



CHRONIC TOXICITY OF MERCURY IN MODERN AND AYURVEDIC VIEW

Gupta Radha^{1*}, Malviya Anshu¹, Gothecha Vinod Kumar², Sharma Anita³, Porte Sharad⁴

¹M.D. Scholar, ²Professor, ³Associate professor, ⁴Lecturer, P.G. Dept. of Agad Tantra, National Institute of Ayurveda, Jaipur, India.

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ABSTRACT

Mercury or *Parad* (80Hg) is well known element due to its specific property and used in various field. It is naturally occurs in several forms include metallic (or elemental) mercury, inorganic mercury, and organic mercury. Due to the huge uses of mercury, it is rapidly comes in our environment. Mercury has various inorganic and organic Poisonous compounds like Mercuric chloride, Mercurous chloride, Mercuric sulphide, Mercuric sulphate, Mercuric cyanide, Mercuric nitrate, Methyl mercury, Dimethyl mercury and Phenil mercury. It leads to elevated blood mercury levels in the developing fetus or newborn child can cause a number of adverse health effects, including harm to neurological and hematological development. In adults, exposure can lead to memory loss and affect fertility and blood pressure. The chronic poisoning of Mercury called Hydrargyrisms having symptoms like anorexia, insomnia, abnormal sweating, headache, lassitude, anemia, lymphocytosis, constipation or diarrhea, jaundice etc and some Specific disease like Mercurial erethism, Mercurial lenticis, Acrodynia or pink disease, Minamata disease. In Ayurveda various *doshas* are mentioned in various *Ras granthas* which is seen in use of *Ashodhit parad*. It is also mentioned that the *shudh sanskarit parad* is not toxic and shows rognashak property and act as medicine. So in the present era the toxicity of mercury is produced by the *Ashudh* form of mercury. Here discussing the symptom produced by the *Ashudha parad* and the symptom produced by toxicity of mercury and correlating them.

*Address for correspondence

Dr. Gupta Radha

M.D. Scholar,

P.G. Dept. of Agad Tantra,

National Institute of Ayurveda,

Jaipur, India.

Email: guptaradha242@gmail.com

INTRODUCTION

Mercury poisoning has been recognized as a serious threat to public health for many years. Mercury (80Hg) is a metal that occurs naturally in several forms. These include metallic (or elemental) mercury, inorganic mercury, and organic mercury. Metallic mercury (also called quicksilver) exists as a liquid above -380 F, vaporizes at a low temperature, and conducts electricity well. Because of these features, there have been many industrial and electronic uses. Metallic mercury has a high affinity for gold and silver making it useful in the mining and metal industries. Inorganic mercury compounds occur when mercury combines with elements such as chlorine, sulfur, or oxygen to form mercury salts. Organic mercury results when mercury combines with carbon containing compounds. Inorganic and organic mercury compounds are used to make pigments, Thimerosal (a medical preservative), and dental amalgams. Historically, mercury has had other medicinal uses.

In the environment, mercury comes from both natural and industrial sources. Mercuric sulfide, or

cinnabar, is the main natural form of mercury. The concentration of mercury in the environment varies depending on location and natural history. Mercury is easily mobilized and is found in the air, water, and soil^[1].

Aim and Objectives

To evaluate, and discussed the sources of chronic toxicity of Mercury and its manifestation.

To correlate the Ayurvedic view of *Parad dosh* and their symptoms with the chronic toxicity of mercury in present era.

Material and Method

The text book of Ayurveda along with its respective commentaries has been review thoroughly. The text book of modern medicine and index medical journal has been also referred to review of material of consent topic.

Epidemiology

EBMLs (Elevated blood mercury levels) in the developing fetus or newborn child can cause a number of adverse health effects, including harm to neurological and hematological development. There is no level of blood mercury that is considered safe. Mercury contamination in water in India is verging on alarming situation due to discharge of industrial effluents containing mercury ranging from (0.058-0.268 mg/l) against 0.001mg/l. as per WHO and Indian standards. The concentration of mercury in blood and hair of human population has been reported as high as 100 µg/dl and 8 µg/g respectively at industrial site compared to 5 µg/dl. and 1 µg/g, respectively in unexposed population [2].

