



Toxicological Aspect of *Somala Dhatu Visha* (Arsenic) and Its Recent Advances – A Review

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ABSTRACT: Human health is mainly depends on our surrounding environment. Arsenic is present in air, water, soil and food hence affecting many people across the world. Arsenic toxicity is now global health problem. The main source of arsenic toxicity is contaminated drinking water. In Ayurved Samhita *Somala* (Arsenic) is described as *Sthawar Dhatu Visha*. *Acharya Sushruta* first described *Somala* as *Dhatu Visha*. In *Rasashastra* *Somala* (Arsenic) is classified under *Sadharana Rasa*. Instead of highly toxic in nature Arsenic in proper dose act as medicine. It is use in many Ayurvedic medicinal preparations. Different compounds of Arsenic are used as insecticides, weedkiller, rodenticide, in flypaper, for sheep deep, as fruit spray, in medicine, as depilatory, colouring agent, and in industries. Arsenic trioxide is now used to treat acute promyelocytic leukaemia. Arsenic is mainly use to treat syphilis since ancient time. Arsenic is often used as a part of extremely diluted homeopathic remedies. Its improper medical use leads to accidental poisoning hence it should be take in proper doses. Arsenic is easily available and cheap hence it is use as homicidal agent in India. Inorganic Arsenic is carcinogenic to humans. Most of population get indirectly exposed to Arsenic as it is accumulates in rice plants in large quantity and in drinking water. This study is design to elaborate toxicological properties of Arsenic, its various sources of poisoning so that everyone should aware of its lethal effect on human being and its recent advances.

KEY WORDS: Arsenic, *Somala Dhatu*, toxicological aspect, recent advances, sources.

INTRODUCTION

Metallic arsenic is not poisonous, as it is not absorbed from alimentary canal. When volatilised by heat, arsenic unites with oxygen and forms poisonous vapour of arsenic trioxide^[1]. According to Ayurved also *ashuddha* (impure) *Somala* is like poison. It causes many diseases. It leads to *daha*, *chittabhrama*, *atilalastrava*, *atitrushna*, *vamana*, *virechana*, many types of *vedana*, many types of *vyadhi*, and *mrutyu*^[2]. Arsenic inactivates upto 200 enzymes which are involved in cellular energy pathway and DNA synthesis and repair^[3]. Exposure to arsenic leads to many diseases such as cancer of many organs, arsenical dermatosis, arsenical neuropathy, pulmonary, cardiovascular, liver diseases, diabetes mellitus and gastrointestinal disorders^[4]. Arsenic use in medicines since ancient time, it is also use in Ayurvedic and Homeopathic medicine, therefore these medicines should take in proper dose under proper guidance and supervision of qualified practitioner^[5]. At present compare to acute poisoning there are more cases of chronic arsenic toxicity. Population is now directly expose to arsenic in drinking water and environment.

Long term exposure to arsenic can cause cancer and skin lesions. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults^[6].

This study is design to elaborate poisonous compounds of arsenic and its toxicity. Sources of arsenic through which human being get exposed to it and facing many health problems. Recent studies are done to explain how long term arsenic exposure causes many diseases. Therefore it is necessary to develop new techniques to minimize arsenic content in ground water and soil.

REVIEW OF LITERATURE

In Ayurved Samhita *Somala* is described as *Sthawar Dhatu Visha*. Acharya Sushruta first described *Somala* as *Dhatuvisha*^[7]. In *Rasashastra* it is described as *visha*. In *Rasashastra dravya* are classified according to their *rognashak guna* (medicinal uses), and hence *Somala* classified under *Sadharana Rasa*^[8].

Synonyms of *Somala* : *Shankhamusham, Dalmusham, Shanakhavisham, Darumoch, Gauripashankam, somal, Aahkupashan, Mushak, Raktchurn, Mallak, Vikat, Rasabandhakar, Vyaktdeh, Hatchurnak, Fenashmbhasm, Sambalam*^[9].

Gunkarma (properties)^[10]

Guna : *Laghu*(light), *Ruksha*(dry), *Tikshna*(sharp)

Rasa : *Katu*(Bitter)

Virya : *Ushna*(Hot)

Doshagnata : *Kaphavata*shamak

Properties of impure Arsenic (*Ashudha Somala Dhatu*)^[11]

In *Ayurveda* Acharya said *ashuddha* (impure) *Somala* is like poison. It causes many diseases. It leads to *daha, chittabhrama, atilalastrava, atitrushna, vamana, virechana*, many types of *vedana*, many types of *vyadhi*, and *mrutyu*.

