DENTAL AMALGAM DISSOLUTION STUDY

Purpose

The purpose of this study is to determine the effect of tap water on dental amalgam. It has been assumed that the dental amalgam is insoluble in water and does not create a hazard to the environment. The dental amalgam has an average of 50% mercury. Though amalgam is a blend of primarily silver and mercury, it is the mercury that is considered the more hazardous of the two major ingredients. The amalgam used for this study is the amalgam used in the ISO 11143 separator testing standard. The dissolved mercury that is generated by the slow dissolution into water is more difficult to remove and can affect the discharge of waste water treatment plants into natural waters and the aquatic environment.

Mercury and the Environment

Mercury has not always been considered an environmental hazard as it is today. Mercury was commonly used in many devices and found in many science class rooms. It was known to cause mental instability "Mad Hatters Disease" when used to clean felt hats. As a waste entering the environment, it was not considered very hazardous and often considered insoluble in water. In the 1980s the level of mercury entering a waste water treatment plant was not a concern unless it was over 2 parts per billion. The drinking water standard at that time allowed the limit for mercury to be as much as 2 parts per billion (2 ug/L or 2000 ng/L). It was the issue regarding mercury in the food supply that changed the thinking regarding mercury.

The primary issue is the conversion of mercury from the elemental form to a more hazardous form. It was well known that halogen forms of mercury were hazardous to humans if improperly used but there were several forms of mercury halogens used as an antiseptic ($HgCl_2$) or purgative such as Calomel (HgCl). What changed the attitude regarding mercury was the discovery of high concentrations of mercury in fish. Not only were many types of fish high in mercury content but it was found to be primarily Methyl Mercury. Methyl Mercury was found to be highly toxic and attacks the nervous system. The result is a Parkinson like syndrome due to methyl mercury poisoning. From the historical issues a new regulatory limit was established.

The New Discharge Limit

The USEPA established a recommended discharge limit of 12 ng/L (0.012ug/L vs 2.0ug/L) for discharged into natural bodies of water under the Clean Waters Act. This means that publicly owned treatment waste facilities (POTWs) must remove mercury from their discharge to this standard. Though this is a recommended standard, many states have adopted their own standards near or below the recommended standard. Those states the discharge into the Great Lakes have an even lower standard to attain of 1.3ng/L (0.0013ug/L). This recommendation also affects industrial and private discharges into natural waters. Pretreatment programs at many facilities (including POTWs) have significantly reduced the discharge of mercury into the natural waters.

7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com

Why is Dental Amalgam an Issue?

The mercury discharge from dental offices is now considered the target for further mercury reduction. The assumption is that by removing the solid articles of amalgam from the influent of POTWs further reduction of mercury will occur and lower discharge limits will be achieved. Though removing the amalgam particles will achieve some reduction in mercury, the dissolved mercury created by dental office and the amalgam separator will create a more difficult challenge to mercury reduction in the environment.

It has been assumed that amalgam does not dissolve in water and physical removal will solve the issue of mercury entering the POTW and the final discharge will be cleaner. The amalgam separator will solve a long term issue of amalgam entering the waste water system and continuously being a hazard but it will not completely resolve the mercury problem. Large treatment facilities with discharges over 3 million gallons per day (3mgd) may not be affected by dissolved mercury from dental offices, however smaller facilities may be affected. Understanding the impact of dissolved mercury may help drive the separator industry into building a better system.

The Data

The tables below is a short term study of the dissolution of amalgam from a dental office sludge into water. The pH of the water was 7.1 at the start of the study and remained at that pH throughout the two studies.

Table 1 below is a time study in which 4 gram of amalgam sludge from a separator is placed in 125 milliliters of pure water neutral pH (6.9) and allowed to dissolve over a 30 day period in the same manner that it dissolves in a separator.

