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Arsenic pollution status and repair technology: an overview

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Abstract. The article focuses on the status quo of drinking water, groundwater and soil arsenic pollution at home and abroad, and expounds the harm of chronic arsenic poisoning and acute arsenic poisoning on human skin, respiratory system and nervous system. The leaching technology, solidification stabilization technology, physical repair technology and its effects of arsenic-contaminated soil remediation were introduced selectively, and the nanotechnology repair arsenic pollution was briefly introduced.

1. Introduction

Arsenic is a kind of metal that is widely used in production and is highly toxic. It has been identified by WHO as one of the human carcinogens. It is accumulated in the natural environment and is gradually eroding environmental safety and human health. As early as 2004, the World Health Organization's Global Water and Arsenic Pollution Report pointed out that more than 50 million people worldwide are threatened by arsenic-contaminated water sources. By 2018, the number of people threatened by arsenic-contaminated water sources has quadrupled, reaching about 200 million people [1]. The international standard for drinking water is 10 ppm. In developing countries, the arsenic content of drinking water exceeds the standard. Some developed countries such as the United Kingdom and the United States also have excessive levels of arsenic in drinking water. China's drinking water standards also implement international standards, but the groundwater arsenic content standard is 40 ppm, and in Shandong, Shanxi, Henan and other places, there are reports of groundwater arsenic exceeding the standard [2]. According to some surveys, about 10% of well water in Zhengzhou is higher than 10 ppm [3]. Arsenic pollution not only threatens the safety of water, but also reports of soil arsenic pollution. The survey shows that arsenic pollution is widespread in developed and developing countries. There are arsenic contamination in 41% of the contaminated sites in the US Environmental Protection Agency's Superfund program [4], and there are more than 10,000 sites with arsenic contamination in Australia [5]. The average concentration of arsenic in soil in China is about twice that of the world average ($6 \text{ mg} \cdot \text{kg}^{-1}$) [6]. According to the 2014 National Soil Pollution Status Survey Bulletin, the rate of as content in soils in China exceeded 2.7%, is the second largest pollutant after Cd. Shanxi Province is the region with the



most serious arsenic pollution in the country. There are also sites with serious arsenic pollution in Guangxi, Yunnan and Qinghai [7-9].

2. Arsenic pollution harms human health

Low doses of arsenic do not harm the human body, but are beneficial. However, when arsenic is ingested, it will gradually accumulate in the human body. Long-term consumption of food containing arsenic or drinking water containing arsenic may cause chronic arsenic poisoning, which is manifested as nervous sensation such as dullness and numbness of limbs. If you continue to ingest, it will further damage the peripheral nerves, causing movement disorders, feeling decline and so on. In addition, it can cause a variety of skin inflammation and respiratory diseases such as rhinitis, cough, laryngitis, bronchitis, severe toxic hepatitis or cirrhosis, and some people with low immunity may cause hematopoietic dysfunction or leukemia. A large intake of arsenic can cause acute poisoning. It has obvious damage to the gastrointestinal system, respiratory system, skin and nervous system. The main symptoms are fatigue, vomiting, abdominal pain and headache. In severe cases, it will be severely comatose until it is difficult to breathe, which will eventually lead to heart failure and death. Arsenic pollution into the soil will also result in a simplification of the biome structure, causing biological death in severe cases. Studies have shown that low as stress can stimulate the growth and reproduction of as sensitive microorganisms, such as *Desulfovibrio* and *Allobaculum*, making the community structure more complex and diverse. High As (400 mg/kg) has obvious inhibitory effect on microorganisms, leading to the extinction and diversity of some species. As stress induces anti-As microorganisms (such as *Pseudomonas*) to become dominant groups, and the community structure tends to be stable and single [10].

3. Arsenic-contaminated soil remediation technology

The chemical repair technology mainly uses the addition of chemical reagents (such as phosphates, citric acids, carbonates) to the soil to change the mobility of arsenic pollutants, reduce its bioavailability and toxicity, and achieve the leaching of arsenic pollutants or the purpose of fixing the soil. At present, the chemical repair technology has carried out a lot of research at home and abroad, and the technology is relatively mature. The common chemical repair methods include the leaching method and the fixing/stabilizing method. The rinsing and repairing technology mainly increases the mobility of arsenic contaminants by adding reagents such as phosphoric acid and citric acid, and discharges the soil with the eluent. Studies have shown that after arsenic-contaminated soil is washed with 9.4% H_3PO_4 for 6 h, the soil arsenic is nearly completely removed, the removal rate is 99.9% [11], and the removal rate of arsenic in yellow brown soil by K_3PO_4 can reach more than 40% [12] The arsenic removal rate of citric acid in soil at a concentration of $0.25 \text{ mol} \cdot \text{L}^{-1}$, soil-to-liquid ratio of 1:50 and 21 h of action time can reach more than 70% [13].

