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Research Progress on Remediation of Heavy Metal Pollution in Soil by Garden Plants

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ABSTRACT. *With the rapid development and change of industry and towns, the accumulation of heavy metals in the soil system is increasing, which may directly threaten the safety of human life. Therefore, the problem of soil heavy metal pollution needs to be solved urgently. Therefore, the remediation technology of soil contaminated by various heavy metals has become a research hotspot. Compared with other technologies, phytoremediation technology is relatively safe and cheap, which is considered to be one of the better measures for the remediation of heavy metal contaminated soil. However, garden plants occupy an important position in phytoremediation due to their own advantages.*

KEYWORDS: *garden plants, phytoremediation, soil contamination, heavy metal*

1. Introduction

Building a beautiful ecological environment is our common goal. However, the situation at this stage is not optimistic. Environmental pollution has become a problem around the world. We must not only pay attention to air pollution, water pollution, but also soil pollution.

Soil contaminated by heavy metals not only threatens people's health, but also affects the country's economic construction. In soil pollution, heavy metals have the characteristics of wide source, variety and great harm in the soil environment.

2. Soil Heavy Metal Pollution

In 2014, data from a communiqué jointly issued by the Ministry of Environmental Protection and the Ministry of Land and Resources of China showed that the national total heavy metal pollution point exceeded the standard rate of 16.1%, and the area of heavy metal contaminated soil is increasing at a rapid rate. The research investigation found that the proportions of light, light, moderate and severe pollution points of cultivated land reached 13.7%, 2.8%, 1.8% and 1.1% [1].

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From the point of view of excessive pollutants, the problem of cadmium is the most serious, followed by arsenic and copper, followed by mercury, lead and chromium [2].

In 2017, my country's heavy metal contaminated soil area has exceeded 100,000 square kilometers, and the contaminated area is constantly rising, and most of them are concentrated in more economically developed areas [3]. A large number of heavy metal elements have entered the soil ecology through industrial and domestic sewage discharge, sewage irrigation, industrial and mining metallurgical industry waste residues and non-degradable waste stacking, transportation tail gas and industrial exhaust gas deposition, use of pesticides and agricultural fertilizers, etc. In the system, this not only affects the structure and function of the soil, resulting in a decline in the quality of the soil environment, but more importantly, it can be absorbed by passive plants and interfere with the life metabolism of soil organisms, thereby threatening the quality and safety of agricultural and sideline products, and through the food chain. Movement causes unpredictable harm to people's health [4]. Therefore, the treatment of soil contaminated by heavy metals is urgent.

3. Phytoremediation Technology

Phytoremediation technology is a general term for using natural growing plants or plants cultivated in a certain way to repair heavy metal contaminated soil environment. It treats soil environmental pollutants by means of plant extraction, volatilization, fixation, and root filtration, and has become an efficient and useful method for remediation of heavy metal contaminated soil [5].

Plant remediation technology has become a research hotspot in contemporary remediation technology because of its safe and cheap advantages in the environmental management of heavy metal contaminated soil. Among them, garden plants, as an important part of urban greening environment system construction, have various advantages such as purifying air, beautifying the environment, regulating the climate, and improving the urban ecological environment. They occupy a key position in plant restoration [6]. The use of willow, wintergreen and other garden plants to repair heavy metal contaminated soil can not only beautify the environment and purify the air, but also be further processed into handicrafts, producing economic benefits, but also have very significant social value.

In the 1970s, as the concept of phytoremediation technology was proposed and recognized internationally, scholars in my country began to pay attention to and study the application and development of this technology in China. In 1986, Professor Gao Zhengmin, a well-known soil science and ecology expert in my country, expounded his academic views on the use of phytoremediation technology to restore heavy metal contaminated soil ecosystems and productivity. In 2001, Ke Shaoying believed that the side effects of physical and chemical methods prompted people to seek a new method that is economical, simple, and does not destroy soil fertility. This new method is the restoration of plants. In 2014, Chuan Limin and others proposed the urgency to study the need for economic, efficient and feasible

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advantages of soil heavy metal pollution remediation technology. In 2019, Fang Songlin and others believed that the use of plants to repair heavy metal pollution in the soil could change the severe situation of heavy metal pollution in my country [7].

