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ORIGINAL ARTICLE

Detection of Mercury Vapor in Selected Governmental Dental Health Care Centers in Al-Karkh- Baghdad

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ABSTRACT

Almost all governmental centers in Iraq are still using mercury amalgam in spite of available alternatives; that make the initial assessment very important to assess the current situation. The survey included visiting (17) site within health centers in three locations in each (the room space, amalgam capsule containers and medical waste storage containers). (510) measurements (10 readings in each location) have been taken for every health care center in Al-Karkh side in Baghdad (10 general health centers, 7 specialists' center). Potential quantity of emitted mercury vapor has been measured using a portable mercury vapor detection device (TRACKER 3000 IP). Broad variability was noted in the concentration of Hg vapor emitted depending on the amount of empty capsules that were collected, opened or closed container, room area, number of chairs in the room and patients per day, number of full containers and applying environmental and health safety rules. 94.1 % of visited centers exceeded the lowest allowed occupational levels, 76.5 % recorded high concentrations exceeding Ceiling Limit Value while 94.1 % exceeded the Minimum Risk Level. The mercury vapour concentration in work space and the mercury vapour intake by inhalation of chronic daily exposure have linear relation. Mercury dental amalgam and its empty capsules in healthcare centers are a major source of emitting toxic mercury vapor causing chronic and acute exposure to population and for most dentists.
Keywords: Mercury vapours; Occupational exposure limits; Dental Mercury Amalgam

INTRODUCTION

Atmospheric mercury pollution has become an important environmental problem. The average global atmospheric mercury deposition rate is (23-25) $\mu g.m^2$. year [1]. Health care organization is the major source that release mercury into the environment as the most toxic heavy metal [2-3]. The main uses of mercury are in dental amalgam, sphygmomanometers, and thermometers [4]. In dentistry, heavy metals are used to restore the decayed or to replace the missing teeth [5] specifically Mercury which is one of the most hazard material that released as by-product in dental waste and emitted as a vapor to the atmosphere by using mercury amalgam filling in a dental therapy [6]. Dentist may be exposed to significant risk due to daily work in dentist centers as well as accidental spills of elemental mercury that might be stored on-site. Estimates of mercury used in dentistry suggested that 2 to 3 pounds (1 to 1.5 kg) are being used on an annual basis [7].
Mercury is considered by WHO as one of the top ten chemicals or groups of chemicals of major public health concern ; Exposure to mercury – even small amounts may cause toxic effects on the central and peripheral nervous of digestive and immune systems, and on lungs, kidneys, skin and eyes [8].There is insignificant difference in the limits permissible of occupational exposure to mercury that set by governmental organizations and the competent authorities in the world, thus these levels have been summarized in many references as shown in table (1) which refers to indoor level [9].

Table (1) Environmental and occupational health standards for inhalation exposure to mercury vapor

Agency	Mercury concentration in $\mu g/m^3$
OSHA ceiling limit (1)	100
NIOSH REL(2)	50
ACGIH TLV (3)	25
ATSDR MRL (4)	0.2
ATSDR action level for indoor exposure	1
EPA Reference concentration	0.3
(1) Ceiling limit = the concentration of mercury vapor that cannot be exceeded. (2) REL = Recommended Exposure limit, for 8 hrs. day. (3) TLV = Threshold Limit Value, for 8 hrs. day. (4) MRL= Minimal Risk Level.	

Iraq has been using mercury for decades, whether in private sector, governmental and specialized dental centers, which makes the issue of mercury vapor detection important to assess the current situation and identify the level of mercury vapor in selected dental health care centers at governmental sector.

Experimental:
Portable device: Potential quantity of emitted mercury vapor has been measured using a portable mercury vapor detection device (TRACKER 3000 IP).

