ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 2, April - 2023, Page No. : 329 – 337

Estimating the Mercury content of smokeless tobacco products by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Method. An Analytical Study.

[1]Dr. Karibasappa G N, Professor & Head Department of Public Health Dentistry D Y Patil Dental School Pune.

[2]Dr. Gayatri Gundap, Intern D Y Patil Dental School Pune.

[3]Dr. Rasika Gogawale, Intern D Y Patil Dental School Pune.

[4]Dr. Priyanka Ghogare, Intern D Y Patil Dental School Pune.

[5]Dr. Divya Ghune, Intern D Y Patil Dental School Pune.

[6]Dr. Srushti Hange, Intern D Y Patil Dental School Pune.

[7]Dr. Shriram Gururaj Kulkarni, Senior Lecture D Y Patil Dental School Pune.

Corresponding Author: Dr. Karibasappa G N, Professor & Head Department of Public Health Dentistry D Y Patil Dental School Pune.

Citation of this Article: Dr. Karibasappa G N, Dr. Gayatri Gundap, Dr. Rasika Gogawale, Dr. Priyanka Ghogare, Dr. Divya Ghune, Dr. Srushti Hange, Dr. Shriram Gururaj Kulkarni, "Estimating the Mercury content of smokeless tobacco products by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Method. An Analytical Study", IJDSIR- April - 2023, Volume – 6, Issue - 2, P. No. 329 – 337.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Tobacco and its ingredients increase the health risk; studies have shown presence of various toxic metal and mercury in cigarette, sparse data available about mercury level in smokeless tobacco. This study aimed at estimation of mercury level among commonly used Indian Smokeless tobacco products.

Material and Methods: Indian marketed smokeless tobacco product selected for this study and for mercury analysis were Khaini, Vimal pan masala, Gaichhap tam, Mishri, Flavoured tobacco and Vimal Gutkha, the samples were decoded, sealed and transported to the test Center to assess mercury concentration by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Method.

Results: The present study showed Mishri (25,65ppb hg) and Gai chhap (24.43 ppb hg) had higher mercury concentration followed by other tested smokeless to bacco i.e., Gutkha (0.86 ppb g), Vimal Pan Masala (1. 65 ppb) Khaini (12.58 ppb hg), and Flavoured tobacco had 14.10 ppb hg. All the samples had higher mercury concentration than the permissible limit as per international guidelines.

Conclusion: Mercury coupled with other ingredients in smokeless tobacco products could alter the immune

system. Tobacco habit increases the risk of mercury exposure among users, affecting many organs and organ systems. Public should be encouraged to abstain from consuming tobacco products.

Keywords: Health, Mercury, Smokeless Tobacco.

Introduction

Tobacco is the most easily accessible, legally available addictive substance which contributes significantly to premature death and long-term suffering, and also being a major risk factor for cardiovascular diseases, chronic obstructive pulmonary diseases, cancers, reproductive outcomes, and oral diseases.[1]

As per Global Adult Tobacco Survey-India (GATS2) [2] India is home to over 28.6% of all tobacco users and world-wide it is the second largest producer and con summer of tobacco products.3 Available estimates in India show that tobacco smoking and smokeless tobacco (SLT) resulted in 930, 000,and 350,000, annual death respectively together accounting for about 1,280,000 deaths per year or approximately 3500 deaths every day.4,5 In addition, tobacco also impacts the economic development of the country, and as per studies con ducted by the Health Ministry, the total economic costs attributable to tobacco use from all diseases and deaths in the year 2011 was INR 104,500 crores, which is huge burden for a developing country like India.[6]

Tobacco and several chemicals in tobacco suppress the activity of different types of immune cells that are involved in general and targeted immune responses.[7] Tobacco habit has become addictive among users and the term "additive" means any substance, intended for use as a flavorings or colouring or in producing, Manu facturing, packing, processing, preparing, treating, pack aging, transporting, or holding, etc.[8]

Marketed SLTs vary considerably in form and other in gradient's, Apart from nicotine many harmful ingredients include heavy toxic metals. Many scientific studies show clinical association of heavy toxic metals and its effect on health. The role of copper (Cu) in submucous fibrosis and Cu in gutkha may be responsible for the fibrosis in oral cavities has been reported. [9] Early symptoms of chronic Cu poisoning include precancerous oral lesions (Leukoplakia-small white patches) and sores in the mouth or tongue, followed by oral submucous fibrosis and difficulty in opening the mouth. Lead exposure is very dangerous for the younger age group, as chronic exposure result in the lowering of the IQ and its poisoning effect on the brain may not be reversible [10,11,12]. Arsenic exposure can cause skin pigmentation and cancer problems, ulcerations of the mouth, low haemoglobin, leukaemia, acute renal failure, seizures, and nerve damage [13] , and it is also a potential carcinogen.[14] Excessive doses of Cd are known to cause lung and bone damage, and increased blood pressure [15] and causation of cardiovascular disease.[16,17,18]

