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Environmental Bioremediation Technology of HM Pollution Based on Big Data Algorithm

Venpaty Velmugan[*]

University of Peshawar, Pakistan

[*]*corresponding author*

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Abstract: HM pollution(HMP) in soil has attracted worldwide attention due to its high hazard. In addition to reducing the absorption of soil nutrients by plants, heavy metals(HMs) also enter the human body through food, threatening human health. Therefore, it is of great significance to control the content of HM elements in soil and to remediate HM-contaminated soil. Taking soil HM remediation as an example, this paper uses the leaching technology of environmental bioremediation technology to remediate soil. Then, the removal effects of three degradable chelating agents(DCA), GLDA, IDS and EDDS, on Cd, Cu, and Pb at different concentrations and different LRTs were analyzed, and the leaching RR of HMs was calculated by big data algorithm. The experimental results show that the removal effect of HMs is the best when the leaching concentration(LC) of the DCA is 15mmol/L and the leaching reaction time(LRT) is 2h.

1. Introduction

In recent decades, my country's industry has developed rapidly, and urban pollution has intensified. The HM components brought by the industrial production process have caused great pollution to the soil. HMs can stay in the soil for a long time without decay, and eventually accumulate in the human body under the interaction of plants, climate, and human activities, and ultimately damage human health [1]. Due to the lack of attention to soil pollution in the past, the research on the causes of soil HMP and the corresponding soil remediation technology started relatively slowly. Therefore, it is urgent to solve the problem of soil HMP.

In recent years, my country's soil HMP has become increasingly serious, resulting in poor soil environmental quality, and soil HMP remediation has gradually become the subject of in-depth research at home and abroad. The researchers found that the use of compost to remediate Cu, Cd polluted soil can increase CEC with increasing organic matter(OM) content. This may be because

OM has an important contribution to soil CEC. Some studies have shown that the CEC of soil and sediments increases after the application of biomass fuel ash to polluted soil, because biomass fuel ash itself causes a large amount of cation exchange [2]. Some scholars use oxalate cleaning to remove arsenic from contaminated soil. Their results show that using oxalic acid as a cleaning agent can achieve high arsenic RRs with minimal damage to soil structure. In addition, increasing OM content with organic amendments results in a decrease in soil bulk density and an increase in soil aeration due to redistribution of pore space [3]. A series of research methods such as XRD, SEM, BET, XRF and FT-IR have carried out a comprehensive and systematic study on the basic characteristics of biomass fuel ash, and found that biomass fuel ash can effectively adsorb HMs, which is a As a good soil HM stabilizing agent, the application of biomass fuel ash also helps to increase plant biomass [4]. Although more and more attention has been paid to the problem of soil pollution, and relevant policies and regulations have been gradually improved, there is still a big gap between the remediation methods for polluted soil and developed countries.

This paper first introduces several environmental bioremediation technologies, and then focuses on the analysis of soil pollution remediation. The removal effect of HMs in soil is studied by the remediation method of DCA leaching. Then, the two factors affecting the removal of HMs were analyzed, and the leaching parameters were determined accordingly.

2. Environmental Bioremediation Technology

The advantage of bioremediation is that it represents an efficient and economically viable method with low biosorbent concentrations and does not produce any toxic secondary products. The important roles involved in the biosorption process include precipitation, ion exchange, complexation, reduction, chelation and coordination [5].

(1) Microorganisms

According to the principle of biosorption or bioaccumulation, a variety of microorganisms can be used to treat HMs. The former involves the physicochemical adsorption, complexation and chelation of HMs on the surface of biological agents. Biosorption is greatly affected by parameters such as the pH value of the medium, but both live and dead microorganisms can achieve the purpose of HM adsorption [6]. Another advantage of biosorption is that by changing the pH to lower levels, metals can be desorbed from the biosorbent, thereby recovering HMs from the biosorbent [7]. For example, the exopolysaccharides of some microorganisms were irreversibly attached to the silica gel column, and its adsorption efficiency for Cu^{2+} and Pb^{2+} was found to be 99.9%, while the metal recovery rates for Cu^{2+} and Pb^{2+} were 86% and 90%, respectively. The use of dead cells in wastewater HM remediation also eliminates concerns about microbial treatment required for post-treatment wastewater. Furthermore, in other studies using MgO nanoparticles to remove HMs,t pathogenic E. coli was also killed during wastewater treatment [8-9]. Bioaccumulation, on the other hand, involves the use of intrinsic microbial proteins to sequester and utilize bioaccumulated metals in microbial cells. The tolerance of cultured microorganisms to HMs helps the metalloproteins of some microorganisms to avoid the toxicity of HMs [10].