Table 1

Days in Water	Quantity of Mercury dissolved in ng/L
1	119,000 ng/L
2	600,000 ng/L
3	818,000 ng/L
4	1,060,000 ng/L
10	2,410,000 ng/L
30	3,110,000 ng/L
EPA Limit	12 ng/L

 7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com

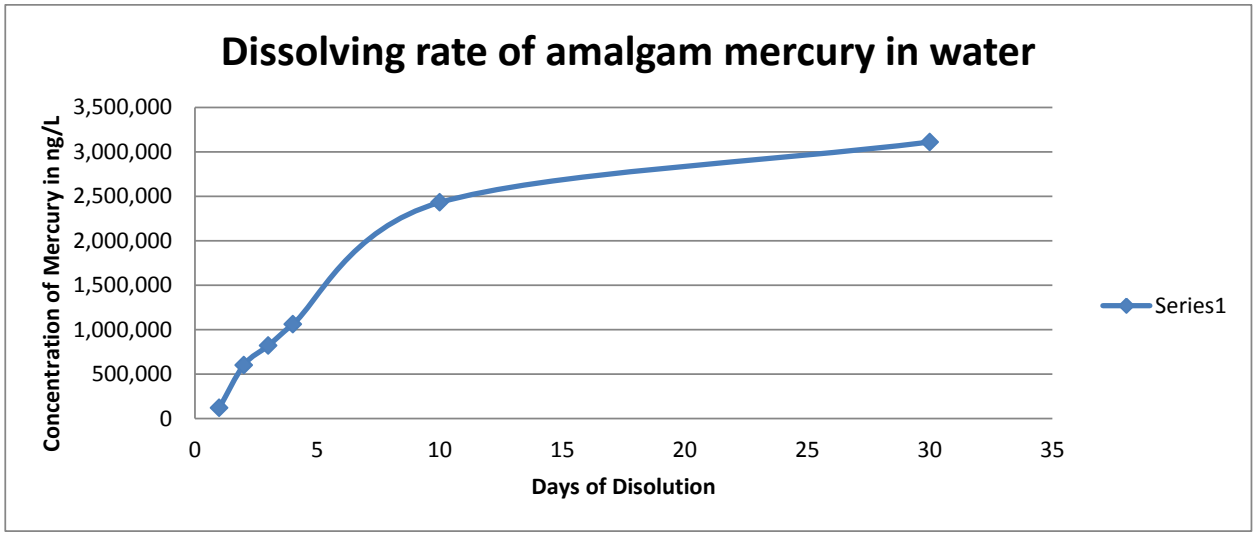
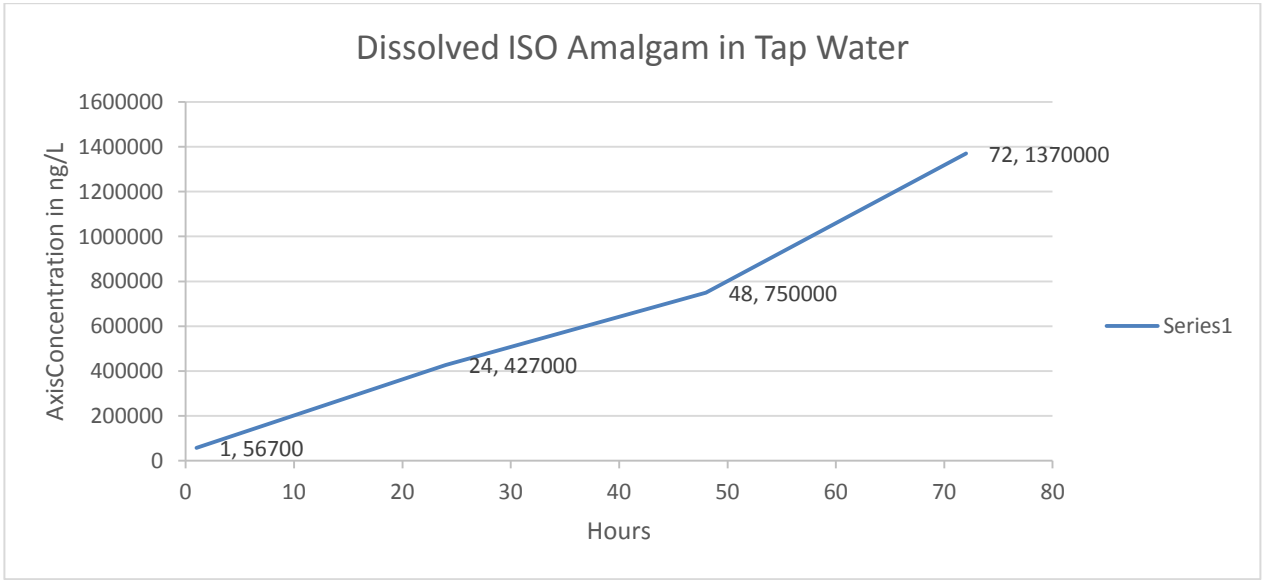


