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Brief Discussion on Mercury Poisoning, Its Sources and Remedies to Cure It

Tabinda Sattar

PhD Scholar, Institute of chemical sciences, Bahaudin Zakaraya University, Multan, Pakistan

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KEYWORDS

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ABSTRACT: The review briefly focuses the wide usage of sources of mercury, despite its hazardous effects. This study is aimed at the search for alternate sources of the mercury, in order to minimize its poisoning effects. This review elaborates the precautionary measures which may be adopted to reduce mercury poisoning. Due to its multifunctional properties in different fields of life, mercury has actually proved a necessary poison up till now. Previously mercury toxicity in human life was considered minimal because of ignorance about the hazards created by even very low amounts of mercury exposures to human body. Mercury poisoning can cause serious chronic and neurological disorders in humans if they are exposed to it for longer times. Fetal autism disorders areone of the critical aspects caused by mercury exposures of pregnant women. After Minamata mercury poisoning influences, there is a strict need to use alternative materials of mercury in order to reduce mercury poisoning. Methods to reduce mercury poisoning include the use of alternative materials like polymer resins rather than mercury.Case study of this review briefly discusses the mercury sources, mercury hazards and precautionary measures of mercury poisoning, related to present age. Concluding remarks elaborate that mercury poisoning can be reduced if some precautions are adopted.

INTRODUCTION

Mercury occurs naturally and is found throughout our environment. It is the only metal found in liquid state at room temperature and was known nearly 4000 years ago [1, 2]. Before going towards the beneficial and non-beneficial aspects, formerly we may talk about the main sources from which it entered into atmosphere. About 30, 000 to 150,000 tons of mercury added into air through the degassing of earth's crust and oceans [3-5]. Human activities such as burning of coal can release 2000 to 3000 tons of mercury in atmosphere. It is found in air, water and food [6, 7]. The estimated daily amount of consumption of mercury per person is 10.20 micro grams. One unique property of mercury is to form alloys with other metals except iron that is called amalgamation [8]. Now a day mercury is widely used in the fields medicine, dentistry, agriculture, mining and industry, due to its rare chemical and physical properties. Mercury is usually found in inorganic, organic, elemental and vapor forms [9-11].

Vapor mercury

Mercury vapors may be entered into atmosphere by out gassing of Mercury vapors especially from amalgams [12]. These vapors can cause significant toxicity if inhaled in

*Corresponding author: tabindasattarahsan22@gmail.com (T. Sattar)
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larger amounts continuously. Acute pneumatics, renal failure, neurological dysfunction and insomnia are some of the toxic effects of mercury vapors ingestion [13-15].

Inorganic mercury

Inorganic mercury can exist as elemental/metallic Hg^{o}, mercurous (Hg_2^{++}), mercuric(Hg^{++}). Mercuroros mercury in the form of salt is poorly soluble in water [16]. Research on mercurous mercury elaborate that it is a transitional state between metallic and mercuric mercury inside the human body [17]. Both the metallic and mercuric mercury possess a great tendency to adhere to sulfhydryl groups. Mercuric mercury is unable to cross the blood brain barrier, but it can adhere to the placental tissues and causing severe harm to fetal tissues and amniotic fluids [18]. Mercuric mercury deposits have been found in liver, epithelial tissue, choroidal plexus and testes. Inorganic mercury is highly poisonous, having caustic nature and can cause severe nausea, vomiting and cardiovascular collapse if inhaled accidently [19,20]. On the other hand, the short and long chain organic compounds (both alkyl and aryl) of mercury can enter into human body through sea food, thus causing neurological disorders in them [21]. Elemental form of mercury is usually considered as less toxic but can cause poisoning of low scale if ingested [22].

Organic mercury

Organic mercury compounds are very dangerous to human health. These are alkyl and aryl compounds of mercury and these compounds enter into the food chain through atmosphere and get their way to humans through seafood [23]. These organic mercury compounds have long half-lives and can stay in human stomach causing poisoning for a long time. Degenerative neurological disorders are some of the diseases which are caused by the organic mercury compounds usually present in industrial wastes [24]. Methyl mercury can very easily cross the placenta of a pregnant women. And it can result in still births and birth defects. Although no evidences about use of amalgam and pregnancy damage are present in literature [25].

As described in abstract that mercury has become a necessary poison now a day, because of its uses in major health fields [26]. This brief review on mercury poisoning is aimed at the brief discussion about mercury sources, in order to make familiar a common human being about the hazards that mercury can cause seriously and slowly [27]. This review is also aimed at the searching of alternate materials that can be adopted in order to reduce the hazards caused due to mercury. The major aim of this review is to provide some precautionary measures in order to reduce the mercury poisoning effects.