The device works by displaying continuous measurements on the screen by taking an air sample and analyzing it through a 1-micron filter into the optical cell (made of synthetic quartz) by membrane pump. Radiation of mercury lamp passes through the cell and it measured by solid state detector. The attenuation to the UV light reaching the detector depends on number of mercury atoms in the cell. Internal computer performs the quantitative evaluation of mercury concentration in the sample at site [10].
Sampling method: Forms were prepared to facilitate data collection and recording readings, (510) measurements have been taken to record Mercury vapor concentration (µg/m3) for 17 health care center and specialist center in Al-Karkh side in Baghdad (10 general health centers and 7 specialists center). Most room centers were crowded by doctors as well as patients. The survey was conducted at moderate weather, where room temperatures ranged between 16-20 ◦C, since Mercury evaporates at normal temperatures, as such evaporation will increase as temperature increases. Samples were collected from definite three locations within the dental room of the clinic:
Location (1): the room space: Any space within the room but the most far away from working spot (chair) and containers.
Location (2): amalgam capsule containers: In every dental filling room there is a container (one or more) to collect the empty amalgam capsules. As containers being opened several time a day, working environment might be exposed to high amount of mercury vapor arising from these containers. Measurements were recorded directly at the containers mouth to record emission concentration as capsules still have residue of mercury and still pose a significant hazard to the working staff.
Location (3): medical waste storage containers: Finally, measurements were undertaken at the mouth of medical waste container in dental rooms (specialized waste container).

RESULTS AND DISCUSSION

Measurements of the 3 different spots were conducted in every dental room where (10) readings were recorded in every location. Table 2 exposes the average of the 10 readings for each location as well as the highest measurement reading in the room:

Table (2) Average and highest Mercury vapor concentrations in 17 visited health care center

Visited centers	Average Mercury vapor concentration (µg/m^3)			Highest concentration (µg/m^3)
	Location(1)	Location(2)	Location(3)	
Al-dora	1.7	1339.2	24	1690
Bellatt al- shuhadaa	1.6	266.7	272.3	360
Al-huria Al -oula	0.3	151.5	32.4	215
Al-zahraa	0.6	104.9	27.3	220
Jnadin	0.6	28.9	1.9	40
Al-Saidia	1	305.3	19.6	555
Al-Jamiaa	2.6	822.8	102.3	2400
Hettin	1.2	1092	49.3	2900
Al-Ameria	1.5	616.6	22.6	2010
Al-Mahmudia Al-oula	0	262.1	0	390
AL- Amreria specialist center	5.9	77.2	5.4	95
AL Kadhimia specialist center	3.3	580.2	151.9	1350
AL karamma specialist center	0.6	1.8	0.3	3
AL mamoon specialist center	0.9	726.2	0	1090
AL noon specialist center	1.8	0	80.1	110
AL mahmudia specialist center (room1)	6.2	586.7	86.2	816
Room 2 (for kids)	6.7	76.7	44.8	120
specialist preventive center _ Kids	0	0	0	0
Mean	2.147059	414.0471	54.14118	844.9412
median	1.5	266.7	27.3	390
Standard deviation (σ)	2.132814	404.3983	70.46163	912.668

The highest concentration that were recorded in 9 out of 10 visited centers exceeded the ceiling limit, the highest concentration recorded reached (2900) µg/m^3 in (Hettin center) as shown in figure (1). High concentration was recorded in five from seven specialist dental centers exceeding the ceiling limit reaching to (1350) µg/m^3 in AL Kadhimia center as shown in Figure (2), with the exception of two sites. Al karamma center which didn't have amalgam container where the medical waste was thrown directly to the waste container, and the second (Preventive center) that didn't use amalgam as it is intended for children.

