Sri Lanka Journal of Forensic Medicine, Science & Law — 2023; 14(1):24-31
DOI: https://doi.org/10.4038/sljfmsl.v14i1.7909

CASE REPORT

FORENSIC APPROACH TOWARDS CRIMINAL USE OF MERCURY IN DOMESTIC VIOLENCE

Sinha S[1]*, Rao K[2], Rawat A[1]
[1]*Chemistry Division, Forensic Science Laboratory, Delhi, India*
[2]*GD Goenka University, Gurugram, India*

ABSTRACT

The prevalence of criminal cases against women is not first-hand with statistical data from the National Crime Records Bureau in India proclaiming an even rise in cases of domestic violence. Despite numerous laws to protect women against various crimes including rape, sexual harassment, dowry death, etc., there is less respite from violence toward women in India. Indian society needs to stand up and address the existence of many socio-cultural reasons for crime against women apart from literacy to lower these crime statistics. Forensic experts play a pivotal role in the scientific examination of evidence to support the criminal justice system which in the end affects the lives of millions of female victims. A case of attempted domestic homicide is presented wherein a 21-year-old married female was poisoned with some unknown substance laced in her milk by her in-laws. This case is of interest to the scientific community as well as to persons working within the medical and judiciary fraternity.

Case history: A married woman aged 21 years alleged her in-laws including her husband of attempt to murder her by giving her milk laced with some unknown substance. She had severe vomiting after drinking milk where she noticed some shining materials in the vomitus. The vomitus and the gastric lavage were analyzed subsequently.

Methodology: Physical and Chemical Examinations including visual analysis and solubility, odour, etc were initially conducted on the exhibits (Gastric Lavage and Vomitus samples) and results were further confirmed by Atomic Absorption Spectrometry.

Results: An abnormally high level of mercury i.e. 9.88 ppm and 332.15 ppm were detected in Gastric lavage and vomitus respectively.

Conclusion: The various scientific investigations determined that the female had been poisoned by using mercury justifying the essential role of forensics in linking shreds of evidence scientifically.

Keywords: *Atomic Absorption Spectrometry; Forensic Science; Homicide; Mercury; Poisoning*

Corresponding Author: Sinha S
sweta.fsl@gmail.com
ORCID iD: https://orcid.org/0000-0001-5585-7528

ARTICLE HISTORY
Received: 20.08.2022 Received in revised form: 15.03.2023
Accepted: 11.04.2023 Available online: 26.06.2023

INTRODUCTION

Crime against women in Indian society has spread its roots long and continues even to date in various measures. Violence is noticeable to Indian women in many forms like sexual harassment, dowry death, honour killing, and acid attack cases to name a few including female foeticide even before they are born[1]. Although a culturally rich country like India holds its women on a high pedestal, unfortunately, the copious attempts to control crime against women have been futile. National Family Health Scheme (NFHS) findings underscore the extent and

severity of violence against women, where one-third of 30% of married Indian women suffer even today[2,3]. National Commission for Women (NCW) registered a 2.5 times increase in domestic violence complaints during the pandemic lockdown[4,5]. National Crime Records Bureau data for 2021 records 503 domestic violence cases, even though India has powerful laws like the Protection of Women from Domestic Violence Act, 2005 (PWDVA) and IPC section 498A to safeguard the women population[6,7]. However, the bench of Honourable Justice Joseph Kurian and R F Nariman pointed out appropriately that "the perpetrators and abettors of domestic violence" include both genders[8]. However, the legal approaches to protect female victims have brought several changes in law from the Dowry Prohibition law of 1961 to The Criminal Law (Amendment) Act of 2013 but still, little success is seen in controlling the crime[9,10].

Domestic violence cases are brushed under the carpet unless it reaches the critical stage where the victim might suffer minor injuries and then garner courage for action. There is extensive literature pointing toward homicidal cases in domestic violence and its evidentiary challenges faced by enforcement agencies, forensic scientists, and the criminal justice system. Scientific evidence reported by Forensic Scientists plays an important role not only as expert admissibility in a court of law but also enables decision-makers to have a distinct vision to conclusions, eradicating inevitable misconceptions and incomprehensible contradictions regarding the victim, scene of crime evidence, and crime perpetrator.

