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# Health Issues Related to Arsenic Poisoning in Nepal: An Overview

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**Abstract** Public health care in Nepal is deteriorating day by day and there is a great challenge for the government to provide better health service to the people. The massive destruction of forest and decline position of the river conditions of Nepal is the determining factor that invites the natural calamities. Nepal is rich in water resources. Still, the rural people here are far from the reach of pure drinking water. This review article depicts the information about the status of arsenicosis in Nepal and the arsenic purification techniques suitable for the rural people. The various arsenic filter systems made by locally available materials have designed by the joint study report of national and international agencies to mitigate the arsenic problem and these have the very good impact in improving the healthcare.

**Keywords** Arsenicosis, Health issues, Melanosis, Keratosis, Arsenic filter

## Introduction

Arsenic exposure through drinking contaminated groundwater is a global public health concern and devastating lives in Nepal. A report says: a 60 mg of arsenic concentration in the human body invites the instant death of people. Arsenic is a naturally occurring element which is widely distributed in the earth's crust. It is a shiny metalloid with no proper taste and smell, and one cannot detect its presence if ingested. The concentration of arsenic in earth's crust is on average 2 mg/kg. Its presence in the environment is either in metallic or compound forms [1]. Various human activities can further lead to the unintentional release of arsenic components in nature. The arsenic components released from the industries through the effluents are also the cause of its contamination of water bodies and agriculture sector. Weathering of rocks, biological and volcanic activities are the dominant natural processes for the release of arsenic components in the environment [2]. Its presence drives significant pollution parameters of soil and water. Besides these natural events, many other human activities like extensive use of arsenical pesticides, fertilizers, herbicides, and pharmaceuticals can cause the anthropogenic release of arsenic in the environment. The agriculture sector is badly polluted by these activities. The arsenic and its compounds are known to be highly toxic for the human health. It enters the living body through the drinking water or through food habits. The major route for the transmission of arsenic to the human body is drinking of arsenic contaminated groundwater [3-4]. Rock-water interaction leads to the contamination of groundwater with arsenic compounds and drinking of such water can cause serious health damage. Despite its negative health effects, some arsenic containing drugs are used to treat diseases like syphilis, asthma, rheumatism, cough, pruritus and itching. Pentavalent arsenic is used to treat chronic trypanosomiasis and acute promyelocytic leukemia is treated with arsenic trioxide. Several research studies revealed that inorganic arsenic is more toxic than the arsenic present in its organic form even at an elevated concentration [5]. Since the ancient times, arsenic has been known as a plant and animal poison, and its large oral doses can cause to death. In the present paper, it is focused to overview the scenario of health effects posed by drinking of untreated and arsenic contaminated water in context to Nepal.

**Status of Arsenic in Nepal**

Nepal is a small landlocked country bordered by China to the north and India to the south, east and west. The Nepal Living Standard Survey (NLSS) 2010/11 data forecasts that approximately 25% Nepalese people are below of the absolute poverty line. In terms of human development concept for the measurement of the poverty line, the recent data provided by UNDP, 2014 forecasts 31.1% people below of poverty line which was 65%, three years ago. This critical issue of the poverty line is directly linked to the public health [6-7]. The World Bank remarks the extreme poverty for the people with official monetary of 1.25 dollar a day and this value for Nepalese people is 0.6 dollar a day. There is marked variation of this data in rural and urban areas and even in geographical distribution. There are intra-country disparities in poverty line and distribution. The people in the urban areas are above the extreme poverty line as calibrated by World Bank. There is a vast difference in the literacy rate of rural and urban people and also the remarkable difference in their living standard. The complex geological composition of Nepal, ranging from high altitude Himalayas to flatlands of terai makes diversification in the human population distribution. The southern belt of Nepal also called terai region is the main place for human habitation [8]. Terai region is densely populated due to intra-migration of the people. The current Nepal population report 2016 displays the increasing rate of population distribution in all the three geographical regions (mountain, hill and terai) of Nepal. Moreover, the population distribution is increasingly high in terai region with > 392 persons per square kilometer. This value is very low in the mountainous region with > 34 persons per square kilometer and hilly region with > 186 persons per square kilometer (Nepal Population Report 2011). The majority of people in terai region are habituated to consume untreated underground water. Safe drinking water supply system is limited to the urban areas and even it is poorly managed. The rural people use underground shallow water for the drinking purpose which does not meet the criteria of WHO standard for drinking water. There is massive contamination of underground water with various inorganic salts, most of them come as dissolved salts. The soluble arsenic salts contaminate with the underground water and cycled to the human body through drinking process. The review work of WHO guidelines for drinking water quality has presently remarked 10 ppb arsenic as the allowable concentration. Moreover, the different countries in the world have retained different arsenic concentration values up to 50 ppb as their national standard. This is regarded as the maximum permissible concentration.

