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Assessing mercury levels in two dental clinic wastewaters in Tehran

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ABSTRACT

Considering the presence of high amounts of mercury in amalgam, the importance of mercury, and the problems it creates for the environment, including humans and other living organisms, this study was conducted to measure the amount of mercury in the wastewater of two dental clinics. We collected 30 wastewater samples from two dental clinics at the end of each day. Then the samples were digested by the USEPA 245.1 method. The samples were used for mercury determination by an atomic absorption spectrometer (Spectra AA 220 FS, Varian). The results showed that the amount of mercury in the wastewater resulting from the treatment of amalgam and others (68.7170 µg/L) was higher than in non-amalgam treatments (0.7290 µg/L). The amount of mercury in the wastewater samples was higher than the maximum allowed (0.002 mg/L). The relationship between the type of dental treatment and the amount of mercury was significant (P<0.0001). The amount of mercury in samples treated with amalgam was higher than in others. Moreover, the output of mercury from the clinic's wastewater was higher than the maximum amount recommended by the EPA. Therefore, it is necessary to monitor the mercury output of the clinics' wastewater and treat it.

Highlights

- Mercury in dental wastewater exceeds environmental safety limits.
- Amalgam procedures significantly elevate clinic effluent mercury levels.
- Clinic-specific mercury loads vary, indicating differing amalgam use or management.
- Non-amalgam treatments show minimal mercury, below detection limits.
- Study underscores urgent need for amalgam separators in Iranian clinics.

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1. Introduction

Amalgam has been the most commonly used dental filling material for over 200 years (Tibau & Grube, 2022). One of its main components, mercury, is of particular concern due to its potential adverse effects on humans and the environment (Joy & Qureshi, 2020). It is estimated that the annual consumption of mercury for dental applications is 3-4% worldwide (approximately 300 metric tons of mercury) (Chin et al., 2000; Khwaja et al., 2014). Although the use of amalgam as a restorative material has recently declined, amalgam restorations and their release into the environment continue to be a widely used dental restorative material. According to recent studies, dental clinics are responsible for a significant amount (10–70%) of daily mercury entering the environment through wastewater treatment plants (Jamil et al., 2016; Molina et al., 2014).

Mercury may bioaccumulate in fish and other organisms and therefore can impose an environmental mercury burden on the entire food chain (Gupta & Yadav, 2024; Qu et al., 2022). Among the groups directly exposed to mercury are dentists and their patients, who have been reported to have significantly increased plasma mercury concentrations compared with

controls (Manyani et al., 2021; Warwick et al., 2019). On the other hand, people and the environment are indirectly exposed to this element through mercury emissions from waste incinerators and mercury in wastewater from dental clinics and households (Cheng & Hu, 2012). Several studies have shown that mercury exposure may lead to several health complications, such as disruption of the developing central nervous system, pulmonary and nephritic damage, and impaired osmoregulation functions (Fernandes Azevedo et al., 2012). These complications are usually attributed to the strong affinity of mercury for sulfur and sulfhydryl groups within living organisms (Houston, 2014).

Increased knowledge about the risk of toxic effects from anthropogenic accumulation of mercury in ecosystems has led to increased pressure to reduce the discharge of mercury waste into the environment. As a result, the problem of mercury waste in dental clinics has received increasing attention, and restrictions on the transport and disposal of contaminated waste have been imposed in several countries. Studies show that mercury emissions from dental clinics can be reduced by improved waste disposal system design, the use of high-pressure water cleaning, and frequent replacement of amalgam separators and filters (Eshrati et al., 2024; Musliu et al., 2021). For example, it was reported that the use of mercury separators reduced the mercury content in the wastewater of some dental clinics from 270 mg mercury per dentist per day to only 35 mg mercury per dentist per day. As a result, many countries such as Switzerland, Germany, Sweden, and Denmark have introduced mandatory installation of amalgam separators in dental clinics (Arenholt-Bindslev and Larsen 1996; Arenholt-Bindslev 1998). However, the use of these separators in dental clinics in Iran is still uncommon. Furthermore, despite the fact that a large part of the recycled wastewater is reused for irrigation, it is necessary to investigate the amount of mercury discharged into the wastewater collection system.

Therefore, this study aimed to quantitatively assess the mercury load in wastewater from some dental clinics. The results of this project will contribute to the Ministry of Health's efforts to reduce mercury concentrations in wastewater by providing new measures for the handling and disposal of mercury-containing waste from dental clinics.