Since entering the 21st century, my country's research achievements have been remarkable. In 2002, Yang Xiaoe and others discovered a perennial grass in southeast Zhejiang Jingtian has an enrichment effect on zinc [8]; Xue Shengguo and others in 2003 discovered a super-accumulative perennial herbaceous plant Shanglu that can enrich manganese [9]; In the same year, Liu Wei and others discovered that Baoshan Viola can be used as a super-enriched plant of cadmium in Hunan [10, 11] This is the result of a batch of earlier studies since the 21st century. Of course, foreign research results are also very valuable. In 1989, Baker et al. for the first time studied the super-enriched plant Sky Blue Cabbage can effectively accumulate zinc and cadmium in the form of a field experiment; Blaylock et al. found that mustard can absorb and enrich a variety of heavy metals, such as lead, Cadmium, zinc, etc.

According to the different mechanisms and action processes, phytoremediation technology can be divided into four categories: plant extraction, plant volatilization, plant fixation and root filtration.

3.1 Plant Extraction

Plant extraction technology refers to the use of some plants that have a heavy metal enrichment effect to adsorb heavy metals in the soil. The heavy metals are absorbed by the plant roots and then transferred to and stored in the plant stem and leaves. Heavy metal pollution [12]. In 1994, Baker and others in the United Kingdom used the principle of plant extraction for the first time to use Thlaspi caerulesences to repair land contaminated with heavy metals, providing an experimental basis for the feasibility of plant extraction [13]. Tang Yetao et al. also conducted an experimental study in 2005. This is the first time in China that Arabidopsis thaliana has enrichment ability for lead, zinc and cadmium [14].

3.2 Plant Volatilization

Plant volatilization is the use of some special substances secreted by the rhizosphere system of super-enriched plants to convert the heavy metals in the contaminated soil (mainly heavy metals with relatively low gasification points) into gas forms to volatilize the soil and plant surface and release Into the atmosphere [15]. In 1997, Banuelos et al. discovered that kenaf can convert non-heavy metal trivalent selenium in the soil into gaseous state for removal, confirming the feasibility of plant volatilization [16]. In 2000, Meagher's research found that tobacco can convert the more toxic divalent mercury into gaseous mercury, thereby volatilizing the mercury in the soil into the atmosphere [17].

3.3 Plant Fixation

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Plant fixation is the use of certain characteristics of plants and some special substances secreted to absorb toxic heavy metals in the soil and convert them into less toxic or relatively harmless substances, thereby reducing the content of toxic heavy metals in the soil and reducing further contamination of the soil The possibility of environmental or air environment [18]. In 1995, Dushenkov et al. used the principle of plant fixation to find that the combination of lead and phosphate secreted by plants can form lead phosphate, which is fixed at the root of the plant and reduces the harm of lead to soil environmental quality [19].

3.4 Root Filtering

Root filtration technology is a technical method that uses some powerful root-rich plants to fully absorb and filter harmful heavy metal substances in contaminated water bodies, and effectively treat heavy metals in water bodies, the purpose is to repair heavy metal pollution Water body [20]. In 1998, Hansen et al. conducted an experimental study and found that the wetlands close to the bay in San Francisco’s bay area can well absorb the waste sewage containing non-metallic selenium, which also confirmed the role of root filtration [21].

4. Garden Plants Enriched in Heavy Metals

4.1 Cadmium Enriched Garden Plants

As a heavy metal with strong toxicity, cadmium has great environmental destructive power. At the same time, cadmium can enter the food chain and harm organisms. Based on the strong hazards of cadmium, in 2005, Nan Xuyang et al. concluded that cedar can be used as a cadmium-enriched garden plant through field investigations [22]; in 2009, Yang Weidong et al. The heavy metal cadmium has a good enrichment effect [23]; in 2016, Lin Lijin and others used the high concentration cadmium pollution method to screen the cadmium enriched garden plant chrysanthemum [24].