Compounds of Arsenic^[12]

1. Arsenious Oxide or Arsenic Trioxide (Sankhya or Somalkhar) (As_2O_3) - Arsenious oxide is commonly known as white arsenic or arsenic. It is white, gritty, crystalline powder or in the form of solid mass or cake. It is largely used in calico printing, in taxidermy, in preparations of wallpapers and artificial flowers and as mordant in dyeing. It is principal ingredient of flypapers and many powders and pastes used for killing rats and vermin. It is an adulterant of complexion or violet powders. In India it is used for preserving timber and skins against white ants. It is frequently used by hakims and vaidyas in treatment of fever, rheumatism, skin disease, syphilis and impotence. It is also used in insecticides, paints, ceramics and for preparation of textiles, leather and furs.
2. Arsenites – Arsenites are more toxic than arsenates. It is commonly used as a poison.
3. Potassium Arsenite (K_3AsO_3) and Sodium Arsenite (Na_3AsO_3) – Potassium and sodium arsenates are poisonous , freely soluble in water and used in manufacturing flypapers, sheep-dips, weed – killers, rodenticides and fungicides.
4. Copper Arsenites (Scheele' s Green) $CuHAsO_3$ and Copper Aceto-Arsenite(Paris Green, Schweinfurt Green or Emerald Green), Hirwa $Cu(C_2H_3O_3)_3 \cdot 3Cu(AsO_2)$ – These salts were used for colouring artificial flowers, wallpapers, articles of dress, toys and sweetmeats.
5. Arsenic acid (H_3AsO_4) – It is used in manufacturing aniline dyes and flypapers. It is less poisonous than arsenious acid.
6. Arsenates – Arsenic acid combines with metals to form salts, called arsenates. These salts are poisonous and used for homicidal purposes and for destroying cattle.

7. Arsenic Sulphides – Arsenic sulphides are found naturally as the ores of arsenic, these are realgar (*manseel*), red arsenic or arsenic disulphide (As_2S_2) and orpiment (*hartal*), yellow arsenic or arsenic trisulphide (As_2S_3). Both are used as pigments in the field of arts.

Organic compounds of Arsenic – The important organic compounds of arsenic which are now rarely used in medicine are cacodylic acid, sodium cacodylate, atoxyl, stovarsol, tryparsamide, salvarsan, neosalvarsan, silver salvarsan and sulpharsenobenzene.

SOURCES OF ARSENIC

Drinking water^[13] - Naturally occurring arsenic contamination of groundwater causes serious chronic public health risk. At least 70 countries and more than 140 million people are affected due to contaminated drinking water. Value for arsenic in drinking water was 50 parts per billion (ppb) 4 over a lifetime of exposure but this was revised in 1993 and now it is set at 10ppb due to high risk of death by cancer. Arsenic is readily absorbed in uterus increasing the risk of stillbirth and the intake of arsenic by children increases the risk of impaired intellectual development and associated impacts later in life. Other sources of arsenic exposure include food (from crops irrigated with water contaminated with arsenic that is then transferred into the food) or air (from the burning of contaminated coal or plant matter that has been irrigated with arsenic contaminated water). Top soil irrigated with arsenic- contaminated water can affect crops even after irrigation has ceased. Arsenic is also toxic to the crops. Increasing levels of arsenic in the soil also have a significant negative effect on crop yields. Human activities such as mining and geothermal changes such as volcanic activity may also cause severe arsenic contamination.

Air^{[14],[15]} – Airborne concentrations of Arsenic range from 1 ng/m³ to 10 ng/m³ in rural areas and from few ng/m³ to 30 ng/m³ in non contaminated urban areas. The sources of air contamination are non ferrous metal smelters and power plants burning arsenic rich coal. Air contamination causes acute, sub acute and chronic health effects. Increased incidence of lung cancer has been seen in several occupational groups exposed to inorganic arsenic compounds.

