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Current Situation and Control Measures of Heavy Metal Pollution in Farmland Soil

Wanying Li

Shaanxi Land construction of hotel management group Co., LTD., Xi 'an, Shaanxi 711700, China

Abstract

Heavy metal pollution of farmland soil can cause serious problems such as decreased farmland quality, reduced grain production, and farmland degradation, and pose a threat to human health through biological cycles. Soil pollution control has long been a hot topic of research for many scholars, and the study of soil heavy metal pollution remediation technology is a major part of soil remediation work. This article starts from the current situation of heavy metal pollution in soil in China, analyzes the main sources of heavy metal pollution in farmland soil, and proposes targeted measures for the remediation of soil heavy metal pollutants through physical, chemical, biological remediation, and joint remediation technologies, in order to provide reference and guidance for alleviating soil safety issues in farmland in China.

Keywords

Heavy Metals; Soil Pollution; Sources of Pollution; Repair Measures.

1. Introduction

As an important material foundation for human survival, arable land resources have always been of great concern to many scholars. The importance of arable land is linked to the vital interests of the people. Therefore, national policies, local regulations, and relevant departments have all proposed to strictly implement the protection of arable land. According to the analysis of the third national land survey data, both the total amount of arable land resources and the retention of high-quality arable land resources in China have experienced negative growth, and soil heavy metal pollution is one of the important factors affecting food security. Heavy metal pollution is an important pollution problem facing the world today. With industrial pollution, agricultural activity pollution, mineral development, and the discharge of pollutants from abandoned mines, farmland soil is susceptible to heavy metal pollution from various sources. After entering the soil, heavy metal pollutants can cause serious harm to the ecological environment of farmland and the living space of soil microorganisms due to their easy accumulation, strong concealment, and difficulty in eradication. In addition, some heavy metals can also be transformed into more toxic compounds. As a major agricultural production and consumption country, the importance of soil safety in arable land is self-evident. Farmland contaminated with heavy metals can not only reduce land resource utilization, but also lower the quality of arable land, resulting in large-scale crop reduction or failure. More seriously, some soil pollutants carry toxic side effects and enter various organs of the human body through the food cycle, causing chronic poisoning and other problems, seriously damaging human health. In order to more effectively solve the problem of heavy metal pollution in farmland soil, many scholars have conducted experimental research from multiple aspects such as monitoring, sources, treatment plans, and post remediation evaluation of heavy metal pollutants in farmland soil. However, the depth and treatment capacity of heavy metal pollution remediation technology in farmland soil in China are relatively weak, and it cannot be applied to large-scale engineering remediation [1-4]. Therefore, how to fundamentally identify the

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sources of heavy metal pollution in farmland soil and develop effective soil remediation measures will be a key research direction for improving and enhancing heavy metal pollution in farmland soil in China.

2. The Main Sources of Heavy Metal Pollution in Farmland Soil

2.1. Soil Heavy Metal Pollution Caused By Industrial Waste Discharge

Industrial production is the main driving force behind China's economic development, but with the extraction and consumption of a large amount of mineral resources, serious environmental pollution and ecological damage will occur, as well as the production of a large amount of toxic heavy metal substances. For example, in the mining and combustion of coal resources, the development and utilization of lead-zinc mines, and the mining and smelting of arsenic containing metal mines, heavy metal substances produced will flow into farmland through channels such as rainfall leaching, and settle and accumulate in farmland soil. The open-air stacking of coal gangue not only generates a large amount of toxic exhaust gas, but also enters farmland through atmospheric deposition, especially the sulfur dioxide heavy metal pollutants it produces, which accumulate in the soil for a long time and cause farmland pollution, making it impossible to grow crops. In addition, with the saturation of urban population and exploitable land resources, some industrial enterprises have relocated their factories to rural areas and carried out industrial production and development. The industrial wastewater they discharge is currently one of the most common and typical sources of heavy metal pollutants in farmland soil. Although the country has strictly controlled the discharge of industrial wastewater and sewage, driven by the profit seeking nature of enterprises, a large amount of untreated or substandard industrial wastewater is directly or indirectly discharged into surface water such as rivers and other rivers. Long term use of polluted water sources that have not been completely degraded enters the farmland irrigation system, and is eventually adsorbed by colloidal particles and crop roots in the soil, thereby endangering human health through the food chain.

