed was clear but still contained significant dissolved mercury. This level is to be expected due to the cutting and disturbing of the original plumbing. A sample was taken 4 days later and found to be significantly lower.

Table 2

	Mercury Concentration
After Plumbing changes	328,000 ng/L
After Separator	64,800 ng/L

Phase 4

At phase 4 the implementation of a new technology was used. A new device called a CAPT-ALL by ECO 100 was used only when removing amalgam. This device captures 99+% (see appendix) of the amalgam at the patient so that very little amalgam goes to the separator. The discharge sample taken one week following the installation had a discharge concentration of 924 ng/L.

Table 3 is a summary of the data to date.

Table 3 Summary

Sample	Mercury Concentration
Before Clean LINZ Initial Sample	6,700,000 ng/L
After Clean LINZ	4,100,000 ng/L
After Plumbing changes BMP being continued	328,000 ng/L
After Separator	64,800 ng/L
Discharge 4 days after CAPT-ALL and full system implementation	924ng/L
Sample after Three weeks	123ng/L
Sample after One Month	61.7ng/L
Sample after Two Months	293 ng/L
Sample after Three Months	308 ng/L
Sample after Four Months	277 ng/L
Sample after Five Months	279 ng/L
Sample after Six Months	286 ng/L

Other Issues

During changes in practice such as line cleaning, plumbing changes and vacuum flow rate can affect the level of amalgam/mercury discharge temporarily. Over time the system will normalize, and discharge

concentrations will stabilize. It is prudent to follow manufacturer's recommendations and regular maintenance procedures.

Cost

The cost of the plumbing changes was significant and required by the POTW and unusual for the average office. The cost of the separator was $1179 to be amortized over three years ($393 per year). The cost of the CAPT-ALL devices is $432 box of 72 and is expected to last one year at this practice. Both products include disposal after their use life. The cost of the maintenance products is less than $300 which should be a routine item. The additional cost to a practice using the newer technology is very close to the $800 that the USEPA estimated in the rule.

Conclusion

The study demonstrated that the use of BMP and the introduction of an amalgam separator had a significant impact on the mercury discharge levels. The lowest level may be a system using a combination of the CAPT-ALL and the separator that has a media that adsorbs dissolved mercury such as the Liberty Boss. The changing of plumbing can have a significant spike in levels due to fine amalgam particles and biofilm being dislodged on an old system when sampled just after installation and resolution may not be immediate.

The plumbing, vacuum and discharge piping will have residual mercury that clings to the walls of the pipe and any metal in the system. Results may vary depending upon continued cleaning and dislodging of material from older plumbing. The vacuum pump itself will have significant levels of mercury amalgamed to the metal parts. The sample data days after installation demonstrate that system is improving over time and the residual mercury may reduce to a constant level. The continued reduction will depend upon the maintenance habits of the practice.

"US EPA's intent in promulgating the regulations in 40 CFR 441 was to decrease the mercury discharges from dental facilities to environmentally acceptable levels using affordable BMPs and devices. The study shows that the use of BMPs in conjunction with the MARS Bio-Med amalgam separator and the CAPT-ALL devices is extremely cost effective and obtains the desired result, compared to removing existing plumbing, lining discharge pipes and other measures that may be required."

Terry Korzan, City of Elyria

Appendix

Procedures Used

Sampling was a modification of US EPA Method 1669. The modification was needed for sampling location issues and did not risk contamination from outside sources.

Analysis was performed using a modification of Method 245.7. The digestion was modified to a 12 hour digestion as used in US EPA method 1631E. The analytical cell was change from the normal setup to provide a greater linear range and reduce errors due to dilution. The changes met all EPA QA/QC requirements.

The all data points after 12/28/17 were run by EPA Method 1631E.

CAPT-ALL Study

(including raw data and calculations)

See Attached

Procedure for Testing the Capt-all Device

1.0 Introduction

The Capt-all Dental device is a unique single use device to remove amalgam from the patient's mouth while removing or placing amalgams. The unique application is to contain amalgam waste as it is being remove or place into a patient within the device. This means that it virtually eliminates the chair side trap and containing a majority of the amalgam before the waste goes to the amalgam separator. The device provides the benefit of longer life of the separator and a significant reduction of mercury entering the environment.

