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ARSENIC (AS): A MAJOR THREAT TO THE PEOPLE OF LOWER INDO GANGETIC PLAINS (IGP) OF WEST BENGAL

Popular Article

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ABSTRACT

Arsenic with its varied adverse health effects has become a serious concern to the people of this part of the country. The extent of its contamination is advancing in a rapid rate due to havoc extraction of groundwater for drinking and irrigation purpose. In this situation it is very much needed to employ several preventive and mitigation option such as use of arsenic free drinking water, harvesting of rain water for drinking purpose, adoption of low cost infiltration system to minimize its level below the permissible limit, cultivation of low water requirement crops as well as cultivars with low As loading etc. to minimize its contamination and keep the people away from its exposure.

Introduction

Arsenic (As), a heavy metalloid with the atomic number 33 has become a serious threat to the people of lower Indo Gangetic plains of West Bengal due to its wide toxic effects on man and animals. It is widely present in the natural environment and in multiple forms with many minerals. It is present in both inorganic and organic forms. About one-third of the arsenic present in the environment comes from natural sources and the rest through the man made activities. The natural sources are volcanic eruption, weathering of rocks, arsenic containing salts present in the sea water etc. Although, the main sources of arsenic is of natural origin, different man-made activities like mining, metal smelting, burning of fossil fuel, use of arsenic in the preservation of timber, upliftment of ground water for drinking and irrigation purpose, use of arsenic containing pesticide in the agricultural land etc. has brought it to the direct contact with the man and his domesticated animals. The lower Indo Gangetic Plains of West Bengal which includes the districts like Nadia, North-24 Parganas, Hooghly, Burdwan, Murshidabad etc. is highly intensive cropping areas where the farmers usually cultivates two or more crops in a year. It is traditionally kharif rice based cropping areas and a significant portion of areas covers the cultivation of boro rice and potato during the rabi season. Huge extraction of groundwater for irrigating the rice and potato during winter season brought the poisonous arsenic present in the water soluble forms from the deeper layer to the surface area and gives a direct exposure to the people. In addition, the withdrawal of ground water for drinking purpose also leads to the contamination of it. This poisonous metal affects the gut, the heart and the nervous system acutely. Besides, the long-term exposure to high levels of arsenic in drinking water also causes cancer of the skin, lungs, bladder or kidney. Due to these reasons it has become an emerging concern to the people of this area.

Forms of arsenic

Arsenic and its compounds are ubiquitous in nature and exhibit both metallic and nonmetallic properties. The trivalent and pentavalent forms are the most common oxidation states. From both the biological and the toxicological points of view, arsenic compounds can be classified into three major groups: inorganic arsenic compounds; organic arsenic compounds; and arsine gas. The most common trivalent inorganic arsenic

compounds are arsenic trioxide, sodium arsenite and arsenic trichloride. Pentavalent inorganic compounds include arsenic pentoxide, arsenic acid and arsenates, e.g. lead arsenate and calcium arsenate. Common organic arsenic compounds are arsanilic acid, methylarsonic acid, dimethylarsinic acid (cacodylic acid) and arsenobetaine. Arsenic trioxide is only slightly soluble in water; in sodium hydroxide it forms arsenite and with concentrated hydrochloric acid it forms arsenic trichloride. Sodium arsenite and sodium arsenate are highly soluble in water. Interchanges of valence state may occur in aqueous solutions, depending on the pH and on the presence of other substances which can be reduced or oxidized. Soils contain both organic and inorganic arsenic species. Inorganic As species include arsenite and arsenate, which are the most abundant forms found in the environment. The majority of As in aerated soils exists as H_2AsO_4- (acid soils) or $HAsO_4^{2-}$ (neutral species and basic). However, HA_3sO_3 is the predomiant anaerobic soils, where arsenic availability is higher and As(III) is more weakly retained in the soil matrix than is As(V). Within the soil-plant system, there is a distinct difference in behaviour of As under flooded conditions, where arsenite (AsIII) predominates, and under nonflooded conditions, where arsenate (AsV) predominates. The former is regarded as most toxic to humans and plants.

