

Review On Arsenic Toxicity: Effect On Human Health And Biochemical Aspects

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Abstract

Looking at the global scenario, it has been found that a huge percentage of population around the globe consider groundwater as their main source for drinking. But unfortunately, this main source is being heavily exposed to various heavy metals like mercury, cadmium, arsenic making it unfit for consumption, ultimately posing threat to human health out there. Although groundwater is considered as safe, but high concentrations of heavy metals like arsenic (As) (above the permissible limit) in ground water can pose risk to human health. Toxicity level of inorganic arsenic is more than the organic one. Arsenic contamination is having a worldwide effect. Arsenic is found to be carcinogenic in nature, genotoxic as well as cytotoxic. Prolonged exposure to arsenic causes various health hazards like arsenicosis, skin cancer, pigmentation, neurobehavioral effects, impaired intellect and various other chronic illness. Creating awareness and providing proper medical care still remains a big challenge. The biomarkers of arsenic exposure include nails, hair, urine and blood sample. This paper provides an overall overview of ground water arsenic contamination, its health hazards, its toxicity and metabolism in human body. The paper also reviews various analytical techniques that are being used to detect arsenic, the collective steps required to eradicate this global problem and provide high quality safe drinking water for the future generations to come.

Keywords: Biosensors, biological markers, arsenic contamination, analytical methods

Introduction

Arsenic is a naturally occurring allotropic pnictogen and odourless metalloid trace element which is widely distributed in earth's crust having atomic symbol As, atomic number 33, and atomic weight 74.92 respectively and it usually appears in three allotropic forms- black, yellow, and grey. when heated it rapidly gets oxidised to arsenic trioxide (As_2O_3) which has a garlic colour. It is found in water, air, soil, food and plays the role of a micronutrient. Arsenic mainly exists in four valency states: As(-III), As (0), As (III), As(V) with oxidized As (III) and As(V) as the most widespread forms in nature.[1] Today arsenic has become an element of high concern for human health. Arsenic compound is mainly classified into two - inorganic arsenic and organic arsenic. Inorganic form of arsenic is generally found in abundance, whereas organic arsenic compounds such as arsenobetaine, arsanilic acid are mainly found in seafood, fish, as a result of which increases the risk to human exposure [29]. many epidemiological evidences indicates that it is carcinogen for both human beings as well as for animals. Antifungal properties of arsenic help in the treatment and preservation of wood. chromated copper arsenate is used above for such purpose. [3] Before the evolution of antibiotics, many compounds of arsenic were used as pharmaceuticals, like for example Salvarsan also known as arsphenamine was used for syphilis [30] and arsenic trioxide was used for treatment of cancer.[31] natural phenomena like volcanic activity, mining processes, weathering are some of the ways by which arsenic is released in the environment cycle causing threat to human life. [7] It is a by-product in smelting processes for many ores including gold, lead, cobalt, nickel, and zinc.[7] Exposure

to arsenic causes skin pigmentation, cardiovascular disease, hyperkeratosis and also effect the overall mental development of a child.

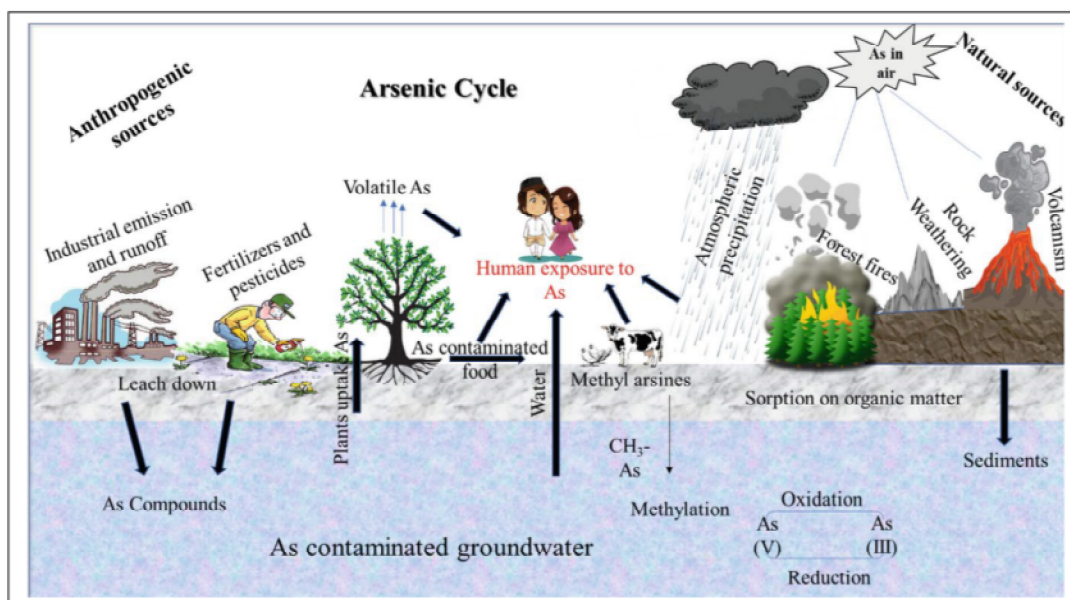


Fig-1- Arsenic cycle in the environment

World scenario

The natural contamination of arsenic in ground water has been reported all over the globe and majority of these contamination belong to South Asian and south American regions. one of the most arsenic polluted areas includes south east Asian belt which consist of countries like India, Bangladesh, Nepal, Vietnam and China [56,57]. developed countries in the world like USA, Canada, has experienced wide levels of arsenic contamination in groundwater.[58] Most of the arsenic polluted zones are located in the sedimentary basins which are particularly close to the mountain belts and deltaic areas.[4]. One of the main source of exposure to arsenic in groundwater in America is due to natural phenomenon like volcanic activities and geothermal fluids.[27] Generally tropical climate favours the release of Arsenic from arsenic compounds due to which countries falling in the tropical regions are more exposed to arsenic contamination.[28] some of the worst arsenic affected African countries includes Botswana, Burkina Faso, Ethiopia, Morocco, Nigeria, South Africa, Tanzania, Togo, and Zimbabwe [61].

