ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0009

Current Status of Soil Pollution by Heavy Metals and Application of Remediation Technology

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Abstract

With the continuous advancement of the industrialization process and the continuous impact of human production activities, the status of serious soil heavy metal pollution has been triggered. Because heavy metal pollutants have the characteristics of high concealment, easy accumulation, difficult migration, and significant hazard effects, the impact of soil pollution on The harm is significantly higher than water pollution and air pollution. Based on the harm caused by the status quo of soil heavy metal pollution, this paper reviews the application of physical and chemical remediation technology, bioremediation technology, and combined remediation technology in soil heavy metal remediation, in order to provide some reference for the prevention and repair of soil heavy metal pollution in China.

Keywords

Heavy Metals; Soil Pollution; Pollution Status; Remediation Technology.

1. Introduction

Soil is a place that affects the activities of animals and plants and the exchange of materials by microorganisms, and is an important part of the ecosystem. With the advancement of industrialization and urbanization, human activities have had a significant impact on changes in soil quality. Especially in recent decades, the production and use of various chemical products, the unreasonable and random stacking of solid waste from human domestic waste, the application of agricultural chemicals, and the open-air stacking and leaching of waste generated by human mining activities have resulted in A large number of pollutants cause serious damage to the soil, water bodies and the atmospheric environment. In particular, heavy metal pollutants have the characteristics of high concealment, easy accumulation and difficult migration, and significant harmful effects, which have a greater impact on the soil ecological environment. The soil itself has a certain degree of self-purification and erosion resistance, but once the pollutants entering the soil exceed the critical value of the soil's bearing capacity, it will cause serious soil pollution. Heavy metal pollution refers to the pollution caused by complex physical and chemical reactions of metals and their compounds with a specific gravity of more than 5 in the organic matter, minerals, and microorganisms in the soil. The concentration of heavy metals in the soil is affected by the dual effects of natural soil forming conditions and human activities. However, with the continuous advancement of science and technology and the accelerated development of the industrial system, the scope and extent of soil heavy metal pollution have intensified, threatening almost every country in the world.

2. Current status of soil heavy metal pollution

Soil heavy metal pollution is an important source of inorganic pollution. After soil heavy metals enter the soil, they cannot be decomposed by microorganisms in the soil. Instead, they are easily

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0009

synthesized with some substances in the soil into methyl compounds, and even produce toxic chemicals and substances. Through enrichment and absorption in the soil by crops and migration to the human body through the food chain and other forms, causing very serious harm. Generally speaking, the pollutants that cause heavy metal pollution in the soil mainly include Pb, Hg, Cd, Cr, Cu, Zn, Ni and As. Due to the influence of their own structural components, a large part of the heavy metal elements cannot be absorbed and used by plants, and even some heavy metal elements are toxic, and at the same time, some of the elements can be absorbed and used by plants, and will have a certain degree of benignity to human health. The effect becomes a substance that is beneficial to the ecological environment. Therefore, in the face of heavy metal pollution prevention and control work, it is not necessary to identify all heavy metal elements as pollutants. However, it can be seen that if the heavy metal elements that are beneficial to crop absorption and utilization are excessive, It will still cause certain adverse effects. Since different types of heavy metal pollution have different migration and transformation characteristics and pollution properties, and there are also large gaps in the form of existence in the soil. Therefore, when evaluating the possible harm caused by heavy metal pollutants, it is not only necessary to qualitatively determine the type of heavy metal pollutants. To conduct research, we must also consider the total amount of pollutants and the respective contents of different pollutants in a quantitative and comprehensive manner. According to the investigation of my country's agricultural department, the irrigation area of farmland soil sewage in my country is 1.4 million hm^2, and the area affected by heavy metal pollution accounts for 64.8% of the total irrigated area. The area of arable land polluted by heavy metals such as Pb, Cr, As, and Cd is nearly 20 million km^2. Accounting for nearly 20% of my country's total arable land [1]. Grain production is reduced by more than 10 million tons per year due to heavy metal pollution. my country's solid waste storage and land destruction are 0.13 million km^2. Industrial wastewater and solid waste contain a large amount of heavy metal pollutants such as Cd, Pb, Hg, Cr, etc., The annual direct economic loss caused by heavy metal pollution reaches 12 million tons, and the annual direct economic loss exceeds 20 billion yuan [2]. The 2014 "National Survey of Soil Pollution Status"has already elaborated on the soil heavy metal pollution in China. Generally speaking, the soil environmental quality of cultivated land in China is poor. There are already serious heavy metal pollution problems in some areas, and the total soil pollution rate in the country is exceeded. The percentage of arable soil sites exceeded the standard was 16.4%, among which the percentages of slightly, lightly, moderately and severely polluted sites were 13.7%, 2.8%, 1.8% and 1.1% respectively. The main pollutants were Cd, Ni, Cu, As, Hg, Pb, among them, the excessive rate of heavy metal Cd even reached 7.0% [3]. In addition, the agricultural department has investigated the status of heavy metal pollution in farmland soil across the country, and formulated the "Implementation Plan for the Prevention and Control of Heavy Metal Pollution in the Production Area of Agricultural Products", but so far it has not made substantial progress. Song Wei et al. [4] analyzed and estimated data from 138 typical regions of the country's farmland heavy metal pollution, and the results showed that the probability of soil heavy metal pollution in farmland in my country was close to 16.67%, of which the proportion of heavy pollution accounted for 14.49%, and the proportion of moderate pollution accounted for 1.45%. , And light pollution only accounts for 0.72%. Among the various toxic heavy metal elements, the probability of being caused by Cd pollution exceeds 25%, covering an area of 13,000 hm^2, involving 25 regions in 11 provinces, and the probability of being caused by Ni and Hg pollution is the second, reaching 8.48%. From a geographical perspective, my country's Liaoning and Shanxi provinces have the highest levels of heavy metal pollution. The pattern of heavy metal pollution in cultivated land in my country is higher in the central part and lower in the east and west. The "China Cultivated Land Geochemical Survey Report (2015)" shows that the proportion of heavy metals in heavy metal pollution or exceeding the standard accounted for 2.5%, covering an area of 2 million 325 thousand and 300 hm^2, and the proportion of light to light pollution or exceeding the standard accounted for 5.7%. With an area of 5.266 million hm^2, the polluted or over-standard arable land is mainly distributed in the southern Hunan, Hubei, Anhui, Jiangxi, Fujian, Yueqiong, and Southwestern regions. Zhang Xiaomin et al. [5] showed that soil Pb and Zn pollution in my country is mainly distributed in the western region, but

