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Innovation The Research Concept

Biosorption of Arsenic in Contaminated Water: A Review

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Abstract

Water is one of the most essential need of life. Water is very important and required substance in order to sustain vital activities like nutrition, respiration, circulation, excretion. Now a days the water contamination in various ways such as Inorganic contamination,Organic contamination, Biological contamination Radiological contamination. In Inorganic contamination Arsenic is one of them.Arsenic is now a perceive hazard of water, particularly in the groundwater. The problem of naturally occurring Arsenic in the groundwater is more or less a global reporting. Direct utilization of Arsenic contaminated water is extremely harmful. Thus, a lobby of scientists is engaged in the search of proper, efficient and an economical remedial measure for Arsenic contaminated water. In light of the above, the problem was taken into consideration to study the efficacy of the biological tools in removing the arsenic. On the ground of the literary reports many biological wastes, particularly the agro-wastes were found to be potential enough; and they can be employed for biosorption of Arsenic.

Keywords: Arsenic; Biosorption; Agro-waste; Phytoremediation; Toxins

Introduction

Water is of fundamental importance for life on earth. The synthesis and structure of cell constituents and transport of nutrients into the cell as well as body metabolism depend on water .Water contamination cause problem to health and leads to water borne disease. The contamination present in water disturb the spontaneity of the mechanism and result in long or short term disease. Arsenic is a naturally occurring constituent and forms about 1.5 ppm (parts per million) of the Earth's crust. Arsenic is extremely toxic in inorganic form. It is also present in sedimentary, igneous and metamorphic rocks. It is present in more than 150 different minerals such as arsenides, sulfo arsenides and arsenate. Natural processes such as weathering of rocks and volcanic discharge eads to mobilization of arsenic into ground and marine water [1, 2].

It is also introduced to organic world through various anthropogenic sources such as gold mining, nonferrous smelting, petroleum refining, combustion of fossil fuel in power plants, and the use of pesticides and herbicides containing arsenic [3, 4].

Arsenic is listed as WHO 10 chemicals of major public health concern. The threshold limit of arsenic in drinking-water is 10μg/litre, as recommended by World Health Organization (WHO). A recent survey revealed that the ground water of several parts of eastern Uttar Pradesh and Bihar contain far higher levels of arsenic than is considered safe for human consumption [5].

Acute exposure to arsenic poisoning include severe stomach pain, nausea, headaches and diarrhea, whereas chronic exposure to arsenic includes pigmentation changes, Blackfoot disease, skin lesions and hard patches on the palms and soles of the feet (hyperkeratosis) and neurotoxicity, conjunctivitis, diabetes, enlarged liver, bone marrow depression, destruction of erythrocytes, high blood pressure and cardiovascular disease, infertility, spontaneous abortion, still birth and preterm birth, DNA damage and cancer of skin, bladder and lungs[6].

Arsenic remediation is a matter of global concern. Several conventional techniques are being used for arsenic remediation, such as oxidation, reduction, precipitation, ion exchange, adsorption, lime treatment, solid-liquid separation, physical exclusion, biological removal processes and reverse osmosis, distillation, coagulation with metal salts, iron or manganese removal method, Iron oxide coated sand method, sulphur modified iron method, Granular ferric hydroxide method, Iron filing and photo oxidation method, Acid washing method, Solidification and stabilization method, capping and Soil removal (excavation) method [5,[7]]. Conventional technologies for remediation of arsenic contamination are expensive and tedious, hazardous to workers and the disposal of their byproducts not safe environmentally. At this juncture there is urgent need of an economical, eco-friendly alternative for arsenic remediation.

Type of water contaminants- Water contaminants are four type associated with water pollution.

1- Inorganic contaminants
2-Organic contaminants

3- Biological contaminants
4-Radiological contaminant

1 Inorganic contaminants- The presence of contaminants can also be measured by its chemical parameters hardness in drinking water is naturally occurring contaminate such as Arsenic, Fluoride, Mercury.

2 Organic contaminants- The Major anthropogenic source of organic contamination are pesticide, domestic waste and industrial waste such as pesticide, pharmaceuticals.

3-Biological contaminants- Biological contamination of water is caused by the presence of living organisms such as algae, bacteria, protozoans or viruses.

4 Radiological contaminants- Radiological contamination are caused by radioactive elements. Source of radioactive material could be soils or rocks the water moves through some industrial waste all radiological contamination increase the risk of cancer.

Method for water purification-

1- Physical purification

2-Chemical purification

3-Biological purification

1 Physical purification- Ion exchange, membrane technology, reverse osmosis and evaporation recovery, filtration.

2 Chemical purification- Chemical precipitation, electrochemical treatment oxidation and reduction

3 Biological purification- Biosorption, phytoremediation, phytoextraction.

Biosorption

Biosorption is the passive uptake of heavy metals by natural material or dead biomass. Biosorption is an innovative technology which offers best alternative for removal of toxic metals from polluted streams. It involves the use of natural materials such as agricultural residues [8], forestry waste products [9], microorganisms [10],casein [11] and sugar-beet pulp[12]. Natural materials offer high capacity for heavy metals decontamination. Metal entrapment property of these residues are attributed due to the presence of carboxylic, phosphate, sulfate, amino, amide and hydroxyl groups, which are most commonly found in cell wall [13, 14]. Biosorption is affected by several factors such as pH, simultaneous presence of other metals, kind of biosorbent material and many more. Metal ion uptake by biosorption depends upon substrate and involves complexation, coordination, chelation, ion exchange, adsorption and inorganic micro precipitation [15]. It is well known that many biomolecules, proteins, polysaccharides and extracellular polymers containing SO42-, RCOO-, and PO43-groups are responsible for the bioaccumulation of heavy metals [16-18]. Biosorption capacity for living plants is observed to be a two-stage process the first phase is rapid, and second phase is slow. Adsorption by plant materials follows three steps: surface adsorption (physical and chemical), diffusion into particles and adsorption and fixation.