Mercury (Hg) being one, exists naturally in the earth's crust, with an average abundance of about ppm by mass. [19] Hg can be found in many sources, including waste water, seafood, and the emissions from burning coal. Ancient Chinese believed mercury is good for health, however in modern society mercury is considered harmful and an environmental pollutant.[20] The influence of mercury being toxic through tobacco was studied and established way back among smokers [21], after many attempts and initiative to discourage the smoking habit, many people have adapted to the smokeless tobacco habit. To the best of our knowledge very little in formation is available regarding level of mercury in the SLT products in Indian marketed products. This provided an impetus to assess and compare the mercury content among different smokeless tobacco products by ICP-MS method.

Methodology

The present study is an in vitro study conducted at TUV India Pvt Ltd, Pune, Maharashtra. Institutional Ethical Committee Clearance was obtained before conducting the Study.

Selection and coding of the sample

The various commercially available tobacco products were taken into consideration based on their popularity, widespread use among the people, availability in the vicinity of study (Pune) area, and of those, the following samples were randomly selected which were labelled in the following manner:

A. Khaini

B. Vimal pan masala

C. Gai-chhaptambakhu

D. Mishri

E. Flavoured Tobacco

F. Vimal Gutkha

Indian marketed STPs were purchased from retail stores in Pune. The date of purchase, name of manufacturer, company, and manufacturing date were recorded. Twenty-five forms of different brands of STPs were collected from 10 outlets in various parts of the city. Samples of the same brand were mixed together to obtain a representative sample of that product. The products collected for analysis were Vimal pan masala, gutkha, Zarda, khaini, and Mishri, which are chewing tobacco products that have become more popular, especially among teenagers and young adults in many states of India. The study was conducted over a period of 15 days.

Preparation of material for mercury determination

The samples were weighed according to 100 mg of to bacco content and were sealed in air-tight plastic pouches with labelling of the codes (A, B, C, D, E, and F). The samples were then transported in hygienic and moisture proof conditions to the study Center.

Processing

ICP-MS (inductively coupled plasma-mass-spectrometry) is a technique to determine low concentrations (range: ppb = parts per billion = µg/l) and ultra-low-concentrations of elements (range: ptt = parts per trillion = ng/l). Atomic elements are lead through a plasma source where they become ionized Then, these ions are sorted on account of their mass. The advantages of the ICP-MS technique above AAS (Atomic Absorption Spectroscopy) or ICP-OES (inductively coupled plasma optical emission spectrometry) are

- Extremely low detection limits
- A large linear range.

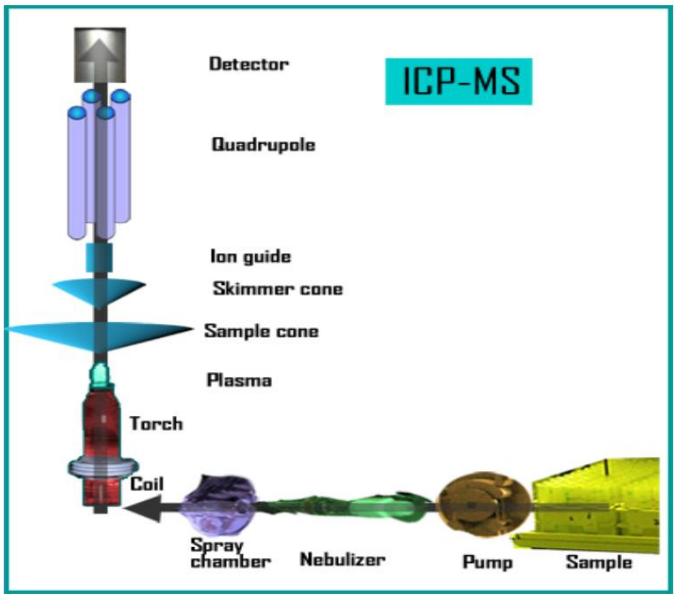

Figure 1:

Possibilities to detect isotope composition of elements The ICP-MS technique has a multi-element character and a high sample throughput, like ICP-OES, but it allows one to perform more sensitive measurements. Disadvantages and weaknesses of the ICP-MS detection are the occurrence of spectral and non-spectral inter Ference and the high costs.