Observing the current mortality rate in Nepal, the situation is becoming worst due to arsenicosis and microbiological contamination of drinking water [9]. The vast migration of people towards the lowland and the rising number with access to groundwater for drinking purpose, the arsenic calamity can reach to levels of death rate as the microbial contamination. In Nepal, the arsenic was detected in the tube wells under the depth of 30 to 300 feet and the soil structure in this range is alluvial which has continued in West Bengal, Bihar, Bangladesh and Myanmar [10-11]. Moreover, the soil structure varies as the time passes. The analytical study of arsenic in Nepal was first started in 1999 by the Department of Water Supply and Sewerage, and the World Health Organization. It was continued by Nepal Red Cross Society and the Japanese Red Cross Society. Their study evidenced the arsenic contamination in groundwater of Terai region. The recent study conducted by various agencies and stakeholders in Nepal reported the arsenic level more than 50 ppb in the tube wells of depth 11 to 30 m. The majority of tube wells of depth 11 to 50 m have the arsenic level in between 11 to 50 ppb. Above 50 m of depth, arsenic level concentration is within the range of WHO guideline. The district wise arsenic level concentration based on number of arsenic tested tube wells in the lowland region of Nepal is also different. Out of 20 terai districts of Nepal, the highest vulnerability of arsenic concentration has recorded in Rautahat district with arsenic level above of WHO guideline [12]. The report suggests that the highest number of tube wells with the arsenic concentration in the range of 11-50 ppb is recorded in Rautahat. Nawalparasi and Kailali have the moderately high arsenic vulnerability. Chitwan is only the district with low vulnerability to arsenic. The remaining 16 districts have moderate range of arsenic vulnerability. Based on the report, Rautahat, Nawalparasi and Kailali districts are found more arsenic exposure districts of Nepal. Bardiya, Sarlahi and Siraha districts have also found moderate arsenic exposure on the basis of statistical data of arsenic tested tube wells.

**Health Issues**

Arsenic ingestion to the human body through contaminated water and food is considered as the primary route of exposure. Besides this, arsenic exposure through inhalation and dermal absorption are other important routes that seriously damage respiratory system and skin. The rejection mechanism of accumulated arsenic from our body is mainly through the urine and before being excreted it has to pass through the bloodstream to the bone, liver, muscles and kidney [13]. These organs do hard work for the arsenic excretion metabolism and eject as toxic arsenic compounds or less toxic methylated arsenic through the urine. About 70 % of the arsenic is excreted by the urinal. Unmetabolised and accumulated arsenic at high concentration is lethal to the human body. However, the symptoms of adverse health effects due to arsenic exposure can be seen if its concentration exceeds the tolerance value. The health effects may be acute or chronic that depends upon the time of exposure and level of arsenic concentration. The brief exposure of high arsenic concentration causes the acute health effect. The long term exposure of low levels of arsenic concentration causes the chronic health effect. The health effect due to arsenic poisoning is more vulnerable in children and in old aged people than the adults. The chronic poisoning of arsenic compounds can be considered as a slow killer, leading to a very chronic disease called cancer [14]. The growth retardation and dwarfism are the primary lethal effects associated with high dose arsenic concentration in children. Besides of the various acute and chronic health effects, the major health issues related to chronic ingestion of inorganic arsenic can be categorized under the following headings.