Although a large number of case studies have been reported in literature related to the mercury poisoning especially due to amalgams and sea foods. This review basically explains the methods to reduce mercury poisoning. Case study involves a general review report of the mercury poisoning and also searching for new alternatives to be used instead of mercury to reduce mercury hazards [27].

Major Sources of mercury compounds

Major sources of mercury compounds in atmosphere are the dental amalgams. Dental amalgam is actually a mixture of liquid mercury and metal alloy which is used to fill the cavities caused due to tooth decay [28]. Low copper amalgams consist of 50 percent mercury along with other trace metals. With the passage of time amalgam became a dental restorative material of choice due to its low cost, easy to apply and durable nature [29,30].

Preliminary research reports indicate that even very low amounts of mercury can cause poisoning [31]. Every time while chewing and brushing of the amalgamated tooth, very low amounts of elemental mercury enter into the atmosphere and we even do not know about it. According to World Health Organization (WHO) about 84% of the mercury exposures are due to amalgamated teeth.According to Maqbool et al. every day release of mercury from dental amalgam is about 30 micro grams per cubic centimeters.Research reports elaborate that the mercury can also bound other heavy metals thus causing an enhanced poisoning [32].

We are living in a world in which there are present electric and magnetic fields everywhere around us created by our mobile phones and other electronic devices [33]. These electric and magnetic field have effects on enhancing the mercury exposures from amalgamated teeth. These mercury release can cause serious neurological disorders in humans. The rate of autism spectrum disorders may be significantly high in those offspring having mothers with amalgamated teeth [34]. Actuallymercury levels in maternal exposure due to strong electromagnetic fields is increased to certain high levels. Offspring born from such mothers have high chances of having these autism spectrum disorders [35]. In this respect the research of Murtazavi*et al* is well to mention here. In 2014 about 1.5% of the offspring were detected with autism spectrum disorders having mothers with amalgamated teeth exposed to magnetic fields and this percentage is increasing every year [36]. Table 1 describes five very common sources of mercury.

Some research reports also indicate thatdental amalgams are safe as mercury used in it is in very low doses and if it is released in environment it is so minimal to cause poisoning [37]. But on the other hand research also says that even very low amounts of mercury can cause poisoning.Neghab et al have reported when dentists group and control group were tested, the disease like hyperpigmentation, respiratory disorders, moodiness, irregular pulse and chronic fatigue were more significant in dentists group as compared to controlled group. Moen et al have reported fatigue and sleep disturbances in dental care workers [38].

Sletvold et al reported the crucial relationship among the urine mercury levels and long term memory loss [39]. Ritichie et al have noted that while fixing age and gender, the urinary mercury concentrations were not associated to kidney problems in dentists. They also reported that number of dental fillings /removal per weak and urinary mercury levels were closely related [40]. Kersai et al have also reported the renal disorders in dentists dealing with amalgam fillings[43]. Yilmaz et al have reported that work place characteristics also greatly influence the mercury exposure levels [40].

Fish consumption is also considered a major source of mercury exposures in human beings. As discussed earlier that dentists dealing with mercury amalgams are more at risk for mercury exposures. Similarly, research reports also elaborate the fact that these dental dealing persons either they are dentists or dental specialists when tested (after eating fish) for mercury exposures were found with greater amounts of toenail mercury as compared to non-dental or control group persons [41-44].

Table 1. Five very common Sources of Mercury Exposures

	Sources	Mercury Limits	Mercury Forms	Mercury Exposure Routes		
				Inhalation	Oral	Dermal
1	Fish & Shellfish	0.73-0.99ppm	Inorganic (Hg^{2+})	Low	Medium	Medium
2	Dental Amalgam	100-1000mg	Elemental(Hg^{0})	High	Low	Low
3	Thimerosal Vaccines	12.5-25 µg	Organic(MeHg, EtHg)	Low	High	Low
4	Mercury Thermometers	500-54,000mg	Elemental(Hg^{0})	High	Low	Low
5	Florescent Light Bulbs	10mg	Elemental(Hg^{0})	High	Low	Low

Minamata disease

A chemical factory for the production of acetylene, acetaldehyde, acetic acid, vinyl chloride, and octanol was opened by the Chisso Corporationin Minamata in 1908.The production of acetaldehyde was started in 1932, producing 210 tons that year [45]. But this production jumped 6,000 tons per year up to1951 and had reached its apex production of 45,245 tons in 1960. The mercury sulphate was used as a catalyst for the chemical reaction to produce the acetaldehyde.An organic mercury compound, namely methylmercurywas released

into Minamata Bay a side reaction of this catalytic cycle [46].

