Scholar Publishing Group
Academic Journal of Environmental Biology
https://doi.org/10.38007/AJEB.2022.030103
ISSN 2789-8407 Vol. 3, Issue 1: 30-37

Heavy Metal Pollution Phytoremediation Technology Based on Six Types of Pollution Indicators

Helian Yang*

School of Horticulture and Landscape Architecture, Henan, China

**corresponding author*

Keywords: Six Types of Pollution Indicators, Heavy Metal Pollution, Phytoremediation, Enrichment Effect

Abstract: Phytoremediation is a low-cost and environmentally friendly remediation technology. It often uses enriched or even highly enriched plants to enrich and remove heavy metals in soil. The phytoremediation method does not destroy the structure of the polluted soil, has less impact on soil microorganisms and animals, and has the advantages of less investment in governance. Phytoremediation of polluted soil can beautify the environment at the same time. It is a promising, safe, reliable and emerging green bioremediation technology. Therefore, this paper uses phytoremediation technology to control soil heavy metal pollution. Due to the plant's strong ability to enrich a variety of heavy metals. In this paper, plants such as Phyllostachys vulgaris were selected to carry out simulation experiments on the soil of an industrial area, and the enrichment effects of six types of pollution indicators such as Pb, Zn, Cr, As, Cd, and Cu in the soil samples and the removal of heavy metals by Phyllanthus sinensis were analyzed. The results showed that P. chinensis had better enrichment effect on Cd, As, Pb, and Cu, and better removal effect on heavy metals such as Cd, Pb, and Cu.

1. Introduction

Heavy metal pollution and remediation research has always been an environmental academia. With the continuous growth of the population and the continuous development of the industrial and agricultural economy, heavy metals continue to enter the soil environment through sewage irrigation, atmospheric dust reduction, and the stacking of production and domestic wastes, making soil heavy metal pollution more and more serious, and the resulting problems are more and more serious more and more attention from scholars. Therefore, this paper takes soil heavy metal pollution as the research direction, uses phytoremediation technology to remove heavy metals in soil, and analyzes the work of soil remediation.

In recent years, there have been many researches on the application of phytoremediation technology in heavy metal pollution at home and abroad, and the applicability is also relatively wide. For example, some researchers have studied the effect of compost sludge on soil improvement through pot experiments using white clover as an indicator plant. Studies have shown that after composting sludge treatment, soil organic matter and other nutrients increased significantly, and the dry weight of white clover biomass increased [1]. A scholar studied the effect of peat on the growth and soil properties of cabbage through a pot experiment using cabbage as an indicator plant. The study showed that after peat treatment, the dry weight of stem and leaf biomass of cabbage was more than double that of the control group, and nutrients such as organic matter in the soil increased. The composition is also significantly improved [2]. A certain scholar conducted a detailed analysis and discussion on the phytoremediation technology and enrichment mechanism of super-accumulated copper. The analysis showed that the enrichment of copper in several species such as Radix japonica and castor was as high as 2000 mg/kg, which was mainly due to these plants. The detoxification mechanism of the cell wall or complexes or the protective mechanism of the cytoplasmic membrane allows these plants to enrich a large amount of copper from the soil [3]. A scholar studied the migration and accumulation mechanism of Cd in mustard, and found that mustard can be used in Cd-contaminated soil, but the disadvantage is that it is very regional, and not all regions can be planted [4]. A scholar studied the hyperaccumulation and tolerance of Pb in common buckwheat, and found that common buckwheat has strong hyperaccumulation and tolerance to Zn, and its transfer coefficient to heavy metals in polluted soil is greater than 1. Moreover, buckwheat has strong survival adaptability and can be widely planted [5]. Although phytoremediation technology can remove heavy metal pollution, this technology has certain limitations.

This paper first introduces the meaning of phytoremediation technology, and then collects soil samples from industrial areas to test the content of heavy metals in the soil, and uses the plant to enrich the heavy metals in the soil, and the removal effect of the plant was analyzed to verify the feasibility of phytoremediation technology in soil heavy metal removal and soil remediation.

2. Phytoremediation Technology and Heavy Metal Enrichment

2.1. Phytoremediation Technology

The phytoremediation process of heavy metal-contaminated soil mainly relies on the fungi around the underground part of plants to absorb the heavy metals in the surrounding environment (soil), and then transport the heavy metals absorbed by the fungi into the plant through the transport of the cell membrane of the underground part of the plant. Plant transpiration and other effects are transported from the underground part of the plant to the above-ground part, and in this cycle, heavy metals are accumulated or transformed in the plant, so as to achieve the effect of phytoremediation [6-7]. Phytoremediation technology includes various fields such as hyperaccumulation phytoremediation and fertilization technology.