2. Materials and Methods

An atomic absorption spectrometer (Spectra AA 220 FS, Varian) equipped with a vapor generation accessory (VGA-77, Varian) and a T-shaped quartz absorption cell was used for mercury determination.

2.1 Reagents and Solutions

All chemicals were of analytical grade. All water used was obtained from a Milli-Q reagent system (EC= 18.2 MΩ cm, Millipore, Bedford, MA, USA). All plastic and glassware were soaked in 4 M nitric acid for at least 12 h, washed with distilled water, and finally rinsed with Milli-Q water before use.

Nitric acid (68.0-70.0%) and sodium chloride (99.5%), sulfuric acid (GPR), hydrochloric acid (37.0%), hydroxylamine hydrochloride (99.0%) and stannous chloride (98.0%), potassium permanganate (99.5%), potassium persulfate (98.0%), mercury (for calibration, solution of 1001 ± 1001 mg/L in 2 mol/L HNO3) were purchased from Merck and Sigma.

2.2 Sample Collection

The samples were collected in acid-washed glass containers from two clinics (each clinic, 15 samples) in Tehran. The samples were collected after a variety of treatments, including amalgam restorations, composite fillings, root canal treatment, cavity preparation plus temporary filling, glass ionomer filling, pulpotomy, scaling plus polishing, fissure sealants, and cementation. Each sample was collected directly from the dental chair exits into collection containers at the end of each treatment.

2.3 Sample Preparation and Testing

The collected samples were stored in HNO_3 (concentrated acid was added to each sample container to obtain a final acid concentration of 1% and stored in a refrigerator at 4°C until analysis). The samples were digested according to USEPA Method 245.1. Briefly, the sample containers were shaken vigorously before taking subsamples for analysis. 50.0 mL of the filtered sample (gravity filtration using Schleicher & Schuell 595 filter papers) was placed in a clean 150 mL plastic bottle, and then 5.0 mL of H_2SO_4, 2.5 mL of HNO_3, 5.0 mL of $K_2S_2O_8$ (5%), and 5 mL of $KMnO_4$ (5%) were added. Then, each sample was kept in an oven at 95°C for 2 hr. After cooling to room temperature, hydroxylamine hydrochloride (12% in 12% NaCl) was added dropwise to each bottle until the $KMNO_4$ color disappeared. If the $KMNO_4$ color reappeared before 15 min after the first addition, more hydroxylamine hydrochloride was added. Approximately 1 mL of hydroxylamine hydrochloride was sufficient to completely reduce the excess $KMNO_4$. Finally, water was added to each bottle to obtain a volume of 100.0 mL. Total mercury was determined using cold vapor atomic absorption spectrometry (CV-AAS).

3. Results and Discussion

The mercury concentration in the wastewater of two dental clinics is given in Table 1. This table also includes the types of treatments provided to each patient. The dental treatments performed are classified into 3 different categories: one is “amalgam restoration only”. The second is “amalgam restoration with other types of treatment”, and the third is “no amalgam restoration”. From Tables 1 and 2, it is clear that the wastewater samples of Clinic 1 have relatively higher mercury than those of Clinic 2. This can be easily explained by the release of mercury from the amalgam itself during the dental treatment or afterwards from amalgam particles deposited inside the drainage pipes. The highest mercury content measured in the effluent was from Clinic 1 (Sample 2), where there were 25 patients, nine of whom had undergone amalgam restorations, and the mercury content was 125.67 µg/L. In addition, in cases treated without amalgam, the mercury content was very low, so that in many cases of treatment without amalgam, the mercury content was below the detectable level. The reason for the higher mercury content in the samples of the second treatment mode compared to the third treatment mode is the use of amalgam, which contains high levels of mercury, while in the third treatment mode, the possible mercury content was very low. Nevertheless, the mercury content in the effluent was higher than the permissible mercury content in the environment according to the EPA

recommendation (0.002 mg/l) (Mirlean et al., 2003; Nevado et al., 2003; Vandeven & Mcginnis, 2005). The mean, standard deviation, and range of mercury concentration in the samples versus treatment type are shown in Table 3.