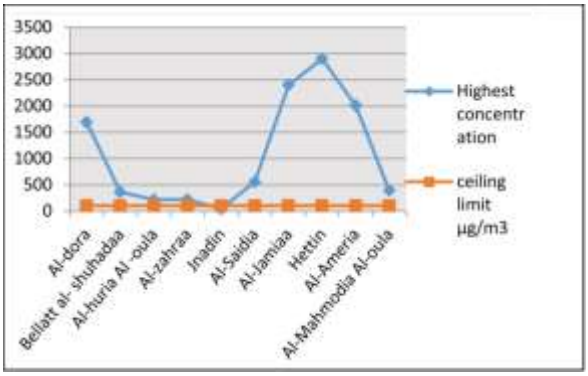

Figure (1) compare the highest concentration recorded in (10) health care centers with ceiling limit

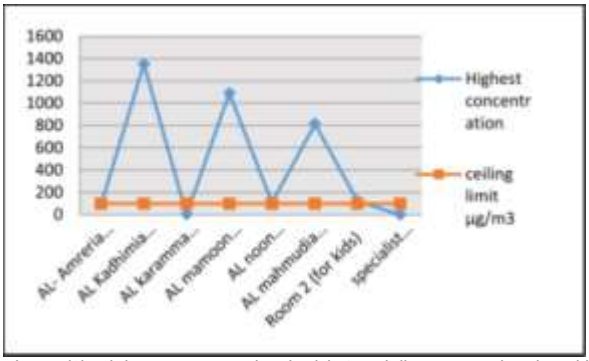

Figure (2) Highest concentration in (7) Specialist centers in Al-Karkh with ceiling limit

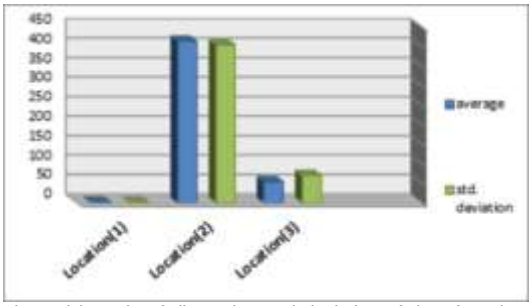

Figure (3) Scale of dispersion and deviation of data from its mean for the three locations in all health centers

Statistical scales (mean, median and standard deviation (σ)) for three locations were presented in figure 3. Standard deviation values for location (1) indicated that there is no dispersion of values from the mean (mean = σ = 2.1). While there is significant dispersion of values in location (2&3) as the standard deviation values were higher than their means as well as the highest concentration values

Percentage of centers number where mercury vapor concentration exceeded the occupational exposure limits shown in figure (4). 94.1 % of visited center exceeded the lowest allowed occupational levels, 76.5 % recorded high concentrations that exceeded ceiling limited value while 94.1 % exceeded the minimum risk level.

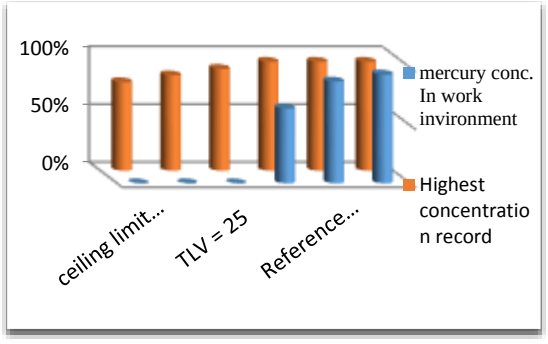

Figure (4) Percentages of centers that were out of occupational exposure standard limits

First: Mercury vapor concentration in every location in each site was compared with the international limits and listed in table (1) as follows.

Location (1):

1. All results were within:

- The ceiling limits of Occupational Safety and Health Administration (OSHA) of 100 (µg/m^3).
- Recommended exposure limit (REL) for mercury vapor of 50 µg/m^3 set by The National Institute for Occupational Safety and Health (NIOSH).
- Threshold limit value (TLV) of 25 µg/m^3 mercury vapor by The American Conference of Governmental Industrial Hygienists (ACGIH).

2. Many sites were recorded concentrations higher than the permissible level from other agencies, as follows:

- Fourteen sites were higher than the permissible level set by the (US-EPA) Environmental Protection Agency of 0.3 µg/m^3 of mercury inhalation exposure for 8 hours of work.
- Fifteen sites were higher than Minimal Risk Level (MRL) of 0.2 µg/m^3 set by Toxic Substances and Disease Registry Agency.
- Eleven sites were higher than the action level for indoor exposure of (1) µg/m^3 according to same agency above.