Ancient Roman, Greek, and Indian civilizations had popular cosmetic and medical usage of mercury including the amalgamation of the tooth[11]. History suggests the homicidal poisoning of kings, scientists, and literary geniuses[12]. Heavy metal poisoning occurs mainly due to excessive exposure to toxic metals like Lead, mercury, arsenic, cadmium, and chromium that affect normal body functioning[13-14]. Therefore, mercury salts and compounds are considered threats as both are chronic and acute poisons[15]. Albers et al reported a rare but interesting homicidal case of fatal intoxication in a 40-year-old man caused by the injection of organic mercury, allegedly in an attack with a syringe fixed to the tip of an umbrella[16]. Hitosugi encountered on fascinating case of criminal mercury vapor poisoning by using grains of mercury in cigarettes which were inserted into a battery holder where the victim inhaled the vapor produced when the battery was heated[17]. Intoxication with mercury compounds is rare, conversely, there have been several reports of homicidal, suicidal, and accidental intoxication of mercury across the world[18-25]. Indian married women in use salt of mercury as a daily cosmetic (vermilion) due to its brilliant hue where this colour property of the cosmetic was used as trace evidence in another forensic case; however, its use with criminal intentions is limited[26].

The toxicity due to mercury poisoning is predominantly determined by the form, dose, and rate of mercury ingestion or inhalation[12]. Symptoms are mostly non-specific in chronic poisoning but severe acute inflammatory reactions are found in cases of acute exposure[27-28]. Organic mercury leads to high damage to Central Nervous System while salts of inorganic mercury chiefly damage the digestive system lining and kidney with symptoms of tremors, gingivitis, abdominal pain, vomiting, and diarrhoea [29-30] as a result of exposure. Mercury finds its use in many industrial processes as a component of batteries, thermometers, and Compact Fluorescent Lamps apart from its wide usage in medical therapeutic applications, thus exposure to this needs thoughtfulness[15,16]. There exist many international laws and guidelines to prevent the misuse, overuse, or restriction of mercury-containing products[31], however, mercury in various forms is still easily accessible. The identification of symptoms in mercury poisoning becomes important from a medico-legal view and its detection in biological samples from a forensic angle.

The case study presented here is an example of poisoning using mercury with detailed insight into the toxicological examination in the forensic laboratory when samples for case examination were limited. The article will benefit law enforcement officers, prosecutors, judges, and forensic experts examining domestic violence cases.

CASE HISTORY

A married woman aged 21 years alleged her in-laws including her husband of attempt to murder her by giving her milk laced with some unknown substance. She had severe vomiting after drinking milk where she noticed some shining materials in the vomitus. She obtained medical assistance and disclosed her troubled married life. Investigating agencies collected samples for chemical examination.

The seized samples by the investigating agency were received at Forensic Science Laboratory, Delhi for chemical examination in suitably packed and sealed condition. All the reagents and solvents used in the analysis were of analytical grade procured from

Sigma-Merck. All glassware used was purchased from Borosil.

The chemicals required were Copper strips, Dilute Nitric Acid (10 times or 1:10), Concentrated Hydrochloric Acid, and Methanol. The first sample analyzed was 7 ml from gastric lavage and the second sample analyzed was 5 ml of vomit.

Preliminary Chemical Examination
Reinsch's Test[32]:

This test is a screening method for metal analysis due to its rapid, sensitive, and reliable results in the forensic toxicological examination without extensive preliminary treatment. Washed with Dilute Nitric Acid and dried copper strips were placed in samples along with a blank sample. 2 ml of Concentrated Hydrochloric Acid (HCl) is added to 4.0 ml of each sample then and gently heated in a porcelain dish for about half an hour under the fume hood to burn out the materials and water portion. If the sample gets reduced add 1ml of water and concentrated HCl and carry on the process till only copper strips with residues are left. Copper strips were then washed with methanol and dried on filter paper.

Microscopic examination of the test copper strip was then carried out at 10x /0.25 on Leica DM 750 compound microscope.

Instrumental Analysis
Atomic Absorption Spectrometry (AAS)

The samples were further analyzed using AAS for the detection of Elemental Mercury. AAS is an excellent analytical technique for element analysis with good sensitivity to measure parts per billion of a gram in a sample. Varian makes AAS of the model - FS 220, which was used to measure the element Mercury at Wavelength (nm) -253.7 nm, lamp current 4mA, fuel acetylene, and slit width 0.5nm.

