Research on the Control of Biomass and Heavy Metal Pollution

Shengao Hou [1], Haotian Sun [2,*]

[1] College of Resources and Environment, Northwest A&F University, Shaanxi, 712000, China

[2.] Faculty of Environmental Engineering and Science, Polytechnic College of Hebei University of Science and Technology, Shijiazhuang, 050000, China

* Corresponding Author Email: 1910660221@mail.sit.edu.cn

Abstract. Faced with the increasing loss of resources and the worsening of environmental pollution, the country is also paying more and more attention to the recycling of resources and pollution control. At present, biomass as a new energy can improve the utilization of resources and environmental conditions. This paper focuses on the basic content of biochar, the status of soil heavy metal pollution and the effect of biochar on the control of heavy metal pollution. Studies have shown that biochar can convert part of exchangeable heavy metals in soil into a stable state through passivation, and the other part of heavy metals can be absorbed by plants to achieve the purpose of repairing soil plants, thereby indirectly improving soil characteristics. In addition, biochar can also use chemical leaching method to remove heavy metal pollutants in soil by leaching solution to improve soil heavy metal pollution. In order to better optimize the use of resources and improve environmental pollution, we should explore the interaction between biomass energy and environmental media more deeply, and innovate the technologies and methods of birth matter energy in pollution control. The combination of biomass and heavy metal pollution control can not only promote more in-depth research on biomass properties, but also make great contributions to human resource recovery and environmental pollution control.

Keywords: Biomass; heavy metal pollution; characteristics; measure; application.

1. Introduction

The main purpose of this article is to analyze how to deal with heavy metals effectively under the background that the state attaches great importance to and has issued a number of policies related to heavy metal treatment. Nowadays, there are a variety of application technology designs for heavy metal treatment, such as: thermal removal repair method, electric repair technology, curing technology, microbial repair technology, chemical leaching technology, biomass carbon and vegetation combination method, etc. Among them, thermal removal repair method, chemical leaching method, biomass carbon and vegetation combination method is a more common and influential treatment technology. Thermal removal method is a technology that heats polluted soil and desorbs volatile heavy metals (such As Hg, AS, etc.) or organic matter from the soil. Although its heavy metal removal rate is high, the device is simple and the equipment is flexible, its energy consumption leads to high cost, in addition, high temperature will change the physical and chemical properties of the soil [1]. However, biomass carbon has raised the treatment of heavy metals to a new height. Chemical leaching technology and the combination of biomass carbon and vegetation both make use of the characteristics of biomass carbon to improve the removal efficiency of heavy metals, improve soil fertility and have a certain recovery effect on leach [2, 3]. Therefore, the application technology combined with biomass carbon should be promoted.

Firstly, the classification, preparation and application of biomass are briefly introduced in this paper. Then in the aspect of heavy metal pollution, the characteristics of heavy metal pollution and measures to reduce heavy metal pollution are expounded. Then, the application of biochar and vegetation combination in removing heavy metals in soil and chemical leaching in removing heavy metals in soil were expounded. Finally, the future development direction of biomass and heavy metal pollution is summarized.

2. Biomass

2.1. Classification

Biomass refers to the organic matter in all living organisms, including all animals, plants, microorganisms, and the waste materials produced by them [4]. Based on the concept of biomass, the most common way to categorize biomass is by source. However, for different types and directions of research, biomass is divided into different categories according to source, and the essence of this difference lies in the fact that biomass plays different roles in different researches. Zhang et al. [5] showed that biomass can be categorized into four main groups according to its source: woody biomass, herbaceous biomass, fruit biomass, admixtures and mixtures. Xiao et al. [6] in the literature classified biomass into four categories according to different sources: domestic waste, crop residues, forest resources and livestock manure. These four categories have played a great role in energy regeneration and environmental protection through scientific conversion and processing. For other researchers, they are categorized differently for the convenience of research.

2.2. Preparation Method

After years of research, it is found that the preparation of biomass char can be mainly from four kinds of direct carbonization method, physical activation method, chemical activation method and hydrothermal method [7]. Fig. 1 and Fig. 2 show the main processes of chemical activation method and physical activation method for biochar preparation, respectively [7]. Among them, the direct carbonization method is the process of forming biochar by direct high temperature cracking of biomass feedstock [8]. Physical carbonization is the process of generating porous biomass char by mixing oxidizing gases with it after high temperature [8]. Depending on the principle, biomass char is prepared in different ways. The biomass char produced by these four different preparation methods can be used as an alternative to fossil fuels and for environmental sustainability.