In the 1950s, an acetaldehyde factory of the Chisso Chemical Company polluted Minamata Bay, Japan, with large amounts of methylmercury, and a similar operation polluted the ocean near Niigata. In both areas the mercury accumulated to very high levels in fish, and residents who ate locally-caught fish were exposed to extraordinarily high methylmercury doses. More than 2,200 people were officially diagnosed as severely poisoned; additional tens of thousands were exposed to high doses and were less severely affected. These recent studies make it clear methylmercury exposure poses risks not just for populations with unusually high fish consumption; it is also a concern for people who eat everyday amounts of fish and have mercury exposure in the high region of the typical range. These studies provide no evidence of a threshold below which adverse effects are unlikely. The studies suggest that perhaps 10 percent of pregnant women and young children in the US and Europe, and undoubtedly a larger fraction than that in countries where fish is a more important part of the diet, are at risk for significant damage to the children's developing brains, from the methyl mercury in the ordinary amounts of fish they eat [3].

Physical Properties

- Atomic number - 80
- Molecular weight- 200.59 daltons
- Specific gravity- 13.56
- Relative density- 12.59
- Freezing point- 36°C
- Melting point - -35.87°C
- Boiling point - 357.25°C [4]

Mercury is the only metal that is liquid at room temperature. It exists in three forms – metallic (Hg^0), mercurous (Hg_2^{2+}) and mercuric (Hg^{2+}). Metallic mercury, also known as quick silver, is a liquid metal having a bright silvery luster. The metal is not acted upon by hydrochloric acid. It is slightly dissolved by dilute cold sulphuric acid but completely dissolved by strong sulphuric and nitric acids [5].

It is easily converted into a dull grey powder when shaken up with oil or triturate with sugar, chalk or lard. The process is known as deadening and is used in preparing mercurial ointment and emplastrum [6].

Metallic mercury is not poisoning if taken by mouth because it is not absorbed or poorly absorbed from GIT. It vaporizes even at room temperature to an extent sufficient to permit the inhalation to toxic amounts [5].

Poisonous Compounds of Mercury

Inorganic Salts

Mercuric chloride or corrosive sublimate ($HgCl_2$) – is available as colourless prismatic crystals or as crystalline powder. It is odorless but has a burning metallic taste. It is used in medicine, in laboratories, as preservative, and in industries. It is the most toxic salt and commonly the cause of acute poisoning.

Mercurous chloride or Calomel (Hg_2Cl_2) – This is known as subchloride of mercury. It is heavy, amorphous, white and tasteless powder. It is insoluble in water and its insolubility is the greatest bar to its toxicity. It is used as purgative as it is nontoxic for human consumption in therapeutic dose [7].

Mercuric sulphide (Cinnabar, Hingul, Ras sindoor, Singarf) (HgS) – It occurs as the chief ore of mercury and is artificially prepared as a red, crystalline powder, which is then known as the pigment vermilion. It is regarded non-poisonous, but its vapours are poisonous. It is not absorbed through the skin. Cases of acute poisoning have occurred from its use as a fumigant. Chronic poisoning has also occurred from it having been used to colour vulcanized rubber meant for artificial teeth. It is used in tattoos on man is known to have caused pruritis and nodular swellings following exposure to the sun [8].

Mercuric Sulphate ($HgSO_4$) – It is a white crystalline powder and acts as a corrosive poison. It has been administered in mistake for sulphocarbonate of sodium and has caused death. It has also been taken with a suicidal intent [8].

Mercuric Cyanide ($Hg(CN)_2$) – It is a fungicide nearly as poisonous as a corrosive sublimate, but has no corrosive action. It exists as white, prismatic crystals, having a bitter, metallic taste but no odour [9].

Mercuric Nitrate ($Hg(NO_3)_2$) – It is crystalline, but deliquescent. It is used for painting on porcelain, and in veterinary medicine. It is also used by hatters and furriers, who are liable to develop chronic poisoning. It acts as a corrosive poison and is similar in action to Mercuric chloride [10].

Organic Salts

Methyl mercury, Dimethyl mercury, Ethyl mercury, Phenil mercury.

Mercury dimethyl (Mercuric Methide) ($Hg(CH_3)_2$) – It is a highly poisonous liquid and has

caused death by the inhalation of its noxious vapour. It also produces insanity^[10].

