Advances in Cd Remediation Techniques for Contaminated Soils

Jiang Changjia1, Cui Shuang2*, Feng Qi1*, Sun Xiuli1

1School of Environmental and Safety Engineering, Liaoning Shihua University, Fushun, Liaoning, 113000, China
2College of Environmental and Chemical Engineering, Shenyang Ligong University, Shenyang, Liaoning, 110159, China

* Cui Shuang’s e-mail: cuishuang@sylu.edu.cn
* Feng Qi’s e-mail: fengqi1976@lnpu.edu.cn

Abstract. For heavy metal Cd pollution, here are two general ideas for solving Cd pollution. Firstly, Cd separated or extracted from the soil and decreased in soil Cd content. Secondly, the existence of Cd were changed in soil, reduced its mobility and bioavailability. At present Cd contaminated soil remediation technology is divided into three main categories: physical remediation technology, chemical remediation technology, bioremediation technology.

1. Introduction

Soil is the material basis for the survival of human beings and most organisms, it is an indispensable part of the continuation and development of life. When the content of some metal elements in soil exceeds the standard value of heavy metal content in China or it is obviously higher than its natural background value, the phenomenon that leads to the deterioration of ecological environment is called soil heavy metal pollution [1]. The National Soil Pollution Survey Bulletin issued in 2014 shows that the excess rate of contaminated soil sites is 19.4%, among all the pollutants, the first content of the pollutants is Cd and the excess rate of Cd points is 7%. Low concentrations of Cd can cause plant lesions or death [2], after being inhaled by human body, it may cause lung cancer, renal dysfunction, fracture, reproductive system and nervous system lesions and many other problems [3]. About 82 to 90 percent of the Cd, emitted by human direct or indirect activities enter the soil, Cd contaminated soil remediation is imminent [4-6].

2. Physical remediation techniques

2.1 Physical barrier technology

Physical barrier technology refers to the use of anti-leakage measures around Cd contaminated soil sites, keep it in the original area. This technology requires high soil and geological conditions and is not suitable for areas with frequent geological hazards and strong soil permeability.
2.2 Vitrification technology
Vitrification technology refers to a high temperature and high pressure environment, fusing Cd contaminated soil into structurally stable vitreous material, fix the metal Cd in the vitrification. Cd vitrification was studied by microwave technique, Microwave irradiation 5 min, Cd fixation was over 95%, the vitreous structure is dense and strong, Cd leaching concentrations meet national standard limits, it have certain application value [7]. The vitrification technology has a large amount of engineering and a long repair time. The repair process needs to supply heat, which is generally used for the remediation of heavily polluted soil.

2.3 Soil replacement technology
The soil replacement technology is to replace contaminated soil samples with fresh and unpolluted soil samples, to use backfilling pure land, removing old soil, removing topsoil and deep buried soil can replace or dilute Cd contaminated soil [8]. Where heavy metal concentrations are high and a small area, the treasure is soil exchange and topsoil removal, the effect is very significant. In some areas where heavy metal pollution is relatively light, the measures of replacement soil and deep excavation are adopted. Soil replacement technology economics costs is too high, which not suitable for large area Cd contaminated soil remediation.

2.4 Electric repair technology
Electric remediation means inserting graphite electrodes at both ends of contaminated sites, and through DC, moving Cd ions from the soil to the electrodes, then re-enrichment. Zhao Shuning and others used electric remediation to treat kaolin with complex heavy metal pollution, the average removal rate of Cd after 96 h of electric repair is as high as 99.43% [9]. Electric remediation has little effect on soil original state, which no secondary pollution, short repair period and high efficiency, it is generally suitable for large area Cd contaminated soil remediation.

3. Chemical remediation technology

3.1 Chemical fixed repair technology
Chemical fixation remediation technology refers to the addition of passivators, modifiers, metal antagonists, surfactants and other reagents to the soil, which changing soil redox potential, pH, cation exchange capacity, organic matter. complexation, adsorption, precipitation, oxidation and reduction with Cd, decrease the bioavailability and mobility of Cd in soil and immobilize it in soil. The advantages are that the technical difficulty is not high, the economy is economical, and it has a good application prospect for large area low concentration polluted soil. The disadvantage is that the Cd is not removed, but is fixed in the soil, changing the occurrence form of the Cd and reducing its activity. Once the environmental conditions change and activate it again, it has the possibility of secondary pollution [10-11].

3.2 Chemical leaching remediation techniques
Chemical leaching remediation technology refers to the chelation, precipitation and adsorption of leaching agent and Cd, transfer the Cd in the soil to the leachate, then treat the filtrate to complete the remediation goal. It has the short repair period, the treatment scope is wide, it suitable for the Cd polluted soil serious, the permeability is strong and the soil quality is rough [12-13], which has good remediation effect on Cd or Pb contaminated soil [14]. Disadvantages are the choice of eluent, the collection of eluent and the need for a large amount of water for eluent remediation [15].
4. Bioremediation technology

4.1 Phytoremediation technology
Phytoremediation technology refers to the Cd absorption, transformation and enrichment of contaminated soil by Cd highly accumulated plants, thus reducing the effective concentration of Cd in soil [16]. The mechanisms of phytoremediation include plant extraction, immobilization and degradation [17]. There are more than 20 species of Cd high accumulation plants found in China [18]. Wang Songliang et al found that the enrichment characteristics of Brassica vegetables on soil Cd [19]; Liu Wei and other studies found that Baoshan cordieri can be effectively enriched Cd, the average content of its aboveground Cd is 1168 mg/kg [20]; Wei Shuhe et al found that sunflower can be used as a Cd super accumulative plant by pot experiment [21].

4.2 Animal restoration technology
Animal restoration technology refers to the use of soil animal growth, development, metabolism and other fixation, transformation or absorption of Cd in the soil. Earthworms can transform Cd from stable state to effective state and improve soil fertility [22]. For earthworms, the longer the incubation time, the stronger the enrichment ability for Cd [23-24]. Earthworm culture technology is simple, also can eat crop straw. In high Cd environment some earthworms can continue to enrich Cd. But earthworms have limited enrichment capacity in high concentrations of Cd contaminated soil, when Cd concentration is too high, will cause earthworm heavy metal poisoning death [25].

4.3 Microbial remediation techniques
Microbial remediation technology refers to the microbial life activities, reduce its biological toxicity, make it into a stable state. Microorganisms have the advantages of fast propagation, wide distribution, fast metabolism, strong adaptability, it plays an important role in Cd contaminated soil remediation. The common bacteria that remove Cd work well are bacteria, fungi and algae [26]. Kawasaki and other studies have found that the bacteria of Staphylococcus and Bacillus salt isolated from fermented foods, these isolates were pH=5-7 and at a temperature of 35 °C, and the removal rate of Cd reached 80%-90% for 48 cultures [27].

5. Conclusions and prospects
Because of the complexity of soil composition and the diversity of pollutants, in some cases, depending on a repair technique, the removal effect can not be achieved. Therefore, according to the nature of the contaminated soil and the composition of the pollutants, the corresponding repair technology was select to achieve complementary advantages. Chemical-biological remediation, plant-microbial remediation, animal-plant-microbi al remediation can be used. The combination of plant-microbial remediation is the use of plant absorption and growth, which also use plants dsorption and Purification of Microorganisms in Root, removal of heavy metal Cd.

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