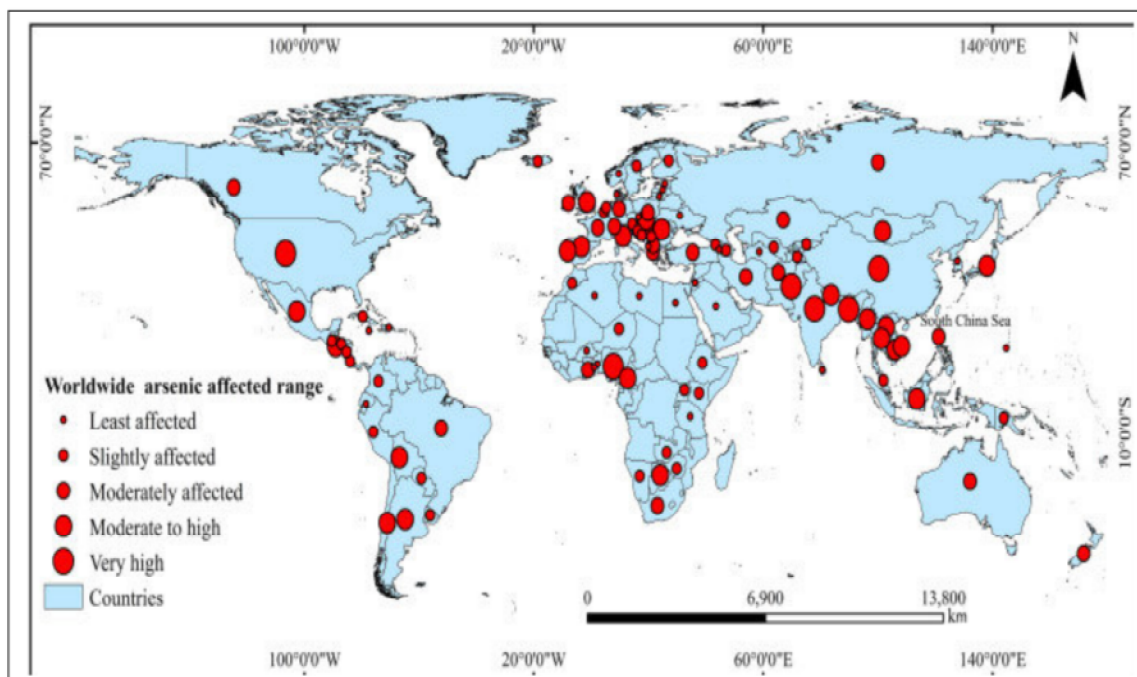


Fig 2: countries affected by arsenic all around the globe is shown by red dots. The south Asian and south American regions are worst affected. Cited from Arsenic contamination of groundwater: A global synopsis , focus on the Indian Peninsula E. Shaji , M. Santosh b , K.V. Sarath , Pranav Prakash , V. Deepchand , B.V. Divya

Arsenic in India

In India groundwater plays an important role in meeting the water demands for domestic, industrial and irrigational needs. The demand for good quality groundwater has increased with increasing population and developmental activities across the globe. Today providing safe drinking water to the world's 7.8 billion people has become one of the greatest challenges of the century [4]. In India the maximum amount of arsenic contamination is found in ganga-Brahmaputra basin. Maximum extraction occurs in the Indo-Gangetic basin in Northern and North western part of India, which as a result has caused a significant decline in water table around many locations [25,26]. west Bengal, Bihar, Uttar Pradesh, Jharkhand, Chhattisgarh are some of the states in India where concentration of arsenic in groundwater has exceeded the permissible 10 ppb limit. [4]

Arsenic occurrence and its sources of exposure

Arsenic in drinking water

One of the most basic sources of exposure to arsenic is via drinking water. People around the globe tend to drink the contaminated water and also use it for preparing food. Agriculture, livestock, metallurgy, medicine are some of the various sections where arsenic compounds are widely used. exposure to arsenic for a very long period of time, mainly through drinking-water can lead to chronic arsenic poisoning [5]. Some of the most significant effects of exposure to

arsenic includes skin cancer, skin lesions. High concentration of inorganic form of arsenic are found in the groundwater of countries like Argentina, Bangladesh, China, India, Mexico, and the United States of America.[5] arsenic enters the food cycle of living beings by drinking the contaminated water containing high level of arsenic, food crops which are irrigated with that water and food items that are being prepared with that contaminated water.[5].dietary sources like fish, shellfish, poultry, dairy products, cereals contains organic arsenic(arsenobetaine), but