Biosorption mechanisms are of two types:

1. Metabolism Dependent, i.e., transport across cell membrane and intracellular precipitation and accumulation.
2. Metabolism Independent, i.e., precipitation, physical and chemical adsorption, ion exchange, and complexation [14].

Biosorption mechanisms are not dependent on cell metabolism and are rapidly reversible [19-21]. It is reported that dead biomass has higher metal uptake capacity, and the process is nutrient independent [22].

Researches in biosorption of Arsenic

Some promising arsenic biosorbents were inactive, dead biological biomass, such as algae [23,24], vascular plants[25] , fungi [26-29] and bacterial materials[19] . Some biochars were recently focused for arsenic immobilisation from soils and adsorptive removal in aqueous media [30-32] stated that the phosphorylation of biosorbent results into higher binding of arsenates to the cell wall. Arsenic removal from solution is also possible through formation of complexes on cell surface [33]. Plants [20] their parts or their dried, seized, and chemically treated seeds [25,34,35] and also the industrial or agricultural residue of vascular plants such as rice polish and orange wastes [32,36] were evaluated as biosorbent material for arsenic removal [25] reported chelation of As (III) with the –OH groups for different fresh parts of the biomass of *Momordica charantia* following Langmuir and Freundlich sorption models. The nature of sorption were evaluated from Dubinin–Radushkevich (D–R) sorption isotherms and used to explain the heterogeneity of surface energies [25]. Fibres, lignins, cellulose, and other cell walls binding substance, such as phenols, cutin, suberins and waxes have also been suggested as a prominent tool for the purpose [37]. Lignin and pectin, are supposed to be connected with the sorption of metal ions [38-41]. Plant fibres are spacious for sorption of metal ions and have been evaluated for water purification [38]. Alginate, the outer cell wall component of brown algae, Prokaryotes cell walls, is made up of polysaccharides, proteins, and lipids (holds abundant metal binding functional groups, such as carboxylate, hydroxyl, sulphate, phosphate, and amino groups) and mushrooms, filamentous fungi, chitin, chitosan, and other fungi have been studied for arsenic retention [23,27,28,33,[42]. However, not much attention has been given to understand the mechanisms behind these bio-sorption processes [43] reported that bark, chitosan, xanthate, zeolite, clay, peat moss, seaweed, dead biomass are potentially low-cost sorbent and they offers highest heavy metal adsorption capacity [44] observed that *Paecilomyces sp.* is a promising biomaterial for removal or recovery of Arsenic (III) from aqueous solution of arsenic. Biomass of *Sargassum sp.,* brown seaweed can probably perform biosorption process, contributing through ion-exchange reactions. The modified biomass of *Aspergillus niger* suggests their potential applications for the removal of metals from contaminated water [45] Modified biomass of *P. chrysogenum* showed promising results in effective removal of As (V) [28]. Byproduct chars from bio-oil production can be explored as cost effective adsorbents for arsenic removal from contaminated water system [46]. FeCl3 pretreated tea fungus, a waste produced during black tea fermentation are effective bio-sorbent for As (III) and As(V) [42]. Rice polish, an agro waste proved efficient adsorbent material for arsenic removal from aqueous solution, as according to [36]. Biowaste from fruit juice processing industry are effective biosorbent for removing of toxic metal ions from metal contaminated aqueous solution [41]. Waste biomass of high fiber and protein content are effective to sorb arsenic [14], [47] reported that biosorption of As (V) by crab shell based chitosan is a promising technique to treat the arsenic contamination. Pyrolysed sludge from sewage is an effective low cost sorbent material and is able to remove arsenic from water [48].

Objective of the Study

Biosorption provides a potential source to recycle waste products as well as to adsorb and degrade arsenic from contaminated system which is not possible from chemical adsorbent. Biosorption is a process which represents a biotechnology innovation as well as a cost effective excellent tool for removing heavy metals from aqueous solutions. It represents a typical technique for using as a economical alternative tool.

Conclusion

The applicability of biomass material by biosorption can be explored, as it is easy, economical and eco-friendly. Substantial progress has been made towards an understanding off Arsenic transformation processes in soils. The waste products can be utilized again for the removal purpose and then can be disposed of without any harm to the environment. It acts as easily handled decontamination method. More studies are needed to the better understanding of biosorption, actual arsenic binding mechanism to the biosorbents, metal desorption and biosorbent regeneration, formulation of new biosorbent materials. Commercial interest is also needed for exploitation of new biosorption technology.

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