Sea food and Rice^{[16],[17]} - Sea food is major source of organic arsenic exposure. Sea food including finfish, shellfish and seaweed are the main sources of arsenic exposure in human population. The increased percentage of arsenic in rice is another big problem. It is due to irrigation of rice paddies with groundwater elevated with arsenic it is seen in Bangladesh and West Bengal in India. Contamination of paddy soil due to industrial and mining activity is common. Growing paddy rice with soil previously treated with pesticides. Brown rice has higher levels of arsenic than white rice. Nowadays rice based products are available in market in the form of baby food. Intrauterine and early childhood exposure may leads to many health issues in newborn and later life. There are many studies carried out to minimize arsenic in rice. We should adopt some cooking habits such as wash rice properly before cook and use plenty of water while cooking rice.

Industrial processes^[18] – Arsenic is used in industrial processes to produce antifungal wood preservatives, which can lead to soil contamination. It is also used in the pharmaceutical and glass industries, in the manufacture of alloys, sheep dips, leather preservatives, arsenic is use to prepare colour pigments and paints. Arsenic compounds are also used in microelectronics and optical industries. High arsenic levels in air can be found in the working environment as well as the general environment around non-ferrous metal smelters, where arsenic trioxide may be formed, and some coal plants.

Smoking - Natural inorganic arsenic content of tobacco causes exposure of arsenic in smokers. This content is increased where tobacco plants have been treated with lead arsenate insecticide.

Therapeutic uses of arsenic^[20]

Thomas Fowler prepared a potassium bicarbonate based solution of arsenic trioxide compound named Fowler's solution. This Fowler's solution was used to treat a variety of diseases during the 18th, 19th, and early 20th centuries. Fowler's solution is used in leukaemia, skin conditions such as psoriasis, dermatitis, herpetiformis and eczema, stomatitis and gingivitis in infant and Vincent's angina. It was also prescribed as a health tonic. Arsenical pastes were used for cancers of skin and breast. Arsenous acid was used to treat hypertension, bleeding gastric ulcers, heartburn, and chronic rheumatism. Organic arsenic was widely used to treat syphilis.

Arsenic is also used in Ayurvedic medicines in proper dose *shudha* (pure) *Somala is rasayana* (prevent aging), *balya* (health tonic), *vrushya*, *vajikar* (aphrodisiac), *kaphavatarognashak*, *kasa* (cough), *sheetjwar*, *shleepad* (filariasis), *firang* (syphilis), *sandhivatanashak*. It is *vruschik vishnashak* (scorpion bite), *shwas* (asthma), *shleepadjanya jwar* (filariasis), *jeernpandu* (chronic anaemia), *rajyakshma* (tuberculosis), *hrutshool* (angina), *atisar* (diarrhea). *Ksharkarmakar*, *shotha* (oedema), *santapa*, *shaithilyatanashak*. *Jwar* (fever), *yakrut vikar* (liver diseases), *Jeerna atisar* (chronic diarrhea), *pradar* (leucorrhea), *madhumeha* (diabetes), *jeernakasa* (chronic cough), it increases immunity, *tridosha nashak*. Arsenic trioxide is now widely used to treat APL (acute promyelocytic leukaemia). Sulphides of arsenic realgar (*manseel*) and orpiment (*hartal*) are used in many medicines. They are used for psoriasis, syphilis, asthma, rheumatism, haemorrhoids, cough and pruritus, and are also prescribed as a health tonic, an analgesic, anti-inflammatory agent, and as a treatment for some malignant tumours.

Fatal dose - 180 mg of arsenious oxide. It has been estimated that exposure to a concentration of one part of this gas in 20,000 parts of air for one hour is dangerous, while exposure to a concentration of 2.5 parts to 10,000 parts of air for half an hour is fatal to adults.

Fatal Period – The average fatal period is 12 to 48 hours^[21].

Tolerance – Some people develop the habit of arsenic eating (arsenophegia), either as a tonic or as an aphrodisiac. They bear it up to 250mg or perhaps more in one dose. In such people chronic poisoning may occur^[21].

Absorption – Arsenicals are rapidly absorbed from the alimentary tract and skin. The process of absorption is an electrogenic process involving a proton (H⁺) gradient. The optimal pH for arsenic absorption is 5.0, though in the milieu of the small bowel the pH is approximately 7.0 due to pancreatic bicarbonate secretion^[22].