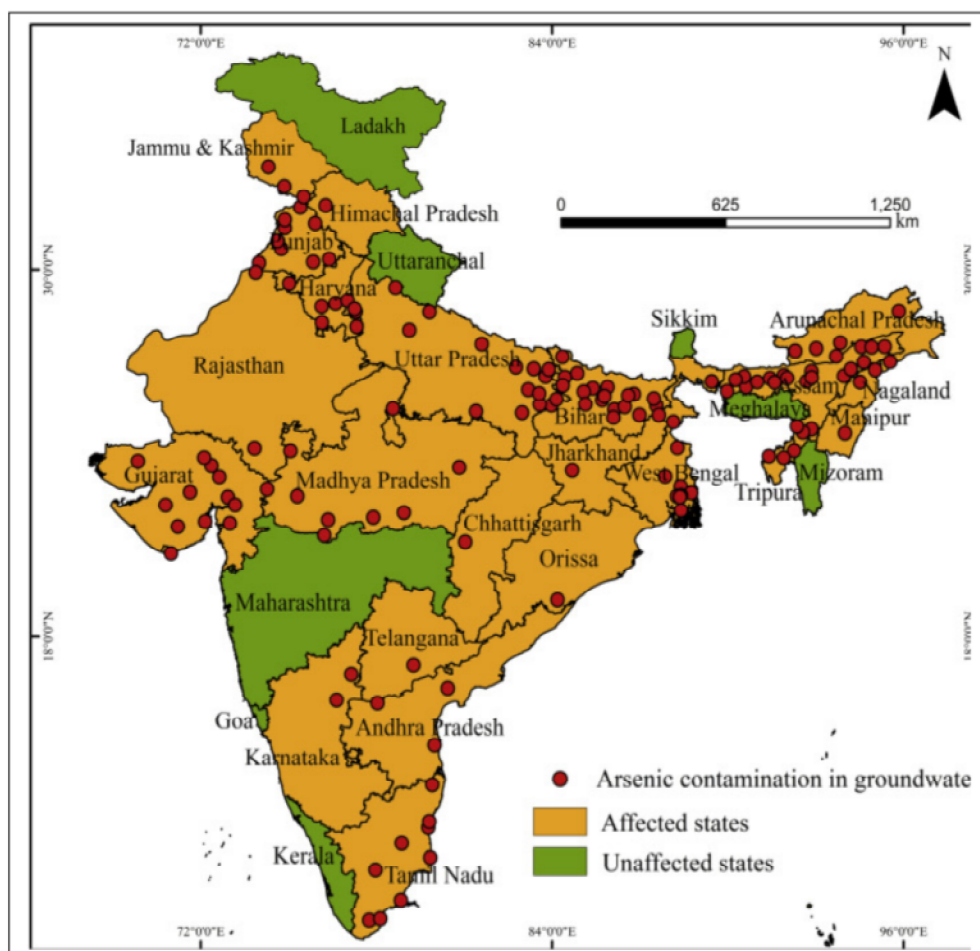


Fig3: States and union territories of India affected by arsenic contamination. Cited from: Arsenic contamination of groundwater: A global synopsis with focus on the Indian Peninsula E. Shaji, M. Santosh, K.V. Sarath, Pranav Prakash, V. Deepchand, B.V. Divya

the United States of America.[5] arsenic enters the food cycle of living beings by drinking the contaminated water containing high level of arsenic, food crops which are irrigated with that water and food items that are being prepared with that contaminated water.[5].dietary sources like fish, shellfish, poultry, dairy products, cereals contains organic arsenic(arsenobetaine), but exposure from these foods is very low compared to exposure through contaminated groundwater.[5]arsenic is also considered to be carcinogenic.[2] In 2006, the US Environmental Protection Agency (EPA) has set a certain permissible limit of 10 µg/L for arsenic concentration in drinking water. [33]

Arsenic in food

Food is one of the important sources of exposure to arsenic in addition to drinking water.[34]. Among food, cereals, such as rice have Arsenic concentrations which are sometimes as high as 0.4 mg/kg dry weight [35]. The main Arsenic species found in rice and other plants irrigated with As-containing water or grown on As rich soil is the inorganic Arsenic [36,37]. The amount of arsenic ingested by human beings on a daily basis through food is highly influenced by the amount of seafood intake in the diet. [6]. Marine organisms contain large amounts of organo-arsenicals (e.g., arsenobetaine) and these arsenic derivatives are not so toxic as the inorganic one because of their low biological reactivity and their rapid excretion through urine. Concentrations of arsenic in seafood amount to 2.4–16.7 mg/kg in marine fish [6]. Wine made from grapes which are sprayed with arsenic pesticides contains appreciable levels of arsenic (up to 0.5 mg/litre) in the trivalent inorganic form [38].

Occupational exposure of arsenic

Occupational exposure to Arsenic compounds is another important source of exposure. It leads to Arsenic poisoning in workers who are working in industries which uses inorganic As in their production wood preservation, vineyard spraying, glass production, production of electronic semiconductors are some of the main processes through which occupational exposure to arsenic occurs. [39]. Inorganic As is emitted from the smelter industries, such as Arsenic or copper smelters, which results in both occupational and environmental exposure. This also results in increased risk of lung cancer among the workers and residents who are in the vicinity of the smelter [40,41].

This is how arsenic is entering in the food chain through water-soil-plant-animal-man continuum.

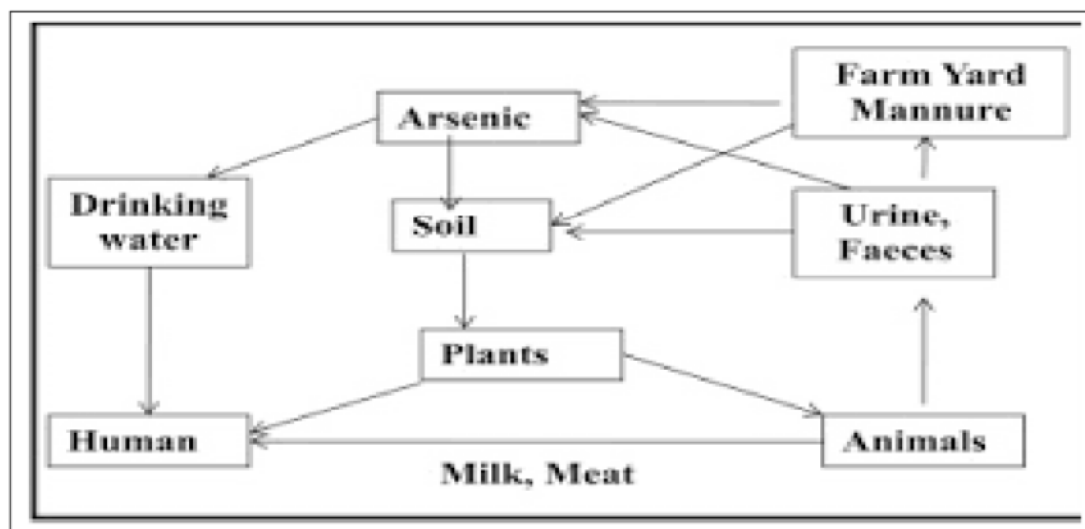


Figure 4: Schematic diagram of exposure to arsenic contamination in both human beings and livestock. Cited from: An insight of environmental contamination of arsenic on animal health, paramita Mandal, Emerging contaminants 3(2017) 17-22