Apparatus

Like for the ICP-OES, the sample solution is introduced into the device by means of a peristaltic pump. There it becomes nebulized in a spray chamber. The resulting aerosol is injected into an argon-plasma that has a temperature of 6000-8000 K. Inside the plasma torch, solution is removed from the sample and also atomization and ionization occur.

Only a small amount part of the ions produced in the plasma further penetrate to the mass-spectrometer part.

Requirement

Reagent / reference materials

- Concentrated. Nitric Acid
- Hydrogen Peroxide (30 %)
- Suprapure/ Ultrapure grade Nitric acid
- Deionized Water
- 1000 µg/ml stock solution of Respective element standard
- ICP Standards Traceable to NIST.

Apparatus

- Micropipette 0.1 to 1 ml & 0.02 to 0.2 ml
- Volumetric Flask-50 ml • What man filter paper no. 41
- Plastic Beaker, funnel.

Equipment

- Microwave digester
- Weighing Balance (Range 0.1 mg to 200 gm)
- ICP-MS (AGILENT 7700)

Sample Preparation for Food Products (By Microwave Digestion)

- Weight 0.1 to 1.0 g of Homogenized sample for metal analysis on ICP-MS & ICP-OES. Transfer the Sample in to microwave digester tube.
- Add 6 ml Supraure grade conc. Nitric acid for sample preparation and 0.3 ml 30 % H2O2 solution add 7 ml deionized water and keep microwave digester tube in microwave digester.

Table 1: Microwave digester program for food samples.

Power	1500 W
Ramp	15 min
Hold	25 min
Temperature	170^0 C
Cooling	15 min

- After completion of the digestion remove tube from digester and cool it to room temperature.
- Observe condition of digested sample, it should be clear. If any presence of particulate matter observed, then again add conc. Nitric acid and H2O2 solution and reediest sample.
- Transfer the clear digested solution to volumetric flask and make volume with De-ionized water.
- If any insoluble observed, filter the solution through what man filter paper.
- This solution is ready for aspiration. Run Sample on ICP as per the working instructions.

Table 2: ICP-MS operating conditions.

Plasma (Ar) gas flow	15 L min^{-1}
Carrier (Ar) gas flow	0.8–1.0 L min^{-1}
Collision (He or H_2) gas flow	4.5–5.0 L min^{-1}
S/C temp	2 °C
Sampler and skimmer cons	Ni
Plasma Power	1500 W
Sample depth	6–8 min
Reflected power	< 20W

Method Critical Points

- Polypropylene wares should be properly cleaned with acid to avoid cross contamination.
- While volume makeup, care should be taken to avoid spillage of solution from tube during transfer into the flask.
- After digestion, the solution should be clear and if any particulate matter observed, then add conc. Nitric acid and H2O2 solution and re-digest sample.
- After re-digestion, if still the solution contains insoluble (generally in case of silica), filter the solution through Whatman filter paper.
- If aspirated concentration of sample is higher than the linearity range, then dilute further to get the aspirated concentration in the linearity range
- The use of nitric acid matrices for ppb Hg determinations by ICP-MS should only be attempted using Au as a stabilizing agent. The gold stabilization method directly prevents decomposition by keeping all mercury in the solution.

Results

Table 3: Distribution of Mercury concentration among tested samples in ppb/ppm.

Sample No.	Name of Element	Weight of sample in g	Volume ml	sample conc in ppb	Conc. in Blank ppb	Actual conc ppb	Further dil ml	Result ppm	Result ppb	SPIKED CONC PPM	RECOVERY %
0032002718 **(A)**	Hg	0.532	50	0.177	0.043	0.13	1	0.013	12.59		
0032002719 **(B)**	Hg	0.514	50	0.026	0.043	0.02	1	0.002	1.65		
0032002720 **(C)**	Hg	0.526	50	0.300	0.043	0.26	1	0.024	**24.43**		
0032002721 **(D)**	Hg	0.536	50	0.318	0.043	0.28	1	0.026	**25.65**		
0032002722 **(E)**	Hg	0.539	50	0.195	0.043	0.15	1	0.014	14.10		
0032002723 **(F)**	Hg	0.584	50	0.035	0.043	0.01	1	0.001	**0.86**		
0032002724 spk	Hg	0.600	50	1.745	0.000	1.75	1	0.145	145.42	0.2	72.7

The present study results show, sample D (Mishri) and sample C (Gai Chhap Tambhabhu) had the maximum 25.65 ppb hg and 24.43 ppb hg respectively and sample F (Gutkha) had the least 0.86 ppb hg and sample B (Vimal Pan Masala) 1.65 ppb mercury concentration when compared to other tested samples.

