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Review Paper

Arsenic in the Environment effectuates Human Health: An Imperative Need to Focus

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Abstract

Arsenic is omnipresent in our environment and humans are always and inevitably revealed to this toxic metalloid. Smelting and mining and processes contribute to arsenic contamination because arsenic is a natural component of copper, zinc, lead, and gold ores. Arsenic Exposure is increasing in our environment day by day which directly or indirectly leads to health defects contributing highest carcinogenic and non-carcinogenic effects on human. The present review focuses on the Arsenic in environment, its health defects and prevention to control the exposure.

Keywords: Arsenic, environment, carcinogenic, non-carcinogenic.

Introduction

Arsenic is an element belongs to heavy metal group having properties of metal and non- metal and widely spread earth's crust[1]. It is an omnipresent element found in the soil, natural waters, atmosphere, organisms and rocks and marshaled through natural processes like biological activity weathering reactions, volcanic emissions and through anthropogenic activities[2]. Insecticides, wood preservatives, pesticides livestock dips and herbicides are anthropogenic sources applied to soil and plant system. Arsenical pesticides undiscriminating use during the early to mid 1900s results extensive deterioration of soils quality worldwide[3]. Smelting and mining processes impart arsenic contamination since arsenic is a natural constituent of zinc, lead, gold and copper ores. Arsenic subsists in −3, 0, +3 and +5 oxidation states. Arsenious acids, dimethylarsinic acid, arsenites, arsenates, methyl arsenic acid, arsenic acids and arsine etc are different form of arsenic found in environment. Arsenic (III) is a hard acid and form complexes with nitrogen and oxides, whereas arsenic (V) behaves is a soft acid forms complexes with sulfide. Arsenic has two valency states, trivalent and pentavalent, which can from a vast range of compounds either in organic and inorganic forms. Dimethyl arsenic acid and Monomethylarsenic acid are the organic forms of arsenic whereas arsenite and arsenate are inorganic forms arsenic. Arsenate and arsenite are more toxic than dimethyl arsenic acid and monomethyl arsenic acid. World Health Organization (WHO) has set a standard for arsenic in drinking water i.e. 10 µ g/l (0.01 mg/l), but increased Arsenic (As) level in groundwater is a major health concern in Asia and world now days. Arsenic is ubiquitous in our environment and humans are always and unavoidably exposed to this toxic metalloid. It may enter into human body by accidental ingestion from a variety of environmental sources like soil, water, air and food.

Arsenic in the Environment

Arsenic in Water: Increased concentration of arsenic in groundwater is an environmental concern due to its risk poses to animals, plants and human health. The EPA is in the process of setting the new arsenic standard for drinking water at 10 ppb (µg/L) to protect humans against the effects of long-term, chronic exposure to arsenic in drinking water. Approximately 5% of community water systems serving 11 million people will have to take corrective action to lower the current levels of arsenic in their drinking water. Higher concentration of arsenic are reported in groundwater sources as compared to surface-water sources and arsenate comprises about 50 percent of the total Arsenic in groundwater[4-6]. Many countries such as Argentina, Bangladesh, Chile, Hungary, India, Taiwan and Mexico have accounted wide arsenic contamination in their groundwater supplies. Arsenic contaminated groundwater has also been accounted in the Mid-west, New England, California and Oklahoma and in Bangladesh it is reported to contaminate up to 2mg/L. Utilization of contaminated water for irrigation purpose has resulted elevated concentrations of arsenic in agricultural soils [7-11]. In northern La Pampa Province of central Argentina arsenic contamination in groundwater surmount the World Health Organization (WHO) suggested value of 10 µg/L. Groundwater arsenic correlated positively with alkalinity, pH, V and F, whereas weaker correlations were observed with Mo, B, Be and U.

Arsenic in soil: Soil with arsenic levels below 40 mg/L is considered to be normal soil and distribution of arsenic in the soil is anthropogenic or natural.Arsenic toxicity soils acquaint

significant environmental risks to animals, plants, and human beings[3]. Arsenic concentration in soils depends on the nature of the contamination, the propinquity to source and time subsequently deposition. Major sources of contamination are releases due to geochemical processes and the sources are pesticides, herbicides, glass industry wastes, petroleum refining industry and wood preservatives disposal[12]. In anaerobic soils arsenic is found as oxysalts whereas in aerobic soils as arsenate.