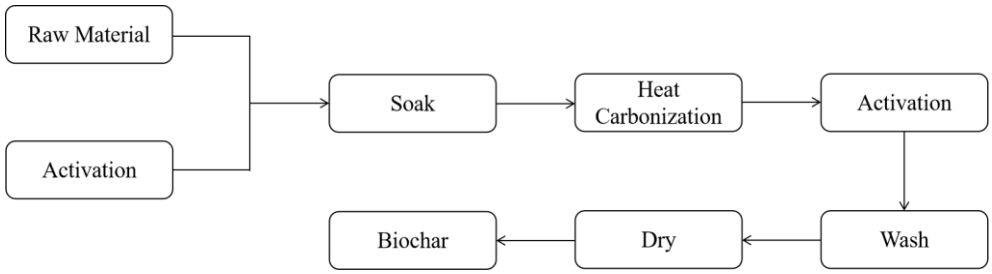

Fig. 1 Process flow chart of chemical activation method.
https://kns.cnki.net/KXReader/Detail?invoice=dZdoWhN8BtFVrooWaHng9YQi1BfkmcwoqFcE6cy081tquhLLx0xueiKi/amPZzALYHDqZV4V0/oMHlteVvmcChLtRTwkEldo7QKtWTR3TmsHDfs6TyNpD1t4HJmoTKefStW4s4tBHGP3jbXiJvCMGaYBgjeBLrscWew3E2DZiJg=&DBCODE=CJFD&FileName=GZHA202024007&TABLEName=cjfdlast2021&nonce=CFF956273CD5455098F23F089C84709B&TIMESTAMP=1689146511711&uid=

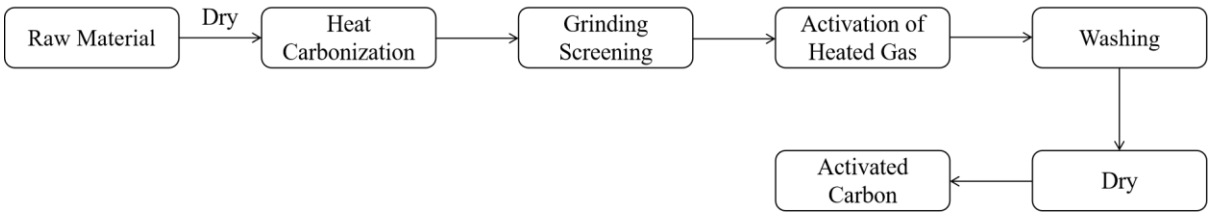

Fig 2. Process flows of physical activation.
https://kns.cnki.net/KXReader/Detail?invoice=evRDH7isUFyrVDKwRgvgF4azljqZRk+nxs37s3XlbPSGBJ+yJKooNUx1+c+1cb70CyRHGjWD3JPwTWYeN0z3Mxx9mQ+rriOGr1hU+qESAdo+YtbF4zVb583kGlY+v9wusDYhFdTFQCo5y3QflaxEZJKjJbY1W02TbRtql4K6Gwg=&DBCODE=CJFD&FileName=GZHA201505007&TABLEName=cjfdlast2015&nonce=EFFB2BA56F154950A0E7AD923D77A8C5&TIMESTAMP=1689147230807&uid=

2.3. Application

At present, the application of biomass is mainly through the preparation of biochar, the generated biomass energy source is directly utilized in power generation or through certain methods to convert biomass energy into other energy sources that can be directly utilized. Due to the drastic reduction of the earth's fossil energy, biomass plays an important role in energy utilization, moreover, it is directly reflected in the power generation process. The biomass power generation processes include direct combustion power generation, gasification power generation, biogas power generation and biomass coal-fired hybrid power generation. Among them, the first three processes are through the direct combustion or conversion of biomass to achieve the purpose of power generation. Not only that, biomass also has great applications in human daily life, chemical industry and agriculture. Processing and production of biomass as raw materials in the chemical industry can not only realize the recycling of resources but also obtain high economic benefits.

3. Heavy Metal Pollution

3.1. Heavy Metal Pollution and Characteristics

Heavy metal pollution refers to the environmental pollution phenomenon caused by some substances of heavy metals remaining in soil or water bodies because they cannot be decomposed [9]. Heavy metal pollution has a serious impact on the ecological environment, mainly reflected in the impact on soil and water bodies and human health. Soil heavy metal pollution is more prominent, mainly due to the difficulty of microorganisms in the soil to decompose heavy metal substances, resulting in a large number of heavy metal substances to the soil as a carrier for the complex organic and inorganic chemical reactions. The heavy metal substances remaining in the soil will be absorbed by crops through the plant root system and enter the human body and affect human health. In addition, as a channel for pollutant discharge, water bodies also contain a large number of heavy metal substances. Heavy metals in water can accumulate in the food chain through aquatic organisms and then flow to human beings. Thus, heavy metal pollution can have a negative impact on human life through the environment and other media, such as toxicity. Characteristics of heavy metal pollution include the wide range of contamination, long duration, possible accumulation through the food chain, and toxicity.

3.2. Measures to Slow Down Heavy Metal Pollution

In the face of heavy metal pollution, we can deal with it from the following aspects, taking the phenomenon of heavy metal pollution in soil and water as an example, and put forward countermeasures for heavy metal pollution. For the heavy metal pollution in soil, we can take physical and chemical methods to separate heavy metals from soil directly or improve the soil environment characteristics through biological action to reduce the harm of heavy metal pollution in soil. For heavy metal pollution in water bodies, the main four aspects are adsorption, new traps, microorganisms and phytoremediation [10]. Where Table 1 is a comparison of the four methods. In addition, not only focusing on the response to heavy metal pollution in soil and water, but also for the overall heavy metal pollution on the environment and ecological impacts to propose a wider range of measures. Environmental protection measures based on heavy metal pollution control should not only consider the methods and technologies needed to mitigate heavy metal pollution, but also take into account the current policy situation, raise the awareness of environmental protection of the whole population, strengthen the pollution emission standards of enterprises, and make joint efforts to mitigate the impact of heavy metal pollution on the environment and ecology.