Chart 1

The rate of dissolution reduces over time as the water hits a saturation point. The change of pH from 7.0 will increase the dissolution rate. A pH less than 5 or greater than 9 may increase the dissolved mercury concentration substantially. The pH of the offices studied ranged in a pH of 6.8 to 8.0.

The amalgam used for this study is the amalgam used in ISO 11143 testing.

Chart 2



The dissolution rate was faster than the previous study and may be due to the purity of the amalgam and the particle size. The second study confirmed the first study in Table 1 that mercury from the amalgam does dissolve in water with a pH of 7 to 8 or neutral pH.

 7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com

Average Dental Office Discharge Volume

Data collected by various dental vacuum manufacturers indicated that the average volume of water discharged is 2 gallons per day per operating chair. Each chair may not be performing amalgam removal or placement but the separator water is being actively exchanged. The exchange of water removes water that has dissolved and suspended amalgam often causing an initial slug of highly contaminated water to enter the waste water system. A current study underway demonstrates this issue. Samples were taken daily at the same time each day for five days after the installation of a new separator at the vacuum system discharge. The vacuum system plumbing was not replaced. The residual (background) level of mercury in the system was taken as a starting point. The separator type is not disclosed in this study until further study of other separator types are examined in the same manner.

Table 2

Sample Description	Day Sampled	Result
Back ground water sample from the discharge side of the pump.	Day 1 Thursday	4840 ng/L
Sample from the discharge with old separator in place. Operated 5 months	Day 1 Thursday	87700 ng/L
Sample from discharge after new separator is installed.	Day 1 Thursday	5050 ng/L
Sample from Discharge	Day 2 Friday	8230 ng/L
Sample from Discharge	Day 3 Monday	46700 ng/L
Sample from Discharge	Day 4 Tuesday	3310 ng/L
Sample from Discharge	Day 5 Wednesday	21300 ng/L

The concentrations will vary day to day based upon activity within the dental office. As the study continues the data will reveal a more accurate discharge history within a dental facility. The type of separator used has a treatment material within the separator that removes ionic and elemental mercury. The removal is highly dependent upon the flow rate through the separator at the time of sampling and the activity within the office.

High concentrations of mercury will typically found on days after no office activity such as Mondays. The amalgam can sit in the water and continue to dissolve over the weekend creating a high concentration of dissolved mercury as demonstrated in Chart 1 using actual sludge from a dental office. Low concentrations will be experienced on days when no amalgam removal or placement is being performed. The concentration increases as amalgam is being removed or placed due to the grinding process. This is primarily due to particle size. When particle size is very small the dissolution rate of the amalgam will be very rapid as demonstrated in chart 2 using the ISO standard amalgam. In separators without treatment these fine particles will pass through the separator and continue to dissolve in the waste water system creating a continuous flow of dissolved mercury entering the POTW. This dissolved mercury is not easily removed by the POTW.