Sources of As

Arsenic appears in nature primarily in the form of sulfides in association with the sulfides of ores of silver, lead, copper, nickel, antimony, cobalt and iron. Trace amounts of arsenic are found in soils and other environmental media.

Arsenic is mainly transported in the environment by water. In oxygenated water, arsenic usually occurs as arsenate, but under reducing conditions, for instance, in deep well-waters, arsenites predominate. In water, the methylation of inorganic arsenic to methyl- and dimethylarsenic acids is associated with biological activity. Some marine organisms have been shown to transform inorganic arsenic into more complex organic compounds, such as arsenobetaine, arsenocholine and arsoniumphospholipids. In oxygenated soil, inorganic arsenic is present in the pentavalent form. Under reducing conditions, it is in the trivalent form. Leaching of arsenate is slow because of binding to hydrous oxides of iron and aluminium. There is ample evidence of biomethylation in the soil and of the release of methylarsines into the air. However, airborne arsenic is mainly inorganic.

Arsenic concentrations in uncontaminated soil are generally in the range 0.2–40 mg/kg (2). However, levels of 100–2500 mg/kg have been found in the vicinity of copper smelters (2,3). In the past, numerous arsenical pesticides were used widely and, as a result, arsenic concentrations of 200–2500 mg/kg occurred in the soil of orchards.

Arsenic is released to the atmosphere from both natural and anthropogenic sources. The principal natural source is volcanic activity, with minor contributions by exudates from vegetation and windblown dusts. Man-made emissions to air arise from the smelting of metals, the combustion of fuels, especially of low-grade brown coal, and the use of pesticides.

Reasons of arsenic contamination in lower IGP of West Bengal

Extraction of groundwater for irrigation purpose

The lower Indo Gangetic plain of West Bengal is a highly intensive cropping area. The cropping intensity of the affiliated districts is near 200 % and even more. The well distributed monsoon rain during June to September helps the farmers to cultivate kharif rice in large proportion. However, sometimes the whimsical nature of south-west monsoon compels the farmers to give supplementary irrigation as it is a high water requirement crop. During winter/boro season the farmers mainly grow boro rice and potato. The water requirement of these two crops is very high which is met through frequent irrigation by extracting ground water. With the extraction of groundwater the water soluble arsenic comes to the surface and contaminates the crop, water bodies etc. which ultimately exerts adverse health effects on the human bodies.

Extraction of groundwater for drinking purpose

The people of lower Indo-Gangetic plains of West Bengal extract ground water for drinking purpose through shallow tube well, deep tube well (Fig 1.) which again opens the door for arsenic to come in close contact with the people.

Extent of arsenic contamination in IGP of West Bengal

Among the 19 districts of West Bengal, six districts namely Maldah, Murshidabad, Nadia, Burdwan, North 24 Parganas and South 24 parganas has been severely

affected by this poisonous metalloid element. Here the concentration of arsenic in the drinking water is very high (>50 mg/liter of water). Arsenic has also become a problem in six other districts namely Kolkata, Howrah, Hooghly, Koch Behar, North Dinajpur and South Dinajpur, but, here the problem is not so acute. Almost every block except a few one in lower IGP of West Bengal has been severely contaminated with this poisonous metal.

