The Influence of Biodegradable Polymer Materials on Heavy Metal Activity in Soil Based on Analysis of Big Data

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Abstract. Biodegradable polymer material is a new type of slow-release organic fertilizer. It contains many nutrients, and has a long degradation cycle. At the same time, it can provide nutrients continuously, and the degradation products are pollution-free, which can significantly reduce the negative impact on the environmental system. According to big data analysis, biodegradable polymer materials can not only provide nutrients during the degradation process, but also solidify heavy metal ions and reduce their activity by increasing soil pH and increasing soil available phosphorus and organic matter content. This article takes biodegradable polymer materials rich in various nutrients as the research object. Through leaching experiments, the environmental impact of biodegradable polymer materials on soil was studied, which provided a theoretical basis for the development of economical and practical chemical remediation techniques for heavy metal contaminated soil[1-2].

Keywords: Biodegradable Polymer Materials, Heavy Metal, Soil, Big Data Analysis

1. Introduction

Biodegradable macromolecule materials have the advantage of long degradation cycle, which can effectively solve the problem of secondary environmental pollution, improve crop yield, change soil physical and chemical properties, and improve soil structure[3-5]. Heavy metal pollution has potential, non-degradability, hysteresis and other characteristics. Although the effects of polymer on the availability of heavy metals in soil have been studied, the effects of biodegradable polymer materials on heavy metals in soil and the related mechanisms have not been studied. The leaching characteristics of heavy metals with different biodegradable polymer materials were studied through laboratory soil column leaching simulation test, which provided theoretical basis for environmental risk assessment of biodegradable polymer materials in contaminated soil improvement.

2. Effects of biodegradable polymer materials on activation and migration of heavy metals in contaminated soils

2.1. Leaching simulation test method

The leaching simulator is shown in Figure 1. The leaching column is made of polyethylene plastic tube,
and a liquid conduit is provided. Dry quartz sand and nylon net washed with deionized water are laid on the lower end of the cylindrical tube to seal the bottom of the cylindrical tube. The air-dried soil was loaded into a cylindrical tube to form a simulated soil column about 90 cm high. When filling the soil column, the soil is divided into two layers and compacted into a cylindrical tube. The height at the top of the column is reserved for watering. Mix the treated fertilizer with the upper soil and fill it on the surface of soil column. When installing soil pillars, special attention should be paid to compact the soil at the edge of the soil pillar wall to ensure that no water seeps out from the wall, so as to prevent the occurrence of edge effect.

Before leaching, the soil column is evenly washed with deionized water until the soil is saturated. After a day's rest, deionized water is added to the soil column. Six treatments were set up: (1) no fertilization (CK). (2) Low solubility NPK-containing biodegradable polymer material (PRFL). (3) High solubility NPK-containing biodegradable polymer material (PRFH). (4) Low solubility biodegradable polymer materials containing Fe-Mn-Cu-Zn (WRFL). (5) High solubility biodegradable polymer material containing Fe-Mn-Cu-Zn (WRFH). (6) Low solubility S-containing biodegradable polymer material (SRFL). (7) High solubility S-containing biodegradable polymer material (SRFH).

![Figure 1. Leaching simulator.](image)

In order to compare with pot experiment, the amount of fertilizer applied was N: P: K = 1:1:2 according to the law of tomato fertilizer requirement. The specific fertilization scheme was shown in Table 1.