Metabolism and molecular targets of arsene toxicity

The metabolism of arsenic has a direct impact on its toxic effects. Arsenic undergoes many complex metabolic conversions. Arsenite, the trivalent form of arsenic is considered to be highly toxic than arsenate, the pentavalent form. Arsenic and its metabolites have an affinity towards thiols and thus they interact with the extra- and intracellular macromolecules, particularly those containing vicinal thiols. The course of the reaction however differs depending on which form of arsenic is been taken into account. [36,42]. Methylated forms of inorganic arsenic has been considered as a part of a detoxification process for many years.[3] many new research indicates that the intermediary metabolites particularly monomethylarsonous acid (MMA-III) and dimethylarsonou acid (DMA-III), are very reactive and toxic [43]. But the final arsenic metabolites- monomethylarsonic acid (MMA (v)) and dimethyl arsenic acid (DMA(v)) are less toxic than the inorganic one. [8] MMA-III and DMA-III get easily oxidized to the less toxic pentavalent forms but the intermediates formed during the course of methylation of inorganic form causes toxic effects which includes DNA-damage [36]

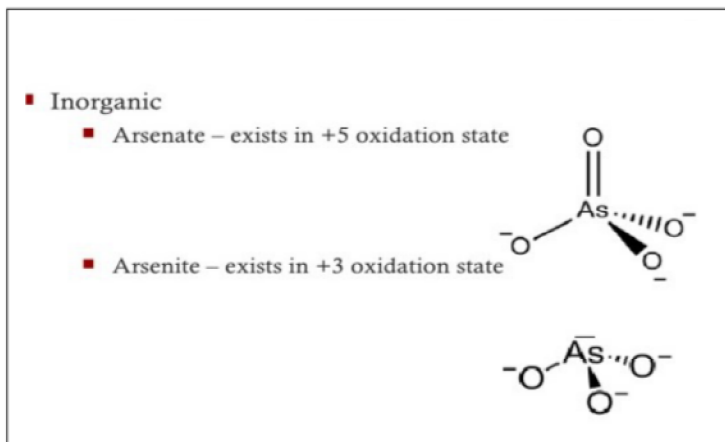


Fig 5: Inorganic forms of arsenic

Course of mechanism of pentavalent form

Arsenate (pentavalent) has a similar structure and similar properties to phosphate and so can replace phosphate in several reactions. In vitro studies indicate arsenate reacts with glucose to form glucose-6-arsenate, which resembles glucose-6-phosphate. Glucose-6-arsenate is a substrate for glucose-6-phosphate dehydrogenase and can inhibit hexokinase, which plays an essential role in glycolysis. In the presence of phosphate, ATP is generated whereas in the presence of arsenate, ATP depletion is observed secondary to diminished ATP formation.[44]

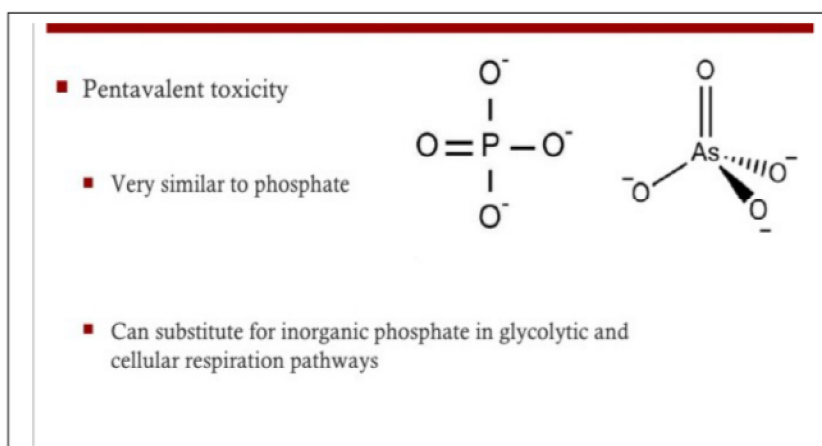


Fig 6: Arsenate and phosphate have similar structure and properties.

Course of mechanism of trivalent form

Compared to arsenate, arsenite is considered as one of the most toxic form of inorganic arsenic which primarily reacts with thiol and sulfhydryl groups. Thiols and sulfhydryl groups are the major organic components of multiple proteins and enzymes found in our body. The reactions between arsenic and thiols causes dysregulation and inhibition of proteins and enzymes involved. One such crucial enzyme effected is pyruvate dehydrogenase, which is a protein complex that requires lipoic acid, a dithiol, for activation. In the citric acid cycle, Pyruvate dehydrogenase (PDH) is a very important enzyme. As a result, any form of altercation of PDH enzyme can lead to impairment of cellular respiration and ATP formation. Arsenite has an affinity for sulfhydryl groups and so it readily binds with such groups which increases the permeability of capillaries and also causes dilation. Arsenite's affinity for thiols, more specifically for dithiols leads to favourable transfer of arsenite to the chelating agent, dithiol 2,3-dimercaptosuccinic also known as succimer.[44]

Arsine gas

Arsine gas is the most toxic form of arsenic over the organic and inorganic forms. Inhalation of arsine gas with concentration more than 10 ppm is considered to be lethal.[7] Arsine gas is colourless, odourless and does not produce tissue irritation because of which the affected individual fails to recognize it's contamination. It is known as a hemolytic agent. Arsine gas, after absorption in the lungs enters the red blood cells, where Hemolysis occur, along with the impairment of the transport of Fe (II) to Fe (III)[7]. Hemolysis or destruction of red blood cells is primarily related to oxidative stress, which overwhelms the antioxidant system of enzymes leading to rapid denaturation of proteins [45].

