# INORGANIC ARSENIC REMOVAL CHALLENGES BY UTILIZATION OF LOW-COST ADSORBENTS AND COAGULANTS AS WELL AS COMBINATION OF THESE TECHNOLOGIES

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**Arsenic (As) contamination is a global phenomenon as it is reported that more than 1,3% of current world population are exposed to As concentration higher than 10 μg/L. Due to its carcinogenic effects on living beings, arsenic is concerned as a group-I human carcinogen. As exist in organic and inorganic form, but in water is usually present as inorganic oxyanions As (III) and As (V). Adsorption of As (III) and (V) using natural materials or the wastes products from industrial or agricultural operations has emerged as an option for developing economic and eco-friendly wastewater treatment processes. For the removal of arsenic from water and wastewater, numerous low-cost adsorbents have so far been studied. Biochars, red mud, dry plants, fly ash, zeolites, blast furnace slags, hydrotalcites. Possible routes of arsenic exposure to humans through the water, soil, vegetation and animal food chain simplified and presented in Figure 1.**

## Emerging low-cost technologies and adsobents for As removal

Adsorption - Adsorption of As (III) and (V) using natural materials or the wastes products from industrial or agricultural operations has emerged as an option for developing economic and eco-friendly wastewater treatment processes.

Biochar - Main mechanisms of As uptake on the biochar surface are ion exchange, reactions with ionizable functional groups, interactions with dissolved organic carbon and surface complexation. Impregnation of biochars has been mostly done by applying iron and by zero-valent iron nanoparticles. For instance, biochar modified with Ni and Mn can be efficiently reused maintaining 98 % removal efficiency after up to three treatment cycles .

Agro-industrial waste - Due to the content of agricultural waste consisted of cellulose, hemicellulose, and lignin, these rich in hydroxyl functional groups materials could be effectively used for metal adsorption from the liquid phase. Among common agro-industrial waste used for As removal are wheat straw, orange waste, red mud, shrimp shells, leather waste, rice husk, rice polish, a biodiesel residue *Pongamia pinnata* seed cake, *Moringa oleifera* and melon rind. Among the most important benefits are selectivity for certain metals, low-cost, easy production and application, the ability of regeneration and supporting waste reusability.

Red Mud - Due to its alkalinity in order to be applicable for As removal it is suggested to be activated by acid or heat activation or its combination, which has been proved as efficient methods, up to 11 % increment has been achieved by combined activation of Bauxsol (red mud). Clays-Bentonite nanoparticles could be modified by Al or Fe and therefore used for As removal. An overall removal achieved by red mud was above 70 %.

Chitosan-based adsorbents. Chitosan, one of the common bioadsorbents, is produced from chitin, which is the structural element in the exoskeleton of crustaceans (shrimp, crabs, shellfish etc.) . It is highly hydrophilic and is characterized by a flexible polymer chain and by a large number of hydroxyl and amino groups that represent potential adsorption sites. Iron impregnated chitosan beads are able to adsorb arsenite up to 95% of the initial value in a broad range of As(III) concentrations

## Coagulation

The *Moringa peregrina (Figure 2.)* seed extract can be used as low-cost coagulants for As(V) removal. In experiment, at optimal pH value (6), while coagulant (*Moringa peregrina*) was added in concentrations between 0.1 and 5 mL/L reduction of initial As(V) concetration (100-500 μg/L) was over 98 %. The *Pistacia atlantica* can be also used as coagulant aid for the same purpose, but usually, it is used with ferric chloride, not as 100 % coagulant .

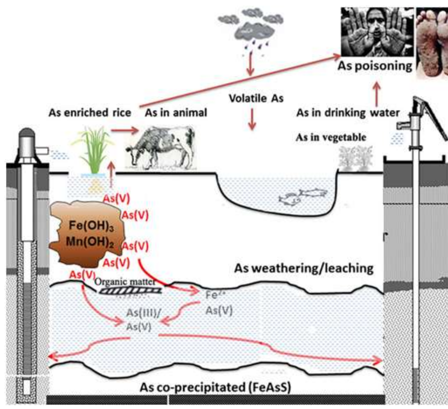


**Fig. 1** The main sources and transport routes of As in the environment

## Hybrid/combined systems

The hybrid systems are usually reported as systems that are partially low cost. For arsenic removal, a hybrid adsorption-wetland system was applied in constructed wetland represented a low-cost part of the system, whereas as an adsorbent activated alumina was used. This system effectively removed around 90 % of As. Wetlands can be also applied after reverse osmosis for the reduction of As from the discharge stream.


**Fig. 2**. *Moringa peregrina* plant and seeds

## Future perspectives and challenges

Environmental consequences of toxic As species present in water have been significant over the past decades. Due to critical health consequences of chronic and acute exposure to As, the remediation of As contaminated ground-surface, drinking and irrigated water as well as As contaminated wastewater through environmental friendly and cost effective strategies is an urgent necessity. The use of industrial by-products as a low-cost sorbent will contribute to improve waste disposal management in developed as well as developing countries due to improper waste handling and disposal practices. The economic benefits represented by the use of low-cost waste materials as a precursor, bioenergy production, and non-activation requirements during the production process justify the use of biochar as a promising alternative for active carbon. The table 1. shows comparison of adsorption capacity ($Q_{max}$ mg/g) of various low-cost adsorbents for arsenic removal.

**Table 1**. Comparison of some adsorption capacity (Qmax, mg/g) of various adsorbents to remove arsenic

| Adsorbent | Initial pH | $C_{Initial}$ (mg/l) | $Q_{max}$ (mg/g) |
|---|---|---|---|
| Bone char | 10 | 0.5-1.5 | 1.43 |
| Leather waste | 1 | 10-100 | 26 |
| Red Mud | 3.5 | 10 | 0.52 |
| C.rihzoma | 8 | 1000 | 22.04 |
| Calcined Mg–Fe LDHs | 6.5 | 206 | 202 |
| Tea fungal biomass | 7.2 | 0.9-1.3 | 0.31 |
| Chitosan | 4 | 400 | 58 |
| Rice polish | 4 | 0.1-1 | 0.14 |

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