(2) Phytoremediation

Phytoremediation is an effective alternative to address HM contamination in large areas of soil, especially in agricultural fields are not cost-effective to remove HMs [11]. It has the advantages of low cost, use in areas that do not require excavation, metal recovery after plant mining, and its minimal harm [12]. However, there is also the problem of HMs entering the food chain, such as the accumulation of HMs in plants such as rice. Therefore, the use of agricultural varieties with less accumulation of HMs to absorb HMs in the soil has received extensive attention. The use of ornamental plants in HM remediation is considered to be more beneficial than crops because the former are safer and less likely to bioaccumulate [13-14].

3. Experimental Research

3.1. On-Site Sampling and Analysis Test

In this paper, the soil around an industrial area was sampled to analyze the HMP in the area. According to the identification of land plot pollution and with reference to relevant technical specifications, the detailed sampling and analysis work plan and work plan shall be determined, and the soil monitoring indicators, site layout, sampling depth, sampling frequency, etc. shall be clearly investigated in detail. According to the detailed sampling and analysis work plan, on-site drilling, sampling, analysis and testing of the plots were carried out, and on-site quality control of sampling and laboratory analysis were carried out in strict accordance with the specifications [15-16].

3.2. Experimental Method

In this experiment, three DCAs, GLDA, IDS and EDDS, were used to study the factors affecting the removal of HMs by ectopic oscillation leaching, in order to provide data support and theoretical basis for the selection of degradable leaching agents and the determination of leaching parameters for soil remediation engineering [17].

3.3. Data Processing Based on Big Data Algorithms

The data processing and statistical analysis in this paper uses Excel to draw the corresponding charts. The calculation formula used in the research process involving the leaching and RR of HMs is as follows:

$$mi = \frac{ai \times V}{bi \times W} \tag{1}$$

$$ni = \frac{ai \times V}{c \times W} \tag{2}$$

$$bi = \frac{ni}{mi} \tag{3}$$

In the formula, mi is the leaching RR of HM i, ni is the measured concentration of HM i, bi is the actual measured concentration of HM i in soil, ai is the concentration of HM i in the eluent, V is the volume of the eluent, and c is the test The mass of the soil, W is the dry matter content of the soil [18].

4. Experimental Results

4.1. Effect of DCA LC

In the process of soil leaching, the leaching efficiency of HMs is affected by the concentration of the leaching agent. The effects of the three degradable integrating agents, GLDA, IDS and EDDS, on the removal of Cd, Cu, and Pb in the soil at different concentrations are shown in Table 1 and Table 2. and shown in Table 3.

Table 1. The removal effect of different concentrations of chelating agent on Cd

	5	10	15	20	25	30	35	40
GLDA	21.5	24.6	31.3	36.8	48.1	55.4	57.2	58.7
IDS	3.2	4.3	11.8	14.7	17.2	19.6	20.4	20.8
EDDS	16.4	18	25.5	31.4	37.3	39.2	40.3	41.2

Table 2. The removal effect of different concentrations of chelating agent on Cu

	5	10	15	20	25	30	35	40
GLDA	16.9	27.1	32.4	40.5	47.8	51.4	52.6	53.2
IDS	15.8	24.5	29.7	36.3	42.9	44.2	45.5	45.8
EDDS	27.6	36.7	45.3	49.2	54.1	57.4	59.8	61.3

Table 3. The removal effect of different concentrations of chelating agent on Pb

	5	10	15	20	25	30	35	40
GLDA	8.7	17.5	28.6	34.2	36.8	43.9	44.7	45.6
IDS	6.1	14.9	30.8	36.7	42.1	39.2	38.5	37.5
EDDS	15.4	32.8	41.7	45.3	46.8	47.6	48	48.2

In general, the change of the concentration of the three DCAs in the eluent has a significant effect on the removal of HMs Cd, Cu, and Pb from the soil.

For Table 1, the three DCAs of GLDA, IDS and EDDS all made the leaching RR of Cd in the soil increase rapidly with the concentration of the eluting agent from 5 to 15 mmol/L. The removal effect of IDS on Cd was poor. When the concentration of the eluent was 15 mmol/L, the RR of Cd in the soil by GLDA reached 31.3%, which was 19.5% and 5.8% higher than that of IDS and EDDS under the same conditions, respectively. When the concentration of the three DCAs is greater than 30 mmol/L, the leaching RR of Cd in the soil tends to be stable, and the variation range does not exceed 5%. When the concentration is 40 mmol/L, the three DCAs are The leaching RRs of Cd in the soil were 58.7%, 20.8% and 41.2%, respectively.

