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Arsenic in Water: Current Status and Future Perspectives

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ABSTRACT

Groundwater pollution with arsenic is a worldwide environmental issue affecting many people, particularly in developing nations. Drinking arsenic-contaminated water from deep wells having high quantities of the trivalent arsenite species was blamed for the "blackfoot sickness" that struck Taiwan more than half a century ago. Comparable arsenic poisoning instances were later documented in China's Inner Mongolia, Bangladesh, and India, all linked to arsenic-contaminated groundwater. Accepting geochemical and mobilization processes, developing sufficient Arsenic removal filters, identifying shortfalls in Arsenic removal procedure act and preservation, describing risk-free deeper aquifers as an alternative source of groundwater, and developing surface water-based water supply schemes in many Arsenic-exaggerated areas. Success stories of community participation in operating Arsenic removal technologies are all examples of community participation in operating Arsenic removal technologies. This study intends to illustrate the current condition of Arsenic groundwater pollution in India, the various state remedial and preventative actions, and the success and failure encountered.

Keywords-- arsenic poisoning, blackfoot, pollution, water purification technology, adsorption, geochemical

I. INTRODUCTION

Arsenic is metal and non-metal that occurs naturally and is highly mobile in the environment. The parent mineral shape, oxidation state, and mobilization processes have a role in its mobility. Arsenic may be found different oxidation states: arsenite (As(III)), arsenate (As(V)), arsenic (As(0)), and arsine (As(III)) [1]. The inorganic arsenite and arsenate forms of arsenic are the most frequent forms found in the water among these four arsenic types. Due to delayed redox reactions, arsenite and arsenate can be found in reduced and oxidized settings. Arsenic appears largely as arsenite in decreasing anoxia habitats (e.g., subterranean waters, sediments have been decreased), Arsenate, on the other hand, is prevalent in aerobic oxidizing conditions (surface waters) [2][3]. In assessing the condition of arsenic, the pH is also crucial. This knowledge is especially relevant in determining arsenic toxicity because various arsenic oxidation states have varying toxicities. Furthermore, because negatively charged arsenate is frequently easier to remove than uncharged arsenite (i.e., H_3AsO_3), this Eh-pH diagram can assist in determining the best arsenic removal environmental conditions. Groundwater contamination by arsenic is especially severe in Asian countries, particularly Bangladesh and West Bengal, India [4]. Most of the population in both places gets its water from tubular wells. Because arsenic is a geologically produced substance, it is projected that 79.9 million people in Bangladesh and 42.7 million people in India are exposed to contaminated groundwater with concentrations exceeding 50 g/L [5]. In certain tube wells in Bangladesh, the arsenic content is as high as 4730 g/L. Arsenic (As) is released through weathering of rocks and minerals, which is then leached and discharged into the soil and groundwater [6]. Anthropogenic sources can also cause it to be discharged into the soil and groundwater. Red-ox potential (Eh), adsorption/desorption, precipitation/dissolution, Arsenic speciation, pH, the presence and concentration of competing ions, biological transformation, and other variables all have an influence on arsenic concentration and transit in groundwater [7][8]. Depending on geological settings, geochemistry, and geoenvironmental conditions, aquifer adsorption and desorption processes, arsenic species, Eh, pH, and solid-phase dissolutions and precipitations may change from aquifer to aquifer. As a result, a thorough geochemical investigation is required to get sufficient information on arsenic geochemistry under diverse hydrogeological and geo-environmental conditions of aquifers in order to design sustainable solutions [9] [10].

II. ARSENIC TOXIN IMPACT

Arsenic is very hazardous to all living things. The WHO has classed this element as a category one carcinogenic substance for humans. Due to multiple arsenic contamination occurrences globally and the concerns linked with them, several researchers have recently undertaken investigation arsenic's environmental destiny and behavior [11]. After consuming inorganic arsenic in concentrations more than 50 g/L in drinking water, various skin diseases (e.g., hyperpigmentation, hyperkeratosis) and malignancies (e.g., skin, lung, kidney, bladder) might develop [12]. This is referred to as arsenicosis. Inorganic arsenic species have been shown to be more hazardous than organic arsenic species, such as monomethylarsenate (MMA) and dimethylarsinate (DMA). These species' toxicity rises in this order: DMA–MMA–arsenate–arsenite. As (III) is more harmful to human health than As(II) because it is more cytotoxic, genotoxic, mobile, and soluble (V). When trivalent intermediates build in the human body, there is a higher chance of developing arsenic-induced diseases [13][14].