Distribution – After absorption arsenic is found in liver in large quantity. As compared to liver kidneys contain less and other organs contain traces of arsenic. It is found in muscles for matter of days, in bones for matter of weeks, and in keratin tissues, hair, nail, and skin for months.

Elimination - Arsenic is mainly eliminated by urine, and also in faeces, bile, sweat, and other secretions. It is found in urine after half an hour and continues to be excreted for about 10 to 14 days or even longer. In chronic poisoning it is excreted in keratin tissues and bones. Arsenic is also deposited in hair and nails^[21].

Laboratory tests^[23]

Urine- Excretion of 100mg or more per day is indicative of poisoning. Urine test is positive within 6 hours of poisoning and continues to be positive for about 2 weeks.

Blood – Peripheral blood picture will show presence of premature red and white cells and basophilic stippling of RBCs.

Stool – Faeces will show presence of arsenic and blood when examined within some hours of poisoning.

Liver, kidneys and bones (in case of death) – In bones arsenic is present for a very long period.

Hair – Arsenic is excreted through hair. More than 75mg% is suggestive of poisoning. Neutron activation analysis is better for test of arsenic in hair. In acute poisoning arsenic concentration in hair may be more than 3mg%.

Nails – Neutron activation analysis is better for detection of arsenic in nails. More than 100mg% of arsenic in nails is suggestive of poisoning.

Chemical tests: Marsh's test and Reinsch's are chemical tests to detect arsenic^[24].

Health effects^[25]

Acute effects – In acute poisoning symptoms appears within half an hour. Main symptoms are nausea, vomiting, colicky abdominal pain, profuse watery diarrhea and excessive salivation. Other features are acute psychosis, diffused skin rash, toxic cardiomyopathy and seizures. Haematological abnormalities occur and renal failure, respiratory failure and pulmonary oedema are common. It also causes peripheral neuropathy or encephalopathy.

Sub-acute effects- Sub –acute form is a condition, which usually results when arsenic is administered in small doses at repeated intervals to cause death. The symptoms are dyspepsia, cough and tingling in throat, followed by vomiting, abdominal pain and purging, dry and congested throat and a feeling of depression. Symptoms of neuritis are more pronounced. Ultimately collapse sets in and results in death.

Chronic effects – It is due to accidental ingestion of repeated small doses of arsenics. Chronic poisoning represented by four stages. First stage of nutritional and gastrointestinal disturbances include symptoms like, loss of appetite, nausea, vomiting and diarrhea. Second stage of catarrhal changes, mucous membranes are inflamed, resulting in conjunctivitis, running of eyes and nose, coughing, hoarseness of voice, and bronchial catarrh. Third stage of skin rashes there is irritation of skin. After long exposure rain drop type pigmentation of skin occur. There is also hyperkeratosis of palm and soles. White bands known as Mee's lines crossing the nails of fingers and toes may be noticed. Fourth stage of nervous disturbances, at this stage, there is tingling and numbness of the hands and feet and tenderness of the muscles, sometimes paresis. Arsenical neuritis also found in some patients. Other symptoms include headache, drowsiness and impairment of vision and mental activity.

Prevention and Treatment of Arsenic Toxicity^[26]:

To overcome acute and chronic toxicity of arsenic everyone should take prevention. Because of low socioeconomic status of large population they cannot afford expensive methods to overcome contamination of water. Therefore it is suggested to use rainwater, or remove the arsenic from water. It is necessary to educate people to distinguish between high and low arsenic source of water and aware them to use low arsenic source of water. The affordable, efficient, low maintenance and household technologies or instruments such as low cost filtration systems and iron hydroxide precipitation for removal of arsenic from contaminated water, could made available by the local administration for the population of affected area.

To eliminate arsenic and reduce toxicity stomach should be emptied and then washed out to remove adherent arsenic. Freshly precipitated hydrated ferric oxide should be given. BAL (British anti lewisite) is an efficient antidote in acute poisoning. But due to its toxic effects presently thio chelators DMSA (meso 2,3 dimercapto succinic acid) and DMPS (sodium

2, 3-dimercaptopropane-1-sulfonate) are use. Demulcents are used to lessen irritation. Magnesium sulphate is used to prevent intestinal absorption of arsenic. Good nutrition and safe drinking water can prevent chronic arsenic poisoning. It is very important to educate people exposed to arsenic about nutrition supplements in day to day life and use household techniques to minimize arsenic toxicity. Before cooking

rice wash it thoroughly and cook it in plenty of water. Functional food jiggery as dietary supplement prevents arsenic induced toxicity.

