Research on Remediation Technology of Heavy Metal Contaminated Soil

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Abstract: In recent years, with the development and progress of society, soil pollution by heavy metals has become more and more serious. It is urgent to adopt appropriate methods to remediate contaminated soil. How to remediate soil contaminated by heavy metals has gradually become a key research topic in the field of ecological environment management. This article analyzes the general situation of soil heavy metal pollution, the use of corresponding remediation technologies and the current research progress, and proposes a combination of multiple remediation technologies to remediate methods, which provides a correct idea for the development of soil remediation technologies.

Keywords: Soil remediation; adsorption characteristics; heavy metal forms; mechanical characteristics; numerical simulation.

1. Analysis of soil heavy metal pollution

Soil heavy metal pollution is a worldwide problem faced by mankind. The soils of all countries in the world have different levels of heavy metal pollution. In recent years, with the rapid development of mining, metal smelting, coal chemical industry and thermal power generation industries, a large amount of heavy metals are discharged into the environment along with waste liquids and wastes[1]. The direct discharge of waste liquids and the accumulation of wastes make the soil heavy metal pollution extremely serious. Seriously threatening people’s health, it is urgent to strengthen research on soil pollution control by heavy metals[2].

At present, heavy metal pollution is relatively serious. The heavy metal pollutants in the soil are mainly lead, cadmium, mercury, copper and arsenic. In recent years, the continuous development and use of land by human society has increased the area of land contaminated by heavy metals by tens of thousands of hectares[3]. In this process, the soil environment has been polluted to a considerable extent, and soil pollution has exceeded its own purification capacity, resulting in a substantial decline in environmental quality, and also seriously threatening social and economic development and human health. Over the years, as many as 30,000 hectares of soil have been contaminated by cadmium, which will eventually cause a considerable number of crop yields to plummet[4].
The analysis of heavy metal contaminated soil shows that the scope of heavy metal pollution is very wide, but the pollution control of heavy metals on the soil did not produce the expected results[5]. For example, the cadmium rice incident once caused a social sensation, mainly due to heavy metal pollution. With the growth and accumulation of rice, heavy metal toxins gradually accumulate in the rice, and the poisoning incident caused by eating this rice. Some mines in our country, especially the Yunnan-Guizhou region, are rich in heavy metal resources, and heavy metal pollution will be more serious.

2. Causes of heavy metal pollution in soil
The sources of heavy metals in the soil are very wide, but they can be divided into two categories, namely: natural sources and man-made pollution inputs.

2.1. Natural sources
The rock produces soil during the weathering process, and different rocks contain different heavy metals. Therefore, the chemical composition of the earth-forming parent rock and the environmental conditions encountered during the soil-forming process can determine the types and initial values of heavy metal elements in the soil; in addition, forests Fires, volcanic eruptions, vegetation discharge, wind blowing dust, sea wave splashing and other processes cause a variety of heavy metals to be suspended in the air. These heavy metals are easily absorbed by plants or enter the soil through dust[6].

2.2. Man-made pollution input
With the rapid development of urbanization and modernization of industry and agriculture, heavy metal pollution caused by human factors has become more and more serious compared with the natural sources of soil heavy metal pollution. Among various human factors, heavy metal pollution caused by industrial, agricultural and traffic emissions is more serious, and the mining and smelting of non-ferrous heavy metals is the main source of heavy metal pollution in the soil. Man-made pollution is mainly point pollution, and its pollution to the soil environment is uneven, which will cause heavy metal pollution in some areas and serious phenomena. At the same time, the heavy metal pollution caused by different human activities is also different[7]. For example, the mercury pollution and lead pollution caused by the development of urbanization and transportation activities are the most serious. In agricultural activities, chemical fertilizers, pesticides, sewage irrigation and waste application are one of the main ways to aggravate soil heavy metal pollution.

3. Methods of soil remediation

3.1. Repair technology for thermal desorption
The thermal desorption recovery method uses electricity or fuel energy to generate heat, and desorbs volatile heavy metals from contaminated soil through infrared heating, steam heating, or direct heating[8]. The purpose of remediation of the heavy metals adsorbed in the soil is to heat and collect the contaminated soil. This method is mainly aimed at the soil contaminated by volatile heavy metals such as mercury. The results show that, under normal circumstances, thermal analysis has little effect on soil fertility. The mercury and remaining mercury in organic soil accounted for 73% and 17%, respectively. Because the scope of application is not large and the energy consumption is too high, it is not suitable for large-scale repair of heavy metal pollution. Improper use may cause secondary pollution and destroy its texture and organic content[9].

3.2. Electric repair technology
The application prospect of electric repair technology is wide, and it is still in laboratory research at this stage. The pH value of the soil has a great influence on the treatment effect. The adaptability of acidic soil in soil acidification should take full account of the characteristics of the soil contaminated by heavy metals; electric remediation technology usually refers to the electrification of heavy metals and some other non-heavy metal pollutants near the electrode In order to promote the restoration of contaminated
areas, the use of electric restoration technology can produce a good restoration and governance effect without harming the environment[10].