 7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com

Historical data

The rate of dissolution reduces over time as the water hits a saturation point. The change of pH from 7.0 will increase the dissolution rate. A pH less than 5 or greater than 9 my increase the dissolved mercury concentration substantially. The pH of the offices studied ranged in a pH of 6.8 to 8.0.

All of the separator manufacturers claim a 6 months or more life on the separator efficiency of 95% minimum. The samples taken for this study assumes that the separators and vacuum systems are maintained as recommended by the manufacturers. Most dental offices do not keep records regarding maintenance of their systems. In most cases they may know when the separator was last changed but system cleaning and maintenance is not available. In this small study, all of the dentist offices claimed the unit had been operating for at least 6 months. The following table is from 7 dental offices that had separators in use for more than 6 months. Offices 3 and 4 were "Green Dentists and do not use amalgams but only remove them.

Table 3

Office	Total Mercury from the Separator in ng/L	Dissolved Mercury from the Separator in ng/L*
1	17,500,000	7,500,000
2	7,290,000	2,530,000
3	660,000	452,000
4	534,000	378,000
5	1,250,000	811,000
6	10,200,000	5,210,000
7	65,600	36,600

*Dissolved mercury content based upon filtration of the discharge through a 0.7 um filter.

Impact on Waste Water Treatment Plants (POTWs)

An exhaustive study was performed by the City of Elyria in Ohio that demonstrated a significant quantity of mercury is being discharged into their system by dental offices. Their pre-treatment program has reduced the mercury from all other sources at street manholes (industrial and residential) to under 100ng/L. The pre-treatment coordinator for the city believes that their primary source of mercury into their system is from dental offices. The study performed over 11 years demonstrated that the average dental discharge is over 24,000 ng/L at the street manhole. The samples were not taken from the dental office discharges themselves but from manholes in the street where dilution is occurring. The limit that they have currently is under a variance. Should their limit be reduced under a new permit, they may not be able to meet the new discharge requirement without setting limits on the dental offices.

When complying with EPA discharge requirements many POTWs are having difficulty meeting their discharge limits. Based upon the data generated above, small POTWs may have mercury issues that are directly attributable dental office discharges. The dental offices will have to improve their

 7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com

maintenance programs and look at their separator and operating practices to reduce their mercury discharge into the POTW.

Other Observations

Visual examination of the waters discharging from the system with treatment in table 2 were completely clear water. The sample with the highest mercury from the new separator was passed through a 0.7 micron filter to see if any particulate was in the sample. There was no visible particulate on the glass filter and all of the other samples taken were clear.

A visual examination of the water from each of the separators in table 3 were cloudy with suspended solids. The difference in the total to dissolved mercury content strongly demonstrates that not only do the separators not remove all mercury but a significant quantity of dissolved mercury is discharged to the environment. Under the proposed EPA Guidelines for separators, the problem of mercury entering the environment will be dissolved and not particulate.

The separator in office #3 was one without treatment. The separator in office #7 the same office as #3 with a different separator that uses treatment and filtration. Based upon current research, the unit in office #7 (which is also #3 which had a different system) is the one unit is capable of removing both solid and dissolved mercury from the environment. Their design provides the highest removal rate under normal operating parameters and treats both the total and dissolved mercury.

Conclusion

These studies are the first of a kind that examines the actual discharge from an amalgam separator. Assumptions that the solid amalgam is the only issue and that 99% removal solves the problem of mercury discharge into the waste water system and eventually the environment is false. Properly designed separators will remove 99% of the solid amalgam from the environment, however, the dissolved mercury will remain an issue for POTWs as discharge limits continue to be reduced. Municipalities and POTWs that wish to be proactive in a mercury reduction plan will have to look very seriously at not only Best Management Practices (BMP) but best technology.

William W Purves
President
Purves Environmental Inc.

Date: 2/2/15

 7484 Woodspring Lane, Hudson, OH 44236 Phone: 330-687-3360
E-mail: wpurves330@gmail.com