# Sources And Mechanisms Of Arsenic Toxicity In Soil And Its Remediation Using Biochar

Sayon Mukherjee[1]*, Dr. S.K. Singh[1], Astha Pandey[1], Abhik Patra[2]

[1]Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences; Banaras Hindu University; Varanasi: 221005

[2]Krishi Vigyan Kendra, Narkatiaganj, West Champaran – 845455, Bihar, India

*Corresponding author: sayon.m@bhu.ac.in

**Manuscript No: KN-V1-01/002**

**Arsenic – a natural contaminant** :

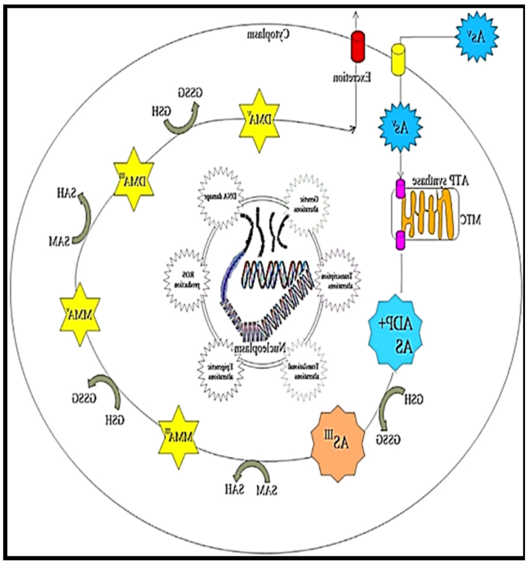
Arsenic, a pervasive metalloid, enters in environment through various natural and human activities, particularly through contaminated water. Bangladesh and India, notably West Bengal, face severe arsenic contamination. Arsenic is a top priority hazardous material in Agency for hazardous materials list of Toxic Substances and Disease Registry. Its presence in drinking water is a grave global concern, elevating the risk of lung, liver, skin, bladder, and kidney cancer. Approximately 200 million people in 70 countries face exposure to arsenic through food, water, and air. In drinking water, the inorganic form predominates, while both organic and inorganic forms are present in food.

**Sources of arsenic contamination:**

Soil contamination is the primary source for arsenic in crops, stemming from both natural (volcanic eruptions, rock weathering) and anthropogenic sources (semiconductor production, herbicides, insecticides, paints, cosmetics, and wood preservatives). To mitigate the health risks associated with arsenic, it is crucial to address the sources and pathways of contamination and implement effective monitoring and remediation strategies, particularly in regions highly affected by this pervasive metalloid. Arsenic (As) forms arsenide when reacting with metals and halides when interacting with halogens. Arsenic salts are water-soluble, leading to its release from the Earth's crust through natural geogenic leaching processes. Anthropogenic factors like geothermal energy extraction, mining, and excessive shallow groundwater pumping further contribute to environmental arsenic dispersion (Masuda, 2018).