The physical repair technology mainly repairs arsenic-contaminated soil through physical methods such as soil modification, isolation, and electric repair. The soil improvement method can be divided into two major categories: the soil turning method and the guest soil method. The tumbling method is to treat the arsenic-contaminated soil by means of tilling. The contaminated soil and the clean soil can be thoroughly mixed to reduce the arsenic content per unit soil on one hand. On the other hand, the physicochemical properties of the original soil can be changed by tilling and the soil is increased. The aeration and water permeability of the body enhances the biological activity of the soil, thereby enhancing the self-purification ability of the soil. The process of changing the soil method is relatively simple. The key is to determine the extent of the pollution area and the arsenic content. The soil-turning method is applicable to sites with low levels of arsenic pollution. The guest soil method is applicable to high pollution levels and clean soil nearby. The isolation method uses a material with low permeability to close the arsenic-contaminated soil to block the spread of pollutants. Isolation and repair technology generally uses materials such as quicklime, cement, bentonite or selectively permeable membrane to build a barrier between contaminated soil and surrounding clean soil to block the migration of arsenic. For example, the mechanism of calcium-based bentonite blocking arsenic migration is to fix arsenic ions in soil particles by adsorption. After modification of ordinary calcium-based bentonite, the ability

of bentonite to fix arsenic can be greatly improved, and thiolated bentonite is used for arsenic ions. The adsorption capacity is close to 100%, and the desorption rate of arsenic ions after adsorption is less than 1% [14]. The electric repair method artificially inserts positive and negative electrodes in the contaminated soil, and adds a liquid as a current to the medium in the soil, and the arsenic ions are directionally moved by the electric field, and finally the precipitate is accumulated at the electrode, thereby achieving the removal of arsenic pollution. The purpose of the object. Ji Dongli et al. used electric combined osmosis reaction grid (EK/PRB) to repair arsenic-contaminated soil. The results showed that the removal rate of arsenic contamination by electro kinetic repair (EK) alone can reach 42%, which can be removed by EK/PRB combined repair method. The rate was increased to 57%, and the removal rate was increased to 68% using hydrochloric acid to adjust the cathode pH. In addition, the oxides produced by electrode electrolysis can also be co-precipitated with arsenic to achieve the purpose of removing contaminants. Brewster et al. found through experiments that when ferrous iron is used as an anode for electric repair, the ferrous ions produced by anodic electrolysis are oxidized to hydrate. Iron oxides react with arsenic ions to form precipitates [15]. The process of electric repair technology is more complicated and costly.

4. Conclusion

With the increasing problem of arsenic pollution in the world, arsenic pollution repair technology has been widely concerned by scholars, and physical, chemical, biological and joint repair technologies are emerging. With the development of science and technology, nano-repair technology has gradually been applied. After 12 years of research and development, the research team of China Medical University and the University of Hawaii developed the world's first nanofiltration device to reduce the concentration of arsenic in drinking water, and obtained the authority of the National Sanitation Foundation (NSF International). The principle of this technology is to use nano-ceramic materials to remove arsenic in water. The arsenic is physically adsorbed in mesopores from 1 to 50 nm, and then chemically reacted with the nanomaterials in the pores to seal the arsenide. By the sealing property of such a small hole, the arsenic after adsorption is no longer released into the environment, and secondary pollution caused by ordinary absorption can be avoided. In the field of soil arsenic pollution repair, some scholars have prepared nano-plate ZnO photo catalysts for arsenic-contaminated soil remediation by hydrothermal synthesis. It is found that adding 204 gram of nano-plate ZnO to trivalent arsenic in 20 ml arsenic-contaminated soil extract the degradation rate is as high as 90% or more [16]. With the continuous development of nanotechnology, new nanomaterials will be developed for the repair of arsenic pollution, creating a bright future for solving the world arsenic pollution problem.

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