3.3. Vitrification repair technology
The vitrification technology uses heat energy to melt heavy metal-contaminated soil into glass at high temperatures, and uses the dense structure of the glass body to solidify heavy metals into the glass body. It is also known as the melting and solidification technology. The vitrification technology is used for the first time to basically realize the solidification of heavy metals in the soil, which reduces the migration and transformation of pollutants in the soil. The speed is fast, but the engineering volume is large and the consumption cost is too high. Therefore, it is usually used in heavy metal contaminated soil that needs urgent treatment.

3.4. Chemical leaching repair technology
Chemical leaching technology is to add a leaching agent to the contaminated soil to promote the entry of heavy metal substances into the leaching solution, as much as possible to wash out the heavy metals adsorbed in the soil, so as to achieve the purpose of soil remediation. The chemical leaching repair method is an innovation of chemical technology. This method is more suitable for sand and gravel soil, and different leaching solutions have different leaching effects on different heavy metals[11]. The chemical leaching remediation method is effective, but it is easy to pollute the surface water. At the same time, certain nutrients in the soil cause the soil fertility to decrease and affect the growth of plants. Some experts and scientists have proved through practical applications that the combination of chemical leaching technology and deep foundation reinforcement technology can achieve better results.

3.5. Microbial remediation technology
Microbial remediation technology is to add microorganisms to heavy metal contaminated soil to limit the migration of heavy metals in the soil and its harm to the environment. The addition of microorganisms will produce extracellular enzymes, making the soil more resistant and fertile. Through continuous practice, it has been found that this technology can play a very good role, and the economic cost is low. In particular, bacteria and fungi with certain specific effects can be added to the soil contaminated by heavy metals to produce specific Glycoprotein, glycoprotein then reacts with heavy metal pollutants to produce complexes, in this way, the migration characteristics of heavy metals in the soil are quickly reduced, thereby improving soil quality to a certain extent.

4. Study on the remediation mechanism of iron-based passivation agent on contaminated soil
Some soil remediation methods were introduced in the previous section. This section mainly introduces the research on the remediation mechanism of iron-based passivators on contaminated soil. The adsorption and immobilization performance of ZVI depends not only on its surface physical properties such as specific surface area and pore structure, but also on the chemical properties of the ZVI surface such as surface phase types. This section mainly uses microscopic detection methods to characterize and analyze the physical and chemical properties of ZVI before and after restoration. At the same time, combining the experimental results, discuss the restoration mechanism of iron-based passivators on heavy metal contaminated soil from multiple angles and multiple levels.

4.1. Characterization method
In this experiment, the ASAP 2020 specific surface area and pore size analyzer from Mike Instruments was used to determine the pre-loaded ZVI sample by adsorbing high-purity N2, and the BET method was used to calculate the specific surface area of zero-valent iron. The total pore volume was at the relative pressure P/Po = Measured under the condition of 0.95, and the pore size distribution is calculated by the BJH method.

In this experiment, Hitachi S-3400N scanning electron microscope was used to directly microscopically image the apparent characteristics of zvi samples before and after loading. After the
sample is sprayed with gold, under the action of the high-energy electron beam impacting the ZVI, various scattering particles will be generated on the surface, and through these signals, the apparent characteristics of the ZVI can be obtained.

In this experiment, the XRD spectra of ZVI before and after loading were obtained by Rigaku RAD-2B ray powder diffractometer. After obtaining the spectrum, compare the various diffraction peaks appearing in the spectrum with the standard PDF card of iron, and analyze the phase composition of ZVI before and after loading.

![Figure 1. ZVI before load](image1)
![Figure 2. Load Hou ZVI](image2)

The ZVI scanning electron micrographs before and after loading lead heavy metals are shown in Figure 1 and Figure 2. Fig. 1 and Fig. 2 respectively show the ZVI imaging images at 5000 and 1000 times before lead adsorption. Obviously, the ZVI particles before adsorption are relatively uniform, smooth and massively distributed, with some voids formed on the surface, and the phenomenon of crystal beam agglomeration is weak, which can provide a good environment for the load. It can be seen from the figure that a large number of small particles are attached to the surface of the ZVI loaded with lead heavy metals, which block the pore pipes of the ZVI, and the agglomeration phenomenon is obvious, resulting in the rough and uneven outer surface of the ZVI. This may be due to a certain change in the structure of the ZVI crystals, through surface complexation or reduction precipitation to generate iron oxide/hydroxide to adsorb lead fu, and finally form flocculent or crystal precipitation.

5. Conclusion

Through a certain microscopic examination of the ZVI before and after loading lead heavy metals, combined with the adsorption and fixation effect of ZVI on the lead-fu heavy metal ions, the mechanism of iron-based passivation on the remediation of lead-fu contaminated soil was explored from a macro and micro perspective. The main conclusions are as follows:

(1) The specific surface area of the iron-based passivator ZVI is hundreds of times larger than that of general commercial iron, and the proportion of mesopores is much larger than that of micropores. At the same time, the ZVI particles are smooth and have weak agglomeration phenomenon, which can be lead-radiated heavy metal ions. Adsorption provides a better environment.

(2) A part of the original ZVI solid does not change its own heavy metals for physical adsorption on the surface, and fixes lead ions on the ZVI surface through surface gluing and electrostatic action.

Therefore, in future research, exploring the zero-valent iron powder restoration method coupled with other restoration methods to treat soil heavy metal pollution is of great significance to soil restoration and ecological restoration, and at the same time reveals the main influencing factors of the restoration process and the promotion and implementation of this method. Effective regulation has important value.
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