Etymology and History

The symbol for the planet Mercury (☿) has been used since ancient times to represent the element. Mercury was found in Egyptian tombs that date from 1500 BC. In China and Tibet, mercury use was thought to prolong life, heal fractures, and maintain generally good health, although it is now known that exposure to mercury vapor leads to serious adverse health effects. The first emperor of China, Qín Shǐ Huáng Dì—allegedly buried in a tomb - the "Mausoleum of the First Qin Emperor" - that contained rivers of flowing mercury on a model of the land he ruled, representative of the rivers of China—was killed by drinking a mercury and powdered jade mixture formulated by Qin alchemists (causing liver failure, mercury poisoning, and brain death) who intended to give him eternal life. In November, 2014 "large quantities" of mercury were discovered in a chamber 60 feet below the 1800 year old pyramid known as the "Temple of the Feathered Serpent," "the third largest pyramid of Teotihuacan," Mexico along with "jade statues, jaguar remains, a box filled with carved shells and rubber balls." The ancient Greeks used mercury in ointments; the ancient Egyptians and the Romans used it in cosmetics which sometimes deformed the face. In Lamanai, once a major city of the Maya civilization, a pool of mercury was found under a marker in a Mesoamerican ball court. By 500 BC mercury was used to make amalgams (Medieval Latin amalgama, "alloy of mercury") with other metals. Alchemists thought of mercury as the First Matter from which all metals were formed. They believed that different metals could be produced by varying the quality and quantity of sulfur contained within the mercury. The purest of these was gold, and mercury was called for in attempts at the transmutation of base (or impure) metals into gold, which was the goal of many alchemists. Hg is the modern chemical symbol for mercury. It comes from hydrargyrum, a Latinized form of the Greek word hydrargyros, which is a compound word meaning "water-silver" (from hydr-the root of "water," and argyros "silver") - since it is liquid like water and shiny like silver. The element was named after the Roman god Mercury, known for his speed and mobility. It is associated with the planet Mercury; the astrological symbol for the planet is also one of the alchemical symbols for the metal; the Sanskrit word for alchemy is Rasavātam which means "the way of mercury". Mercury is the only metal for which the alchemical planetary name became the common name. The mines in Almadén (Spain), Monte Amiata (Italy), and Idrija (now Slovenia) dominated mercury production from the opening of the mine in Almadén 2500 years ago, until new deposits were found at the end of the 19th century^[11].

Routes of Exposure

Inhalation

Inhalation of mercury vapor is the primary route of exposure to elemental mercury. Inhaled vapor is almost completely absorbed by the lungs about up to 80%. Neither liquid mercury nor mercury vapor has an odor and thus, chemical odor provides no warning of hazardous concentrations. Mercury vapor is heavier than air and may therefore accumulate in poorly ventilated or low-lying areas.

Children exposed to the same levels of mercury vapor as adults may receive larger doses because they have greater lung surface area:body weight ratios and increased minute volumes: weight ratios. In addition, they may be exposed to higher levels than adults in the same location because of their short stature and the higher levels of mercury vapor found nearer to the ground.

Skin/Eye Contact

Elemental mercury vapor is very slowly absorbed through the skin in high concentrations, but causes irritation of both skin and eyes and may produce contact dermatitis.

Ingestion

Elemental mercury, a liquid at room temperature, is essentially nontoxic when ingested because virtually none (less than 0.1%) is absorbed. Anatomic gastrointestinal abnormalities such as enteric fistulas or intestinal perforation can sequester sufficient quantities of ingested elemental mercury to allow significant oxidation and subsequent absorption^[12].

Biggest Sources of Mercury Pollution

Warnings about mercury in fish and seafood have gotten plenty of attention in recent years. But where does all that mercury come from in the first place? Apparently, the largest sources of mercury emissions into our air and water are going all but unnoticed. A new study published in the *Journal of Environmental Monitoring* has found that mercury in the atmosphere is an oft-ignored form of air pollution, especially in urban areas where concentrations can reach dangerously high levels. The U.S. Environmental Protection Agency (EPA) has been lax in its enforcement of mercury-pollution standards over the past decade, exempting major polluters. Mercury is a neurotoxin that can harm the developing brains of children and infants; in adults, exposure can lead to memory loss and affect fertility and blood pressure.

Biggest Emitters of Mercury into the Environment

1. Coal-fired power plants- Mercury exists naturally in coal, making coal-fired power plants the largest source of mercury pollution in this country. Coal accounts for nearly 50 percent of the electricity generated in this country—and almost 50 tons of mercury emissions annually.