*Effects on skin*

The long term dermal absorption of arsenic has shown the chronic effect on skin and the children are more vulnerable to this effect. Melanosis and keratosis are the major chronic effects on skin, caused due to dermal exposure to arsenic. In the initial stage of chronic arsenic exposure, the skin color becomes black (melanosis), rough and tough (keratosis). In the next stage of arsenicosis, the black and white spots are seen on the skin (leucomelanosis), hard blisters are seen on palms and soles (hyperkeratosis). The melanosis is categorized into diffuse melanosis (hyperpigmentation), spotted melanosis (spotted pigmentation), nonmelanoma (depigmentation) and leucomelanosis. The symptoms of arsenic toxicity are visible after the combined effect of both melanosis and keratosis [15]. The people working in the smelting industries are more affected by arsenic dermatitis. The arsenic induced skin lesions is a kind of skin cancer, also called Bowen's disease. The basal cell carcinoma and squamous cell carcinoma are the skin lesions caused due to chronic ingestion of inorganic arsenic.

*Effects on respiratory system and lungs*

Direct inhalation of arsine gas and inorganic arsenic, mostly in the industrial areas, is the supreme cause of most of the respiratory problems in human [16]. At its initial stage, there is irritation in nasal mucosa, larynx, bronchi and the respiratory tract, causing lesions on their surface. The perforation of nasal septum may occur and the arsenic compounds enter the bloodstream. This germinates several respiratory diseases like bronchitis, laryngitis and pulmonary insufficiency. The primary symptoms are the increased rate of cough, breathing abnormality and rhonchi in lungs. The long term arsenic inhalation is associated with lung cancer [17]. The workers of the arsenic containing pesticide industries and metal smelting industries are more vulnerable to lung cancer. The prevalence of lung cancer due to arsenic poisoning is even more deadly than the cigarette smoking.

*Effects on nervous system*

The nervous system is the most delicate and complicated system of the human body which perform the action due to synergic work of the brain, spinal cord and reticulated nerves [18]. Heavy metal toxicity is more rudely observed in the central nervous system because it does not perform the direct action for their ejection. The chronic exposure of arsenic has shown the adverse affects in the brain, causing peripheral neurological damage. The nerves are also affected by high concentration of inorganic arsenic that causes arsenic neuropathy. Here the affected people lose their memory, disorientation, confusion and change their behavior. Cerebrovascular and cardiovascular are also the outcomes of severe exposure arsenic [19].

**Prevention Measures**

The current socio-economic structure of Nepalese people stands them under the poverty line and the people are basically dependent on underground water for drinking purpose. Several arsenic mitigation programs, planned and implemented by various national and international agencies and private stakeholders have gone failure. Various chemical treatment processes for the removal of arsenic from drinking water are available but this is no more fruitful in the Nepalese society [20]. The rural people cannot afford the cost of highly advanced chemical technology to make arsenic-free drinking water. Several organizations and agencies like NRCS/ ENPHO have provided few options for the removal of arsenic by using rural technology. The techniques require the locally available material and the operation cost is also very low [21].

*Earthen Pot Filter*

1. Two pots system

This is the simplest technique of arsenic removal from drinking water commonly employed in the Nepalese society. This may be of two pots system or three pots system. Two pots system also called two gagri systems, is very popular in Nepal which is cheap with the very easy method of installation. The two earthen pots are staggered one above the other and the candle filter is set to the upper pot. A mixture of $FeCl_3$, NaOCl and charcoal is added to the arsenic contaminated water at the upper pot. $FeCl_3$ is used as an adsorbent of arsenic and arsenic free-water is collected to the lower pot by passing through candle filter [22].

2. Three pots system

The three pots system (3 gagri systems) also works on the principle of 2 pots system and the purification level is 95-99 %. Three earthen pots are placed one above the other, the top of which contains coarse sand and iron filings. The middle earthen pot contains fine sand and the bottom pot receives filter water. The bottom hole of the upper two pots functions to percolate water from top to bottom pot. According to the size of family, the size of earthen pots can be recommended to filter the arsenic contaminated water. The pictorial diagram is shown in Figure 1.