Arsenic in Air: In air arsenic is present in particulate shape as inorganic form. In the industrial areas, urban and suburban areas methylated arsenic is a minor component in the air and the major inorganic portion is a variable mixture of the pentavalent and trivalent arsenic. Smoke of tobacco may contain arsenic if the tobacco plants have been treated with lead arsenate insecticide. The use of arsenic pesticides is prohibited in many countries but the natural contented of arsenic in tobacco may yet ensue in some vulnerability[13].

Arsenic in Food: Most foods contain normally less than 0.25 mg/kg arsenic with exception to some kinds of seafood. Marine organism posses high amounts of organo-arsenicals which are arsenic derivatives not acutely toxic due to their low biological reactivity and rapid excretion in urine.

Concentrations in seafood amount to 3.5 mg/kg in mussels, 2.4–16.7 mg/kg in marine fish and 100 mg/kg or more in certain crustaceans[14-15]. Wine prepared from grapes sprayed with arsenic pesticides might contain appreciable levels of arsenic in trivalent inorganic form. Arsenic amount ingested daily by human depends on amount of seafood taken in diet. In Japan the amount is higher as the diet has a large seafood component and diet was found to contain 1.1- 3.6% monomethylarsonate, 5.7– 17% inorganic arsenic, 47.9–75.2% arsenobetaine and 6.6–27% dimethylarsinate [16]. Vegetables that are grown in arsenic contaminated soil are reported to contain arsenic in some parts of Bangladesh.