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0009

the content in Xinjiang is less, while the spatial distribution of Cd has many high value areas. Cr pollution is mainly distributed in Yunnan, Jiangsu, the Huanghai-Bohai Rim and the Beijing-Tianjin-Tangshan area. Other areas with high soil content of heavy metals are the border of northern Guangdong Province and Hunan and the Bohai Sea Rim, as well as Hubei and Anhui. Zhao Qiguo et al. [6] pointed out that my country's regional farmland soil heavy metal pollution is serious, especially in the Southwest (Yunnan, Guizhou, etc.), Central China (Hunan, Jiangxi, etc.), the Yangtze River Delta and the Pearl River Delta. Zeng Xibai et al. [7] surveyed the farmland surrounding mining areas in Hunan and Guangdong and showed that the proportion of samples exceeding the current soil environmental quality level II standard reached 21.1% to 62.3%.

3. Soil heavy metal pollution hazards

Because soil heavy metal pollution has the characteristics of concealment, long-term and lagging, the harm caused by large air pollution and water pollution is more serious. A large number of studies have shown that soil heavy metal pollution can cause serious damage to soil quality and safety. Jiang Yongrong et al. [8] have shown that soil heavy metal pollution around lead-zinc mining areas exhibits significant vertical migration characteristics, and Cd pollution has the highest degree of pollution in mining areas, and Will have a certain impact on the microbial community. Chen Chaoshu et al. [9] studied the forms and potential risks of heavy metals in the sediments of the mining area, and the results showed that the contents of Zn, Cd and As in the sediments reached 11.7, 10.6 and 18.8 times of the normal soil, respectively, and the pollution intensity of Cd and As was the highest. , And will cause a higher risk of ecological harm. Chen Weifeng et al. [10] measured and evaluated the soil samples of 9 urban green spaces, and the results showed that the average content of Cd, Cu, Zn, and Pb in the surface soil were significantly higher than the normal level. Among them, the ecological risk of Cd was the highest and appeared A certain degree of heavy metal compound pollution. Chai Lili et al. [11] analyzed the potential hazards of heavy metal elements in urban soil in Baoding, and the results showed that due to human activities, the content of Hg, Pb, and Zn in urban soil is relatively high, which are 5.28 times and 1. 74 times, 1.75 times, the potential ecological harm of Hg element is the most serious. Shi Biling [12] conducted research on the distribution characteristics of heavy metals in the soil of copper mining areas and their impact on the environment. The study showed that the content of heavy metal elements such as Cr, Ni, Zn, As, Cd, Cu, and Pb exceeds the normal value, and Cd, Pb and Zn have the highest impact on the ecological environment. The harm caused by heavy metal pollution in soil is mainly manifested as endangering the safety of human settlements and human health, polluting water resources, polluting air quality, and affecting agricultural production and planting, threatening national food security. It will not only cause huge economic losses, but also cause a certain degree of Social instability factors are not conducive to the stable and orderly development of our country [13-14]. Therefore, the effective treatment of soil heavy metal substances has a significant effect on stabilizing social and economic development, safeguarding human health, and ensuring national food security.