RESULTS

Silver shining deposits were observed on copper strips which suggest positive results for the presence of mercury in Sample 1 and Sample 2 (Fig. 1). When these strips were heated in the test tube, shiny silver deposits of mercury were observed on the walls of the test tube. These copper strips were seen under the microscope (Fig. 2); shiny mercury globules of mercury were evident. Fig. 3 illustrates black spherical globules of mercury of various sizes as, during sublimation, mercury comes in contact with sulfur in the air to form mercury sulfide.

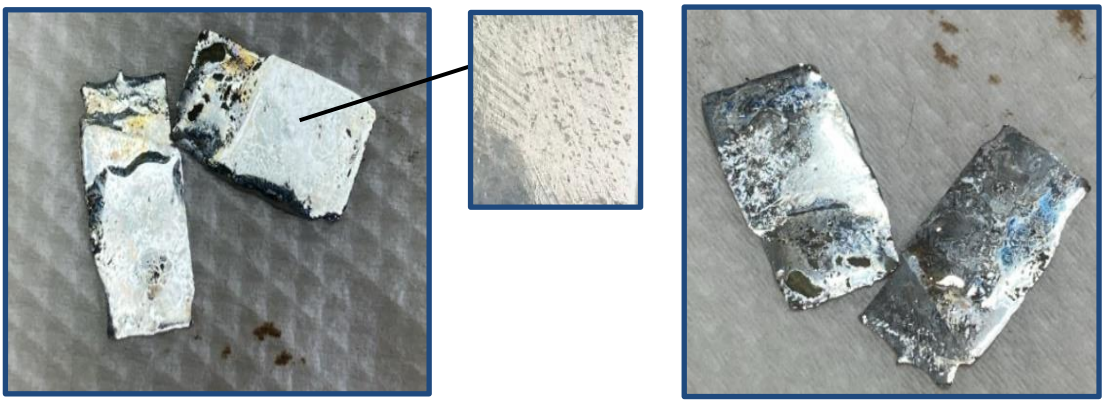

Fig. 1: Silvery shining deposits of mercury appear on the copper strip after Reinsch's test

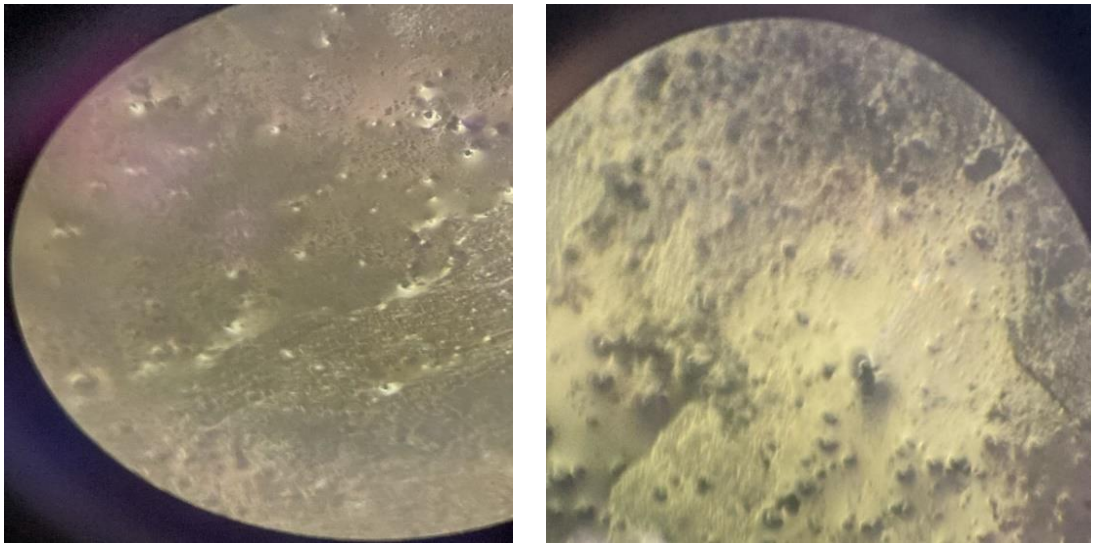

Fig. 2: Microscopic view of the copper strip after Reinsch's test

Fig. 3: Mercury sublimates to form black spherical globules of various sizes on a copper strip