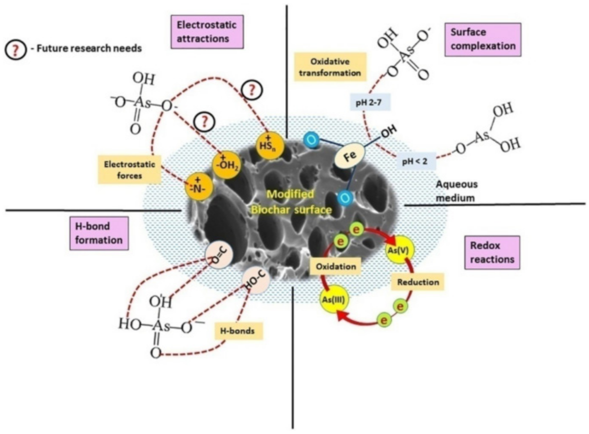
**Toxicity of arsenic:**

While arsenic (As) in trace quantities is vital for energy production in prokaryotes, certain eukaryotes like birds and mammals, it may also play an essential role in human metabolism, although its precise function remains uncertain (Zoroddu et al., 2019). The human body typically harbors 0.08–0.02 mg of arsenic (As) per kilogram, with significant accumulation in the liver, kidneys, lungs, bones, and hair. Widespread environmental arsenic exposure poses a global health concern, as prolonged or excessive contact with its compounds leads to acute or chronic toxicity, causing various medical issues collectively referred to as "Arsenicosis" (Abdul et al., 2015). Both As(III) and As(V) compounds induce acute and chronic health issues, with trivalent arsenicals exhibiting greater toxicity compared to pentavalent forms (Ratnaike, 2003). The intricate process of arsenic (As) toxicity in human is linked to the production of free radicals and initiation of cellular oxidative damage.



**Mechanism of arsenic toxicity:**

Arsenic's toxicity stems from its disruption of mitochondrial enzymes, leading to halted cellular respiration and oxidative phosphorylation uncoupling. Arsenic, resembling phosphorus, substitutes for it in biochemical reactions, inhibiting various enzymes and disturbing mitochondrial processes. Its toxicity arises from interactions with sulfhydryl groups, inhibiting enzymes like thiolase and dihydrolipoyl dehydrogenase. Additionally, it inhibits pyruvate oxidation and beta-oxidation of fatty acids (Fig. 1.). Remediation of toxicity




**Using Biochar:**
Biochar, an eco-friendly and renewable adsorbent, displays immense potential for environmental enhancement by purging air, water, and soil contaminants. It proficiently eliminates a wide array of pollutants, encompassing organic substances like dyes and antibiotics, alongside inorganic contaminants such as nitrate, phosphate, silver, mercury, and lead from water sources. Cost-effectiveness in biochar production hinges on locally available biomass sources, including aquatic grasses, agricultural residues, forest waste, industrial byproducts, manure, municipal waste, and sewage sludge. Biochar's versatility and cost-efficiency render it a valuable instrument for curtailing environmental pollution. Its efficacy in removing metallic species from water involves multiple mechanisms (Fig. 2.), including complex formation, ion exchange, catalytic reduction, co-precipitation, physical adsorption, and electrostatic attraction on the adsorbent's surface (Srivastav et al., 2021).

**Conclusion**
Toxicity of arsenic is widespread and it affects human being in several ways, but generation of biochar and its subsequent application in agricultural fields can be a promising strategy to mitigate its adverse effect in environment and subsequent transfer to food chain.

**References**
*Abdul, K. S. M., Jayasinghe, S. S., Chandana, E. P., Jayasumana, C., & De Silva, P. M. C. (2015). Arsenic and human health effects: A review. Environmental Toxicology and Pharmacology, 40(3), 828-846. https://doi.org/10.1016/j.etap.2015.09.016*

*Masuda, H. (2018). Arsenic cycling in the Earth's crust and hydrosphere: interaction between naturally occurring arsenic and human activities. Progress in Earth and Planetary Science, 5(1), 1-11. https://doi.org/10.1186/s4064 5-018-0224-3*

*Ratnaike, R. N. (2003). Acute and chronic arsenic toxicity. Postgraduate Medical Journal, 79(933), 391-396. https://doi.org/10.1136/pmj.79.933.391*

*Sodhi, K. K., Kumar, M., Agrawal, P. K., & Singh, D. K. (2019). Perspectives on arsenic toxicity, carcinogenicity and its systemic remediation strategies. Environmental Technology & Innovation, 16, 100462. https://doi.org/10.1016/j.eti.2019.100462*

*Srivastav, A. L., Pham, T. D., Izah, S. C., Singh, N., & Singh, P. K. (2021). Biochar adsorbents for arsenic removal from water environment: a review. Bulletin of Environmental Contamination and Toxicology, 1-13. https://doi.org/10.1007/s00128-021-03374-6*

*Zoroddu, M. A., Aaseth, J., Crisponi, G., Medici, S., Peana, M., & Nurchi, V. M. (2019). The essential metals for humans: a brief overview. Journal of Inorganic Biochemistry, 195, 120-129. https://doi.org/10.1016/j.jinorgbio.2019.03.013*