According to several studies, drinking arsenic-contaminated water has been identified as one of the major health concerns for humans during the previous three decades. Measures to prevent arsenic contamination of groundwater and/or ameliorate the impact of such contamination must be created to reduce the health risks of consuming arsenic-contaminated water [15][16]. Traditional ways for removing as species from water. Furthermore, this work will present some novel porous adsorbents that, due to their outstanding characteristics, such as high pore volume and surface area, could act as superior adsorbent materials in the near future, in addition to the use of nanoparticles for the treatment of arsenic-contaminated water [17][18].

Arsenic in Groundwater Occurrences According to several studies, groundwater arsenic pollution is primarily limited to the Ganges delta's alluvial aquifers, which contain sediments transported from mineralized zones rich in sulphides in Bihar and elsewhere in the deposition basin [19]. Recent investigations have found that wells in the Indo-Gangetic alluvium's late Quaternary and Holocene aquifers extend further west, and the Brahmaputra alluvium contain higher arsenic contents [20].

Arsenic produced by sulphide mineral weathering is primarily adsorbed onto the surface of iron oxy-hydroxides created during the oxidizing conditions that occurred throughout Holocene sediment deposition [21]. Redox activities in the sediments, on the other hand, caused the iron oxides to be dissolved in a reductive manner, which resulted in significant quantities of arsenic being transported to aqueous phases via biogeochemical interactions. In the Ganga–Brahmaputra River watershed, arsenic-containing groundwater is held in sediments created by rivers throughout the late Quaternary or Holocene era (12 thousand years). The mineralogy of such sediments includes quartz, feldspars, illite, and kaolinite, and the fine-grained overbank facies have a significant organic content [22]. Various rivers originating in the Himalayas to the north and northeast have pushed out a thick layer of younger alluvium containing sand, silt, and clay. The bulk of documented arsenic issues in the environment are the result of mobilization in natural environments. As a result, arsenic in groundwater in the BDP and Gangetic plains has been recognized as a geological occurrence caused by mobilization under natural hydro-geologic conditions [23][24].

Where does arsenic enter drinking water, and how does it get there?

Natural deposits in the ground or pollution from industry and agriculture can introduce arsenic into the water supply. It is often considered that naturally occurring arsenic dissolves out of specific rock formations when groundwater levels drop sufficiently [25]. Some firms in the United States dump thousands of pounds of arsenic into the environment each year. After it is dumped, arsenic remains in the environment for a long time. Arsenic is removed from the air by rain, snow, and slow settling [26].

After being exposed to arsenic on the ground or in surface water, it can progressively penetrate groundwater. The presence of high levels of arsenic in private wells might be attributed to previous use of arsenic-containing fertilizers or industrial waste [27] [28]. It might also indicate that the well was constructed poorly or that chemical fertilizers or herbicides were utilized excessively previously.

The majority of those who get arsenic skin lesions come from low-income families. From 1983 to 2006, the following characteristics were often seen in endemic arsenic districts of India:

1. Skin itchiness from Sun energy, watery eyes, weight loss, appetite loss, weakness, tiredness, and quickly exhausted restricted physical activity and working capacities.
2. Respiratory problems were also prevalent. More than half of the people had a Coughing for a long time, with or without expectoration.
3. Gastrointestinal symptoms include anorexia, nausea, dyspepsia, altered taste, abdominal pain, enlarged liver and spleen, and ascites (collection of fluid in the abdomen).
4. In several cases, from mild to severe anemia was visible.
5. Leg edoema was less prevalent than conjunctival congestion.