All dental practices that discharge into a Publicly Owned Treatment Works (POTW) that place or remove amalgams must have an Amalgam separator. When amalgam enters the chamber of the separator it slowly dissolves and generates dissolved mercury and mercury vapor. Both create serious environmental issues for both the air and water. Dissolved mercury is very difficult to remove for a POTW. If a large quantity of amalgam is removed before entering the separator the quantity of dissolve mercury will be reduced. This intern reduces the quantity of mercury be discharged in the air and water.

2.0 Scope

A quantity of amalgam approximately equal to an amalgam in a tooth such as a molar is vacuum suctioned with a quantity of tap water from a glass jar. The amalgam represents pieces of varying size to approximate an amalgam that is properly section and removed as per ADA guidelines. The amount of amalgam captured in the device is measured and quantified. The liquid and amalgam that passes through the device is analyzed for total and dissolved mercury.

3.0 Safety Equipment

Because of the hazardous level of mercury, personal safety is a concern. The following should be worn when running the test.

Latex or Nitrile Gloves

Clothing that can be removed after sampling such as a lab coat or similar covering

Safety Glasses or face mask

Dust Mask or similar device

4.0 Equipment

4.1 Mercury Analyzer

There are several mercury analyzers capable of analyzing the water. Ultra-Low level (EPA Method 1631E Fluorescence) mercury units are not recommended for this type of mercury analysis. CVAA (Methods 245.1 and 245.7 Rev 2 Modified) is the recommended analysis for this type of analysis due to the high concentrations of mercury found in water and biological fluids. EPA Method 245.7 Rev 2 with Modified digestion is highly recommended.

Vacuum Pump

Plastic tubing 3/8 to 7/16 ID

Vacuum Flask (to retain liquid)

Stopper fitted to flask

Water bottle

Plastic baggie snack or sandwich size (any Brand will work)

5 ml disposable pipettes

Balance capable of 2 decimal place reading

Dental Amalgam (received for various dental offices) The amalgam for the ISO 11143 test is not available.

5.0 Sampling and Analysis

5.1 Sampling

The recommended quantity of amalgam used is based upon interviews of dental practices (1.5 grams) the quantity can be evaluated at 1 to 3 grams. The amalgam used is a collection from Dental practices and has a very wide range of particle size.

5.1.1 Setup

5.1.1.1 Weigh the flash that is going to receive the water to two decimal places and record the value.

5.1.1.2 Weigh the Capt-all device (unused) and record the mass to two decimal places.

5.1.1.3 Tare an empty baggie and add approximately 1.5 grams of amalgam material. Record the mass of amalgam.

5.1.1.3 Add 3 ml of tap water (do not use deionized water as it is slightly acidic and will bias the test). Record the mass of the water and amalgam.

5.1.1.4 Allow the amalgam and water to set for 2 minutes.

5.1.1.5 Turn on the vacuum pump and vacuum up the mixture using the device. Add enough water to the baggie during suction to assure all of the amalgam is removed from the baggie.

5.1.1.6 After the amalgam is removed, run the pump for another minute to remove as much water as possible. Turn off the pump and set the device and flask aside for weighing.

5.1.1.7 Weigh the device and flask. The mass will include amalgam and water that resides in the tip. The flask will include all water used and particulate less than 10 microns. Record the masses to two decimal places.

5.1.1.8 Remove the water with the disposable pipette (up to 5 ml) and record the volume removed.

5.1.1.9 Place the water into a 125-ml jar and set it aside for analysis using method 245.7 Modified.

5.1.1.10 Re weigh the flask to determine the volume retained.

After all steps are completed, See section 6 for calculations and data evaluations.

6.0 Calculations

6.1 Net Weight of Amalgam for Test

A= Weight of Baggie

B= Weight of Amalgam and Baggie

C= Weight of baggie after vacuum removal

WA= Net Weight of Amalgam = B- (A-C)

6.2 Net/Average Water retained by Capt-all

The device can't be dried in an oven at 130^{o}C. The average water content water retained by the device using the average of three trials.

