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Mini Review

Arsenic in Ground Water: A Possible Impact on Oral Health

Pritha Pal[1]* and Ajanta Halder[2]

[1]Assistant Professor, School of Life Sciences, Swami Vivekananda University, Kolkata, West Bengal, India

[2]Ex-Associate Professor, Department of Genetics, Vivekananda Institute of Medical Sciences, Ramakrishna Mission Seva Pratishthan, Kolkata, West Bengal, India

***Corresponding Author:** Pritha Pal, Assistant Professor, School of Life Sciences, Swami Vivekananda University, Kolkata, West Bengal, India.

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Abstract

Heavy metal toxicity has been playing an important role in the development of cancer. The presence of metals like nickel, arsenic, lead etc. in the soils may turn out to be carcinogenic, by means of their adverse impact on human health. Although arsenic has a therapeutic value in the treatment of certain diseases like promyelocytic leukemia, syphilis, psoriasis, asthma, rheumatism, haemorrhoids, cough and pruritus, its toxicity is a major concern now a days, since it is an established carcinogen. Arsenic can cause acute as well as chronic toxicity. The acute toxicity is manifested through its presence in urine and blood, while its chronic toxicity can be detected by its presence in keratin containing tissues like hair, skin and nails. This metal has shown to exert its toxicity in various internal organs like lung, liver, kidney, gastro intestinal tract, bladder, spleen etc. including skin. It has been well established fact that arsenic has a strong association with the development of skin, bladder, lung carcinoma. Moreover, its association with oral carcinoma is also studied as an emerging area of research in the field of metal toxicity impact on human cancers.

Keywords: Arsenic; Toxicity; Cancer; Carcinogen; Acute; Chronic

Abbreviations

USA: United States of America; WHO: World Health Organization; OSCC: Oral Squamous Cell Carcinoma; US: United States; DST: Department of Science and Technology

Introduction

Arsenic toxicity through the intake of drinking water as a result of accumulation in ground water or other agricultural processes has become a major alarming fact in countries like Bangladesh, Taiwan, India, Mexico, China, Chile, Argentina and USA [1]. Moreover, Taiwan (mainly Central and Eastern parts) [2], Mexico, Finland, Greece have reported cases of oral carcinoma, owing to the cause of arsenic exposure. In the world, Bangladesh and West Bengal (India) are the two most affected areas [3]. West Bengal is considered to the most effected state in India, which is on the verge of a major concern. Several studies stated the occurrence of arsenic level in the groundwater of various districts of this state, above the permissible limit recommended by WHO [4-6]. The Government of West Bengal has planned for an arsenic free state with an aim of eradicating arsenic from the ground water to a level of permissible limit in order to reduce its impact in the development of various fatal diseases including cancer [7]. So, the source of drinking water is a very important parameter to be studied.

Materials and Methods

Worldwide published research works on arsenic toxicity, its association with oral health including different diseases along with cancer; in the form of original articles and review articles were

searched for, in Pubmed, Pubmed Central and Google. Only published data was considered and imprecise descriptions of exposure were rejected. The information collected from authentic sources of publications regarding the topic lies in the inclusion criteria. Languages other than English fell in the exclusion criteria.