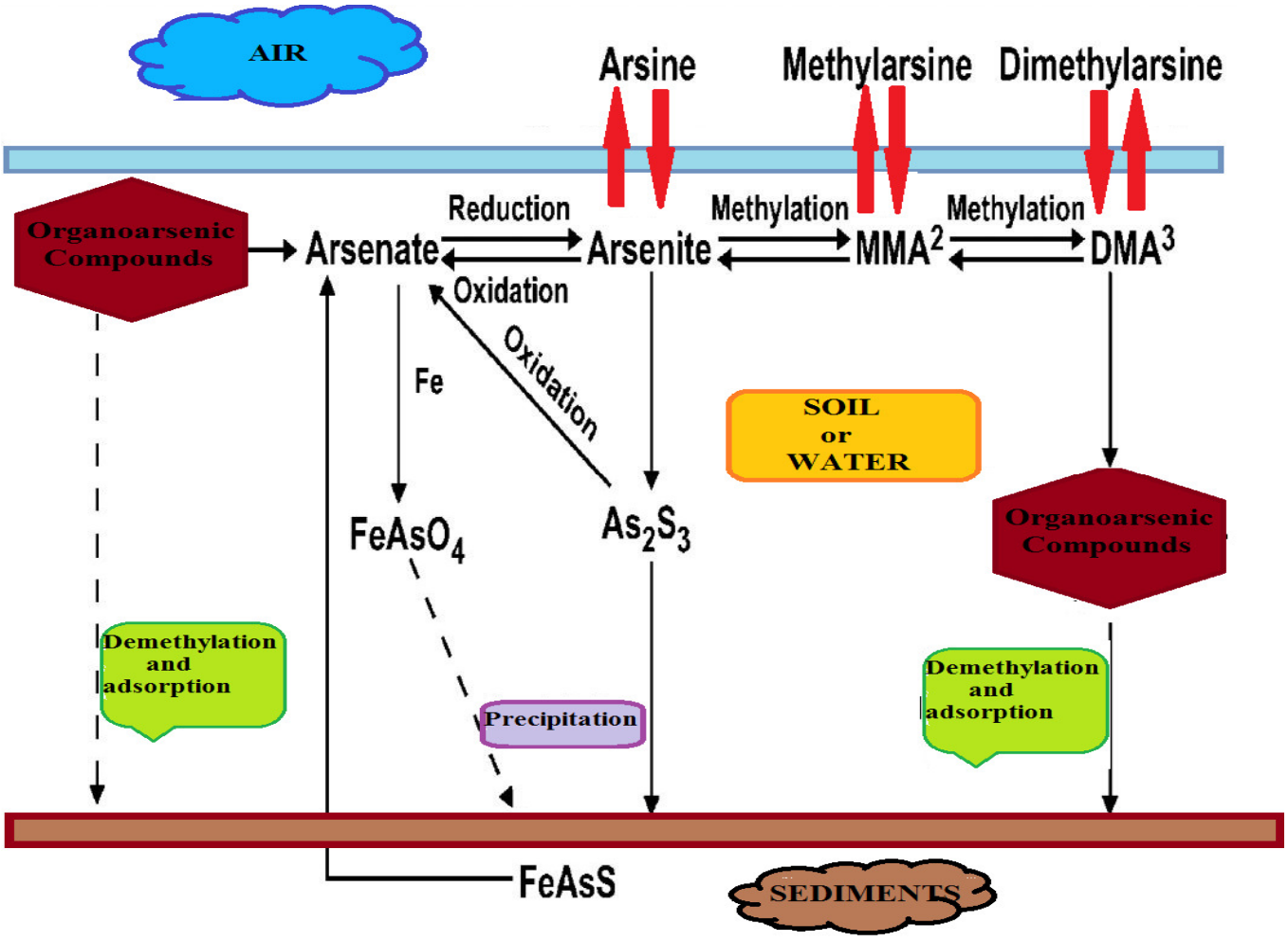

Figure-1
A simplified outline of major arsenic reactions in the environment

Toxicity: Trivalent and pentavalent arsenic are the most toxic inorganic arsenic present in drinking water. Biologically trivalent arsenic is reported to be more toxic than pentavalent arsenic. Toxicity of arsenite is almost 60 times more toxic than arsenate to humans and animals and pentavalent inorganic arsenic is transformed to trivalent complied by methylation to less toxic monomethyl arsenic and dimethyl arsenic[17]. The toxicity order of arsenic species is arsenite > arsenate > monomethyl arsenic > dimethyl arsenic. Arsenic toxicity can be categorized as chronic or acute. Ingestion of large amount of inorganic arsenic leads to acute toxicity which can cause lethal effect on physiological systems of the body and there are no reports of lethality and acute toxicity in humans after ingestion of organic arsenic. Prolonged vulnerability to arsenic can lead to chronic effects such as cancer of the lung, skin, bladder and skin lesions such as skin keratosis and hyperpigmentation. Further chronic vulnerability can affect the peripheral nervous system. Chronic vulnerability of organic arsenic and its effect are not known fully. Organic arsenic used therapeutically have shown some central neurotoxicity and peripheral neurotoxicity and no symptoms were observed in dietary organic arsenic compound[18].

Absorption: Inhalation and ingestion are the major routes of arsenic absorption in the general population. Animal and human data point that over 90 percent of the ingested dose of dissolved inorganic arsenic is absorbed from the gastrointestinal tract. About 75–85 percent of organic arsenic found in seafood is readily absorbed[15]. Absorption of less soluble forms, e.g. arsenic trioxide, is much lower. Particle size, solubility and chemical form are the factors which affects the extent of absorption.

Particles size 10 μm are preponderantly deposited in the upper airways i.e. nasopharynx, particles size between 5 and 10 μm are deposited in the airways cleansed by mucociliary action, and particles size smaller than 2 μm penetrate importantly into the alveoli[19-20]. Arsenic trioxide is the form of arsenic usually found in the air and more than 23 percent of particles of the arsenic polluted were reported to be 5.5 μm in size or more. Arsenic analysis in airborne fly ash from coal-fired power plants pointed that 76 percent of arsenic was retrieved from particles with a size of 7.3 μm or less[21-22].

Distribution: Blood is the fomite for the transport of arsenic. Arsenic motion through blood seems to conform three compartment models that reflect in part of inorganic arsenic biomethylation. Information on tissue partitioning in humans are available from autopsy data. The bones, lungs, muscles and kidneys have absolute amounts of arsenic whereas excretory organs, skin, nails and hairs have the highest concentrations of arsenic. Arsenic transfer through plancenta occurs in human. The effects of arsenic exposure level on the tissue distribution points that arsenic levels in the bile, blood, brain, liver, kidneys, skeleton and skin are 2–25 times more for trivalent than for pentavalent arsenic and significantly increased with higher dose . Autopsy data obtained from retired worker of metal smelter after surcease of occupational vulnerability indicate that arsenic levels in the lung were eight times more than control group[23].