2. Cement kilns- According to the non-profit law firm Earth justice, all the cement kilns in the U.S. combined pump out roughly 23,000 pounds of mercury every year. The mercury comes from coal, which is used to fuel the cement-manufacturing process, as well as limestone, another natural source of the heavy metal. The group released a report last July finding that, individually, some cement kilns emit nearly one and a half times more mercury than the most polluting coal-fired power plants. But because there are fewer kilns, they account for lower levels of atmospheric mercury overall than coal plants.

3. Chlor-alkali plants- Chlorine bleach, laundry detergent, cheap vinyl purses, shoes, and toys made with polyvinyl chloride (or PVC)—making all these products required the use of chlorine gas at some point. The chlor-alkali plants that produce it use mercury to convert salt to chlorine gas, and to convert salt to caustic soda, or lye, which is then used in products like detergent, plastics, and bleach. The nonprofit Natural Resources Defense Council (NRDC) says that while most modern chlor-alkali plants have switched to mercury-free technology, there are still seven plants in the U.S. that use it, and each one has roughly 200 tons of mercury on site at any given time. An unknown amount of that mercury gets lost during manufacturing, whether to the air or surrounding waterways; a 2006 report from NRDC found that operators at four of these plants could account for only 29 of the 159 tons of the mercury they used from 2000 to 2004. (As Rodale News reported earlier this year, some of those plants also make the ubiquitous food ingredient high-fructose corn syrup, and may be tainting food products with mercury).

4. Trash incinerators- Hazardous waste, medical waste, and regular garbage incinerators release 13.1 tons (or about 26,000 pounds) of mercury every year, according to statistics from the EPA. The mercury comes from common household items, such as compact fluorescent light bulbs and thermostats, and from automobile scrap. Despite common perceptions that mercury is used in thermometers and blood pressure machines, the medical industry has switched to mercury-free versions of those tools, and medical waste now accounts for the smallest percentage of mercury emissions from incinerators.

5. Gold mining- According to those same EPA statistics, 11.5 tons of mercury each year are released from gold mining, often called the most polluting industry in the world. Historically, mercury was used to separate gold from mined ore, but in Nevada, which accounts for 80 percent of the gold mined in the U.S., the ore itself contains mercury. The mercury is released when gold is heated to separate the two. The nonprofit group Earthworks estimates that gold mines account for nearly 25 percent of the mercury emissions west of Texas, and it's not just the existing mines that pose problems. Mercury can seep out of long-abandoned gold mines, most of which are in California, which continue to release mercury from underground pools

of mine tailings, despite the fact that they've been closed since the end of the 19th century. The U.S. Geological Survey estimates that mine waters and sediments in these areas today release hundreds to thousands of pounds of mercury every year^[13].

Uses

Medicine- Disinfectant, Dental amalgam, purgative, diuretic, and earlier used in the treatment of syphilis.

Industry- Manufacture of thermometer, Barometer, calibration instrument, fluorescent, mercury vapor lamp, electrical equipment, explosive and fire work.

Miscellaneous- Electroplating, photography, insecticide, germicide, constituent of finger print powder, paints and embalming fluid^[7].

Action

Mercury binds with sulfhydryl groups resulting in enzyme inhibition and pathological alteration of cellular membrane. Elemental mercury methyl mercury is toxic to the CNS. Metallic mercury vapor is also a pulmonary irritant. Inorganic mercury salts are corrosive to the skin, eyes, GIT, and nephrotoxic. Inorganic and organic forms may cause contact dermatitis^[7].

Absorption Fat and Excretion

Mercuric chloride and some other mercurial salts being soluble in gastric juice are readily absorbed through GIT. Vapor of mercury salts are also well absorbed through the respiratory tract, through vaginal tract (douche), and urinary bladder (mercurial antiseptic washing agent). Skin ointment of mercury used for a long period may cause chronic poisoning. After absorption mercury get deposits on other tissue of body, particularly in liver, kidney, spleen, and bones. When absorbed by way of inhalation maximum concentration occurs in brain tissue.

In toxic death the concentration in liver may go as high as 1mg/100gm and the concentration of kidney up to 2mg/ gram. Organic mercurial compound pass placental barrier and foetus may have more concentration of methyl mercury than the mother. Mercury is mainly excreted through the kidney, liver (bile), and large intestine^[14].