Results and Discussion

Arsenic is an important toxic environmental factor, which is a proven human carcinogen. Its contribution in different carcinomas has been well stated, especially skin, lung, kidney, bladder carcinomas, while presently, its relationship with oral squamous cell carcinoma (OSCC) is also suggested [8-10]. Arsenic toxicity has been causing deleterious health effects in millions of people including carcinoma. The recent studies suggest people dwelling in over 35 countries worldwide are impacted by consuming heavily contaminated water coming from arsenic contaminated sources [11]. A lot of people residing in a total of 70 countries are suffering from various diseases as a result of intake of highly contaminated water [12]. In developing countries like Bangladesh, Taiwan, India, Mexico, China, Chile, Argentina and developed country like USA, the drinking water sources on the basis of arsenic contamination has become an alarming fact [1]. In West Bengal, arsenic contamination in ground water has always been a concern [13], even in states like Bihar, Uttar Pradesh, Jharkhand, Assam and Chhattisgarh. This problem regarding arsenic contamination is also prevalent in countries like Bangladesh, Argentina, Canada, China, Mongolia, Taiwan and Saudi Arabia [14]. However, a lower risk is observed in US on account of a decreased concentration in inorganic arsenic [15]. Arsenic contamination mainly takes place from the natural geological sources rather than from sources of mining, smelting or agricultural [16]. However, arsenic can be equally released in air or water in areas of intensive mining activities [17]. On account of these conditions and activities, an elevated arsenic content gets deposited in soil and water. This is mostly evident in dry regions of Northern Chile, where the availability of water is very less and thus the polluted water serves as the only means of drinking and agriculture [17]. It has been stated in some studies carried out in Taiwan and Chile that intake of arsenic above 500 µg/l in a lifetime may cause lung and bladder carcinoma, accounting to 10% of all the deaths. The safety limit of arsenic concentration in drinking water is 10 µg/l and a maximum permissible limit of arsenic in drinking water is 50 µg/l; as recommended by WHO [18]. The arsenic concentration for drinking water is 0.01 mg/l according to Bureau of Indian Standard and it is 0.05 mg/l according to Rajiv Gandhi National Drinking Water Mission, which is known as the "Maximum Permissible Limit" [19]. A number counting to around 200 million of human population in the whole world is getting affected due to this metal contamination, 50% of which has been reported to reside in the most arsenic effected area, "Bengal delta plain" [20]. These two areas are the most affected areas in the world [3]. The arsenic content in these two areas is found to be 800µg/l in drinking water [21]. Studies suggest that 79.9 million and 42.7 million are suffering from high metal toxicity in the groundwater of 42 districts of Bangladesh and 9 districts of West Bengal respectively, for having the arsenic count in the ground water above the WHO recommended permissible limit [22]. Surveys carried on in West Bengal state that the arsenic level in ground water in some areas of this state has been found to be as much as 3.4 X 10^3 µg/l [23]; which is said to be the greatest arsenic calamity in the world [24]. A number over 26 million individuals in this state are impacted by chronic arsenic toxicity from different water sources [25]. In fact, a few studies carried out in this state have indicated the occurrence of OSCC in a considerable number of individuals, who have been exposed to the highly arsenic effected districts [8-10,13]. The most vulnerable rage of age of effected individuals has been found to lie less than 19 years [26]. Men are more likely to be industrially exposed to arsenic than women. However, the difference in male and female individuals on the basis of risk estimation of arsenic induced carcinoma states that it is not the age of the individual but the extent of exposure to the metal, which determines the effect. It is apparent that men are more exposed to arsenic than female in the population, accounting to the occurrence of lower rates of carcinoma in female population. However, both the male and the female population stand on an average risk of metal contamination, owing to no biological reason behind the lower occurrence of carcinoma in females.

The metal has been reported to get accumulated in groundwater as a result of natural weathering from arsenic containing rocks and also from the waste coming out from different industries like those of pesticides, herbicides, glass and ceramics, electronics, wood preservatives, alloys, catalysts, fertilizer, petroleum refining and feed additives/veterinary chemicals [27]. People get exposed to arsenic either through the oral route by the intake of food and water containing the metal or by inhalation of pesticides and also by mining deeds [1]. Arsenic in foods like seafood, fish and algae occurs in the form of comparatively nontoxic organic compounds (arsenobentaine and arsenocholine) [28]. These organic compounds result in higher levels of arsenic in blood of the effected in-

dividuals, although it is rapidly excreted unaltered in urine [29,30]. Arsenic intake is higher through the intake of solid foods than that of liquid foods [31,32]. By means of taking water and food, an individual takes up an average arsenic amount of 300 µg everyday [33]. The intake of arsenic by the plants, both in organic and inorganic forms, occurs through the water taken up from the soil where the plants are grown, by mena sof the various agricultural processes [34]. These issues are much highlighted in countries like Bangladesh, where maximum of the human population in rural areas depend on the availability of ground water for their various activities like irrigation, cooking, drinking etc. [3]. It has been reported in a study of West Bengal that a much high percentage of human individuals have been found to suffer from the genotoxic effects of arsenic, marked in their urothelial cells, although they were not exposed to high arsenic area. The reason lies in the fact of consumption of cooked rice with the metal concentration above 200 µg/kg. So, rice has also been considered to be one of the major exposure routes of arsenic contamination [35]. The presence of elevated arsenic content in cooked rice can be accounted to the higher levels of more toxic inorganic forms of the metal, while the good bioaccesibilities and bioavailabilities of rice also accounts for higher percentage of effected individuals [36]. On the other hand, it has also been suggested that arsenic level in cooked rice is of lower magnitude when compared to the level of the metal present in individually rice, or water, or both rice and water [12].