Health effects of arsenic exposure

Arsenic is a confirmed carcinogen and neurotoxic and is the most significant chemical contaminant in drinking-water globally. drinking water contaminated with high levels of

arsenic over a very long period of time causes a chronic illness known as arsenicosis . It is commonly known as arsenic poisoning. Arsenic is also known to cause genotoxicity and cytotoxicity.

Acute effects

The immediate symptoms for acute arsenic poisoning includes vomiting, abdominal pain, nausea, diarrhoea. These are followed by numbness and muscle cramping and death, in extreme cases.

Long term effects

long-term exposure to high levels of inorganic arsenic causes skin problems which includes pigmentation, skin lesions, formation of hard patches on the palms and soles of the feet (hyperkeratosis). However, such skin problems usually occur if an individual is exposed to arsenic for a period of about five years or more. However, it can also be a precursor to skin cancer [5] Since arsenic is considered to be carcinogenic, it's exposure over a long-term via drinking contaminated water can also cause the bladder and lung cancer. The International Agency for Research on Cancer (IARC) has classified arsenic and arsenic compounds as carcinogenic to humans.[5] Other adverse health effects that may be associated with long-term ingestion of inorganic arsenic includes developmental effects, diabetes, pulmonary disease, and cardiovascular disease. Pregnancy complications were also found to due to chronic exposure from groundwater As which leads to increased fetal loss and premature delivery. [9,19]

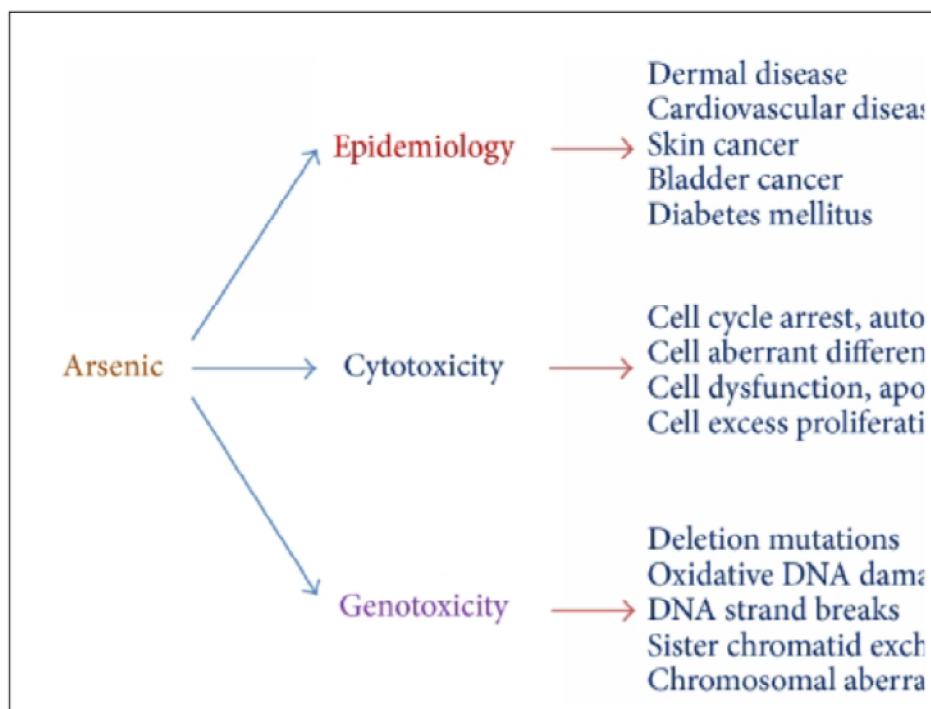


Fig 7:..Arsenic toxicity in humans.

Arsenic and cancer

Arsenic contamination in drinking water is today one of the most significant environmental causes causing cancer in the world. The international Agency for research on cancer (IARC) has considered arsenic as a human carcinogen since 1980[24]. Exposure to inorganic compounds of arsenic increases the risk of lung cancer in the smelter workers who are involved in the production of arsenic containing pesticides [54]. Arsenite plays an important role in the enhancement of UV-induced skin cancer [55]. High level exposure to arsenic via drinking water also increases the risk of lung cancer and bladder cancer.

Non carcinogenic effects of chronic arsenic exposure

Neurobehavioral and Neuropathic Effects on arsenic exposure

Accumulation of arsenic on human body over a very long period of time via different sources can lead to neurobehavioral effects in adolescence which can affect their way of behaving in their later stages of life [21]. Arsenic neuropathy is a recognized complication of arsenic toxicity.[9] Peripheral neuropathy which is an abnormal and usually degenerative state of the peripheral nerves caused due to chronic Arsenic exposure, is one of the most common complications of the nervous system in which the patients suffer from constant pain, hypersensitivity to stimuli, muscle weakness, or atrophy. [22,23]

Effects on Memory and Intellectual Function

A study of children in Mexico suggested that greater the urinary arsenic concentration lesser will be the verbal IQ and long-term memory. [9,20] It was found high level arsenic exposure can affect long-term memory, attention and the ability to understand speech particularly in people with chronic malnutrition. [9,20] However, this study was limited only for a certain period of time as many questions like the role of exposure to arsenic on the intellectual functions remained unanswered.