Phytoremediation grows and survives healthily after tolerant to heavy metal stress in heavy metal-contaminated sites, and can accumulate a large amount of heavy metals in the shoots of plants. The content of heavy metals in the shoots is higher than that in the underground parts. Such plants are hyperaccumulators. Hyperaccumulation phytoremediation utilizes the hyperaccumulation of hyperaccumulators to allow them to absorb and enrich heavy metals in heavy metal-contaminated soils [8]. Restricted by the tolerance of organisms to heavy metals, phytoremediation technology is not perfect. This is because the hyperaccumulator plants are generally short and low in productivity, and it is difficult to find excellent heavy metal hyperaccumulator plants. Most of the toxic heavy metals absorbed by some heavy metal hyperaccumulator plants are concentrated in the roots of the plants, which finally lead to the re-entry of heavy metals into the soil, causing two secondary pollution, and the restoration effect has been abandoned [9-10].

Fertilization is a measure for farmers to increase crop yield under traditional conditions, and it is also one of the useful strengthening methods in phytoremediation. Mainly because soil heavy metal pollution often occurs in mining areas and mining wastelands, lacking the nutrients needed for normal growth of plants. In restoration, it is often necessary to supply fertilizers according to the nutrient status of the soil and the characteristics of the selected plants; Plants that are used to remediate contaminated soil also need to absorb a large amount of nutrients from the soil [11-12]. Therefore, the supply of nutrients needed by plants in soil remediation is ensured by fertilization replenishment. Regardless of the type of fertilizer or the amount of fertilizer used, as long as it can be used reasonably, it can generally improve the efficiency of phytoremediation [13].

2.2. Calculation of Heavy Metal Enrichment

The enrichment factor (BCF) refers to the ratio of the heavy metal content in a certain part of the plant to the corresponding heavy metal content in the soil [14]. Calculated as follows:

$$BCF = P / W \tag{1}$$

Among them, P represents the content of heavy metals in plant parts, and W represents the content of heavy metals in soil.

The transport coefficient (TF) is used to characterize the ability of heavy metals to be transported from the roots of the plant to the shoots. The TF of a certain part of the repairing plant for a certain heavy metal in the soil is greater than 1, indicating that the plant has a strong ability to transport the metal. And the higher the TF value, the stronger the transport capacity. On the contrary, it means that the plant accumulates most of the metal in the roots [15]. If the BCF of a certain part of a plant is greater than 1, it can be judged that the plant accumulates a certain heavy metal. Calculated as follows:

$$TF = \frac{t_1}{t_2} \tag{2}$$

Among them, t1 is the concentration of heavy metals in the aerial parts of plants, and t2 is the concentration of heavy metals in the roots of plants.

Generally speaking, the larger the BCF and TF, the more helpful for phytoremediation of soil.

3. Simulation Experiment

3.1. Test Plants and Soil

It is a Cd hyperaccumulator plant, and it also has a certain enrichment ability for Cu and Pb. It has certain application potential in the remediation of heavy metal-contaminated soils [16].

The 0-20cm topsoil was collected from a sampling point in an industrial area as soil samples), the large clods were broken with a rubber hammer, air-dried and passed through a 2mm plastic mesh screen to remove debris such as gravel, branches and other debris, and then stored Store in plastic buckets for later use [17].

3.2. Experimental Steps

The above-mentioned soil samples were placed in potted plants, and the pot cutting experiment was carried out experimental research on the removal of heavy metals in the soil by using P.

(1) Put 1kg soil samples into polyethylene plastic pots, and take samples to determine the background value of soil heavy metals.

(2) In soil pots, weigh equal amounts of the solids of the heavy metals to be tested, prepare a solution with deionized water, and add them to the soil evenly. Two hours later, samples were taken, and the background content of heavy metals in soil samples was determined [18-19].

(3) On the 15th day, the 30th day, the 45th day, the 60th day, the 75th day, the 90th day, the 105th day, and the 120th day, take samples from the root soil of the potted plants, and then Determination of heavy metal content in soil samples.

4. Experimental Results

4.1. Heavy Metal Content in Soil

On the basis of the experiment, this paper uses the relevant software to analyze and process the experimental data, and obtain the contents of heavy metals Pb, Zn, Cr, As, Cd, and Cu in the soil samples, as shown in Table 1.