Conclusion

A positive correlation has been stated between the occurrence of oral squamous cell carcinoma and arsenic contamination in ground water [10], which indicates the potency of this heavy metal factor contributing to the adverse impact oral health. The factors like dose, duration of metal exposure and the threshold value of arsenic needed to manifest carcinogenic effects will help us to take up the preventive measures against this metal toxicity and also to arrest the occurrence of carcinogenesis in much vulnerable population [37]. In order to find out a link between the toxic manifestations of the metal and general factors like age, gender, nutritional status, any possible genetic polymorphisms etc., much extensive research work is required. The practices of harnessing surface water and harvest rain water can prove effective in reducing the impact of this metal toxicity on the human population. Therapies and supplementation of antioxidants, vitamins applied on human population with prior proper validation can result in reduction of toxic manifestations of this metal contamination, since there has been no established treatment designed for such cases, although, the present situation has turned up with various supportive measures being taken up for designing this metal toxicity related disease management strategies.

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Conflict of Interest

There is no conflict of interest related to the study.

Bibliography

1. Singh AP., *et al*. "Mechanisms pertaining to arsenic toxicity". *Toxicology International* 18.2 (2011): 87-93.

2. Su CC., *et al*. "Incidence of oral cancer in relation to nickel and arsenic concentrations in farm soils of patients' residential areas in Taiwan". *BMC Public Health* 10 (2010): 67.

3. Ratnaike RN. "Acute and chronic arsenic toxicity". *Postgraduate Medical Journal* 79 (2003): 391-396.

4. Chatterjee A and Sarkar I. "Water plant lag in arsenic belt". *The Telegraph* (2011).

5. Mahanta A. "Potable water as thirst choice". *The Telegraph* (2005).

6. Chakraborti D., *et al*. "Status of groundwater arsenic contamination in the state of West Bengal, India: a 20-year study report". *Molecular Nutrition and Food Research* 53 (2009), 542-551.

7. Joshi VK. "Arsenic free water, at last". *The Telegraph* (2008).

8. Pal P., *et al*. "Oral Carcinoma, HPV Infection, Arsenic Exposure-their Correlation in West Bengal, India". *Otolaryngology, Open Access* 6.5 (2016): 266.

9. Pal P., *et al*. "Study of arsenic exposure in oral/oropharyngeal carcinoma in West Bengal". *International Journal of Occupational Medicine and Environmental Health* 30.2 (2017): 271-279.

10. Pal P and Halder A. "Is There Any Role of Arsenic Toxicity in HPV Related Oral Squamous Cell Carcinoma?" *Biological Trace Element Research* (2018).

11. Das N., *et al*. "Arsenic exposure through drinking water increases the risk of liver and cardiovascular diseases in the population of West Bengal, India". *BMC Public Health* 12 (2012): 639.

12. Mondal D., *et al*. "Comparison of drinking water, raw rice and cooking of rice as arsenic exposure routes in three contrasting areas of West Bengal, India". *Environmental Geochemistry and Health* 32 (2010): 463-477.

13. Pal P., *et al*. "Correlation of Arsenic Toxicity with Oral/ Oropharyngeal Malignancy in West Bengal". *Indian Journal of Human Genetics, Supplement 1.* 20 (2014): S82.

14. Singh AL., *et al*. "Effect of Arsenic Contaminated Drinking Water on Human Chromosome: A Case Study". *Indian Journal of Clinical Biochemistry* 28.4 (2013): 422-425.

15. Lynch HN., *et al*. "Quantitative assessment of lung and bladder cancer risk and oral exposure to inorganic arsenic: Meta-regression analyses of epidemiological data". *Environment International* (2017): pii: S0160-4120 (16)30336-1.