	Sample ID	Hg:MVU Actual Conc.	Hg:MVU Actual Conc. Unit
1	[redacted](1) UNTREATED	-1.21	ppm
2	BLK1	-1.21	ppm
3	[redacted](1)	9.88	ppm
4	BLK2	-1.21	ppm
5	[redacted](2)	332.15	ppm
6	BLK3	-0.28	ppm

Fig. 4: Concentration of mercury detected in the samples during AAS analysis

The results of samples 1 and 2 were found to be 9.88 mg/ml and 332.15 mg/ml respectively establishing the fact that both samples had a high concentration of elemental Mercury when analysed in AAS. The various standard solution for mercury was prepared to range from 50, 100, 200, 400 and 600ppm for which the graph was plotted before running the samples.

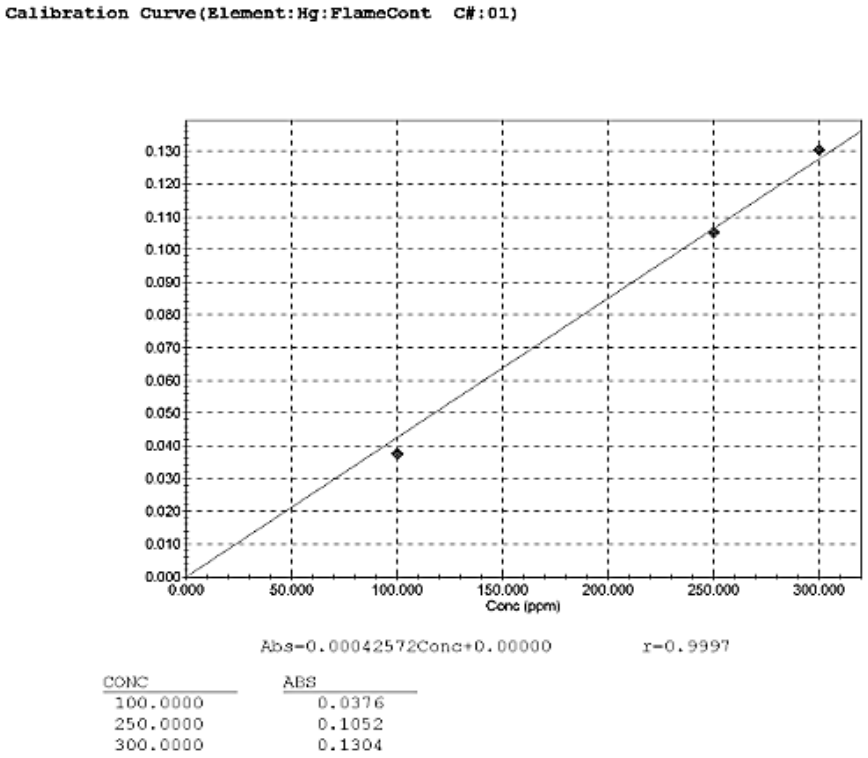

Fig. 5: Calibration curve of the quality control that was run during the quantitation of the mercury