Table 1. Heavy metal content in soil samples

	Pb	Zn	Cr	As	Cd	Cu
Soil samples	63	21	147	46	183	77

Table 2. Coefficient of variation, excess rate and background value of heavy metals in soil samples from the study area

	Coefficient of variation(%)	Exceeding rate(%)	Background values
Pb	62.16	53.67	1.28
Zn	12.34	8.26	16.40
Cr	32.58	100	48.93
As	8.73	35.24	10.55
Cd	27.66	100	3.67
Cu	58.43	68.95	25.36

According to the coefficient of variation of heavy metals in the study soil samples in Table 2, it can be seen that there are obvious differences in the content changes of different heavy metals. Cu and Pb had the largest coefficients of variation, which were 62.16% and 58.43%, respectively, reaching a high level of variation; the coefficients of variation of other heavy metals were in the range of 20%-40%, which belonged to moderate variation. The high coefficients of variation and high concentrations of Cu and Pb may be related to coal combustion and atmospheric deposition in industrial sites. From the exceeding rate, it can be seen that each heavy metal exceeds the soil environmental background value standard to varying degrees, among which Pb, Cr, Cd, and Cu all reach more than 50%, indicating that more than half of the industrial site may be contaminated by Pb, Cr, Cd, and Cu. , the pollution range is large; the Zn excess rate is less than 20%, which is 8.26%, and the pollution range is small.