For Table 2 and Table 3, the concentration of the three DCAs was from 5 to 15 mmol/L, and the leaching RR of Cu and Pb in the soil also increased rapidly, and gradually became flat at 30-40 mmol/L. When the eluent concentration was 15 mmol/L, the RR of Cu by EDDS reached 45.3%, which was 12.9% and 15.6% higher than that of GLDA and IDS, respectively. When the eluent concentration was 25mmol/L, the RR of IDS for Pb reached a peak value of 42.1%, and then tended to balance and slowly decreased. When the eluent concentration was 40mmol/L, the RR of Pb by GLDA, IDS and EDDS reached a The RRs were 45.6%, 37.5% and 48.2%.

From the experimental results, when the concentration of the three DCAs was 15 mmol/L, the RRs of Cd, Cu and Pb increased significantly with the increase of the LC. This is because the average dosage of the eluent in contact with the eluent per unit mass of polluted soil is increasing, which leads to an increase in the number of functional groups that enter the eluent and participate in the complexation reaction, thereby improving the eluent's ability to elute HMs from the soil. In the process of soil leaching, other non-target metals (such as Mg, Fe, etc.) present in the contaminated soil compete to consume part of the DCA. Therefore, when GLDA, IDS and EDDS increase in the low concentration range, the above reaction process occurs. and partially consumed. When the concentration of the three DCAs was 30 mmol/L, the RRs of Cd, Cu, and Pb tended to be gentle with the increase of the LC, and the rate of change of RR was low. This is because the HMs in the soil are mainly adsorbed obligately at this time, and Cd, Cu, and Pb, which can form stable chelating agents with three DCAs in the soil, are basically complexed, and it is difficult to increase the concentration of the DCAs. It is desorbed from the soil, so that the removal rate(RR) of HMs in the soil tends to be stable. In the high concentration range (20-30 mmol/L) of IDS, the leaching removal efficiency of Cu and Pb tended to decrease, which may be due to the presence of chelating agents and HM complexes that were re-adsorbed by soil. Considering the economy and removal efficiency, the optimal elution concentration of GLDA, IDS and EDDS was 15 mmo/L.

4.2. Effect of DCA LRT

The optimal extraction time can be determined by studying the gradient experiment of DCA in different extraction time (0.25h, 0.5h, 1h, 2h, 5h, 10h, 16h, 24h). The experimental results of this part are as follows.

Table 4. The removal effect of chelating agent on Pb under different LRT

	0.25	0.5	1	2	5	10	16	24
GLDA	5.3	17.4	28.1	41.5	52.4	53.6	54	54.1
IDS	5	16.8	27.9	38.4	40.3	41.5	41.8	41.8
EDDS	5.1	17.2	27.3	32.6	34.7	35	35.2	35.6