Location (2)

Highly distributed data were noticed may be attributed to trapped vapors in closed containers which were emitted rapidly out of container when opened to take measurements:

a. Thirteen sites have high concentration that exceeded the higher permissible limits ceiling of (100) µg/m^3. The highest average concentration was (1339.2) µg/m^3 in Al-Dora center.

b. Twelve sites recorded average concentration less than (100) µg/m^3 yet still above standard limits, all these sites suffer from lack of occupational health and safety, where empty capsules were disposed in normal waste containers releasing mercury vapor spreading all over the room.

c. Two sites had recorded zero concentration, for these rooms were dedicated for enfant treatment and no mercury amalgam was to be used.

Location (3):

a. Three sites had high concentration exceeded the higher permissible limits ceiling limit of (100) µg/m^3 and other limits. The highest average concentration was (272.3) µg/m^3 in Bellatt Al- Shuhadaa center. This high concentration may be due to full containers at time of visit.

b. Eleven sites recorded average concentration less than (100) µg/m^3 but still exceeding the rest of the limits. The highest average concentration was (86.2) µg/m^3 at AL Mahmudia specialist center.

c. Three sites had recorded nil as containers being emptied.

In summary, although sites recorded the highest concentrations but they are the best in applying environmental and occupational health safety, where empty capsules were stored adequately and kept sealed in closed containers, in fact there is serious hurdle dentist may face acute and chronic exposure of concentrated vapours every time the container was opened. While those centers that recorded low vapour concentration, despite their intense use of amalgam, are the worse in applying environmental and occupational health safety rules of hazardous waste storage. They either dispose amalgam residues directly in the waste containers or left container s opened, where dentists might face chronic diseases due to highly daily exposure. In both cases, the health care centers were considered major source to Mercury vapour emissions .

Second: Chronic daily inhalation intake by adults of non-carcinogenic chemical have been calculated as a function of concentration by using equation (1) [11]:

$$I = \frac{CA \cdot IR \cdot EF \cdot ED \cdot RR \cdot Abs}{Bw \cdot AT} = \ldots\ldots (1)$$

Where:

I: intake by inhalation (mg Hg/kg.day).

CA: Contaminant concentration in Air (mg/m^3)

IR: Inhalation Rate (m^3/hr), air breathed for adults was national estimated = 0.83(m^3/hr)

ET: Exposure Time (hour/day)

BW: Body Weight (kg) = 70 kg (as standard)

RR: Retention Rate = 100% inhaled air

Abs: Adsorption rate = 100 % inhaled air

AT: Average Time (period over which the exposure is averaged. day)

AT = EF. ED = 365 (day/year)**.** 30 (year) = 10950 days

Where: EF: Exposure Frequency (days/year)

ED: Exposure Duration (years), standard exposure duration = 30 year

$$0.285\ (m^3/kg.\ d)\ .\ CA$$

Applying Eq. (1) using the highest Hg vapour concentration in work space gave a linear relationship versus the inhalation of chronic daily exposure for the 17 sites as shown in figure (5):

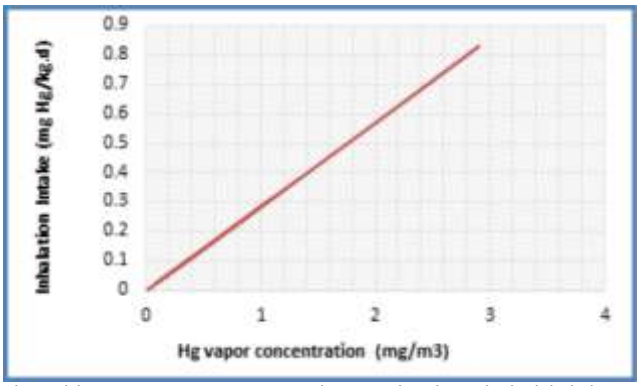

Figure (5) Mercury vapours concentrations vs. chronic Intake by inhalation

CONCLUSION

Mercury dental amalgam preparation, using and disposing are an important source of chronic and acute exposure to mercury vapor affects public health in general and dentists in particular. Almost all governmental centers in Iraq still using mercury amalgam in spite of the available alternatives.