Other tested Samples had mercury concentration as following (A- Khaini) 12.58 ppb hg, (E Flavored tobacco) 14.10 ppb hg. (Table 1).

Discussion

In the present study 5 commonly used Indian smokeless tobacco products; were purchased in 2020 in India and are used commonly in different parts of the country and Maharashtra. Our study shows that the levels of mercury in these products vary widely. Different brands of the same type of product usually contain similar levels of mercury. This observation can be explained by similarities in tobacco processing and is in agreement with the general principle that yields of tobacco- specific

ingredients are influenced greatly by the processes involved in the manufacturing of smokeless tobaccos. 22, 23, 24. The present study findings suggest all tested samples had behind and higher level of mercury i.e., more than 0.07ppb hg 25 (Table 1) that could be a health risk to the consumers.

Efficient and accurate measurement of mercury con centration is a challenge. A direct sample preparation method for reliable inductively coupled plasma-optical emission spectrometry (ICPOES) mercury measurement would be invaluable to chemical manufacturers, testing laboratories, and other industries. Historically, ICP-OES mercury measurements have been plagued by poor mercury detection limits, severe carryover effects, and sample instability. In this study, we used ICP-MS (inductively coupled plasma-mass-spectrometry) which is a technique to determine low concentrations (range: ppb = parts per billion = µg/l) and ultra – low - concentrations of elements (range: ptt = parts per trillion = ng/l).

Due to health and environmental risks associated with mercury exposure, 128 signatories and 25 parties have supported a United Nations treaty from the Minamata Convention on Mercury.26 The world dental body, Fédération Dentaire International, has established guide lines for dental amalgam use to ensure safety for general population and the environment.[27] In 2004, the Joint FAO/ WHO Expert Committee on Food Additives (JECFA) established a tolerable intake of 1.6 µg/kg body weight per week for methylmercury in order to protect the developing fetus from neurotoxic effects.[28] There is a large body of literature on methyl mercury poisoning as well as the toxicology of ingested mercury . [29]

1) Mercury Acute REL	
Reference Exposure Level	0.6 µg Hg/m³ (0.07 ppb Hg^0)
Critical effect(s)	CNS disturbances in offspring
Hazard Index target(s)	Nervous system
2) Mercury 8 hr REL	
Reference Exposure Level	0.06 µg Hg/m3 (0.007 ppb Hg^0)
Critical effect(s)	Impairment of neurobehavioral functions in humans
Hazard Index target(s)	Nervous system
3) Mercury Chronic REL	
Reference Exposure Level	0.03 µg Hg/m3 (0.004 ppb Hg^0)
Critical effect(s)	Impairment of neurobehavioral functions in humans
Hazard Index target(s)	Nervous system

The highest concentration of mercury was found in Mishri and gaichhap. Mishri is prepared by roasting tobacco leaves. The roasted tobacco leaves are powdered, and it is known by various names like ‘Mishri,’ ‘Masher or,’ ‘Misheri’. It is mainly a homemade preparation but is also available in the market under different names. It does not contain anything other than tobacco leaves. We could not compare the present findings with other similar studies as there were no such studies available in the previous literature. Many studies in the previous literature were conducted on smoking form of tobacco [21] and there is paucity of literature regarding smokeless forms of tobacco.

The present study finding is alarming, as the Mishri chewing habit is found considerably high among females and due to high concentration of mercury could potenti ally damage developing brain of human foetus also could be a threat to women having complaints during pregnancy, complications during delivery, pro portion of low-birth-weight babies, and stillbirths. Appro xi mately 7% to 15% of doses of inorganic mercury compounds are absorbed in the gastrointestinal tract after ingestion.

30 Chan 31 suggested that inorganic mercury may be abs or bed through the skin by the transport of mercury across the epidermis and via the sweat glands, sebaceous glands, and hair follicles. These findings suggest the increase chance of mercury penetration while preparing home-made Mishri and other smokeless tobacco preparation.