4.2. Enrichment Ability of Pseudomonas to Heavy Metals

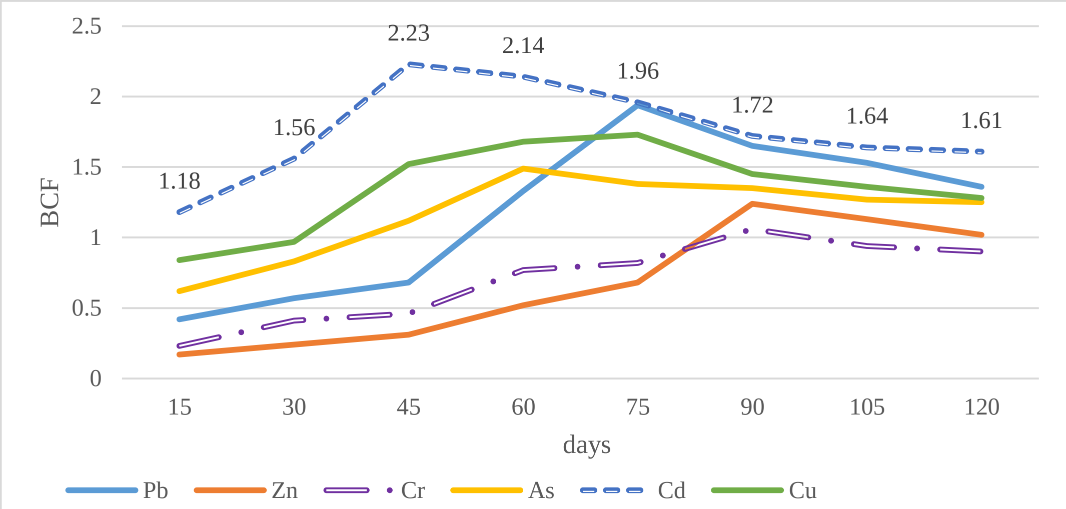

Figure 1. Concentration factor (BCF) for heavy metals

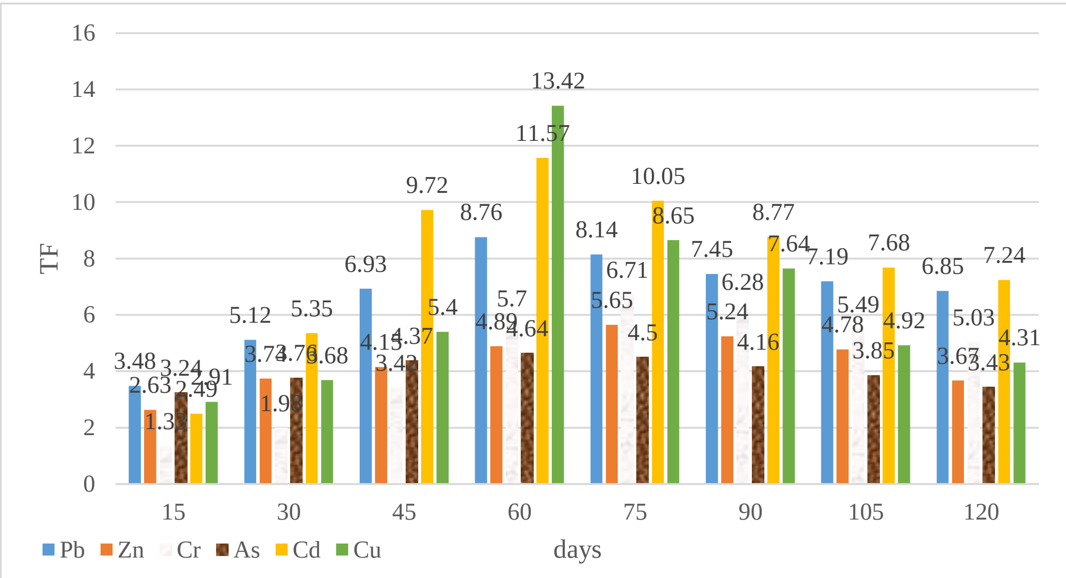

Figure 2. Transport factor (TF) for heavy metals

From the data in Figure 1 and Figure 2, it can be seen that throughout the experiment, the BCF of Pseudomonas sp. to Pb showed a trend of first rising and then falling, and its maximum value was 1.94 on the 75th day of the experiment. TF also showed a variation pattern of first decreasing, then increasing and then decreasing. The maximum value appeared on the 60th day, which was 8.76, and the TF value was always greater than 1, indicating that the Pb absorbed by P. The BCF and TF of water lily to Zn, Cr, As, Cd, Cu all showed a trend of first increase and then decrease. The maximum BCF values of Zn and Cr appeared on the 90th day, which were 1.24 and 1.06, respectively. The maximum value of TF appeared on the 75th day, which was 5.65 and 6.71, respectively. The TF value was always greater than 1. For As, both BCF and TF maximum appeared on day 60, BCF was 1.49, and TF was 4.64; for Cd, BCF maximum appeared on day 45, which was 2.23, and TF maximum appeared on day 60, which was 11.57; For Cu, the BCF maximum appeared on day 75 with a value of 1.73, and the TF maximum appeared on day 60 with a value of 13.42. To sum up, it can be seen that Pseudomonas auratus has a good enrichment effect on Cd, and has a certain enrichment effect on As, Pb, and Cu.

4.3. Removal of Heavy Metals by Elephant Needle

Table 3. Heavy metal removal effect

	15	30	45	60	75	90	105	120
Pb	61.2	54.2	50	41.7	35	26	22	20.6
Zn	20	18	17	16.5	14	12	11.3	11
Cr	135	128.2	105.6	94.7	74.5	63.6	61.8	58
As	43.8	43	39	37.6	35	32	31.7	30.5
Cd	172	158.1	126	97	45.7	36	34	28
Cu	74	69.5	52	41.8	35	32.3	27	26

Table 3 shows the changes in the content of heavy metals in the soil of Pseudomonas serrata. It can be seen from the table that with the passage of time, the content of heavy metals in the soil samples of Pseudomonas serrata gradually decreased. Compared with the initial determination of soil heavy metal content, the reduction of Cu in the 120-day-old soil samples was 51 mg/kg, and the removal rate of Cu in the soil was 66.23%. The reduction of Cu in the soil samples of Pseudomonas serrata was also caused by the self-degradation of the soil, the absorption of plants and the combined action of microorganisms, indicating that P. serrata had a certain absorption effect on the Cu in the soil. At 120 days, the content of Cd was 28 mg/kg, which was 155 mg/kg lower than the content just measured, and the removal rate of Cd in the soil was 84.70%; the removal rate of As was 33.7%, the removal rate of Cr was 60.54%, and the removal rate of Zn The removal rate of Pb was 47.62%, and the removal rate of Pb was 67.3%. It can be seen that the removal of heavy metal Cd is the best, followed by Pb, and then Cu.

5. Conclusion

Some heavy metal elements are trace elements needed in the human body, but most of the heavy metals can cause harm to the human body. Therefore, the harm of heavy metal pollution is very serious, and all human beings must raise their awareness of prevention. Phytoremediation is a soil remediation technology with good effect, low cost, convenient construction and environmental protection, but the accumulation of heavy metals in soil by plants is limited by the limitation of their biomass. The soil samples used in this study have been seriously polluted by industry, with poor soil fertility and high concentrations of heavy metals. If the soil structure is not repaired, it is difficult for plants to grow. Therefore, this paper proposes a phytoremediation technology of Pseudomonas spp. to remediate industrially polluted soils. Studies have shown that the TF of the plant to heavy metals such as soil Pb, Zn, Cr, As, Cd, and Cu are all greater than 1, indicating that the remediation effect of the plant is better. In addition, the removal rate of Cd is as high as 84.70%, and the removal rate of Pb and Cu is higher than 60%.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Prakash A , Kumar P . Evaluation Of Heavy Metal Scavenging Competence By In-Vivo Grown Riccinus Communis L. Using Atomic Absorption Spectrophotometer . Pollution research, 2018, 37(2):420-423.