4.2 Arsenic-Rich Garden Plants

Arsenic is a constituent element of human body, animals and plants, and arsenic and its compounds are also common heavy metal pollutants. In 2002, Chen Tongbin and others discovered that the hyperaccumulation plant Centipede can effectively enrich heavy metal arsenic; at the same time, it was also found that the grass of the genus Paphiopedilum can be significantly enriched in arsenic [25..26]; In 2014, Zou Xiaoli et al. screened the arsenic-enriched willow plant Willow using pot experiment [27].

4.3 Copper Enriched Garden Plants

Copper is a micronutrient element in the human body, animals and plants, as well as an environmental pollution element. Copper pollution in the soil will not only affect the environmental quality of the soil, but also through the absorption of plants will also threaten the quality and safety of agricultural and sideline products, enter the human body through the food chain and cause harm. In 2010, Li Ying and Wang Youbao published an article. The test results in the article showed that Artichoke and Centipede can well absorb the heavy metal copper in the soil and can be used as a copper accumulation plant [28].

4.4 Mercury Enriched Garden Plants

Mercury, as a relatively rare element in the earth's crust, is highly toxic. In recent years, Chinese scholars have been continuously studying super-accumulating plants that can enrich mercury. In 2010, Ding Zhenghua and others discovered through experimental studies that several major mangrove plants have an enrichment effect on mercury [29]; in 2012, Hou Jing and others used hydroponic experiments to study that morning glory can be used as a mercury-rich garden Plants [30].

4.5 Lead Enriched Garden Plants

In nature, lead is difficult to be absorbed by plants, so research is more difficult, but after continuous efforts of scholars from all walks of life, China’s research results are quite rich: In 2004, He Xinhua and others found that bayberry can be effective for heavy metal lead under hydroponic conditions Can be used as a super accumulative garden plant for lead [31]; in 2014, Cui Shuang and others used the pot test method to conclude that beautiful cherry has a strong tolerance to lead [32]; in 2016, Yang Yaqin and others Through field investigations, people found that Osmanthus fragrans can be used as a lead-rich garden plant [33].

4.6 Chrome Enriched Garden Plants

Chromium is an important alloy element and an element required by the human body, animals and plants. The toxicity of chromium is related to its valence in nature. For example, hexavalent chromium is much more toxic than trivalent chromium. Chromium-rich garden plants are commonly found in herbaceous plants, mainly tall fescue, canna, reeds, green dill, bermudagrass, clover, morning glory, etc. In 2012, Wang Aiyun and others compared the results of three herbs on chromium enrichment and found that white flower clover and tall fescue have a strong enrichment effect on chromium, and have a certain development space in the phytoremediation soil heavy metal chromium pollution control [34]. In the same year, Bi Boren et al. found in the tall tree species that the Yunnan Paohua tree showed good resistance and enrichment ability in chromium pollution [35].

4.7 Antimony Enriched Garden Plants

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In recent years, there have been more reports on heavy metals such as cadmium, copper, and lead, but relatively few reports on antimony. However, in recent years, the unreasonable mining and smelting of antimony have caused pollution of the soil environment. Especially in the southern region where antimony mines are relatively concentrated in China, the problem of antimony pollution has attracted wide attention from scholars from various countries. So far, only a few antimony plants with super-enrichment ability and a few tolerant plants have been found, and no super-enriched plants on antimony have been found. In 2014, Wang Xiaoli et al. discovered antimony-tolerant plants: White jade Phoenix fern and Indian shepherd's purse, and found that their tolerant parts are all at the root [36]. In 2017, Zhou Lin et al. showed in their research that the centipede grass, the big-leaf wellhead grass, the big-leaved boxwood, privet, etc. can be used as antimony-rich garden plants [37].

5. Outlook

With the continuous efforts of scholars from all walks of life, garden plants have made great progress in repairing soil heavy metal pollution, but the study of this technology is still a very challenging worldwide problem. Although phytoremediation technology has been highly praised in recent years because of its low cost, environmental friendliness, and beautification of the environment, there are still some problems worthy of our continuous exploration and breakthrough.

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