2.2. Heavy Metal Pollution in Farmland Soil Caused by Agricultural Production

China has long been an agricultural country dominated by agricultural production. In order to ensure the food security of the national population, China has carried out decades of research. The research results show that the heavy use of pesticides, unreasonable fertilization and plastic film in farmland will cause a certain degree of soil pollution. The organic and inorganic materials that make up these agricultural production factors contain a large amount of heavy metals, such as Cu, Zn, and As. The unreasonable excessive use of such substances can cause the heavy metal pollutants to accumulate in the soil and enter the soil tillage layer along with measures such as soil tillage and plowing during crop cultivation. However, only about 30% of pesticide spraying can adhere to crops, while the remaining 70% is spread through the air to the soil, exacerbating pesticide residues in farmland soil and causing heavy metal pollution in the soil. Heavy metal pollutants such as Cu float on the surface of crops and farmland soil, resulting in excessive heavy metal pollutants. In addition, plastic film has been widely used in cultivated land in China. Although it has increased crop yields and public income to a certain extent, the residual plastic film in the soil after crop harvesting will have adverse effects on the cultivated layer soil. As of now, the residual amount of plastic film in cultivated land in China is about 2×10^6 tons, and the residual amount of plastic film in the cultivated layer reaches 60 kg/hm^2. Due to the presence of heavy metal elements such as Cd and Pb in the plastic film, farmers generally do not recycle the plastic film after crop harvesting, but continue to return it to the field through plowing. With the increase in usage, it not only produces white garbage pollution, but also increases the content of toxic heavy metal pollution in the soil, affecting crop yield and quality.

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3. The Current Situation of Heavy Metal Pollution in Farmland Soil

The main heavy metal pollutants in farmland soil include Ni, Hg, Cu, Pb, Cr, As, etc., and generally exist in the form of ions in the soil. Heavy metal elements accumulate to a certain extent in soil, and when their content exceeds the standard, they will affect soil and crops by releasing toxins. In addition to soil decay, it will also affect land quality and crop yield. Based on the distribution characteristics of heavy metals in soil and pollution rating results, the main heavy metal pollutants in farmland soil are Cd and Hg. As of 2014, China's polluted arable land reached 80 million hectares, accounting for 63.5% of the country's arable land area. The soil heavy metal pollution rate had already reached 16.1%, with the proportion of heavy metal pollution reaching 20%. Due to various factors such as industrial activities, agricultural activities, and mining activities, farmland soil has been greatly polluted. In the context of food production and food security, heavy metal pollutants enter farmland soil through various channels, which not only reduces and weakens the fertility and tillage of farmland soil itself, but also pollutes the land due to the inherent properties of heavy metal substances, resulting in the inability to utilize farmland. The dust, pollution particles, wastewater and waste residue generated in industrial development such as metal smelting and mineral resource development will all produce heavy metal pollutants. These heavy metal pollutants have high concealment, strong persistence, and difficult degradation characteristics, and have strong complexity, making them quite difficult to control. They not only require high treatment costs but also require significant technical operability, which brings great pressure to the prevention and control of soil pollution in farmland. In addition, the emissions of heavy metal pollutants in China continue to increase, causing an annual reduction in grain production of over 10 million tons and resulting in economic losses exceeding 20 billion yuan. In addition, due to its high concealment, heavy metals in farmland soil cannot be quickly detected and can only be detected through crop growth and specialized testing. The cost and cycle of controlling heavy metal pollution are relatively long, and effective remediation technologies have not yet been developed. In addition, in some areas, people do not attach enough importance to heavy metal pollution. After harvesting, crops will enter the market and accumulate in the human body along the food chain, causing poisoning hazards.

4. Remediation Measures for Heavy Metal Pollution in Farmland Soil

4.1. Bioremediation Methods

Bioremediation methods mainly include plant remediation and animal remediation. Plant remediation technology is a technique that effectively removes soil pollutants by repeatedly planting plants that can absorb pollutants in polluted areas. This technology has certain limitations, generally only repairing soil with a single and not severe pollution source. If the soil is severely polluted, it will not be able to be repaired and will cause plant death. If these plants are consumed by animals, it may lead to the expansion of contaminated areas. This remediation technology has a minimum lifespan of 3 years, so the selection of time should be comprehensively considered based on the purpose of remediation and the degree of pollution. Bioremediation technology involves adding organic nutrients to the soil for remediation, or controlling the oxygen content in the soil in a reasonable manner. The organic acids produced during the normal physiological metabolism of microorganisms can effectively absorb heavy metal pollutants in the soil, thereby achieving soil pollution remediation and ultimately achieving the remediation effect. However, it is worth noting that the metabolism of microorganisms in soil is a very complex physiological process. Whether there will be disorder between microbial communities or microbial community death due to environmental changes may also cause secondary pollution to the soil. Microbial remediation technology is suitable for

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large-scale soil pollution control, but the treatment period is long, and due to factors such as soil properties and transmission methods, organic matter cannot be evenly dispersed.