[2] Lee G , Suonan Z , Kim S H , et al. Heavy metal accumulation and phytoremediation potential by transplants of the seagrass Zostera marina in the polluted bay systems . Marine pollution bulletin, 2019, 149(Dec.):110509.1-110509.12.

[3] Rahman M S , Babu S , Rahman M , et al. Source of metal contamination in sediment, their ecological risk, and phytoremediation ability of the studied mangrove plants in ship breaking area, Bangladesh . Marine Pollution Bulletin, 2019, 141(2019):137-146.

[4] Dilek, Gümü. Biosorptive application of defatted Laurus nobilis leaves as a waste material for treatment of water contaminated with heavy metal. . International journal of phytoremediation, 2019, 21(6):556-563.

[5] Tomic N T , Smiljanic S , Jovic M , et al. Examining the Effects of the Destroying Ammunition, Mines, and Explosive Devices on the Presence of Heavy Metals in Soil of Open Detonation Pit: Part 1-Pseudo-total Concentration . Water Air & Soil Pollution, 2018, 229(9):301.1-301.19.

[6] Sharma P , Pandey S . Phytoremediation Of Heavy Metal Chromium By Lasiurus Scindicus (Fodder Grass) In Polluted Soil And Water Of Amanishah Nallah, Jaipur . Pollution research, 2018, 37(1):234-237.

[7] Riani E , Cordova M R , Arifin Z . Heavy metal pollution and its relation to the malformation of green mussels cultured in Muara Kamal waters, Jakarta Bay, Indonesia . Marine Pollution Bulletin, 2018, 133(AUG.):664-670.

[8] Omwene P I , MS Öncel, M Çelen, et al. Heavy metal pollution and spatial distribution in surface sediments of Mustafakemalpaa stream located in the world's largest borate basin (Turkey) . Chemosphere, 2018, 159(OCT.):782-792.

[9] Rodriguez Martin J A , Gutierrez C , Torrijos M , et al. Wood and bark of Pinus halepensis as archives of heavy metal pollution in the Mediterranean Region. . Environmental Pollution, 2018, 239(AUG.):438-447.

[10] Danek T , Cheng X , Drozdova J , et al. Soil heavy metal pollution and risk assessment associated with the Zn-Pb mining region in Yunnan, Southwest China . Environmental

Monitoring and Assessment, 2018, 190(4):194.1-194.16.

[11] Narayana A C , Ismaiel M , Priju C P . An environmental magnetic record of heavy metal pollution in Vembanad lagoon, southwest coast of India . Marine Pollution Bulletin, 2021, 167(3–4):1-15.

[12] Asa B , Ssa B , Sba B , et al. Synthetic biology techniques to tackle heavy metal pollution and poisoning . Synthetic and Systems Biotechnology, 2021, 7(3):841-846.

[13] Rplabc D , Ynxac D , Jhzac D , et al. Effects of heavy metal pollution on farmland soils and crops: A case study of the Xiaoqinling Gold Belt, China - ScienceDirect . China Geology, 2020, 3(3):402-410.

[14] Dane H , Sisman T . A morpho-histopathological study in the digestive tract of three fish species influenced with heavy metal pollution . Chemosphere, 2020, 242(Mar.):125212.1-125212.8.

[15] Olowe O M , MD Asemoloye. Phytoremediation technology and food security impacts of heavy metal contaminated soils: A review of literature . Chemosphere, 2021, 288(5):1-12.

[16] Wloka D , Placek A , Smol M , et al. The efficiency and economic aspects of phytoremediation technology using Phalaris arundinacea L. and Brassica napus L. combined with compost and nano SiO_2 fertilization for the removal of PAH's from soil . Journal of Environmental Management, 2019, 234(MAR.15):311-319.

[17] Irga, P, J, et al. The phytoremediation of indoor air pollution: a review on the technology development from the potted plant through to functional green wall biofilters . Reviews in Environmntal Science and Biotechnology, 2018, 17(2):395-415.

[18] Moogouei R . Use of Terrestrial Plants for Phytoremediation of Pollutants from Solutions . Iranian Journal of Science and Technology. Transaction A, Science, 2018, 42(4):1753-1759.

[19] Pettit T , Irga P , Torpy F . Towards practical indoor air phytoremediation: A review . Chemosphere, 2018, 208(OCT.):960-974.