Medicolegal aspect^[27]

- Arsenic is homicidal poison as it is cheap, easily available, colourless, it has no taste and smell hence easily mixed in food.
- It is rarely used as suicidal agent because it causes much pain.
- Accidental death may be due to admixture with articles of food or due to its improper medicinal use.
- It is sometimes ingested or applied locally in the form of paste or ointment to abortion sticks to produce abortion.
- It is mixed with cattle fodder to feed animals.

Gastro-intestinal symptoms^[28]

Common symptoms are abdominal pain, nausea, vomiting, diarrhoea. Acute poisoning causes increased permeability of small bowel vessels, inflammation and necrosis of intestinal mucosa. These changes result in severe hemorrhagic gastroenteritis which may be associated with cardiovascular collapse. In 248 patients with evidence of chronic arsenic toxicity from West Bengal, India who consumed arsenic contaminated drinking water for one to 15 years hepatomegaly occurred in 76.6%, and of the 69 who were biopsied, 63 (91.3%) showed non-cirrhotic portal fibrosis. In another study, arsenic was considered the aetiological agent in five of 42 patients with incomplete septal cirrhosis, an inactive form of macronodular cirrhosis, characterised by slender, incomplete septa that demarcate inconspicuous nodules, and an unusual high incidence of variceal bleeding.

Cardio-vascular system^[29]

Epidemiological studies in various parts of world shows high level of arsenic in ground water increases risk of CVD, including hypertension, carotid atherosclerosis, ischemic heart disease and vascular disease mortality. In cross-sectional study of blood pressure and health effects of arsenic in Bangladesh, shows that there was high blood pressure in the participants drinking water which contain low to moderate arsenic. Further it leads to arterial stiffness which is associated with an increased risk of atherosclerosis. Experimental studies on animals show that arsenic exposure increases oxidative stress in vascular lesions and also increases inflammation in vascular lesions.

Nervous system^[30]

Arsenic exposure for several weeks causes both central and peripheral neuropathy. Central neuropathy causes impairment in neurological functions such as learning, short term memory and concentration. Chronic arsenic poisoning causes delirium and encephalopathy in many people. Neuropsychological test showed mildly impaired psychomotor speed and attentive processes, whereas verbal learning and memory were severely impaired. Peripheral neuropathy seen frequently in arsenic poisoning, it leads to severe ascending weakness similar to Guillan- Barre syndrome. Tingling sensation, numbness, burning soles and weakness is seen in lower limbs. Deep reflexes are diminished or absent. Inorganic arsenic can cause injury to nervous system. Chronic exposure leads to encephalopathy with symptoms of headache, mental confusion, seizures and coma.

Respiratory system^[31]

Ingestion of inorganic arsenic in drinking water results in pulmonary effects manifested by cough, chest sounds in lungs and shortness of breath. Chronic ingestion of arsenic leads to malignant and non malignant respiratory diseases. If airborne particles of arsenic enters in respiratory system causes irritation of nasal mucosa, larynx, bronchi and later perforation of nasal septum. Exposure to inorganic arsenic in crude or refined form causes rhino-pharyngo-laryngitis, trachea bronchitis and pulmonary insufficiency due to emphysematous lesions. Arsenic has been associated with lung cancer to the workers of manufacturing unit and peoples in industries of pesticides, chemicals and metal smelting area. The trivalent form of arsenic shows the activity of carcinogenesis. Exposure to 50 mg/l airborne arsenic to person for long period about 25 years would increase the 3-fold lung cancer mortality.