Parad Dosh

There are various *doshas* are mentioned in various Rasa granthas. According to Rasrastnasamuchaya the *Parad dosha* is 12 in number, which are divided into three types. This three types are-

- 1) *Nesargik dosha- Visha, Vanhi, Mala*
- 2) *Yogik dosha- Naga, Vanga*
- 3) *Saptakanchuk dosha- Parpati, Patani, Bhedi, Dravi, Malakari, Andhakari, Dhvankshi*^[15,16]

S. NO.	Granth	Dosh no.	Dosh	Karma
1	Ras Ratna Samuchchay	12	Visha	Maran (Death)
			Vahni	Santap (burning sensation)
			Mala	Murcha (unconscious)
			Naga	Jadya (rigidity)
			Vanga	Aadhyaman (tympanitis) Kushtha (skin disorder)
			Bhumij	Kushtha (skin disorder)
			Girij	Jadya (rigidity)
			Varij	Vata sanghata (Flatulense)
			Dve Naga	Vatadi dosha
			Dve Vanga	
2	Rasa Tarangani	8	Visha	Mratyu (Death)
			Vahni	Santap (Burning sensation)
			Mala	Vanhiruja (Burning pain)
			Chapalya	Beejnash (Aspermia)
			Giri	Sphota
			Naga	Vrana (Wound)
			Vanga	Kushtha (skin disorder)
			Asahyagni	Moha (Clouding of consciousness)

Shodhana of Parad (Purification Of Mercury)

There are two types of *Shodhan* mention in *Rasa granth* for *Dosha nivaran* (Purification) of *Parad*^[17].

- Samanya Shodhan:-** The *Parad* is mixed with equal quantity of lime and *Mardan* for 3 days and then separate it. Now it is mixed with Garlic and Salt in *Kharal* (Pestle) to *Mardan* till the Garlic paste become black. Now it is washed with water or *Kanji*.
- Vishesh Shodhan:-** *Shodhan* for the specific *Doshas* of *Parad*. In this *Parad* is mixed with specific drugs for the *Mardan* in *Kharal* and then wash with water or *Kanji*.

Dosha	Vishesh shodhan (Mardan by following drug and then Prikshalan (wash) by Kanji or water)
Visha Dosha	Triphala
Vahni Dosha	Chitrak
Mala Dosha	Aragvadha
Chapalya Dosha	Krishna Dhatura
Giri Dosha	Trikatu
Naga Dosha	Graha dhum + Ishthika churna+ Haridra
Vanga Dosha	Indrayan+ Ankol+ Haridra
Asahyagni Dosha	Gokshur

Chronic Poisoning (Hydrargyrisim)

This may occur due to- after effects of acute attack, excessive therapeutic use, injudicious medical use, if an ointment is used as an external application for a long time, continuous accidental absorption in individuals working with the metal or a salt as in the manufacture of thermometer, barometers, fur felt and ultraviolet apparatus or in police personnel engaged in fingerprint detection work where the powder contains mercury^[18]

Symptoms

The chronic toxicity of Mercury produces symptom like nausea, digestive disturbance, colicky pain, vomiting diarrhea, salivation is a constant symptom, which is accompanied by foul breath, swollen and painful salivary glands, inflamed and ulcerated gums, which occasionally presents a brownish blue line at their junction with the teeth,

later, the teeth may become loose and rarely necrosis of jaw develops. Evidence of nephritis may be seen. Chronic intoxication from inhalation of mercury vapor produces a triad of tremors, neuropsychiatric disturbance and gingivostomatitis. Chronic ingestion causes constant metallic taste, loss of weight, anorexia, insomnia, abnormal sweating, headache, lassitude, anemia, lymphocytosis, constipation or diarrhea, jaundice, increased urination, restricted field of vision, irritation of skin, sore mouth and throat, chronic inflammation of kidneys and impairment of renal function, CNS toxicity and impairment of motor speed, memory and coordination.

CHARACTERISTIC FEATURES

Intention tremors (Danburg tremors/ shaking palsy)- It occurs first in the hands (fingers), then progress to the lips and tongue and finally moves the arms and legs.

Tremor is moderately course and is interspersed by jerky movements. The patient may not display much tremor during an accustomed job, but if he is being observed, he may being to shake violently.