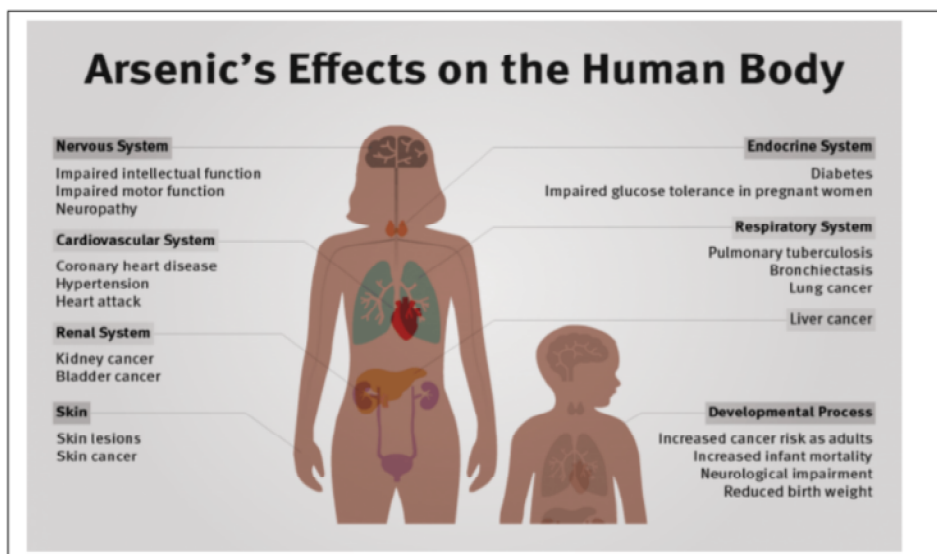


Fig 8: Effects of arsenic on human body

In a study of Bangladesh, it was found that about 21.6% of participants had skin lesions such as melanosis and/or keratosis. Out of this about 13.9% were currently drinking water with arsenic levels less than 10 $\mu\text{g/L}$. This suggest that either previously there has been a high-level exposure to arsenic or that even at low levels below the current guidelines it is not safe for drinking and for other purposes [9,15].

Analytical methods for analysis of arsenic species

For effective measurement of arsenic in drinking water expensive and Sophisticated instrumentation are important.[1] methods currently used for arsenic speciation are mainly based on the concept of HPLC combined with sensitive and element-specific detection methods like high-performance liquid chromatography with a flame atomic absorption spectrophotometer (HPLC/AAS), high performance liquid chromatography with atomic fluorescence spectroscopy (HPLC/AFS) or high performance liquid chromatography with inductively coupled plasma mass spectrometry (HPLC/ICP-MS) [10,46,47,48].

Hydride generation

One of the most common instrumental methods used for analysing metal and metalloids is atomic absorption spectroscopy (AAS) but due to its poor reproducibility, imperfect detection limits an alternative method in place of AAS has been introduced. Hydride generation atomic absorption spectroscopy (HGAAS) is one such alternative method for arsenic analysis.[49]. It is one of the most popular sample derivatization method for inorganic arsenic detection [10]. Hydride generation is mainly based on the formation of gaseous hydride for some elements, in the presence of some reducing agents, e.g., NaBH_4 , KBH_4 . These reducing agents are used to produce arsines which in turn helps in separating arsenic from the liquid products of the reaction. This process separates As (III) from As (V) as As (III) reacts with tetra hydroborate at a higher pH than As (V). [1] Transition metal ions creates interference in this process because of the reaction between the interfering metal ions with the NaBH_4 reductant.[1] To prevent this L-cysteine is used [1] Although HG-AAS technique accurately measures arsenic in environmental samples several drawbacks are also present which are as follows

- (i) limited only for the materials which can form volatile arsines;
- (ii) strictly controlled reaction conditions.
- (iii) presence of interfering transition metal ions reduces the efficiency of HG [50]
- (iv) method is laborious and HG cannot detect monomethyl arsonate and Dimethyl arsiniate.

Moreover, the development of this method requires significant amount of investing and high running costs which limits their use in most laboratories.[10]

ICP-MS

It is a type of mass spectrometry which involves inductively coupled plasma. This plasma further ionises the sample and creates atomic and small polyatomic ions, which are detected through this method. In AAS method the output or the response varies with the species but here the plasma ionizes all forms of arsenic as a result of which the response does not vary with the species. [1]. The ICP-MS technique provides higher precision, greater speed and selectivity. It suffers great interference from chloride due to the formation of argon chloride in the plasma.

Electrochemical methods

Cathode stripping voltammetry

An alternative way to differentiate inorganic arsenic species is by electrochemical techniques. These techniques known to be simple, sensitive, and inexpensive methods to speciate arsenic directly because of different electroactivity of As (III) and As (V). [51,52] Stripping voltammetric techniques is an example of electrochemical technique which is considered to be an effective method for arsenic determination in the environmental samples [10]. In this technique, the analyte(arsenic) is preconcentrated on the working electrode that is on the hanging mercury drop electrode (HMDE) [1]

Deposition: $2\text{As}^{3+} + 3\text{MHg} + 6\text{e}^- \rightarrow \text{M}_3\text{As}_2 + 3\text{Hg}$

Stripping: $\text{M}_3\text{As}_2 + 12\text{H}^+ + 12\text{e}^- + 3\text{Hg} \rightarrow \text{AsH}_3 + \text{H}_2 + 3\text{MHg}$

where M = Se or Cu [1]

Most of the areas having high arsenic contamination are unfortunately also the areas having least access to these highly expensive techniques. As a result of which today high demand for simpler techniques which are robust and inexpensive becomes more urgent and important to detect arsenic instead of the standard laboratory-based techniques such as atomic fluorescence spectrometry, inductively coupled plasma-mass spectroscopy etc [59,60].