4. Application of Soil Heavy Metal Pollution Remediation Technology

4.1 Application of physical and chemical repair technology

Wu Qiumei et al. [15] used hydrocalumite to remediate Cd pollution in the soil, and the results showed that adding hydrocalumite to the soil can increase the soil pH and significantly reduce the effective content of Cd in the soil by 97.7%. Jiang Renxia et al. [16] used soil conditioners to carry out soil heavy metal cadmium pollution remediation experiments, and the results showed that the use of soil conditioners may significantly increase soil pH and significantly reduce the cadmium content in rice. An Mengjie et al. [17] discussed the use of remediation agents to restore the heavy metals Pb and Cr in the soil. The study found that the application of cotton meal humic acid and potassium polyacrylate reduced the content of Pb and Cd in the soil by 62.6% and 52.3%, respectively. Has a greater impact on the distribution of microbial communities. Xu Jianchen [18] studied the remediation effects of different amendments on soil heavy metal pollutants, and the results showed that the single

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0009

application of 2% peat had the most significant passivation effect on the soil heavy metals Zn and Cu, and 1% vermiculite and 1% bone meal had the most significant effect on Cd content. The reduction effect is significant, and the treatments of 2% peat, 1% vermiculite+1% peat and 1% vermiculite+1% bone meal have the most significant reduction in the content of Cu, Zn and Cd in the crop. Wu Lieshan et al. [19] used ammonium sulfate, humus and lime to study the passivation effect of soil heavy metal elements, and found that 2% lime has the best passivation effect on heavy metal pollutants, which is significantly higher than that of humus and ammonium sulfate. Chen Xinyuan et al. [20] conducted a study on the leaching effect of disodium ethylenediaminetetraacetate, citric acid and ferric chloride on soil heavy metal elements, and the results showed that these three chemical reagents have an effect on the heavy metal elements Pb, Cd, Cu, Zn. The leaching effect is the best, and disodium edetate has the best leaching efficiency. In addition, studies have shown that biochar has a good adsorption effect on soil pollution of heavy metals [21-23]. Zhou Jinbo et al. [24] showed that biochar has a significant absorption effect on Cd. Wang Dandan et al. [25] have shown that the adsorption effect of cow dung biochar on soil Cd is very significant. Wang Hong et al. [26] showed that the higher the preparation temperature of biochar, the better the adsorption of heavy metal pollutants, and the amount of biochar added is proportional to the adsorption of Pb and Zn. Zhou Qiang et al. [27] used rice husks to prepare biochar and studied its effect on Zn adsorption. The results showed that the greater the amount of biochar, the stronger the adsorption of Zn. Qin Tingting et al. [28] showed that the amount of cations carried by biochar is inversely proportional to the adsorption efficiency of soil heavy metal Pb. Ma Jianwei et al. [29] found that biochar has a significant effect on reducing the content of Cu and Zn in the soil. Zhang Yiteng et al. [30] found that the application of chicken manure biochar can inhibit the release of Zn, and can significantly fix Cu and Zn in the soil.