In the advanced stage, the person is unable to dress himself, write legibly, or walk properly. They are also called hatter's shake or glass blower's shakes, as they are common in persons working with mercury in glass-blowing and hat industries. The most severe form of tremors is known as concussion mercurilis when literally no activity is possible.

Mercurial erethism- Erethism is seen in persons working with mercury in mirror manufacturing firms. This cluster of symptoms was first described by kussmahl and the term is used to refer to the neuropsychiatric effects of mercury toxicity. These includes insomnia, anxiety, depression, amnesia, timidity, shyness, frequent blushing, explosive irritability, loss of confidence, feeling of embarrassment, suicidal melancholia, delusions, hallucinations, emotional instabilities-sudden attacks of anger

Mercurial lentis It is a peculiar eye change due to exposure to mercury vapour. It is due to brownish deposit of mercury through the cornea on the anterior lens capsule. Slit lamp examination gives a malt brown reflex from the anterior lens capsule. It is bilateral and has no effect on visual acuity.

Acrodynia or pink disease- It is seen mostly in children due to idiosyncratic hypersensitivity reaction to repeated ingestion or contact with Hg. There is pain in the extremities, flushing, itching, swelling, tachycardia, hypertension, excessive salivation or perspiration, weakness, irritability, pinkish morbilliform/ acral rashes and desquamation of palms and soles.

Minamata disease It is due to chronic mercury intoxication caused by eating contaminated fish and shellfish. Symptoms includes disturbances in hand coordination, gait and speech ,chewing and swallowing difficulty, visual blurring, tremors, rigidity, seizures and clouding of consciousness [19,20,21]

RESULTS AND DISCUSION

Mercury has ability to alloy with most metals, liquidity at room temperature, ease of vaporising and freezing and electrical conductivity make mercury an important and very popular industrial metal. It has 3,000 industrial uses, primarily in the caustic soda-chlorine production, the manufacturing of thermometers and other instruments and of electrical apparatus, as well as the formulation of various compounds. Paints and industrial instruments are also among the major uses of mercury [22].

Mercury has various inorganic and organic Poisonous compounds like Mercuric chloride, Mercurous chloride, Mercuric sulphide, Mercuric sulphate, Mercuric cyanide, Mercuric nitrate, Methyl

mercury, Dimethyl mercury and Phenil mercury. The biggest emitters of mercury into the environment are coal-fired power plants, cement kilns, chlor-alkali plants, trash incinerators, gold mining. It leads to elevated blood mercury level in human being. The mercury is bioaccumulat in the body and show Biomagnification. The Biomagnification is progressive accumulation of heavy metals by successive tropic levels. Once in aquatic systems, mercury can exist in dissolved or particulate forms and can undergo a number of chemical transformations. Inorganic mercury becomes methyl mercury, which is organic, toxic and persistent, travelling from one medium to another in the environment. Methyl mercury is most harmful to humans and wildlife due to its ability to bioaccumulate in the food chain. This results in its building up as it goes up the aquatic food chain [23].

The toxicity of Mercury is occurred due to Inhalation, Ingestion, contact on skin and eye.

After absorption mercury get deposits on other tissue of body, particularly in liver, kidney, spleen, and bones. When absorbed by way of inhalation maximum concentration occurs in brain tissue. Organic mercurial compound pass placental barrier and foetus may have more concentration of methyl mercury then the mother. Mercury is mainly excreted through the kidney, liver (bile), and large intestine [14].

The chronic toxicity leads to various characteristics features like Intention tremors, Mercurial erethism, Mercurial lentis, Acrodynia or pink disease, and *Minamata* disease and symptoms like Clouding of consciousness, skin disorder, Burning pain, Burning sensation, rigidity. These Symptoms are very similar to the symptom produced by administration of *Dosh yukta parad* as mentioned in Ayurveda. In present era no body use the shodhit mercury for its use except Ayurvedic *Rasa Aushadh* because of this the mercury which enter in the body by environment, food, water in any route is *Ashudh* mercury which causes the toxicity of Mercury.

CONCLUSION

The chronic toxicity of mercury is very saver problem for the world, it leads hazardous effect on human being in all age group specially infants and growing children. Ayurveda already mentioned this type of toxicity which is developed by the use of *Ashudh* Mercury. And also mentioned that the use of *Sudha parad* does not produce any toxicity rather it has *Rognashk* properties.

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