Biosensors and bioassays

For biosorption of toxic elements many microorganism-like algae, fungi, yeast, and bacteria are used.[1] for example, *Chlorella vulgaris* can transform inorganic arsenic compounds and easily oxidize arsenic (III) to arsenic(V). [1] The arsenite oxidizing bacteria so far isolated can gain energy from arsenite oxidation or they do so as part of a detoxification process. [1] microorganisms have the ability to reduce arsenate into arsenite or even arsine (AsH_3). It has been found that Marine algae transforms arsenate into a non-volatile methylated arsenic compound which are found in sea water such as Methylarsionic acid and dimethylarsinic acid .[1] Today's modern biology techniques can create an arsenic responsive DNA control sequence and link it to a reporter gene which can further act towards the development of an arsenic biosensor.[1] .Bacteria-based bioassays are basically act as an alternatives to the abiotic sensors created for arsenic detection since those sensors many times shows inaccurate results in the concentration range below $50\text{ }\mu\text{g/L}$. [11] Generally most of the bacteria carries a sensitive defence system against arsenite and arsenate, that can be further exploited for arsenic detection .[11]

Table 1: Different analytical methods for the analysis of arsenic.[1]

Method	Limit of Detection (LOD) μgL^{-1} (ppb)	Comments
ICP-AES	0.7	Has high sensitivity, however equipment is expensive.
ICP-MS	0.002-0.06	Has higher precision and lower detection limits compared to ICP-AES
Neutron Activation Analysis	0.001-0.02	High sensitivity, possible spectral interferences
Colorimetric Assays (Gutzeit)	1-30	Simple method, but generates arsine gas and is prone to false positive and falsenegative readings
Cathodic Stripping Voltam-metry (CSV)	0.5	Sensitive, however copper interference a problem and use of mercury a concern.
Anodic Stripping Voltammetry (ASV)	0.05-0.5	Highly sensitive, however interference from other metals (copper) a major concern, analysis time can be lengthy. Reusability of electrodes and reproducibility of signal a concern
Arsenite Oxidase Based Biosensor	1.0	Sensitive and very selective to As(III). No interference from copper and fast analysis time (10 s)
Biosensor (AcP and PPO)	1.5	Sensitive and selective to As(V), however enzymes can be inhibited by other metals and chemicals

Biological monitoring of arsenic

Both trivalent and pentavalent forms of arsenic are found in the water sources from wells and tube wells. [9,17] Inorganic arsenic and its methylated forms that is monomethyl arsonic acid (MMA), dimethyl arsinic acid (DMA) are used as biomarkers of arsenic exposure [9]. Generally arsenic biomonitoring can be done by four methods. The first method includes determination of the concentration of As in urine samples. They are able to evaluate the amount of inorganic As an individual has received from drinking water. [9,18] The second method is measuring the arsenic amount in blood. A particular individual's amount of arsenic intake can be roughly estimated through Blood and urine samples .[9] The third method involves estimating the arsenic concentration in hair because inorganic arsenic and DMA are usually stored in the hair root which as a reflect the individuals past exposure to arsenic.[9] The last method involves measuring amount of arsenic in nails since nails of fingers or toes reflect the arsenic storage so, hair and nails are used as biomarkers to estimate average arsenic exposure.[9,17]

Magnitude of the problem

Arsenic contamination of groundwater has become a great concern for public health. There are a number of regions where arsenic contamination in drinking-water has become a significant problem. A huge section of population over the world have been drinking water containing arsenic at levels higher than the limit set by WHO. [53]. The worst effected countries with arsenic contaminated water and huge cases of arsenic poisoning are Southeast Asia, including Bangladesh, Vietnam, India, and Cambodia.[11]. Generally, the most common symptoms and signs found in living beings, caused by long-term exposure to inorganic arsenic, differ greatly from one individual to another individual, population groups and geographical areas to a large

extent. so, there is no universal and specific definition of the disease caused by arsenic contamination or exposure. This further complicates the assessment of arsenic.[5] food products like vegetables and rice when cultivated using arsenic contaminated groundwater and consumption of these becomes a source of chronic arsenic poisoning. The impact of arsenic contamination, is not only on public health, but also on the socio-economic level like economy, personal incomes and crop productivity [9,14]. Populations that are at highest risk are those using private well-water as their drinking water source. Absence of taste, odour, colour, make Arsenic impossible for a layman to detect and avoid.

Prevention and control

Arsenic toxicity is increasing day by day at an alarming rate all over the world so to prevent further exposure it is important to remove this contaminant from the environment by taking necessary steps and provide safe and quality water for drinking, food preparation and irrigation of food crops. There are a number of ways by which we can reduce the levels of arsenic in drinking-water.[5] They are as follows:

- Water sources contaminated with arsenic like for example groundwater can be replaced by microbiologically safe sources such as rain water, treated surface water which has a low content of arsenic and can be used for drinking, cooking and for irrigation purpose. The highly contaminated water can be used for washing clothes and bathing. This reduces its exposure inside the human body.[5]
- Installing various arsenic removal systems – either centralized or domestic – and ensuring proper disposal of the removed arsenic. Technologies for removal of arsenic includes oxidation, coagulation-precipitation, absorption, ion exchange, and membrane techniques.[5]
- Proper education and awareness among community is important for ensuring safe drinking water. Individuals all across the globe needs to understand the risks of high arsenic exposure, its adverse effect on health and its sources of exposure which includes arsenic contaminated drinking water, food crops irrigated with that arsenic contaminated water, occupational sources etc. proper awareness must be spread to control its overgrowing exposure day by day. [5]

WHO's Response

Among WHO's 10 chemicals of major public health concern, arsenic found to be one of them. The current recommended limit set for arsenic in drinking water is 10 µg/L and efforts are being made collectively and effectively to keep the concentration of arsenic below this above set limit by setting new guidelines, providing risk management suggestions. WHO published a guideline for arsenic contamination in its *Guidelines for drinking-water quality*. The Guidelines published are intended for use as the basis for regulation worldwide.[5]

Present scenario suggests that a huge section of population around the globe are exposed to arsenic concentrations that is higher than the permissible value mentioned in the guideline and so to reduce its over exposure a thorough survey on public health is necessary.[5]