DISCUSSION

A poison can be any substance that causes harmful effects when administered accidentally or in a homicidal manner to living organisms depending on exposure and dose. Homicidal poisoning in crime cases more than often results in fatal incidences where the most common factor is that the perpetrators of the crime had effortless access to poisonous substances either due to their occupation or available over the counter. Here also, large industrial belts of Delhi are engaged in numerous operational processes involving mercury and its compounds [33-36] making it accessible to the public. The odorless character of mercury was utilized in this crime as it was easily mixed in milk without creating suspicion in the victim. Toxic ingestion has a corrosive effect on the digestive tract and thus increases the permeability of the gastrointestinal tract. In the bloodstream, it adheres to sulfhydryl groups on erythrocytes, cysteine, or glutathione to poison cellular function by altering the tertiary and quaternary structure of proteins by binding with sulfhydryl and selenohydryl groups[29]. Thus, mercury has the potential to cause significant health issues through sequences of biochemical reactions in the human body. Within minutes of intoxication, the toxicokinetic action begins with wide distribution in blood, liver, kidney, and muscles[19]. Interpretation of the effects of poison in the biological environment is a mandatory aspect of forensic toxicology. As the dose ingested is important for the poisoning effect to arise, it can be perceived in the said case that the victim was conscious and oriented when she approached for medical and police assistance. It is pertinent to mention here that vomiting through which most of the intoxicant was expelled out of the body played a vital part in her survival which can also be correlated with the amount of mercury detection as in Fig 4. The presence of mercury in vomitus and gastric lavage in such high amounts indicated poisoning of mercury as it is not an integral constituent of human body tissues and cells. So, the mere presence gives legal value proof beyond a reasonable doubt. Such type of mercury poisoning can often be misdiagnosed due to non-specific signs and symptoms to some extent due to lack of knowledge and expertise among investigating agencies or during initial medical documentation. Thus, the documentation of the case was necessary. The presence of mercury could also have been ascertained from the glass of milk even, if, timely seizures and chemical examination would have been conducted as mercury must have settled at the bottom of the glass according to its physical property. This evidence was absent or rather was not considered of importance during the scene of crime visit.

Because of its extensive commercial use, the element is freely available to individuals and the lack of legal measures gives liberty for this toxic element's use in crime effortlessly. Most of the commercially used mercury including waste, remains unregulated, posing a threat to human health as well as the environment and crime. Significantly, there is no national mercury monitoring program in India. Although the Hazardous Wastes (Management and Handling) Rules of 1989, prohibit the import and export of mercury-bearing waste, transportation, handling, and storage and stipulate environmentally sound management, mercury continues to make its way into our Indian territory in various forms[37-38]. Crime cases must propel the government to have strict regulations and standards for its use in various activities. The authorities must wake up to this toxic challenge before it is too late until then medical practitioners and forensic scientists across the globe are expected to continue to encounter mercury poisoning cases.

The legal approaches followed to provide justice to the victim is encouraged by good scientific evidence reports in domestic violence case. Although governments keep amending laws to protect women from domestic violence the effectiveness of laws in reducing the incidences of violence has been limited due to several reasons. One major barrier is proving the incident in a court of law as often the testimony of the victim about the abuse changes due to social stigma. Intoxication cases cause a major problem not only for the victim but also for the multiple investigating agencies as the case needs forensic evidential justification to establish the nature of poisoning whether suicidal or homicidal, at the same time taking into account the circumstantial evidence collected during the process of investigation. Under these conditions, scientific evidence bridges the gap between crime and the victim to search for truth. Investigating Agencies play a very active role with strategic implications in gathering physical shreds of evidence along with proper medico-legal documentation followed by forensic analysis.

CONCLUSION

Due to social stigma even in today's time, domestic violence against women in India is way more than documented and therefore needs attention. United Nations claims violence against women is one of the widespread and devastating violations of human rights. Thus, each incidence matters in the survival of life and mental agony. Even though laws exist to control violence against women, the government needs to form a holistic approach including the whole of society to counter this crime. Homicidal poisoning by heavy metals including mercury is rare in today's conditions but forensic scientists and medical experts need awareness of the possibility of deliberate intoxication. From the eyes of forensic toxicologists in this study, analysis of case exhibits paved a path for discrete unblemished scientific evidence followed by chemical examination and confirmation by instrumental technique. Domestic violence is still a significant national problem but good scientific evidence can help the criminal justice system to work effectively and create a sense of fear among the culprits.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to Ms. Deepa Verma, Director, Forensic Science Laboratory GNCT of Delhi for her keen research interest. The authors are particularly grateful to Shri Srinarain, Head of Office, Forensic Science Laboratory GNCT of Delhi for his encouragement to write this research article.

CONFLICTS OF INTEREST

There are no financial, or other, reasons that could lead to a conflict of interest.

ETHICAL ISSUES

None

SOURCES OF SUPPORT

None

AUTHOR CONTRIBUTIONS

SS: Study conception and design, acquisition, analysis & interpretation of data, original draft, and editing; **KR:** Chemical analysis; **AR:** Interpretation of data & review of the draft.