Table 1 Mercury concentration in wastewater samples collected from dental clinics, along with the type of treatment performed

Sample	Type of Treatment	Total No. of patients treated	Treated with amalgam	Hg (µg/L)
1	2	30	7	98.32
2	2	25	9	125.67
3	2	27	6	78.44
4	2	32	5	80.62
5	2	21	6	83.54
6	۳	26	0	3.25
7	2	28	8	114.67
8	2	21	3	31.92
9	2	23	2	19.87
10	2	27	4	43.22
11	2	22	6	75.41
12	2	27	5	71.33
13	3	26	0	1.16
14	3	20	0	ND
15	3	37	0	ND
16	3	39	0	0.84
17	2	35	7	60.42
18	2	32	6	45.63
19	2	40	8	93.74
20	2	42	7	71.23
21	2	48	8	88.55
22	2	46	6	65.92
23	2	39	5	42.25
24	3	40	0	ND
25	3	42	0	0.54
26	3	44	0	n.d.
27	2	43	4	19.95
28	2	37	6	63.64
29	3	43	0	1.29
30	3	41	0	0.21

Table 2 Mean, (standard deviation), maximum, and minimum mercury levels by type of dental treatment

	Type of Treatment	n	Min.	Max.	Mean	SD
Clinic 1	2	11	19.87	125.67	74.82	32.74
	3	4	0	3.25	1.11	1.53
Clinic 2	2	9	19.95	93.74	61.26	23.02
	3	6	0	1.29	0.48	0.51

According to Table 3, the mercury content in treatment mode 2 was higher than in treatment mode 3, and the type of treatment also had a significant relationship with the mercury content. The reason is that most of the mercury in the wastewater of dental clinics comes from amalgam, which is used a lot in treatment mode 2, while amalgam is not used in treatment mode 3 (Mukherjee et al., 2004; Vandeven & Mcginnis, 2005).

Table 3 Relationship between treatment type and mercury content based on *t*-test

Type of Treatment	n	Hg (µg/L)	SD	F	Sig	df
2	20	68.72	28.9	15.64	0.0001	28
3	10	0.73	1.02			19.09

4. Conclusion

This study confirms that wastewater effluent from sampled dental clinics in Tehran contains mercury concentrations substantially exceeding permissible environmental limits, with levels directly correlated to the use of dental amalgam. The findings demonstrate that procedures involving amalgam restorations release significant quantities of mercury into clinic wastewater, whereas treatments that do not utilize amalgam result in negligible, often undetectable, mercury levels. This stark contrast underscores amalgam as the primary source of mercury pollution within this setting. The environmental and public health implications are considerable, given mercury's persistence, capacity for bioaccumulation, and toxicity. The discharge of such contaminated wastewater into municipal systems poses a risk of wider environmental contamination, ultimately affecting ecosystems and human health through indirect exposure pathways. Consequently, these results underscore the urgent need for the widespread adoption and strict enforcement of mitigation measures in Iranian dental practices. Mandatory installation and maintenance of efficient amalgam separators are essential first steps, alongside the implementation of best management

practices for amalgam waste. Furthermore, the development and enforcement of specific national regulations for dental effluent are crucial to significantly reduce this preventable source of mercury pollution. Future research should expand the scale of monitoring to quantify the total national mercury load from dental clinics and rigorously evaluate the real-world efficacy of available separator technologies in diverse clinical environments.

Statements and Declarations

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the author.

Data availability

Data will be made available on request.

Conflicts of interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contribution

S. Fardi: Investigation, Writing the main Draft; H. Mohammadi: Conceptualization; Writing – Review & Editing.

AI Use Declaration

During the preparation of this manuscript, the authors used ChatGPT for language translation. All content has been carefully reviewed and revised by the authors, who take full responsibility for the final version of the manuscript.

References

Cheng, H., & Hu, Y. (2012). Mercury in municipal solid waste in China and its control: a review. *Environmental Science & Technology, 46*(2), 593-605. DOI: 10.1021/es2026517

Chin, G., Chong, J., Kluczewska, A., Lau, A., Gorjy, S., & Tennant, M. (2000). The environmental effects of dental amalgam. *Australian Dental Journal, 45*(4), 246-249. DOI: 10.1111/j.1834-7819.2000.tb00258.x

Eshrati, M., Momeniha, F., Momeni, N., Ahmadi, E., Hashemian, A., Kashani, H., & Alaeddini, M. (2024). Clinical Guide Adaptation for Amalgam Waste Management in Dental Settings in Iran. *Frontiers in Dentistry, 21*, 44. https://doi.org/10.18502/fid.v21i44.17053

Fernandes Azevedo, B., Barros Furieri, L., Peçanha, F. M., Wiggers, G. A., Frizera Vassallo, P., Ronacher Simões, M., Fiorim, J., Rossi de Batista, P., Fioresi, M., & Rossoni, L. (2012). Toxic effects of mercury on the cardiovascular and central nervous systems. *BioMed Research International, 2012*(1), 949048. DOI: 10.1155/2012/949048

Gupta, S., & Yadav, U. (2024). Biomagnification of mercury in aquatic ecosystem and effect on human being. *Journal of Pharmaceutical and Biological Sciences, 12*(1), 8-18. https://doi.org/10.18231/j.jpbs.2024.003

Houston, M. C. (2014). The role of mercury in cardiovascular disease. *Journal of Cardiovascular Diseases & Diagnosis, 2*(5), 1-8.