4.2. Physical Repair Methods

The physical restoration methods mainly include electric restoration technology, soil exchange technology, and thermal desorption restoration technology. Electric repair technology is based on the migration of electrons in an electric field for repair. During the remediation process, metal ions present in the soil are migrated through the action of an electric field, achieving the effect of remediation and pollution control. The advantage of electric remediation technology is that it can regularly repair soil without damaging its own structure, with a wide range of applications and simple and convenient operation methods. The disadvantage is that there is a significant consumption of resources during the repair process, which may cause sudden changes in acidity and alkalinity, making it difficult to achieve stable repair results. In practical applications, active agents are generally used as strengthening agents to improve the repair effect. The technology of soil exchange and remediation is mainly aimed at soils with less pollution. This technology involves mixing clean soil into polluted soil to alleviate pollution problems and achieve remediation effects. Soil replacement is the process of replacing contaminated soil with clean soil, which will improve the original contaminated soil. Both of the above methods have many disadvantages and are subject to many limiting factors, so they are less commonly used in practical applications. The main characteristics of physical remediation are that although polluted soil can be effectively improved in soil conditions after treatment, the removal effect of pollutants is also significant, and the time required is relatively short, the remediation cost is high, and it is prone to secondary pollution and other problems during the remediation process, which cannot achieve the effect of large-scale soil improvement.

4.3. Chemical Remediation Methods

Chemical remediation methods mainly include solidification technology and soil leaching technology. Solidification technology involves adding solidifying agents to the soil to cause physical and chemical reactions between soil pollutants and solidifying agents, ultimately fully encapsulating the pollutants in solid materials, converting them into substances with stable chemical properties, and then diffusing and transferring them to effectively remediate the soil. This technology has a wider range of applications and is relatively mature in development and application. However, in the application process, a large amount of solidifying agent is required, and the final effect is not ideal. At the same time, it may also affect the properties of the soil itself. If not handled properly, secondary pollution may occur. Therefore, before remediation, it is necessary to fully understand the soil pollution situation and clarify the remediation goals. Soil leaching technology is the process of mixing soil with chemical detergents to allow harmful substances and detergent substances to react, thereby separating soil and pollutants. After separation, they are promptly recovered to achieve the goal of remediation and achieve the desired remediation effect. The disadvantage of this technology is that regardless of the composition of the detergent, it will reduce soil fertility after use. Detergents can be divided into two categories based on their composition: alkaline and acidic. Acidic detergents have good remediation effects, but can seriously damage soil and cause changes in soil properties. At present, the internal components of chemical detergents are usually replaced by biological surfactants, which can reduce soil damage and effectively restore polluted soil. However, there is still a high possibility of secondary soil damage in practical applications, so this remediation technology is rarely used. Therefore, it is necessary to continuously explore and research the joint application of this measure and other technologies to minimize the degree of soil damage and improve the remediation effect of polluted soil. Only in this way can it be widely applied and promoted.

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5. Conclusion

The main mechanism for controlling soil heavy metal pollution is to remove toxic substances of heavy metals in the soil, and to achieve control of soil heavy metal pollutants on the basis of restoring the essence of the soil as much as possible. The basic way is to carry out soil remediation based on the principles of physics, chemistry, biology, or a combination of them. China proposed the "Action Plan for Soil Pollution Prevention and Control" in 2016, which provides policy basis for the development of heavy metal pollution remediation technology in farmland soil in China. This article starts from the main sources of heavy metal pollutants in soil, analyzes the current situation of heavy metal pollution in farmland soil, and proposes targeted remediation technologies for heavy metal pollutants in soil, in order to better serve the remediation of heavy metal pollutants in farmland soil and effectively ensure national food security.

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