4.2 Application of bioremediation technology

Wang Yao et al. [31-32] studies have shown that plants also have a significant impact on the remediation of soil heavy metal pollutants. Guo Yuan et al. [33] studied the effect of jute plants on the restoration of heavy metal Cd in farmland and found that jute has a good Cd accumulation effect. The Cd content per hectare of jute can reach 53.3 g, and the wooden part of jute has an adsorption effect on Cd. The most significant, it can reach 33.11%~42.99% of the total adsorption capacity. Miao Xinyu et al. [34] used maidenhair to remediate soil contaminated by heavy metal cadmium (Cd)-polychlorinated biphenyls. The study found that maidenhair has strong heavy metal pollution tolerance and remediation potential, and adsorption of Cd The amount can reach 100 mg/kg, and the degradation rate of PCBs has also increased by 42.72%. Fei Weixin et al. [35] studied the influence of Brassica napus on the soil cadmium and copper pollution remediation ability, and the results showed that the absorption of cadmium by rape plants is mainly concentrated in the stem, and the absorption of copper is mainly concentrated in the roots and seeds. on. Yang Ruyue et al. [36] explained in detail the process of transport, storage, and detoxification of heavy metal pollutants from the perspective of plant genes, and established a response mechanism for plant growth testing in the actual environment. Zhang Xuan et al. [37] studied the effects of Proteus rhizomes of Robinia pseudoacacia on soil heavy metals cadmium, zinc, and lead, and the results showed that Proteus has the most prominent removal ability of soil Cd, Zn, and Pb, with removal amounts of 64.5% and 74.1%, respectively. And 90%. Zeng Peng et al. [38] studied the remediation potential of woody plants to soil heavy metal pollution, and the results showed that the interplanting of Arundo and Broussonetia papyrifera and mulberry can effectively repair heavy metal pollution in the soil. The adsorption effect of soil Pb and Zn increased by 171% and 124%, and the adsorption effect of reed bamboo-mulberry interplanting was 150% and 76.5% higher than that of single mulberry and reed bamboo. Jia Weitao et al. [39] reviewed the research progress and existing problems of high-biomass economic phytoremediation of heavy metal contaminated soil, which provided a reference for the wide application of bioremediation technology. Wang Zinan et al. [40] have shown that adding straw and earthworms can strengthen the growth of sedum sedum grown on neutral hydroponic anthropogenic soils, and increase the above-ground biomass and Cd,Zn uptake of plants.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0009

4.3 Application of joint repair technology

Liang Anna et al. [41] mixed mineral powder, cement clinker and silica fume in different proportions to study its effect on soil Pb passivation, and the results showed that the mixture has a significant effect on soil Pb passivation and can transform it from an unstable state. In order to stabilize, reduce the migration and pollution of Pb in the soil. Zhang Jingjing et al. [42] studied the effect of bentonite and lignite composite materials on the effect of soil Pb passivation and restoration, and the results showed that the addition of composite materials can reduce the Pb extraction content in the soil by up to 50.8%, and increase the residue content by up to 40.5%. Chen Ji et al. [43] combined potassium fulvic acid and milk vetch to remediate heavy metal contaminated soil, and the results showed that the combination of organic matter has a significant impact on soil heavy metal remediation, and the adsorption and accumulation of Zn and Gr exceeded 28.37% and 265.44 of CK. , But the repair cycle takes 4-8 months. Wang Caicai et al. [44] studied the remediation effect of ethylene glycol bis (2-aminoethyl ether) tetraacetic acid and double superphosphate on soil heavy metals Cu, Zn, Pb and Cd. The results showed that ethylene glycol double (2-Aminoethyl ether) tetraacetic acid has a higher elution rate for Cu and Cd, but a lower elution rate for Zn and Cd, and heavy superphosphate application can greatly reduce the leaching concentration of Pb. Wang Mingxin et al. [45] used leaching/passivation combined to repair heavy metal contaminated soil, and the results showed that the combined leaching/passivation repair greatly reduced the leaching concentration of Pb and Cd. When the amount of EDTA was 1 g/L and the addition of nano-hydroxyphosphorus When the limestone content is 1%, the total environmental risk reduction rate of soil heavy metals reaches 74.12%. Xu Weiwei et al. [46] discussed the effect of activators and plants in repairing heavy metal Cd pollution. The results showed that the application of activators promoted the adsorption of Cd by crops, while rapeseeds had the lowest adsorption effect on Cd and could be used for food.

5. Conclusion

Soil is the foundation of human existence, the place where crops exchange water, fertilizer, and heat. It is an important support for my country's economic development and food production safety. The problem of soil heavy metal pollution has become a worldwide problem, and the status quo of different types of heavy metal pollution is in a growing trend. Regarding the restoration of soil heavy metal pollutants, a large number of scholars have conducted in-depth research, and at the same time proposed corresponding restoration measures and programs, which have achieved significant results, and are of great significance to the protection of the ecosystem and the improvement of the living environment. Starting from the status quo of soil heavy metal pollution and the harm caused, this article reviews the application of physical and chemical remediation technology, bioremediation technology and joint remediation technology in soil heavy metal remediation, hoping to provide some reference for the prevention and remediation of soil heavy metal pollution.

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