Presence of alarming level of mercury in SLT should be used as Common risk factor approach to disseminate knowledge for discouraging tobacco habit. With regard to smokeless tobacco habit, it is noticed that majority of the consumers had the habit for longer duration tobacco use that has an effect on oral mucosal lesions; presence of mercury in these SLT products could be absorbed and cross the chronic mercury reference exposure level resulting in impairment of nervous system. The present study has its own limitation with respect to the number of samples tested due to financial burden. We could not exactly estimate the form and nature of the mercury that was behind the objective of our study. Further studies are to be needed with larger sample and various brand available in market with emphasis on form of mercury, Is it volatile or particulate, Is it inorganic or methylated and Is it bio available or not. The higher mercury concentration coupled with addictive nicotine in various SLT products are a health risk when the toxicity potential from dietary as well as other environmental exposure is taken into consideration. Considering all these facts the authors feel that the STPs should be labelled with level of mercury as per international guidelines and that their production and promotion should be adhering to the stricter government guidelines.

Conclusion

All tested samples had higher concentration of mercury, among them Mishri and Gai chap had higher mercury followed by others It is well known fact that tobacco and its products are not the only source of the mercury toxicity, for human organism, however ab stensim and reduction of consuming tobacco products may be crucial for the reduction of the organism abilities to secrete and absorption of mercury.

Key Messages

Implications for policy makers

- labelling the smokeless tobacco products with level of mercury content on packages
- Warning sign about the hazards of mercury on smokeless tobacco products
- Quality control of marketed SLTs adhering to the international guidelines of permissible limit of mercury.

Implications for public

The higher mercury concentration coupled with addictive nicotine in various SLT products are a great threat for being healthy. Public should be made aware about the higher level of mercury in different SLTs products. Health campaigns should be carried out to empower public about the harmful effects of mercury on several organ and organ systems; this might help public to make informed decision regarding the personal choice and abstain the Smokeless Tobacco Products. Mercury exposure is dangerous to tobacco consumers and also results in environmental pollution.

Acknowledgements

We would like to thank all the staff members and lab technician of TUV India Pvt Ltd India House, Pune, Maharashtra, for helping us to successfully conduct the study.

Reference

1. Bhawna G. Burden of smoked and smokeless to bacco consumption in India – Results from the Global adult Tobacco Survey India (GATS-India)-2009-2010. Asian Pac J Cancer Prev 2013; 14:3 323-9.

2. Global adult tobacco survey-WHO. [internet] [cited 2021 march 15] Available from https:// who. int / to bacco/ surveillance/ survey/ gats/ GATS _ India_2016 - 17_Fact Sheet.pdf.

3. Mishra GA, Pimple SA, Shastri SS. An overview of the tobacco problem in India. Indian J Med Paediatr Oncol 2012; 33:139-45.

4. Jha P, Jacob B, Gajalakshmi V, et al. A Nationally Representative Case–Control Study of Smoking and Death in India. N Engl J Med 2008; 358:1137-1147.

5. Sinha DN, Pali Pudi KM, Gupta PC, et al. Smokeless tobacco use: a meta-analysis of risk and attribute able mortality estimates for India. Indian J Cancer. 2014;51 Suppl 1: S73-77. doi:10.4103/0019-509 X.147477.

6. John RM, Rout SK, Kumar RB, Arora M. Eco nomic Burden of Tobacco Related Diseases In India. New Delhi: Ministry of Health & Family Welfare, Government of India. 2014.

7. COVID-19 Pandemic and Tobacco Use in India. [internet] [cited 2021 march 15] Available from from https://www.mohfw.gov.in/pdf/COVID19PandemicandT obaccoUseinIndia.pdf

8. Family Smoking Prevention and Tobacco Control Act. [internet] [cited 2021 march 15] Available from: http://www. fda. gov/ to bac co products/ labelling/ .../ ucm237092.htm

9. Trivedy, C., Meghji, S., Warnakulasuriya, K. A. A. S., John son, N.W., and Harris, M. Copper stimulates human oral fibroblasts in vitro: a role in the pathogenesis of oral sub mucous fibrosis. J. Oral Pathol. Med.2001; 30: 465–470.

10. IARC Monographs (2006) Inorganic and Organic Lead Com pounds. Suppl. 87. International Agency for Research on Cancer: Evaluation of Carcinogenic Risks to Humans.

11. Raghunath, R., Tripathi, R.M., Khandekar, R.N., and Nambi, K.S.V. Retention times of Pb, Cd, Cu, Cu and Zn in children's blood. Sci. Total Environ. 1997; 207: 133–9.