Very first symptoms of Minamata disease appeared in a five-year old girl as difficulty in walking, difficulty in speaking, and convulsions. This led to official discovery of Minamata disease. Then there appeared several cases of cats where they got mad and ultimately die [47]. There were several cases in which crows were fallen dead from sky, no seaweed grew on the sea bed, fish floated dead on the surface of the sea. Researchers from Kumamoto University also began to focus on the cause of the strange disease. The main victims of this disease were those hunting fish at Minamata bay and those cats which used to eat scraps from family table were suffering from this strange disease [48]. So, the researchers were of the view that it was due to some kind of food poisoning which probably have some connection with sea food also. After more research it was assumed that this Minamata disease is caused due to fish eating and that fish would be the cause of heavy metal entering into human body [49].

After a continuous research it was observed by the researchers in 1959 that the symptoms of Minamata disease were resembled with those of symptoms of mercury poisoning. 705 parts per million (ppm) was the maximum mercury level which were recorded in hair samples of patients of mercury poisoning [50]. Mainly, the Minamata disease caused by the consumption of large quantities of fish and shellfish living in Minamata Bay and its surroundings and central nervous system is affected by it [51].

Minamata disease also called as Chisso-Minamata disease is caused by severe mercury poisoningIt is a neurological syndrome.Ataxia, numbness in the hands and feet, loss of peripheral vision, general muscle weakness and damage to hearing and speech are common signs and symptoms of this disease [52]. Insanity, paralysis, coma, and deathare the main results of Minamata disease in extreme cases. A fetuses in the womb can also be affected by the congenital form of the disease.

In Minamata city the Minamata disease was discovered for the first time in Kumamoto prefecture, Japan, in 1956. The main cause of this diseasewas the release of methylmercury in the industrial wastewater from the Chisso Corporation's chemical factory [56]. It continued from 1932 to 1968. From shellfish and fish, that highly toxic chemical was bioaccumulated in Minamata Bay and the Shiranui Sea. So when the local population ate them, it resulted in mercury poisoning [57]. The government and company paid only little attention to prevent the pollution, although cat, dog, pig, and human deaths continued for 36 years. The "dancing cat fever" was the main effect in animalsdue to this disease [58].

2,265 victims of Minamata disease had been officially recognised till March 2001. Among those 1,784 of were died.Financial compensation from Chisso was given to only10,000. $86 million in compensation was paid in 2004 by Chisso Corporation and in the same year it was also ordered to clean up its contamination [59]. Yet uncertified victims were given a settlement on March 29, 2010. In 965 at Niigata Prefecture, a second outbreak of Minamata disease occurred.Among the four big pollution diseases of Japan the original Minamata disease and Niigata Minamata disease were included [60].

Symptoms of mercury poisoning

Mercury poisoning can cause serious infection. Poor coordination muscle weakness, numbness in the hands and feet, anxiety, skin rashes, memory problems, trouble hearing, trouble speaking or trouble seeing are the main symptoms of mercury poisoning depending upon the type, dose, method, and duration of exposure. A very high level of exposure to methylmercury can cause the Minamata disease [61]. The pink disease (acrodynia) in which the skin becomes pink and peels may be due to mercury poisoning. Many long-term complications including kidney problems and decreased intelligence may be caused by methyl-mercury exposure in children. The effect of long-term low-dose exposure effects of methyl mercury is still not clear. Attempted suicide is a method of mercury poisoning. The amount of mercury may be tested in blood, urine, and hair but sometimes the results may vary from the actual amount of mercury present in body [62].

Peripheral neuropathy (paresthesia or itching) burning, pain, or even a sensation are very common symptoms of mercury poisoning [68]. It includes skin discoloration (pink cheeks, fingertips and toes); swelling; formication, resulted from the feelings of small insects crawling on or under the skin; desquamation, resulted from shedding or peeling of skin. Selenium-dependent enzymes are mainly irreversibly inhibiting and may also inactivate S-adenosyl-methionine, which is necessary for catecholamine catabolism by catechol-O-methyl transferase [60]. As body is unable to degrade catecholamines (e.g. epinephrine), so a person may experience profuse sweating, increased salivation, tachycardia (persistently faster-than-normal heart beat) and hypertension (high blood pressure) which are some of the common symptoms of mercury poisoning.