WCE= Weight of Capt-all Empty

WCW= Weight of Capt-all After 10 ml of water is passed through.

WR= Water Retention=WCW-WCE

6.3 Weight of added Water to amalgam in Baggie

B=Weight of Amalgam and Baggie

W = Weight of Water

TTW= Total Test Weight = B+W

6.4 Amalgam Capture by Capt-all

WCE= Weight of Capt-all Empty

WCS= Weight of Capt-all After Suction

AW= Weight of Amalgam and Water = WCS-WCE

AC= Weight of Amalgam Capture = AW-WR from 6.2

6.5 % Retained Amalgam

%Retention = AC/WA from section 6.1

6.6 Testing for Total Mercury in Retained Water

6.6.1 Weight of Water Retained in Flask

WF= Weight of Flask empty

WFW= Weight of Flask and water

RW= Retained Water = WFW-WF

6.6.2 Weight of Water Used to Transfer Flask Contents to Analytical Bottle.

WJ= Weight of Jar Empty

WJT= Weight of Jar after transfer form flask

WW= Weight of Water= WJT-WJ

6.6.3 Dilution Factor

DF= Dilution factor used in transfer= WW/RW

This factor will be used after the instrumental analysis of by EPA Method 245.7 Rev 2 Modified

7.0 Analysis by CVAA

7.1 Method 245.7

This EPA Method is also an excellent method for the analysis of dental waste for Mercury. The method is modified in the following manner.

7.1.1 Digestion

The digestion method must be modified to perform a 12-hour digestion at room temperature or a 6-hour heated digestion to consume both inorganic and organic mercury. The BrCl digestate may have to be added in excess of the method requirement. If the final digestion maintains the characteristic yellow color after 12 or 6 hours digestion, then the digestion is complete.

7.1.2 CVAA vs CVAF

It is recommended that Cold Vapor Atomic Absorption be utilized rather than Cold Vapor Atomic Fluorescence Due to the need for a large analytical range. The fluorescence cell may become contaminated and is difficult to clean.

The suggested modifications are appropriate for the method as long as all quality control parameters meet the recovery of QC ranges required.

8.0 Reporting

The data will be attached to this report.

9.0 Analytical Errors

There were no statistical out liars in the three trials. The analytical results were as expected. The amalgam used in the testing was from actual removals that had been sectioned as per ADA requirements. It contained both fine and coarse particles. The particle size distribution is not known. The particle size can have a direct effect on the % retained and the Total Mercury result. It is the professional judgment of the author of this paper that the data is as sound as it can be under the current operational setup.

10.0 Conclusion

The Capt-All maintained an average 99.4% retention with a Standard Deviation of 1.23%. The additional bonus is that the total Mercury that passed through is below 0.00001%. The table below provides a comparison to Standard Amalgam Separators. The samples in the table below came from the contents of separators directly in offices 1,2,5,6,7. Office 7 was the same office as #1 but with a separator that has treatment for dissolved Mercury. Offices 3 and 4 samples were taken at the vacuum trap.

Office	Total Mercury in ng/L	Dissolved Mercury in ng/L	Separator Type
1	17,500,000	7,500,000	Dual Chamber No Treatment
2	7,290,000	2,530,000	Dual Chamber No Treatment
3	660,000	452,000	Dual Chamber No Treatment
4	534,000	378,000	Dual Chamber No Treatment
5	1,250,000	811,000	Single Chamber No Treatment
6	10,200,000	5,210,000	Single Chamber No Treatment
7	65,600	36,000	Dual Chamber With Treatment
Capt-all	5283	N/A	N/A

The data clearly shows that the Capt-all not only retains 99% of the amalgam but even retains mercury that would have entered the environment by factors of 10 to over 3000 times.

Disclaimer

The data generated and published is the property of Purves Environmental, Inc. Purves Environmental, Inc. received no financial support for this research and data displayed in the table above. The testing platform and procedures were solely developed by Purves Environmental, Inc.

3/26/18

William W. Purves