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Current Status of Soil Arsenic Pollution and Research Progress in Phytoremediation

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Abstract

Arsenic is a toxic metal element that is ubiquitous in nature and widely used by humans in life. Soil arsenic pollution has gradually been paid attention to with the development and utilization of arsenic. The article systematically discusses the source of arsenic, the process of arsenic pollution, its toxicity to the human body, and the current status of soil arsenic pollution, and clarifies the severe situation facing humanity today. Aiming at the remediation of arsenic-contaminated soil, the application status and effectiveness of phytoremediation, an environmentally friendly remediation technology, were systematically introduced, and the further development of phytoremediation technology was prospected.

Keywords

Arsenic; Phytoremediation; Soil; Remediation.

1. Introduction

Metalloid arsenic is an element that is ubiquitous in nature (atmosphere, soil, rock, water and other environmental media), has a certain toxic effect on the human body, and is easily carcinogenic. Arsenic in nature is mainly found in rock minerals. Common arsenic-containing minerals include sulfide minerals (such as pyrite, pyrrhotite, Maxi ore, galena, sphalerite, chalcopyrite, etc.), oxides Minerals (such as hematite, magnetite, ilmenite, etc.), silicate minerals (such as quartz, feldspar, mica, amphibole, pyroxene, etc.), carbonate minerals (such as calcite, dolomite, meteorite Iron, etc.), sulfate minerals (such as gypsum, barite, etc.) and other minerals (apatite, fluorite, etc.), rock minerals gradually disintegrate through weathering or erosion, or are derived from strong geological movements (such as volcanoes) Explosion), microbial activity, arsenic is released into the surrounding soil, and then gradually spread through the transport action of wind or water. The release of arsenic under natural conditions rarely reaches the level of harmfulness to the human body. Only a few areas have high arsenic content in minerals, environmental conditions conducive to release and migration, and low-lying terrain. As a result, the arsenic content in soil and groundwater is harmful to humans. The degree of toxic effect causes endemic arsenic disease. Most of the release, migration and pollution of arsenic are caused by human activities, including the mining, smelting and transportation of arsenic-containing minerals and the utilization of arsenic-containing substances. In the process of mining and utilization of arsenic-containing minerals, arsenic-

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containing substances are inevitably leaked and discharged. Arsenic-containing pesticides and phosphate fertilizers are used in agricultural production, and arsenic-containing compounds such as roxarsone are often used as feed additives in livestock breeding. The additives are metabolized by livestock to produce arsenic-containing manure which is used as farmyard manure, which is also one of the important sources of arsenic. These arsenic released by human activities will cause pollution of the air, water and soil environment in the area. Due to atmospheric sedimentation, water dissolution and transportation, and soil adsorption characteristics, most of these pollutants will eventually be carried by the soil, and arsenic-containing substances continue to be carried. Accumulate in the soil, its content will eventually reach the threshold of harm to the human body, causing diseases such as the human respiratory system, nervous system, and immune system. In severe cases, it can lead to paralysis or carcinogenesis. Some acute arsenic poisoning may also directly lead to death.

2. Current status of arsenic pollution

The content of arsenic in the earth's crust is about 1.5 $mg \cdot kg^{-1}$, the content of arsenic in the soil is about 5-10 $mg \cdot kg^{-1}$, and the content of arsenic in the soil of our country is about 11.2 $mg \cdot kg^{-1}$, which is the average arsenic content of the world's soil 1.5 times. With the release of arsenic-containing substances in the soil through human activities, the problem of arsenic pollution in some areas has gradually become prominent. According to the data of the National Pollution Survey (2005-2013), the rate of excess arsenic pollutants in the national soil is 2.7%, among the 8 inorganic pollutants of cadmium, mercury, arsenic, copper, lead, chromium, zinc, and nickel Ranked third. There have been soil arsenic pollution incidents in Dushan County of Guizhou, Chenxi County of Hunan, Shimen, Hechi City of Guangxi, and Yangzonghai of Yunnan in China. There are also related reports of soil arsenic pollution in Mexico, Poland, Chile, and the United States [1-3]. The groundwater pollution problem closely related to human health is also prominent in our country. The area with arsenic content exceeding 10 $\mu g \cdot L^{-1}$ (WTO drinking water standard) covers an area of 150,000 square kilometers, and nearly 20 million people live in groundwater at high risk of arsenic pollution. And about 200 million people worldwide are threatened with high arsenic exposure[4]. Therefore, it is necessary to develop reasonable and efficient arsenic pollution remediation technology to prevent and control arsenic pollution, which is of great significance for protecting human health, realizing the ecological circulation of land, and ensuring food security..