III. ARSENIC POLLUTION IS A WORLDWIDE ISSUE

Only in the last several decades has arsenic been recognized as a severe health hazard. Only in the 1980s did the WHO establish precise drinking water criteria of 10 g/l or 0.01 mg/l. Many nations have reported excessive levels of arsenic in a portion of their groundwater supplies at the moment [29] . For example, it is a serious issue in Asian nations such as Afghanistan, Bangladesh, Cambodia, China, India, Myanmar, Nepal, and others. Several research studies have recorded and published findings on arsenic pollution in groundwater [30]. The problem of groundwater arsenic poisoning in several regions of the world, particularly in Bangladesh, is so critical that immediate plans and strategies are required to address it. It is critical to provide sufficient drinking water to all severely impacted communities [31][32], despite the lack of a sufficient decontamination pathway for arsenic-contaminated groundwater. By pursuing sustainable development, one of the major tasks that may be performed is to reduce pollution from anthropogenic sources, particularly agricultural and industrial operations [33]. Avoiding the use of arsenic-contaminated water for drinking reasons will also need more public awareness and education. Human health will be compromised if these actions are not taken seriously in extremely polluted areas [34][35].

IV. CONCLUSION

Arsenic is a persistent pollutant in groundwater that has a negative influence when ingested in this manner; it has a positive impact on human health, for e.g., water to drink. Arsenic emissions from natural and manmade sources, including numerous Asian countries, necessitate on-site treatment to reduce toxicity risks [36][37][38]. Arsenite is first oxidized by either ambient oxygen, bacterial action, or chemical reagents; traditional procedures mainly focus on arsenate removal. A coagulation/flocculation procedure can increase the particle size of soluble species, allowing them to be removed by a later process of precipitation or membrane filtration [39][40]. Ion-exchange resins may also directly immobilize ions of arsenic, however, this method is hampered by pH fluctuations and opposition with co-existing ions like phosphate and silicate. However, because their adsorption capabilities are still too low and there is no way to regenerate and reuse the adsorbents, the practical application of these conventional and non-conventional approaches is still restricted [41][42][43]. Arsenic contamination in groundwater exceeding the permissible limit of 50 g/L has been reported in seven Indian states: West Bengal, Jharkhand, Bihar, and Uttar Pradesh in the Ganga River flood plain; Assam and Manipur in the Brahmaputra and Imphal River flood plains; and Rajnandgaon village in Chhattisgarh state [44][45]. After drinking arsenic-contaminated hand tube-well water, people in these states have been exposed to arsenic for a long period. With each new survey, more arsenic-affected villages and persons suffering from arsenic-related illnesses are reported, and the problem-solving challenges are growing more sophisticated due to a number of unknown factors [46][47][48]. It is now largely assumed that the source is geological in origin, with fertilizer residue percolation perhaps contributing to its further amplification. Parental rocks or outcrops in the Ganga-Brahmaputra-Barrak valley's river paths have yet to be discovered, including their sources, routes, transportation, speciation, and presence in Holocene aquifers [49] [50]. The polluted waters were enriched in Fe, Mn, Ca, Mg, bicarbonates, sulphate, fluoride, and chloride and deficient in sulphate, fluoride, and chloride; pH varied from 6.5 to 8; and the redox state was generally decreasing. high organic matter content; lodged mostly in sand coatings, or sorbed on clays, HFOs, and organic matters; pH ranged from 6.5 to 8; redox condition was usually reducing; lodged mostly in sand coatings, or sorbed on clays, HFOs, and organic matters; pH ranged from 6.5 to 8; redox condition was usually reducing; lodged mostly in sand coatings, or sorbed on clays [51][52]. Arsenic has been shown to have a positive or negative affinity for iron in groundwater, depending on the situation. This raises the prospect of inventing in situ as pollution treatment by removing Fe from groundwater prior to extraction. Arsenic removal devices of several types have been invented, each based on a distinct operating principle, and have been used in fields [53][54]. Many of them were unable to deliver sufficient results or failed to owe to a lack of O&M or sludge disposal issues [55]. Iron co-precipitation and lime softening have been touted as the most successful techniques of removal, and have been found to work effectively in situations where a public-private partnership manages management and maintenance. To make arsenic removal procedures suitable and sustainable for large-scale application, present methods must be modified [56][57].

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