Method Article

The influence of passivating agent on soil pollution

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Abstract

In this paper, different materials such as phosphogypsum, raw coal and iron slag, which are more concerned in chemical passivation, are selected to mix an efficient and cheap passivation agent to repair Cd and As compound contaminated soil and realize the reuse of solid waste resources. The heavy metals Cd and As are not only toxic to the soil-plant system, but also migrate to animals and humans through the food chain, destroying normal physiological functions, and causing great harm to the human body. The essential functions of the newly developed heavy metal passivator are as follows:

- Changed the microscopic morphology of the soil
- Greatly reduce the bioavailability of Cd and As in the soil

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Method details

Background

Soil is not only an important part of the ecosystem, but also the basic resource of agricultural production and the material basis for human survival [1]. Soil can be used as a filter for pollutants, but once the amount of pollutants exceeds its buffer capacity, the pollutants can enter the environment and the food chain [2]. There are many ways for heavy metals to enter the soil, but mainly through both native and exogenous sources [3]. The primary pathway is derived from the soil-forming parent material. In the long-term weathering process, the parent rock weathered into the atmosphere, and the dust settled into the soil through rainfall or other natural activities such as volcanic eruptions. The soil heavy metal content produced in the soil formation process is quite different, which results in a high soil heavy metal background value in the region. The second is pollution caused by human factors, such as mineral development, sewage irrigation, metal smelting and processing, unreasonable application of fertilizers and pesticides, and transportation, etc. This is also the main source of soil heavy metal pollution in my country at present [4]. The heavy metals in the soil will not only affect the quality and yield of crops, but also cause the quality of the soil to decline, and it is difficult to degrade. Heavy metals accumulate in crops through the soil-crop system, and then gradually expand along the food chain and migrate to the human body. [5,6]

At present, the commonly used soil heavy metal treatment methods at home and abroad are physical [7,8], chemical [8–10] and biological [11–14] methods, of which chemical methods are one of the economic and efficient ways to control heavy metal pollution. Currently, the types of...
chemical passivators commonly used in my country are: organic passivators, inorganic passivators and organic-inorganic hybrid passivators. Organic passivators mainly include biochar, grass charcoal, crop straws, animal manure and other organic fertilizers and humic acids; inorganic passivators are a type of material that is widely used in chemical passivation and remediation of heavy metal contaminated soil. There are more types, which are divided into phosphorus-containing substances, alkaline substances, clay minerals, industrial wastes, etc. according to their properties and sources; the application of organic-inorganic composite passivators overcomes the restoration of a single type of passivator to a certain extent The shortcomings, to a large extent, improve the remediation efficiency of heavy metal compound contaminated soil, and reduce the remediation cost.

Due to the complexity of soil matrix and the coexistence of heavy metals in heavy metal contaminated soil, there are complex interactions between heavy metals and the interface between heavy metals and soil. Therefore, the passivation effect of different passivators for heavy metals in different types of soil is not the same. However, most of the studies only focus on the remediation of a certain heavy metal, and there are few reports on simultaneous passivation and simultaneous remediation of multiple heavy metal contaminated soils. In this paper, the compound polluted soil in Gejiu Mining Area of Yunnan Province was used as the test soil, and some industrial by-products and agricultural production wastes (phosphogypsum, raw coal and iron slag) were used as passivators to study their effects on the bioavailability of CD and as in the soil. A passivator with better passivation effect was selected through the test, and the passivation rates of available CD and as were determined respectively It reached 39.76% and 29.80%.

Fig. 2. SEM photograph of soil before and after solidification/stabilization (×2000).
Procedures

(1) Original phosphogypsum (9.03%Na₂O, 1.08%MgO, 3.88%Al₂O₃, 16.33%SiO₂, 0.53%P₂O₅, 28.58%CaO, 0.3%K₂O, 40.27%SO₃), desilication phosphogypsum (the original phosphogypsum component is removed 16.33%SiO₂), raw coal (0.5% total sulfur content, 40.5% ash content, 28.0% combustible volatile matter), and iron slag are dried in a vacuum oven at 70 °C for 2 h, dried and ground water after drying. The scanning electron microscopes of the four materials are shown in Fig. 1:

(2) Mix the four materials in different proportions, T1: original phosphogypsum 80% + C raw coal 20%, T2: desilication phosphogypsum 80% + C raw coal 20%, T3: original phosphogypsum 10% + B Desiliconized phosphogypsum 66% + C raw coal 14% + D iron slag 10%.

(3) Put the three kinds of heavy metal passivators in a muffle furnace for calcination at 1300 °C for 5 h.

(4) After the passivator is calcined, let it stand, cool and grind finely at room temperature.

(5) Three kinds of passivators T1, T2, T3 and two kinds of commercial passivators were added according to the proportion of 1%, 3%, 5% of the heavy metal Cd and as contaminated soil respectively, and mixed well, and put into the beaker.

Two commercial passivators are numbered T4 and T5, respectively. T4: Biochar (carbon ≥20%, oxygen ≥40%, silicon ≥20%, Cd 0.076 mg/kg, As <0.001 mg/kg, Jiangsu Multiplier Biotech Co., Ltd.); T5: mineral-source humic acid bio-organic fertilizer (humic acid ≥ 60%, fulvic acid ≥ 2%, organic matter ≥ 60%, effective live bacteria cfu ≥ 20 million/g, Cd 0.031 mg/kg, As < 0.001 mg/kg, produced by Shanxi Tiancui Ecological Agriculture Technology Co, Ltd.).

(6) Keep the soil moisture content at 70% of the field maximum water holding capacity, and repeat each treatment three times.

Final remarks

Fig. 2 shows that the better the passivation effect, the smaller the soil pores and the denser the structure. Before and after the passivation of Cd and As contaminated soil, the microscopic
Fig. 4. Effective state As passivation effect under different treatments.

Fig. 5. Effective state Cd passivation effect under different treatments.

Morphology of the soil has changed. The original soil sample before stabilization has larger voids, fewer particles, sparse structure, and irregularities. Therefore, the soil particles have strong fluidity and a relatively big environmental risk. After adding passivating agent, soil moisture and particle size, a network-like material structure appears in the soil, and certain regular clusters and cross-linked flocculent particles can be observed, and the structure is tighter than the original soil.
As shown in Fig. 3, the pH values of the tested soils under different treatments were affected to varying degrees. The pH values of the five different passivators under the three dosage treatments were increased compared with the control, and the pH values of T1 and T2 were the highest under the 3% dosage treatment, increased by 1.1 and 1.5 units, respectively. The results showed that the pH value of T3 reached the maximum of 7.50 when the dosage was 5%; the change trend of T4 and T5 was the same when the dosage was 1%, and the difference was significant among the treatments.

Figs. 4 and 5 show that the three passivating agents have different degrees of passivation effects on Cd and As contaminated soils. Among them, the passivation effect was the best when the T3 addition amount was 5%, and the difference between the treatments in the group was significant, the Cd content in the soil decreased by 39.76%, and the As content decreased by 27.18%.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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