Health Effects of Arsenic Exposure

There is a overwhelming reports of arsenic exposure and its effects on health. Some reports of health effect are mentioned below.

Carcinogenic Effects oF Chronic Arsenic Exposure: Skin Cancer: Arsenic exposure leads to skin cancer. Rossman in 1988 reported that arsenite enhance UV-induced skin cancers. The mechanism of action may involve effects on DNA methylation and DNA repair[24]. Epidemiological evidence also indicates that arsenic is related with cancers of skin as well as internal organs.

Bladder Cancer: In a study conducted in U.S. on a population with chronic arsenic exposure by drinking water could not depict the clear relation between arsenic exposure and bladder cancer [25]. Still there was report of an elevated risk of bladder cancer in smokers when exposed to arsenic in drinking water 200 μg/L and these points out that arsenic is synergistic with smoking. Kreppel in 1990 that latent period of arsenic exposure inducing bladder cancer can be more than 40 years [26].

Lung Cancer: Hopenhayn-Rich in 1993 report that death rate due to lung cancer increased with increasing arsenic ingestion[27]. Arsenic exposure and cigarette smoke are synergistic which increase the chance of lung cancer. In a study conducted in Taiwan in a residential area with arseniasis endemic reports increased risk of lung cancer.

Non–Carcinogenic Effect of Chronic Arsenic Exposure

Cardiovascular Disease: Arsenic one of the factors causing cardiovascular disease. Morton *et al.* 1994 accounted Arsenic ingestion impacts on the platelets [28]. In vivo study proved that arterial thrombus formation in rats increased due to Arsenic in drinking water. Arsenic in drinking water and its long-term vulnerability increased platelet aggregation.

Ischemic Heart Diseases: Ischemia is localized tissue anemia due to obstruction of the inflow of arterial blood. In a study conducted in southwest Taiwan villages with arseniasis hyper-endemic reported that a possible relation between long-term arsenic exposure and ischemic heart diseases.

The study includes 462 people living in a Blackfoot disease area and was drinking well water form many years. Examining the ages of the people with respect to ischemic heart diseases report those individuals with more than 60 years old was more prone to highest rate of ischemic heart diseases[29].

Effects on Hormonal System: Arsenic interrupts endocrine system by altering hormone gene transcription at low doses of 0.4 μg/L arsenite. Regulation in cells at different levels can be affected by different doses of Arsenic. It is hinted that arsenic effectuates gene expression depending on internal conditions of human body. Arsenic exposure is responded differently by different organs in the body[30].

Diabetes: Inorganic arsenic is diabetogenic in humans, but little is known about pathophysiological mechanisms.

Respiratory System Diseases: Chronic exposure to **Arsenic** induces chronic cough and chronic bronchitis[31].

Treatment of Chronic Arsenic Toxicity

There is no absolved treatment for treating chronic arsenic toxicity. The effectiveness of drugs was studied in clinical trials which showed that one form of chelation therapy can stop deterioration of chronic toxicity symptoms, while at the same time preventing outcomes such as cancer. 2, 3-dimercapapto-1-propanesulfonate and dimercapto succinic acid are two main treatments for arsenic exposure. The study points that dimercapto succinic acid are unable to improve the skin lesions of patients with chronic arsenicosis[32]. In counterpoint 2, 3-dimercapapto-1-propanesulfonate bettered chronic arsenicosis significantly. In an another study conducted by Mazumder in 1998 indicates that dimercapto succinic acid are unable to improve patient health status as well skin lesions due to chronic arsenicosis. Still 2, 3-dimercapapto-1-propanesulfonate increased arsenic excretion in the urine and patients with chelation therapy had significant improvements in symptoms. People exposed to arsenic are advised to increase protein consumption from plant origins as plants lots posses' lots of medicinal properties[33-35].

Prevention

Prevention is better than cure and basic efforts should be emphasized for the reduction of arsenic toxicity. Arsenic health effect prevention is adopted by many countries. Arsenicosis a health effect due to arsenic exposure has no effective treatment.

Conclusion

There is overwhelming evidence which suggested inorganic arsenic forms are more toxic and found extravagantly in our environment. This arsenic in environment is causing many serious health related problems. Therefore proper screening and extraction of Arsenic in from environment by pytoremediation as well as with help of microbes is required to lower risk of toxicity[36-38].

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