Fig 1. Sources of drinking water

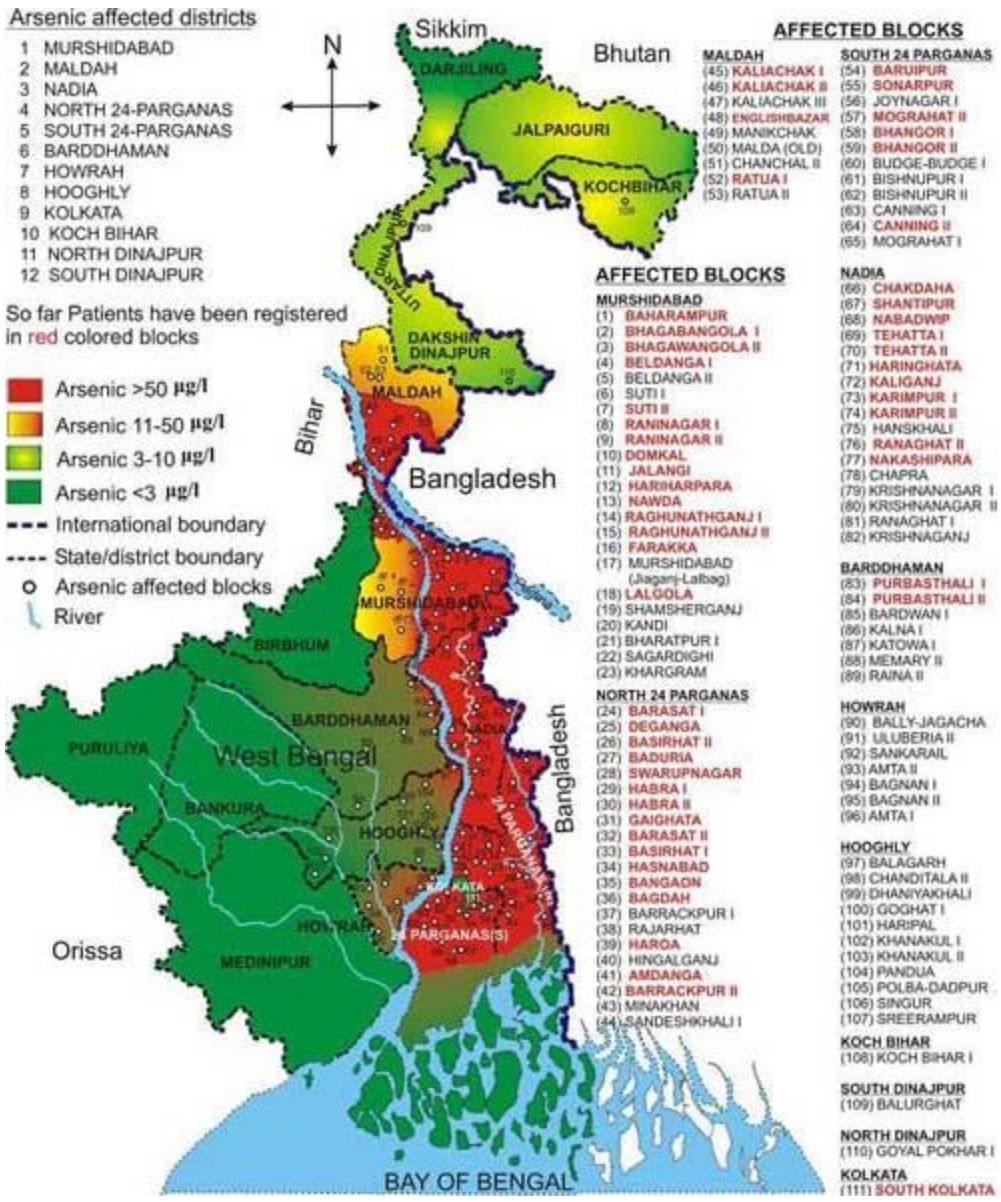

Fig 2. Ground water arsenic contamination status in West Bengal, India (Sept, 2006)

The problem is more severe in North 24 Pargana where 16 blocks out of 21 becomes the victims of it followed by Murshidabad (15 out of 23) and Nadia (11 out of 17). The arsenic affected blocks of lower IGP are shown in Fig. 2.

Harmful effect of arsenic contamination

Long term exposure of arsenic has multiple hazardous effects on the human health. Chronic ingestion of it in the human body through drinking water, dietary food or through inhalation cause characteristic damage to the skin, lungs, kidney, bladder, liver, nervous system and many more.

Effect on skin

The initial symptom of chronic (long term) arsenic exposure is manifestation of skin damage. Firstly, dark brown patches with scattered pale spots appear on the skin. In severe cases these brown patches extends all over the body broadly covering chest, back, hand and the abdomen. The skin lesions that occur most frequently in arsenic-exposed humans are hyperkeratosis (thickening of the outermost layer of the skin), hyperpigmentation (darkening of an area of skin or nails due to increased synthesis of melanin) and skin cancer (Fig 3 and 4).