The health care centers were considered major source to Mercury vapour emissions, (510) measurements was recorded at seventeen sites within health centers in Baghdad Al-Karkh side. 94.1 % out of 17 visited centers exceeded the lowest allowed occupational levels while 76.5 % of recorded high concentrations exceeding Ceiling Limited and 94.1 % exceeded the Minimum Risk Level.

There is no dispersion of values from their arithmetic mean in recorded data at location (1). While there is wide dispersion of values in location (2&3). It is quite noticeable that mercury vapour concentration in work space and the mercury vapour intake by inhalation of chronic daily exposure have a linear relation.

Fairly broad variability was noticed in the concentration of Hg vapor emitted in (17) centers that depended on the amount of empty collected capsules, opened or closed container, room area, number of chairs patients per day, number of full containers that were stored inside the room and how far safety measurement was applied.

Special attention should be paid not only to occupational exposure to mercury but also on administration of amalgam by adopting a tight management plan to the mercury amalgam and its waste with the trend towards gradual reduction to phase out amalgam mercury used in dental until the final cessation of its use and relying entirely on the use of alternatives, especially as Iraq

had been a member of Minamata Convention since the end of 2021.

Conflicts of interest: There are no conflicts of declare.

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REFERENCES

1. Cheng, H., & Hu, Y. (2012). Mercury in municipal solid waste in China and its control: a review. Environmental science & technology, 46(2), 593-605.
2. Salem, mohammed alameen and majeed, N. (2019) “Removal of Cadmium from Industrial Wastewater using Electrocoagulation Process”, Journal of Engineering, 26(1), pp. 24–34. doi: 10.31026/j.eng.2020.01.03.
3. Ebrahim, S. E. and Alhares, H. S. (2015) “Competitive Removal of Cu2+, Cd2+and Ni2+by Iron Oxide Nanoparticle (Fe3O4)”, Journal of Engineering, 21(4), pp. 98–122. Available at: https://joe.uobaghdad.edu.iq/index.php/main/article/view/445 (Accessed: 31 May 2022)
4. Baatartsol, D., Suvd, D., Ser-Od, H., Battuvshin, B., Oyu, T., Och, G., ... & Unursaikhan, S. (2015). A study of mercury determination in the waste storage area of health care organizations in Ulaanbaatar City. In Applied Mechanics and Materials (Vol. 768, pp. 220-224). Trans Tech Publications Ltd.
5. Abbas, H. M., Alhamaoy, A. R., & Salman, R. D. (2020). The effect of titanium oxide microparticles on mechanical properties, absorption and solubility processes of a glass ionomer cement. Journal of Engineering, 26(3), 160-173.
6. Vigarniya M., (2020) Review on toxicity of dental materials with an emphasis, Department of Dentistry Saheed Hasan Khan Mewati Government Medical College, Nalhar, Haryana, India. Indian journal for research.
7. Bhawan, P., & Nagar, E. A. (2010). Environmentally Sound Management of Mercury Waste in Health Care Facilities.
8. WHO, 2017, Mercury and health, published: 31 March 2017, WHO (World Health Organization). Available at:
9. https://apps.who.int/iris/bitstream/handle/10665/345443/9789289055888-eng.pdf.
10. NEWMOA, 2003. Indoor Air Mercury, (Northeast Waste Management Officials' Association), www.newmoa.org › prevention › mercury › MercuryIndoor.
11. Ecotech,2015. mercury tracker 3000 Operating Manual English Version 2.1. by Mercury Instruments GmbH, Karlsfeld (Germany) 2009. Available at:
12. https://www.ecotech.com/wpcontent/uploads/2015/03/Tracker-3000-IP-E-V-2.1.pdf
13. Watts, R. J. (1998). Hazardous wastes: sources, pathways, receptors.