REFERENCES

1. UN Women. *Types of violence against women and girls*. Available from: https://www.unwomen.org/en/what-we-do/ending-violence-against-women/faqs/types-of-violence [Accessed 04th Feb 2023].
2. Ministry of Health and Family Welfare of India. *National Family Health Survey (NFHS-3)*. Available from: http://motherchildnutrition.org/india/pdf/nfhs3/mcn-NFHS-3-Domestic-Violence.pdf [Accessed 01st July 2022].
3. Ministry of Health and Family Welfare of India. *National Family Health Survey (NFHS-5) 2019-2021*. Available from:

https://dhsprogram.com/pubs/pdf/FR375/FR375.pdf [Accessed 01st July 2022].
4. Dhawan H. Not rape, domestic violence is top crime against women. *Times of India*. 2020. Available from: https://timesofindia.indiatimes.com/india/not-rape-domesticviolence-is-top-crime-against-women/articleshow/78494876.cms [Accessed 01st July 2022].
5. Seth P. Decoding the extent to which domestic violence is under-reported in India. *The Wire.* 2021. Available from: https://thewire.in/women/domestic-violence-india-underreported [Accessed 01st July 2022].
6. Press information bureau, Ministry of Women and Child Development of India. *Increase in Domestic Violence against Women*. 2020. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=1797704 [Accessed 01st July 2022].
7. National Crime Records Bureau, Ministry of Home Affairs of India. *Empowering Indian Police with Information Technology*. 2022. Available from: https://ncrb.gov.in/en [Accessed 01st July 2022].
8. Supreme Court of India. *Hiral P. Harsora and Ors vs Kusum Narottamdas Harsora and Ors on 6 October.* 2016. Available from: https://www.aironline.in/legal-judgements/ [Accessed 31st July 2022].
9. Ishwari P. How to read Crime against women data? *The leaflet*. 2021. Available from: https://theleaflet.in/how-to-read-the-latest-crime-against-women-data/ [Accessed 01st July 2022].
10. United Nations. *International day for the elimination of violence against women, 25th November*. Available from: https://www.un.org /en/ observances/ending-violence-against-women-day [Accessed on 4th Feb 2023]
11. United states Environmental Protection Agency. How People are exposed to Mercury. 2022. Available from: https://www.epa.gov/mercury/how-people-are-exposed-mercury [Accessed on 30th June 2022].
12. Rao GS. Fatal mercury poisoning cases in forensic practice. *International Journal of Forensic Practice and Research*. 2013;3(1):7-12.
13. Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN. Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology.* 2014;7(2):60-72. https://doi.org/10.2478/intox-2014-0009.
14. Balali-Mood M, Naseri K, Tahergorabi Z, Khazdair MR, Sadeghi M. Toxic Mechanisms of Five Heavy Metals: Mercury, Lead, Chromium, Cadmium, and Arsenic. *Frontiers in Pharmacology*. 2021;12:643972. https://doi.org/10.3389/fphar.2021.643972.
15. Rustagi N, Singh R. Mercury and health care. *Indian Journal of Occupational and Environmental Medicine.* 2010;14(2):45-8. https://doi.org/10.4103/0019-5278.72240.
16. Albers A, Gies U, Raatschen H J, Klintschar M. Another umbrella murder? – A rare case of Minamata disease. *Forensic Science, Medicine and Pathology*. 2020;16:504–509. https://doi.org/10.1007/s12024-020-00247-y
17. Hitosugi M, Tojo M, Kane M, Shiomi N, Shimizu T, Nomiyama T. Criminal mercury vapor poisoning using heated tobacco product. *International Journal of Legal Medicine.* 2019;133:479–81. https://doi.org/10.1007/s00414-018-1923-4.
18. Lech T. Detection of mercury in human organs and hair in a case of a homicidal poisoning of a woman autopsied 6 years after death. *The American Journal of Forensic Medicine Pathology*. 2015;36:227–231. https://doi.org/10.1097/paf.0000000000000164.
19. Ramalingam S, Narayanan S, Narendar R. A suicidal heavy metal poisoning mimicking corrosive acid poisoning: A rare case report. *Indian Journal Forensic Community Medicine.* 2021;8(4):242-250. https://doi.org/10.18231/j.ijfcm.2021.049.
20. Kelly BD. Murder, mercury, mental illness: infanticide in nineteenth-century Ireland. *Irish Journal of Medicine Science*. 2007;176:149–52. https://doi.org/10.1007/s11845-007-0045-7.
21. Lu Q, Liu Z, Chen X. Mercury poisoning through intravenous administration: Two case reports with literature review. *Medicine.* 2017;96:e8643. http://dx.doi.org/10.1097/MD.0000000000008643.
22. Triunfante P, Soares ME, Santos A, Tavares S, Carmo H, Bastos MdeL. Mercury fatal intoxication: two case reports. *Forensic Science International*. 2009 Jan 30;184(1-3):e1-6. https://doi.org/10.1016/j.forsciint.2008.10.023.
23. Samuels ER, Heick HM, McLaine PN, Farant JP. A case of accidental inorganic mercury poisoning. *Journal of Analytical Toxicology*. 1982;6(3):120-2. https://doi.org/10.1093/jat/6.3.120.
24. Sarikaya S, Karcioglu O, Ay D, Cetin A, Aktas C, Serinken M. Acute mercury poisoning: a case report. *BMC Emergency Medicine.* 2010;10:7. https://doi.org/10.1186/1471-227X-10-7.
25. Yan P, Huang G, Li D, Li L. Homicide due to intravenous metallic mercury injection followed by sodium cyanide injection. *The American Journal of Forensic Medicine and Pathology.* 2012;33:273–5. https://doi.org/10.1097/paf.0b013e318221b693.
26. Goyal K, Sinha S. Forensic Identification of Sindoor Stain on Cloth as Trace Evidence Analysis- A Case Study from Delhi, India. *International Journal of Forensic Sciences.* 2020;5(2):000186. https://doi.org/10.23880/ijfsc-16000186.
27. United States Environmental Protection Agency. *Mercury, Health effects and Exposures.* Available from: https://www.epa.gov/mercury/health-effects-exposures-mercury [Accessed 30th June 2022].
28. Agency for Toxic substances and Disease registry, United States Department of Health & Human Services. *ToxFAQs for Mercury*. 2022. Available From: https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=113&toxid=24 [Accessed 30th June 2022].
29. Bernhoft RA. Mercury toxicity and treatment: a review of the literature. *Journal of Environment and Public Health.* 2012;1-10. https://doi.org/10.1155/2012/460508.
30. Park JD, Zheng W. Human exposure and health effects of inorganic and elemental mercury. *Journal of Preventive Medicine and Public Health*. 2012;45(6):344-352. https://doi.org/10.3961/jpmph.2012.45.6.344.