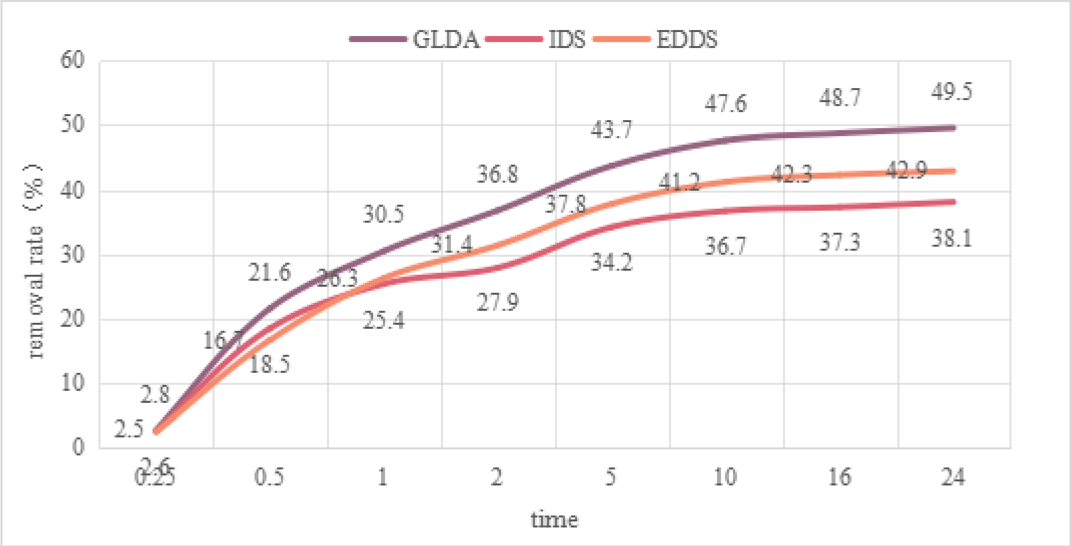

Figure 1. The removal effect of chelating agent on Cd under different LRTs

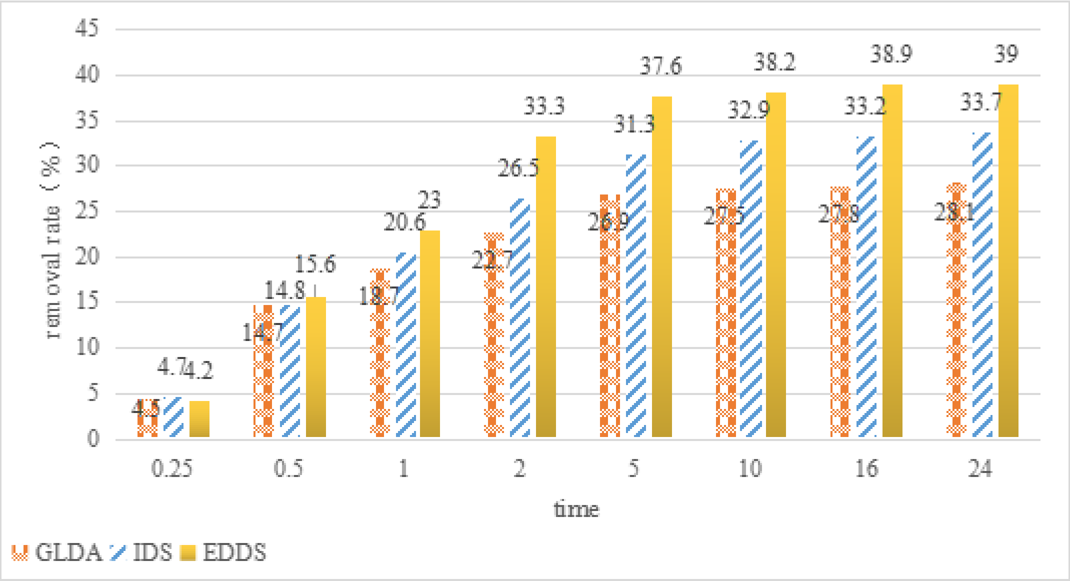

Figure 2. The removal effect of chelating agent on Cu under different LRTs

Table 4, Figure 1 and Figure 2 show the removal effects of three DCAs on Pb, Cd and Cu under different LRTs. Overall, with the prolongation of reaction time, the removal efficiencies of GLDA, IDS and EDDS for Pb, Cd and Cu increased first and then stabilized. After 10h leaching, the RRs of Pb, Cd and Cu did not fluctuate greatly. At this time, the removal effect of GLDA on Cd and Pb was basically the best, and the RRs were 47.6% and 53.6%, respectively. Compared with IDS and EDDS, GLDA can elute more Cd^{2+} and Pb^{2+} in a shorter time. During the whole experiment, the RR of Cu by GLDA and IDS was low, only 26.9% and 31.3% respectively when the reaction time was 5h, which was lower than 37.6% of EDDS. This may be related to the lower chelation constant of GLDA and IDS for Cu, and GLDA and IDS preferentially complexed with other non-target metals (such as Fe3+).

In the initial stage (0-2h) of oscillating leaching, the RRs of Cd, Cu, and Pb in the soil increased significantly, and after the reaction time continued to increase, the leaching efficiency became slower. In the late stage of oscillation leaching (2-24h), the RRs of Cd, Cu, and Pb in the soil tended to be gentle, and the change range was small. This may be due to the complexation reaction between the eluent and the non-target metal ions, so that the chelating active site of the chelating agent is occupied by the non-target metal, so that its chelating ability gradually decreases; on the other hand, it may also be due to the due to adsorption. Considering the economy and removal efficiency, the optimal leaching time for GLDA, IDS and EDDS was 2h.

5. Conclusion

Environmental issues are related to the vital interests of everyone. Countries all over the world are working hard to carry out environmental-related governance actions in response to environmental problems in their own countries. my country has listed the construction of ecological civilization as an important development strategy, which shows that my country is responsible for the environment. Issues are given considerable attention. As an efficient, low-cost and environmentally friendly remediation technology, environmental bioremediation technology has become the mainstream technology in the future. This paper uses this kind of technology to remove soil HMP, and analyzes the removal effect of chelating agent leaching on soil HMP through experiments. The results showed that with the increase of chelating agent concentration and LRT, the RR of HMs first increased and then tended to be flat.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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