12. Khandekar, R.N., Mishra, U.C., and Vohra, K.G. Environ mental lead exposure of urban Indian popu lation. Sci. Total Environ.1984; 40: 269–278.

13. Byrd, D.M., Roegner, M.L., Griffiths, J.C., Lamm, S.H., Grumski, K.S., Wilson, R., and Lai, S. Carcino genic risk of inorganic arsenic in perspective. Int. Arch. Occup. Environ. Health 1996; 68: 484–494.

14. La Grega, M.D., Buckingha, P.L., and Evens, J.C. (1994) Hazardous Waste Management. McGraw-Hill, New York.

15. IARC Monographs (1993) Cadmium and Cadmium Com pounds. Suppl. 58. International Agency for Re search on Cancer: Evaluation of Carcinogenic Risks to Humans.

16. IPCS (1992) International Programme on Chemical Safety: Environmental Health Criteria: Cadmium. Ser. 134. World Health Organization, Geneva.

17. ATSDR (1997) Agency for Toxic Substances and Diseases Registry. Toxico logical Profile for Cadmium. Draft for public comment. Department of Health and Human Services, Public Health Service, Atlanta.

18. Jarup, L., Berglund, M., Elinder, C.H., Nordberg, G., and Vahter, M. Health effects of cadmium exposure and risk estimate. Scand. J. Work Environ. Health. 1998; 24: 1–52.

19. Ehrlich, H. L.; Newman D. K. Geo micro bio logy. 2008; CRC Press. p. 265. ISBN 978-0- 8493-7906-2.

20. Yogesh Parikh, Huifang Lang, Samantha Mah moud, James Lallo. Sample Preparation Method for Mercury Analysis in Reagent Chemicals by ICP-OES 2015; 30 (11): 8–17

21. Radoslaw kowalski and Janusz wierciński mercury content in smoke and tobacco from selected cigarette brands n Ecological Chemistry and Engineering January 2009

22. Hoffmann D, Brunnemann KD, Prokopczyk B, Djordjevic MV. Tobacco- specific N- nitrosamines and areca- derived N- nitrosamines: chemistry, biochemistry, carcinogenicity, and relevance to humans. J Toxicol Environ Health 1994; 41: 1– 52

23. Hecht SS, Chen CB, Hirota N, Ornaf RM, Tso TC, Hoffmann D. Tobacco specific nitro samines: formation from nicotine in vitroand during tobacco curing and carcino genicity in strain A mice. J Natl Cancer Inst 1978; 60: 819– 24.

24. Andersen RA, Kasper Bauer MJ, Burton HR, Hamilton JL, Yoder EE. Changes in chemical com position of homo genized leaf- cured and air- cured burley tobacco stored in controlled environ ments. J Agric Food Chem 1982; 30: 663– 8.

25. Mercury Reference Exposure Levels DRAFT [internet] [cited 2021 march 15] Available from https:// oehha.ca.gov/media/downloads/air/document/mercurypo stsrp3.pdf

26. United Nations Environmental Program “INC7”. Minamata Convention on Mercury [internet] [cited 2021 march 15] Available from from: http:// www. mercury convention. org/Countries/tabid/3428/Default.aspx. 27) FDI Policy Statement. Mercury Hygiene Guidance [inter net] [cited 2021 march

27. Available from: http:// www. fdiworl dental. org/ media/ 11271/Mercury-hygiene guidance-2007.pdf.

28. JECFA (2004) Methyl mercury. In: Safety evalu ation of certain food additives and contaminants. Report of the 61st Joint FAO/WHO Expert Committee on Food Additives. Geneva, World Health Organization, Inter national Programme on Chemical Safety. WHO Techni cal Report Series 922 pp 132-139. http:// whqlib doc. who.int/trs/WHO_TRS_922.pdf

29. Gasoline related air pollutant [internet] [cited 2021 march 15] Available https:// oehha. ca.gov/ media/ down loads/ air/document/mercury112508.pdf

30. Liu J, Goyer RA, Waalkes MP. Toxic effects of metals. In: Casarett LJ, Doull J, Klaassen CD, editors. Casarett and Doull's toxicology: the basic science of poisons. 7th ed. New York: McGraw-Hill; 2008. pp. 93 1–979.

31. Chan TY. Inorganic mercury poisoning associated with skin-lightening cosmetic products. Clin Toxicol (Phila) 2011;49(10):886–891