**Table1. Fertilization scheme.**

| Processing code | Fertilizer application rate (g/100g soil) |
|-----------------|------------------------------------------|
| CK              | 0                                        |
| PRFL            | 0.0402                                   |
| PRFH            | 0.0476                                   |
| WRFL            | 0.0612                                   |
| WRFH            | 0.0416                                   |
| SRFL            | 0.0581                                   |
| SRFH            | 0.0581                                   |

The experiment lasted for about three months. The leachate was collected to determine the content of each index. During the experiment, the leachate samples collected were fully mixed and stored in the refrigerator. The samples were thawed before the determination. After the elution test, the soil column was poured out as it was and divided into four layers to determine the available heavy metal content in each layer of soil sample.
2.2. Leaching simulation test results and analysis

Biodegradable macromolecule material is a new type of slow-release fertilizer with a variety of nutrients which can be completely degraded. Previous pot experiments showed that the application of biodegradable macromolecule material in soil can increase the pH value of soil, thereby increasing the negative charge in soil to fix heavy metal ions. In addition, it can also increase the content of organic matter and available phosphorus in soil to increase the adsorption and complexation of heavy metal ions, thus reducing the mobility of heavy metal ions.

The pH value of leachate can indirectly reflect the buffer capacity of soil. As can be seen from Figure 2, the pH value of leachate without biodegradable polymer material fluctuates greatly. With the increase of leaching times, the pH value increases first and then decreases to 8.0. The pH value of leachate treated by biodegradable polymer fluctuates between 7.5 and 8.5, and increases first with the increase of leaching times, reaches the maximum at the third leaching, then decreases, and finally stabilizes around 7.80. It can be seen that the application of biodegradable polymer materials has a certain effect on the pH of leachate.

![Figure 2. Variation curve of electrical conductivity.](image)

The electrical conductivity of leachate is a parameter reflecting the total ionic activity in the solution. Figure 2 shows the variation curve of electrical conductivity (EC) of soil leachate treated with different biodegradable polymer materials. The conductivity of leachate without biodegradable polymer material treatment fluctuates all the time, while the treatment of biodegradable polymer material tends to be stable after the fifth time, especially the treatment of NPK-containing biodegradable polymer material and S-containing biodegradable polymer material. However, the treatment of biodegradable polymer materials containing Fe-Mn-Cu-Zn has a larger range than that of other biodegradable polymer materials because of the trace elements Fe, Mn, Cu and Zn.

![Figure 3. Changes of copper and zinc in leachate.](image)

Figure 3 shows the changes of copper and zinc in leachate from different treatments. From Figure 3 (a), it can be seen that the content of copper in leachate without biodegradable polymer material treatment fluctuates up and down with the increase of leaching time, while that of NPK-containing biodegradable polymer material and S-containing biodegradable polymer material is stable after the fifth leaching, and that of Fe-Mn-Cu-Zn-containing biodegradable polymer material contains trace element copper.

The change trend of Zn concentration in leachate of high and low solubility NPK biodegradable polymer materials and high and low solubility S biodegradable polymer materials is basically the same. Fig. 3 (b) shows that the concentration of Zn in leachate is the highest at the beginning, then decreases, but there are also slight fluctuations, but the leachate after the sixth time is stable. The biodegradable polymer materials containing Fe-Mn-Cu-Zn contain Zn element, so there is a slight increase in the final.
3. Conclusion
According to the results of big data analysis, the application of biodegradable macromolecule materials has a significant effect on the pH value of leachate. The pH value of leachate increases significantly in the initial stage of leaching, and finally stabilizes at 7.80-8.05 with the increase of leaching times. Concentrations of Zn and Pb in leachate treated with biodegradable polymer materials decreased gradually with the increase of leaching times and finally stabilized. Concentrations of Cu and Cd in leachate increased greatly, but they did not exceed the irrigation water standard. The available forms of heavy metals Cd and Pb mainly accumulated in the surface layer of soil, and finally had a downward migration trend, and the migration of Pb was lower than that of Cd. The available content of Cu and Zn in the upper soil is higher, but the available content of the four elements decreases with the increase of soil depth, indicating that biodegradable polymer materials can effectively reduce the risk of groundwater pollution, but the leaching of Pb and Cd and their accumulation in the soil should be the focus of attention.

Acknowledgements
1. Scientific research fund project of Liaoning Province (LSHYST201903);
2. Scientific and technological plan project of Jinzhou (18B1E42).

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