31. United states Environmental Protection Agency. Environmental Laws that Apply to Mercury. Available from: https://www.epa.gov/mercury/environmental-laws-apply-mercury [Accessed 30th June 2022].
32. Jaiswal AK, Millo T. *Handbook of forensic analytical toxicology*. Jaypee Brother's Medical Publishers (P) Ltd; 2014.
33. Sharma DC. Concern over mercury pollution in India. *The Lancet*. 2003;362(9389):1050. https://doi.org/10.1016/s0140-6736(03)14456-x.
34. Central Pollution Control Board. *Mercury-Environmental implications and Toxicity*. 2009. Available from: https://cpcb.nic.in/uploads/News_Letter_Mercury_2017.pdf [Accessed 12th July 2022].
35. Down To Earth. *India a Mercury hotspot*. Available from: https://www.downtoearth.org.in/news/india-a-mercury-hotspot-13770 [Accessed 12th July 2022].
36. Down To Earth. *Delhi's industrial areas are toxic hot spots, finds survey*. Available From: https://www.downtoearth.org.in/news/delhis-industrial-areas-are-toxic-hot-spots-finds-survey-45835 [Accessed 12th July 2022].
37. United States Environmental Protection Agency. International Actions for Reducing Mercury Emissions and Use. Available from: https://www.epa.gov/international-cooperation/international-actions-reducing-mercury-emissions-and-use [Accessed 30th June 2022].
38. Health and Environment Alliance (HEAL). *Mercury pollution- Where does it come from?* Available from: https://www.env-health.org/IMG/pdf/mercury_chapter2.pdf. [Accessed 30th June 2022].