Jamil, N., Baqar, M., Ilyas, S., Qadir, A., Arslan, M., Salman, M., Ahsan, N., & Zahid, H. (2016). Use of mercury in dental silver amalgam: an occupational and environmental assessment. *BioMed Research International, 2016*(1), 6126385. DOI: 10.1155/2016/6126385

Joy, A., & Qureshi, A. (2020). Mercury in dental amalgam, online retail, and the Minamata convention on mercury. *Environmental Science & Technology, 54*(22), 14139-14142. DOI: 10.1021/acs.est.0c01248

Khwaja, M. A., Abbasi, M. S., Mehmood, F., & Jahangir, S. (2014). Study of high levels indoor air mercury contamination from mercury amalgam use in dentistry. *Science Technology and Development, 33*(2), 94-106. https://inis.iaea.org/records/3r1gy-9w930

Manyani, A., Chaou, H., Rhalem, N., Soulaymani, A., & Bencheikh, R. S. (2021). Dental amalgam risks in dental staff: systematic review. E3S Web of Conferences, https://doi.org/10.1051/e3sconf/202131901001

Mirlean, N., Andrus, V. E., & Baisch, P. (2003). Mercury pollution sources in sediments of Patos Lagoon estuary, Southern Brazil. *Marine Pollution Bulletin, 46*(3), 331-334. DOI: 10.1016/S0025-326X(02)00404-6

Molina, G. O., Oliveira, M. T., Constantino, H. V., Milioli, E., Ghizoni, J. S., & Pereira, J. R. (2014). Evaluation of mercury contamination in patients and water during amalgam removal. *The Journal of Contemporary Dental Practice, 15*, 165-168. DOI: 10.5005/jp-journals-10024-1508

Mukherjee, A. B., Zevenhoven, R., Brodersen, J., Hylander, L. D., & Bhattacharya, P. (2004). Mercury in waste in the European Union: sources, disposal methods and risks. *Resources, Conservation and Recycling, 42*(2), 155-182. DOI:10.1016/j.resconrec.2004.02.009

Musliu, A., Beqa, L., & Kastrati, G. (2021). The use of dental amalgam and amalgam waste management in Kosova: An environmental policy approach. *Integrated Environmental Assessment and Management, 17*(5), 1037-1044. DOI:10.1002/ieam.4408

Nevado, J. B., Bermejo, L. G. A., & Martín-Doimeadios, R. R. G. (2003). Distribution of mercury in the aquatic environment at Almadén, Spain. *Environmental Pollution, 122*(2), 261-271. DOI: 10.1016/s0269-7491(02)00290-7

Qu, P., Pang, M., Wang, P., Ma, X., Zhang, Z., Wang, Z., & Gong, Y. (2022). Bioaccumulation of mercury along continuous fauna trophic levels in the Yellow River Estuary and adjacent sea indicated by nitrogen stable isotopes. *Journal of Hazardous Materials, 432*, 128631. DOI: 10.1016/j.jhazmat.2022.128631

Tibau, A. V., & Grube, B. D. (2022). Alarming Findings on Mercury Dental Amalgam–Latest Research Using the National Health and Nutrition Examination Survey (NHANES) Database: A Mini-Review. *Oral Health and Dental Science, 6*(2), 1-6. DOI: 10.33425/2639-9490.1109

Vandeven, J. A., & Mcginnis, S. L. (2005). An assessment of mercury in the form of amalgam in dental wastewater in the United States. *Water, Air, and Soil Pollution, 164*(1), 349-366. https://doi.org/10.1007/s11270-005-4008-1

Warwick, D., Young, M., Palmer, J., & Ermel, R. W. (2019). Mercury vapor volatilization from particulate generated from dental amalgam removal with a high-speed dental drill–a significant source of exposure. *Journal of Occupational Medicine and Toxicology, 14*(1), 22. DOI: 10.1186/s12995-019-0240-2