The main diagnostic steps of elemental or inorganic mercury poisoning will be the determination history of exposure, physical findings, and an elevated body burden of mercury [61]. Mercury concentrations in blood are usually 6 μg/L, but diets rich in mercury can enhance its level up to 200 μg/L. Although mercury has a short half-life in blood, so it is difficult to assess accurate levels of organic/inorganic mercury [62]. For a high level of diagnosis, urinary mercury level is more reliable than the whole-blood or hair analysis [63].

Minamata mercury convention

The protection from anthropogenic emissions and releases of mercury and mercury compounds are the main objective of the Minamata Convention. The provisions that include the entire life cycle of mercury controls and reductions across a range of products, processes and industries where mercury is used released or emitted is the main objective of this convention. The direct mining of mercury, its export and import, it's safe storage and its disposal once as waste are mainly addressed by the treaty [63]. Some of the implements of this convention may relate with pinpointing populations at risk, better training of health-care professionals and boosting medical care in identifying and treating mercury-related effects will be obtained.

The main point of focus of Minamata Convention is that the myriad of products containing mercury, the manufacture, import and export of will hopefully be altogether prohibited by 2020. But some countries have requested an exemption for an initial 5-year period [64]. Certain types of batteries, lamps such as compact fluorescent lamps, relays, soaps, cosmetics, thermometers, and blood pressure devices are among the mercury-emitting substances. This convention also regulated the amalgam based dental fillings which will be used with precautionary measures [64].

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An international treaty was designed to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds, which was named the Minamata Convention on Mercury [69]. After a time of three years of meeting and negotiating,this Convention was designed, after which the text of the Convention was approved by delegates representing close to 140 countries on 19 January 2013 in Geneva. It was adopted and signed later that year on 10 October 2013 at a Diplomatic Conference held in Kumamoto, Japan [69]. The name of the Convention was Minamata convention due to the name of the Japanese city Minamata, which suffered due to devastating incident by mercury poisoning. It is expected that this international agreement will enhance the reduction of mercury pollution over the next few decades, from the targeted activities responsible for the major release of mercury [69].

Toxicity of mercuryand mercury compounds to human health and the environmenthave long been known [91]. Minamata disease and Niigata Minamata disease were two large-scale public health crises due to mercury poisoning, which drew attention to the issue. Japanese junior high school student Shinobu Sakamoto, disabled as the result of methylmercury poisoning *in utero*was witnessed by delegates to the Stockholm Conference on the Human Environment in 1972. Shortly thereafter the UN Environment, previously UNEP (United Nations Environment Programme) was established [70]. First priority of UN Environment is to actively being engaged in bringing the science of mercury poisoning to policy implementation. Governing Council invited the Executive Director of UN Environment in 2001. To undertake a global assessment of mercury and its compounds, this council was designed. The long-range transport, chemistry, health effects and sources, prevention and control technologies relating to mercury were among the main purpose of this council [70].

There was sufficient evidence of significant global adverse impacts from mercury when the Governing Council considered this assessment in 2003 [71]. The risks to human health may be reduced from their release to the environment which owes to the main purpose of it. Governments were urged to adopt goals for a growing reduction in mercury emissions and releases. Technical assistance and capacity-building activities were initiated by UN Environment in order to meet these goals [71].

In 2005, the concerns posed by mercury was established by a mercury programme to address. UNEP Global Mercury Partnership further strengthened the governments in 2007. The options of enhanced voluntary measures and new or existing international legal instruments are involved in the conclusions made by the Governing Council in 2007, the main focus of which would be on the review and assessment in order to make progress in addressing the mercury issue [72]. A global legally binding instrument on mercury was made by the Governing Council of UNEP in February 2009.

For the negotiations made by the countries and the text of the convention, an intergovernmental negotiating committee (INC) was promptly established [73]. Other intergovernmental and non-governmental organizations including in the process, also participated as stakeholders, and shared views, experience and technical expertise [73]. Fernando Lugris of Uruguay chaired the Intergovernmental Negotiating Committee and Chemicals and Health Branch of UN Environment's Economy Division supported them. Five sessions were held by INC in Sweden, Japan, KenyaUruguay and Switzerland,20102011, 2011, 2012 and 2013 respectively in order to discuss and negotiate a global agreement on mercury [74].

140 governments agreed to the draft convention text on 19 January 2013. On 10 October 2013, the Convention was adopted and opened for signature for one year, at a

Conference of Plenipotentiaries (Diplomatic Conference) in Kumamoto, Japan [75]. It was further preceded by a Preparatory Meeting from 7–8 October 2013. The convention was signed by the European Union and 86 countries and it was opened for signature on the first day. On 11 October 213The Convention on the final day of the Diplomatic Conference was further signed by 5 countries. In total, the Convention has 128 signatories [103].Further it was proclaimed by Fernando Lugris, the Uruguayan chair delegate, that this all has been done in the name of vulnerable populations everywhere and it will represent an opportunity for a healthier and more sustainable century for all peoples [75].