Dermal^[32]

Arsenic in drinking water affects skin and causes skin lesions such as melanosis and keratosis. Long term exposure to arsenic leads to skin cancer. Organic and inorganic arsenical penetrate through the epithelium and cause an allergic contact dermatitis and conjunctivitis. Chronic ingestion of arsenic causes milk and white complexion and skin eruptions occur. Transverse white Mees lines on fingernails are appear after 15 days of exposure. Aldrich-Mees Lines, 1-2 mm broad, stretch completely across the fingernails and appear in the same relative position in all fingers. Generalised or localized hyperpigmentation seen, rain drop type pigmentation appear on covered part. Epithelial hyperplasia and formation of discrete, multiple, hard wart like keratosis occur on palm and soles. This condition leads to basal cell carcinoma. The nails become brittle and show linear pigmentation. Hair become dry and may fall off. Arsenical dusts may lead to flexural eczema and a pigmentation of the head and neck and painless perforation of nasal septum. (modi)

Carcinogenicity^[33]

Arsenic exposure leads to several malignancies such as skin cancer, lung cancer and liver malignancies. Arsenic is a class I carcinogen as declared by the International Agency for Research on Cancer (IARC), and its carcinogenic effect may be mediated by abnormal DNA repair, aneuploidy, and other cellular mechanism. The first manifestation of arsenic toxicity is seen on skin. Chronic arsenic exposure causes hyper pigmentation, hypo pigmentation, Bowmen's disease and keratosis. Some individual develop squamous cell carcinoma, basal cell carcinoma, or other cutaneous malignancies. Pathophysiological mechanism of arsenic induced carcinogenesis is not clear, but it may be due to increasing oxidative stress, chromosome abnormalities, with uncontrolled growth, and aberrant immune developments. Chronic exposure of inorganic arsenic increases risk of lung cancer. Arsenic toxicity initially inducing cellular toxicity that leads to cellular proliferation, this proliferation then promotes the growth of induced or endogenous mutations, which then lead to additional cancer. There is direct relation between rate of human lung cancer and arsenic exposure. The lung may function as a target tissue for arsenic carcinogenesis due to dimethylarsine is excreted via lungs. High partial pressure of molecular oxygen found in lung may be reason for development of cancer in lung. Labors working in mines with lung cancer have large number of arsenic particles in their lungs. Arsenic dust particles cause irritation and inflammation of lung tissue. Arsenic exposure causes hyperkeratosis in palms of hands and soles of feet and pigmentation and hyperpigmentation of trunk. Arsenic concentration in food and water responsible for development of transitional cell carcinomas of the bladder, kidney and ureter cancers. It is also responsible for adenocarcinoma of the bladder in male. Arsenic exposure causes hepatomegaly and hepato fibrosis.

Pregnancy^[34]

There are many studies on effect of arsenic exposure on pregnancy. In women with highest concentration of arsenic in drinking water (501-1200mg/L), there was an increase in spontaneous abortion. In the village of west Bengal studies carried out on 202 pregnant women with arsenic concentration in drinking water (> 200mg/L) reported spontaneous abortion, still birth, congenital defect, neonatal mortality and infant mortality. Across the globe women are exposed to high, moderate and low concentration of arsenic. In some studies low birth weight and preterm birth also reported.

Toxic effect of arsenic on liver^[35]

Liver is main organ of metabolism in the body. It plays important role in energy production and detoxification of body. Therefore it is easily affected by any toxins in the body. It is site of biotransformation in which toxic compounds transformed in less harmful form. Long term consumption of arsenic contaminated water causes non cirrhotic portal fibrosis in mice. In west Bengal, in one of the study 248 cases of arsenicosis was studied out of which 190 patients found with hepatomegaly. Non cirrhotic portal fibrosis was found in 63 patients, portal hypertension found in some patients.

CONCLUSION

Arsenic compounds (Somal dhatu visha) are very toxic compounds with bad effect on human health. At present chronic poisoning of arsenic is common. Arsenic directly and indirectly enters in our food chain. Arsenic exposure in people is mainly due to water contaminated with arsenic it is also present in soil, rice and grains in small amount. People exposed to arsenic shows acute, sub-acute and chronic symptoms. Long term exposure to arsenic such as drinking arsenic contaminated water and occupational exposure leads to chronic poisoning. Chronic exposure leads to ill effect on brain, lungs, heart, liver, kidney, gastro-intestinal tract. According to some recent studies arsenic exposure is responsible for spontaneous abortion in pregnancy. Arsenic is carcinogenic to human being, it can cause cancer of skin, bladder, lungs, liver, prostate and kidney. To avoid these ill effects of arsenic there is need of public awareness about harmful effect of arsenic intake and how to avoid it. Occupational exposure to arsenic and its compounds should be at low levels. All possible measures should take to minimize contamination of water and soil from arsenic and its compounds.

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