16. Matschullat J. "Arsenic in the geosphere—a review". *The Science of the Total Environment* 249 (2000): 297-312.

17. De Gregori I., *et al*. "Monitoring of copper, arsenic and antimony levels in agricultural soils impacted and non-impacted by mining activities, from three regions in Chile". *Journal of Environmental Monitoring* 5.2 (2003): 287-295.

18. Steinmaus C., *et al*. "Dietary intake and arsenic methylation in a U.S. population". *Environmental Health Perspective* 113 (2005): 1153-1159.

19. Nickson R., *et al*. "Current knowledge on the distribution of arsenic in groundwater in five states of India". *Journal of Environmental Science and Health* 42 (2007): 1707-1718.

20. Washington DC. "Arsenic in drinking water". National Academy Press: National Research Council (NRC) (2001).

21. Kinniburgh DG and Smedley PL. "Arsenic contamination of ground water in Bangladesh: Volume 2: Final report". *Keyworth, Nottinghamshire: British Geological Survey* (2001).

22. Chowdhury UK., *et al*. "Groundwater arsenic contamination in Bangladesh and West Bengal, India". *Environmental Health Perspective* 108 (2000): 393-397.

23. Guha Mazumder DN., *et al*. "Arsenic levels in drinking water and the prevalence of skin lesions in West Bengal, India". *International Journal of Epidemiology* 27 (1998): 871-877.

24. Mandal BK., *et al*. "Arsenic in ground water in seven districts of West Bengal, India-the biggest arsenic calamity in the world". *Current Science* 70 (1996): 976-986.

25. Banerjee N and Giri A. "Arsenic Induced Health Effects, Genetic Damage and Genetic Variants in the Population Exposed to Arsenic through Drinking Water in West Bengal". *Proceedings of the National Academy of Sciences* 80.3 (2014): 565-581.

26. Bronstein AC., *et al*. "Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 28th Annual Report". *Clinical Toxicology (Phila)* 49.10 (2011): 91041.

27. Singh AL., *et al*. "Effect of Arsenic Contaminated Drinking Water on Human Chromosome: A Case Study". *Indian Journal of Clinical Biochemistry* 28.4 (2013): 422-425.

28. Edmonds JS and Francesconi KA. "Transformations of arsenic in the marine environment". *Experimentia* 43 (1987): 553-557.

29. Buchet JP., *et al*. "Assessment of exposure to inorganic arsenic, a human carcinogen, due to the consumption of seafood". *Archives of Toxicology* 70 (1996): 773-778.

30. Han B., *et al*. "Estimation of target hazard quotients and potential health risks for metals by consumption of seafood in Taiwan". *Archives of Environmental Contamination and Toxicology* 35 (1998): 711-720.

31. Thomas KW., *et al*. "Population-based dietary intakes and tap water concentrations for selected elements in the EPA region V. National Human Exposure Assessment Survey (NHEXAS)". *Journal of Exposure Analysis and Environmental Epidemiology* 9 (1999): 402-413.

32. Tripathi RM., *et al*. "Arsenic intake by the adult population in Bombay city". *Science of the Total Environment* 208 (1997): 89-95.

33. Kwong YL and Todd D. "Delicious poison: arsenic trioxide for the treatment of leukemia [letter]". *Blood* 89 (1997): 3487-3488.

34. Tamaki S., *et al*. "Environmental biochemistry of arsenic". *Reviews of Environmental Contamination and Toxicology* 124 (1992): 79-110.

35. Banerjee N and Giri A. "Arsenic Induced Health Effects, Genetic Damage and Genetic Variants in the Population Exposed to Arsenic through Drinking Water in West Bengal". *Proceedings of the National Academy of Sciences* 80.3 (2014): 565-581.

36. Banerjee M., *et al*. "High arsenic in rice is associated with elevated genotoxic effects in humans". *Scientific Reports* 3 (2013): 2195.

37. Abernathy CO., *et al*. "Arsenic: health effects, mechanisms of actions, and research issues". *Environmental Health Perspective* 107 (1999): 593-597.