3. Research on phytoremediation of arsenic pollution

Phytoremediation is the use of enriched plants and their secretions to degrade and absorb arsenic pollutants in the soil. It has the characteristics of no secondary pollution and low cost, but it takes a long time to repair and usually requires screening of arsenic super-enriched plants. Common arsenic-enriching plants such as centipede grass have a strong ability to accumulate and tolerate arsenic. Under the conditions of proper application of phosphate fertilizer to regulate the growth of centipede grass, the removal rate of soil arsenic can reach 7.84% after 7 months of planting. And the arsenic content of centipede grass can reach 1.62 $g \cdot kg^{-1}$ [5,6]. The absorption of As (V) by centipede grass requires the participation of phosphate transporter [7]. The absorption of As (III) is usually done by channel protein. He et al. first developed that a TIP-aquaporin (PvTIP4) is involved in the absorption of arsenic. The resistance and absorption capacity of centipede grass to arsenic also originate from arsenic-reducing bacteria in its body and rhizosphere. Wang Jiao et al. extracted 23 arsenic-reducing bacteria from centipede grass and rhizosphere soil. The adaptive tolerance to pentavalent arsenic was 80-140 $mmol \cdot L^{-1}$, and the tolerance to trivalent arsenic was 5-30 $mmol \cdot L^{-1}$. In a medium containing 1 $mmol \cdot L^{-1}$ pentavalent arsenic, the strain's arsenic accumulation rate was 3-79%, and 3 of the strains with

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an arsenic accumulation rate of 75-79% and an arsenic reduction rate of 81-100% have been screened out (Pseudomonassp. S2, Pseudomonassp. P3, Staphylococcusso. S14 and Agrobacterium sp. P1) [8]. In addition to centipede grass, which is an arsenic hyper-accumulating plant, scholars have found through research that reeds, ramie, pterocarpus, wormwood, awn, pokeweed, setaria, etc. also have a certain ability to accumulate arsenic. Yang Jinhong and others planted reeds in Xinjiang to repair arsenic-contaminated soil and found that the arsenic content of reeds was positively correlated with the soil arsenic content [9], the arsenic content of each part of the reed root>leaf>overground stem>underground stem.

With the further in-depth research, scholars have discovered that through certain adaptations of external conditions, the efficiency of plant repairing arsenic pollution can be effectively improved, usually by adding exogenous stimuli to improve plant tolerance or adsorption performance. Studies have shown that in soil with an arsenic content of 55 $mg \cdot kg^{-1}$, spraying 25 $mg \cdot L^{-1}$ of indole acetic acid and 20 $mg \cdot L^{-1}$ of kinetin on the soil after planting centipede grass can improve the extraction efficiency of arsenic from centipede grass. The combined application of sodium tripolyphosphate and citric acid can increase the absorption of arsenic by centipede grass by more than 40% [10].

4. Prospect

Soil arsenic pollution is an environmental problem that threatens human health and is not easy to be completely repaired. If effective restoration techniques cannot be developed, with the development of society and economy, the problem of soil arsenic pollution will inevitably become more and more serious. Phytoremediation, as an environmentally friendly remediation technology that can completely extract arsenic from the soil, has great development potential in the field of arsenic-contaminated soil remediation. The current main problem restricting the development of phytoremediation is the efficiency of remediation and the treatment of arsenic-containing plants. This requires scholars to balance the relationship between the improvement of soil arsenic mobility and the tolerance of remediation plants, and the extraction of arsenic from arsenic-containing plants or the treatment of arsenic Carry out more in-depth research on solidification to promote the rapid development of phytoremediation technology in the field of soil arsenic pollution remediation.

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