To the preceding of the opening of the first meeting of the Conference of the Parties, the Convention intergovernmental negotiating committee was mandated further to the adoption of the Convention, which was further needed in order to meet during the interim period [76]. After that two sessions of the INC were held in Thailand and Jordan in 2014 and 2016 respectively.

Many technical, financial as well as administrative and operational aspects were covered in these discussions [78]. The deposit of fifty instruments of ratification, acceptance, approval or accession by States or regional economic integration organizations were main requirements of the Convention On 18 May 2017, This fifty-ratification milestone was reached, hence the first meeting of its Conference of the Parties was held on 16 August 2017 from 24 to 29 September 2017 in Geneva [78].

Replacement of amalgam with polymer resins

Several research reports on the hazardous effects of mercury amalgams have strengthen the use of some alternative materials for dental fillings [108]. Among these polymer resins are the best choice. But in spite of the mercury poisoning these amalgams have capability to tolerate the clinical conditions and also to tolerate the moisture which is a common thing during tooth restoration [109,110]. Polymer resins are quite sensitive to both of these factors discussed earlier. Also mercury contain property of bacteriostatic agent, but certain polymer resins can cause the growth of microorganisms in tooth filling thus creating some kinds of infections there [79]. Several reviews are present in literature which discuss about the use of resins as compared to amalgams. Previously research reports support the usefulness of dental amalgams and considering no side effects caused by mercury (perhaps negligible). But present minamata convention on mercury has focused the previous ideology to change and focus on the hazardous effects caused by mercury amalgams [80].

Recent research on New England children's amalgam trial have also supported the previous ideology about the longevity of amalgams in dentistry [80]. As compared to resins and composite resins mercury amalgams are long lived. A most recent research also describes the use of composite material instead of amalgams under circumstances where enamel sites or thevisible portion of tooth are the points of restoration according to cosmetic requirements [80].

Minamata convention on mercury was held in Kumamoto, Japan in October 2013 [81]. It was named after a Japanese city, Minamata which faced a devastating incident by mercury poisoning. Delegates of nearly 140 countries signed the convention. And it has become effective from 16 August, 2017 [81]. Convention writings consist of completely avoiding the mercury-based products by 2020. Although some countries have given a time of five years to manage mercury alternatives in all fields of life especially including dentistry(use of amalgam for cavity fillings) [82].

Precautionary measures to be adopted to reduce mercury poisoning

While talking about countries like United State, there was a common practice to dispose of mercury amalgamated waste into drain. These mercury poisons are not recycled and remain there causing poisoning [83].U. S. Environment protection agency in 2017 has approved a guideline to use mercury-based materials in which it is strictly prohibited to dispose the dental amalgams wastes in drain water [84]. Some precautions can be adopted in order to reduce the poisoning effects of mercury.

- Resin composites, glass ionomers and gold inlays are the materials that can be used in replacement to dental amalgams [85].
- It should be completely banned to dispose of the dental wastages in drain water outside the dental care offices in all countries of the world.
- A mercury separator should be arrangedin drain water so in case amalgam present in drain water can separate the mercury and recycle it.
- Dentists should make necessary precautions while dealing with amalgams. They should minimize the chances to come in direct contact with amalgams. They may use health friendly equipment during tooth fillings.
- Women should avoid the mercury amalgamated tooth fillings during pregnancy.
- Fish consumption should be low in mercury poisoning areas.
- Gold miners should use borax instead of mercury in order to extract and smelt gold. That will not harm the environment.
- Black-smiths should collect the mercury vapors into the dirt flask by using lid and pipe, in order to reduce mercury pollution.
- Dentists should make health checkups on monthly basis in order to know about any hazards created by mercury.
- An open public campaign should be raised by higher authorities at country level in the whole world in order to aware the common people about mercury poisoning.

CONCLUSIONS

In conclusion, this study focuses on the poisoning effects of mercury in a present modern age. Mercury remains always in our atmosphere due to radiations of electronic devices around us. And we, human beings silently consume it on daily basis even without knowing about it. But two major sources like mercury tooth amalgams and fish consumption have worse effects while transferring mercury in human beings. Although after Minamata mercury convention, some precaution measures have been adopted by European and United states. But still there is a need of making these precautionary arrangements in all other countries of world to reduce mercury poisoning. This study also discusses about the precautionary measures, which may be proved somewhat helpful for curing human beings from mercury poisoning.

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Conflict of interest

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