3. Biosand Arsenic filter (Kanchan filter)

Biosand filter (Kanchan Filter) (Figure 2) has suitably designed for the filtration of both minerals and micro-organisms and is also very popular in Nepalese society. It was developed by the joint research effort of Massachusetts Institute of Technology (MIT) and a Nepali NGO, Environment and Public Health Organization (ENPHO), after the extensive field studies in the rural village of Nepal [23-24]. It works in the principle of slow sand filtration technique similar to natural filtration process occurring in the earth's crust. The untreated water passes through a thick bed of sand which resists the flow of microbial pathogens and minerals. The diffuser contains Iron chips which absorb arsenic of water. The organic matter present in water is trapped at the surface of the sand bed and makes a biological layer which actively removes pathogens and contaminants. Finally, the filtered water passes through outlet pipe and collects in the receiver.

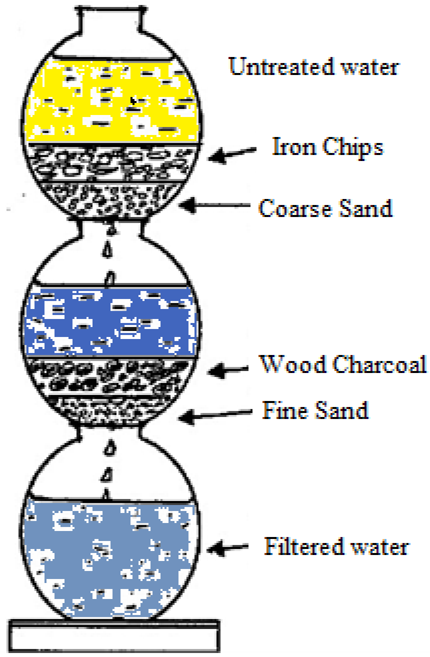


*Figure 1: Three pots system Filter*

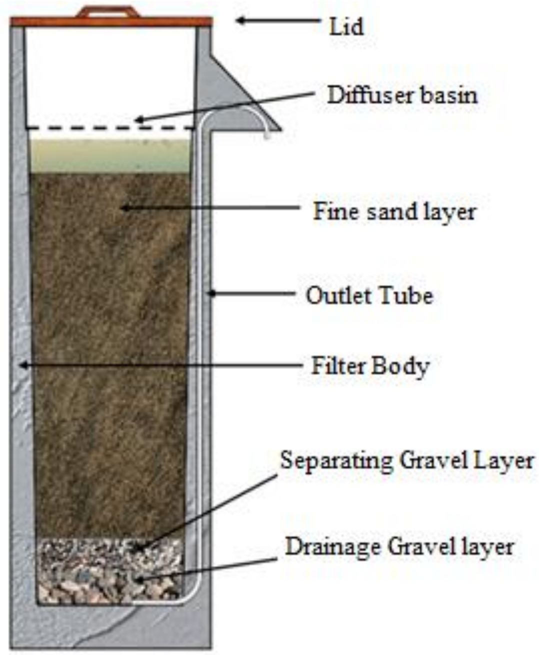


*Figure 2: Biosand Filter*

**Conclusion**

The low land region, also called terai, in Nepal is facing numerous health problems due to scarce of the visionary planning of government and vast migration of people for habitation to this area. One of the major problems that the people are facing is the compulsion of drinking untreated arsenic contaminated water which causes severe health damage of the people. The graph of poverty is increasing continuously and in the near future, arsenicosis will be the part of mortality of Nepalese people. Most of the tube wells are under the depth of 10 to 30 m and arsenic concentration is above of WHO guidelines. Rauthat and Nawalparasi districts of Nepal are more vulnerable to arsenicosis. The study has revealed the presence of a moderate arsenic concentration of the tube well water of Bardiya, Sarlahi and Siraha districts. The international agencies in support of national organizations have designed filter systems for filtration of arsenic contaminated water. Hope for the reduction of drinking water problems in Nepal by the government sector.

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