Neurological effect

In high level of acute (short term) arsenic exposure different adverse effects such as increased sweating, muscle cramp, muscle tenderness, spontaneous pain may occur in human body whereas ascending weakness and paralysis may be evident in more severe poisoning. However, according to International Agency for Research on Cancer (IARC) and the National Research Council (NRC) [IARC 2004; NRC 2000] chronic arsenic exposure has limited effect on nervous system.

Renal effect

Arsenic has an adverse effect on the renal system which in severe cases may lead to renal failure. But, there is limited strength of association between chronic arsenic exposure and renal cancer.

Cardiovascular effect

Both acute and chronic arsenic exposure results in wide adverse effect on cardiovascular system although the effect of chronic arsenic exposure is not very high. These effect include-hypotension, hypertension, shock, peripheral vascular disease, cardio vascular mortality etc.

Respiratory effects

Inhalation of high concentrations of arsenic compounds such as arsenic trioxide cause lesions in mucous membrane and irritation of the nasal mucosa and these effects are more common in the industrial area. Exposure of arsenic through other routes instead of inhalation can also affect the respiratory system badly. In lower Indo-Gangetic plains of West Bengal peoples are suffering from chronic cough, shortness of breath, chest sound in lungs etc. due to long term arsenic exposure and these problems are becoming severe day by day.

Reproductive effects

Arsenic is a reproductive toxicant and it is readily mobile in the reproductive system. The people of lower IGP of West Bengal are facing the problem of spontaneous abortions and congenital malformations due to repeated arsenic exposure and the problem is increasing day by day.

Carcinogenic effect

The most severe form of arsenic exposure is cancer. It causes cancer of bladder, kidney, liver, lung, prostrate and skin and all these have brought turmoil in the life of the people of this area.

Mitigation options

Use of antidote: In case of acute arsenic toxicity antidote should be used to combat with its adverse health effects. The different antidotes effective for arsenic are British anti-leusite chemically known as 2,3-dimerceptopropanol, meso 2,3-dimercaptosuccinic acid (DMSA), sodium 2, 3-dimercaptopropane-1-sulfonate (DMPS) and monoisoamyl DMSA (MiADMSA). Among these antidotes DMPS is very much effective.

Fig 3. Initial symptom of arsenic contamination

Fig 4. Advance symptom of arsenic contamination

Prevention: Mitigation of adverse effects of arsenic is a very difficult task. Due to low socioeconomic status of the large population of lower IGP of West Bengal, it is not possible to eliminate total arsenic and to afford the arsenic free drinking water to everyone. In this situation the best way to minimize its toxicity is the prevention. The first major priority is preventing the use of arsenic contaminated drinking water to stop further exposure or providing the arsenic free drinking water or drinking water with arsenic below to the MCL of WHO and USEPA that is 10 $\mu g\ l^{-1}$ to avoid the future exposure.

Awareness: Different awareness campaign should be made to aware the people about the adverse effects of arsenic on the human body and how to stay away from its contamination.

Screening of rice cultivars with low arsenic loading: This part of the country is enriched with large number of rice varieties. These HYV and local varieties should be screen out and the cultivar having low as loading should be recommended to the farmers. Initiative must be taken to popularize those varieties among the farmers.

Cultivation of low water requirement crops: During winter season different low water requirement crops like maize, mustard, lentil, chickpea, sunflower etc. can be grown instead of rice and potato to minimize the extraction of ground water.

Use of alternative source of drinking water: The people of lower IGP of West Bengal should rely on alternative source of water such as rain water instead of ground water for drinking purpose.

Employment of low cost infiltration system: The affordable, efficient, low maintenance and household technologies/ instrument such as low cost filtration systems and iron hydroxide precipitation for removal of the arsenic from contaminated water, for the population of affected area, could be made available by the local administration to combat with it.

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