The WHO and UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene effectively monitors the progress towards global targets on providing safe and high-quality drinking water to each and every citizen out there. Under the new 2030 Agenda for Sustainable Development, "safely managed drinking water services" calls for tracking the

population accessing drinking water which is free of heavy metals contaminants including arsenic.[5]

Conclusion

A huge section of the population around the globe mostly depends on ground water for drinking purposes. This section of people, particularly are the ones who are getting worst affected by exposure to the heavy metals like arsenic. As a result, today exposure to arsenic toxicity has imposed a huge health issue around the world. Depending on the toxic level inorganic form is considered to be more toxic than the organic form. Arsenic exposure can occur through many ways. Exposure from natural source include soil, air, drinking water, food, from industrial and occupational source like in smelter industries, in preservation of wood and many more. Drinking water and food are the two principal sources through which arsenic enter the human body and shows adverse health effects like arsenic poisoning, skin cancer etc. so there is a critical need to monitor the overgrowing arsenic levels in human body as well as in the environment. chelation therapy is one of the promising treatment available today that can reduce or arrest the arsenic toxicity levels in human body if not fully remove it. Owing to its overgrowing exposure around the globe, there is a urgent need for simple, uncomplicated methods to test arsenic toxicity levels in the field or in the laboratory. Various analytical techniques are available like ICP-MS, AAS for determination of arsenic species which provide accurate and reproducible results. Today a proper education and awareness about the consequences of arsenic poisoning to various communities particularly in the rural areas where groundwater is the only drinking source available, is very important if we want to control its overgrowing exposure. Proper awareness must be spread especially in rural areas which unfortunately receives very little research and monitoring support from government agencies, corporations, and Non-Government Organizations. There is need to develop a better understanding of the relationship between chronic arsenic exposure and its various adverse effects in humans, its environmental occurrence and cycling of arsenic and also the underlying mechanism of action of arsenic. The challenges to provide safe and high-quality drinking water has become a matter of global concern even for many developed countries like Canada. UNEP and WHO must look into this over growing arsenic exposure with utmost priority and must initiate and launch several awareness programmes among health workers communities, NGOs, and try to find effective solutions for this problem and work towards it. Communities as a whole must get involve at all stages of groundwater development programmes which includes doing initial surveys; decisions on siting of wells on proper places, monitoring arsenic levels and doing proper surveillance of the above program.so from this study we can conclude that

Arsenic exposure in drinking water is increasing day by day in various parts of the world

It is entering the food chain through drinking water, soil, animals.

Drinking arsenic contaminated water over a long eriod of time causes adverse health effects like arsenicosis.

Arsenic is genotoxic, carcinogenic and cytotoxic as well

Many analytical methods are present to detect arsenic but to make these accessible to various parts where arsenic contamination is there is difficult, so we need more user friendly, simple low-cost technology which must be accessible to every community.

WHO must look on to this critical matter with utmost priority and necessary steps to eradicate it must be taken into account. This includes awareness on arsenic poisoning, proper education on adverse effects of arsenic, finding effective solutions and working towards it, proper surveillance and monitoring. Financial assistance must also be provided for smooth running of the process. Perhaps by taking a collective step we can reduce the arsenic contamination before it gets out of our hand and provide safe, clean high quality drinking water for the future generations to come.

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Indian sacred groves: Floristic diversity, Ecology and conservation

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Abstract

Practice of conservation of biological diversity in India had been carried out since dates back and sacred groves, the socially protected forest patches, are such classic evidence. Since pre-Vedic period, India has its legacy of harbouring numerous sacred groves almost in every part of the country especially in the Western Ghats and North-East Himalayan region. These small fragmented forest patches are well known especially for sustaining rich biological heritage, entailing ecological history of the region and being a local biodiversity hotspot through *in-situ* conservation of both floral and faunal components especially the rare and endemic ones. Sacred groves also represent ideal community organization for functioning of many ecological processes providing valuable ecosystem services like soil and water conservation, nutrient cycling and many more. In India, various systems of traditional conservation practices have been reported as the country is known for its socio-cultural diversity. In the past few decades, the existence of sacred groves is being challenged through serious threats like encroachment, loss of belief in taboos and many modern developmental practices. It is the need of hour to protect these ecological heritage by adopting integrated sustainable management practices through community involvement and convergence of various schemes of different sectors.

Key words: Sacred groves, floristic diversity, ecosystem, conservation

Indian scenario

One of the valuable outcomes of ancient tradition of nature conservation is the dots of sacred groves prevalent in the different geographical terrain of the Globe (Hughes and Chandran, 1998). Sacred groves are prevalent in different parts of the World and are mostly distributed in Asia, Africa, Australia, Europe and America (Chandrashekara and Sankar, 1998; Ramakrishnan, 1998; Hughes and Chandran, 1998; Ramakrishnan, 1996; Man and Biosphere 1995; Hughes, 1994; Castro, 1990; Khiewtam and Ramakrishnan, 1989; Gadgil and Vartak, 1975) excepting the new world (Gadgil and Guha, 1992) and seems to be most numerous in Asia and Africa (Roy Burman, 1996).

In Indian scenario, it had been rooted since the pre-Vedic periods (Ray *et al.* 2014; Chandran 1997) and many sacred groves had been identified to be as old as Indus Valley Civilization (Chandrakanth and Jeff Romm, 1991) which is also reflected in the words of Skolmowski (1991) as sacred groves are '*as old as the civilization itself*'. India harbours nearly 100000 to 150000 sacred groves (Malhotra *et al.* 1999) and age of most of the sacred groves are yet to be estimated and may be determined from the age of very ancient temples and tombs associated with them (Deshmukhet *al.* 1998). Sacred groves have been explored from different parts of the country mostly from South India (Chandran and Hughes, 1997) and Western Ghats (Chandran *et al.*, 1998, Gadgil and Vartak, 1976; Vartak *et al.*, 1987), Central India (Patnaik and Pandey, 1998; Pandey,

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