Table 1. Comparison of four heavy metal wastewater treatment methods [10].

Methods	Treatment Efficiency	Effluent Quality	Alkali Consumption	Multi-heavy Metal Processing Capacity	Engineering Cost	Running Cost	Technical Control
Adsorption	Medium	Preferable	No	High	Medium	Low	Simple
New Trap Agent	High	Nice	Bit	High	Medium	Medium	Strict
Microorganism	High	Nice	Cost	High	High	Low	Strict
Phytoremediation	Medium	Common	No	Low	Low	Low	Convenient

4. Application of Biomass in Heavy Metal Pollution

4.1. Application of Biomass Charcoal Combined with Vegetation

This treatment is a combination of biochar passivation and plant treatment of soil heavy metals. Biochar converts part of the heavy metals in the exchangeable state of the soil to the stable state through passivation, while part of the heavy metals are absorbed by plants. The study of Wang et al. [11] showed that the application of sheepshead biochar caused the transformation of soil heavy metal Cd from exchangeable state to carbonate-bound, Fe-Mn oxide-bound, organic-bound and residue states, thus significantly reducing the hazard of heavy metal Cd. Biomass charcoal not only has a dense pore structure and surface charged functional groups that can adsorb heavy metals in the soil, but also can help plants to absorb heavy metals. It greatly improves the efficiency of heavy metal absorption. For example, biochar can increase the activity of microorganisms in the soil by increasing the fertility of the soil itself and thus the activity of microorganisms in the soil. This leads to the growth of the root system in the soil, and the efficiency of biochar to repair soil plants is higher.

4.2. Application of Chemical Leaching

Chemical leaching removes heavy metals by combining biomass charcoal with a leachate. Although this method has the advantages of long-lasting and easy to operate, it produces a large amount of leachate, which has the risk of contaminating the groundwater if it is not treated properly. As biomass charcoal has dense pores and contains a large number of negative charges, these properties are favorable to the combination of application with the drenched liquid, such as the use of biomass charcoal to adsorb the drenched liquid, which can achieve the purpose of recycling water resources and zero discharge of wastewater [12].

4.3. Recommendations for Upgrading the Application Methodology

4.3.1 Screening of leaching agents

The study of Xu et al. [13] showed that under the same concentration, the selection of different leaching agents would produce different removal efficiencies for heavy metals, so it is necessary to select the best leaching agents to achieve the best removal efficiency as far as possible.

4.3.2 Concentration of leaching agents

Studies have shown that the removal of heavy metal ions from lead-contaminated soil is related to cation exchange and the concentration of leaching agents used is the main factor affecting ion

exchange, so it is particularly important to select the appropriate concentration of leaching agents [14].

4.3.3 Solid-liquid ratio of eluting agents

With the increase of the solid-liquid ratio of leaching agent, the removal rate of lead decreases and the ratio of solid to liquid increases. The reason is that the volume of leaching agent added to the same soil quality decreases, the removal effect of lead-contaminated soil is weakened, and the corresponding removal rate decreases. Therefore, it is necessary to correctly prepare the solid-liquid ratio of the eluting agent.

4.3.4 Temperature of biochar preparation

Azeem et al. [14] used bovine bone as raw material to produce biochar by pyrolysis at 500 ℃ and 800 ℃, and compared the effects of the two kinds of biochar on the response of microbial biomass, bacterial community and diversity index in the polymetallic polluted soil of the smelter. The results showed that the application of biochar prepared at 500 ℃ showed high microbial biomass and bacterial gene abundance, such as the abundance of pseudomonas (up to 793%) and saccharomyces (583%) at a biochar dosage of 10%. Therefore, it is particularly important to choose the appropriate biochar preparation temperature.

4.3.5 Raw materials of biochar

The higher the lignin content of the feedstock, the lower the cellulose content in it and the higher the yield of biochar. The mineral composition and metal substances in the raw materials also have a certain impact on the properties of the prepared biochar. Studies have shown that the nitrogen content of faecal-derived biochar under the same conditions is higher than that of other raw materials [15].

4.3.6 Modification of biochar

Luo et al. [16] used corn stalk biochar to repair CD-AS composite contaminated brown soil, and the results showed that the leaching rate of Cd in brown soil was significantly reduced by only 34.6%. Therefore, in order to make the remediation capacity of biochar more widely applicable to different soil types, biochar should be further modified to improve its remediation properties.

4.4. Future Development Direction

How to maximize the potential of the combination of biomass charcoal and plants for heavy metal removal from soil when combined with plants is an important development direction for the future. (i) Further improve the awareness of the impact of biochar on plants and improve the passivation effect of biochar. (ii) Innovate ways of biochar and combined phytoremediation, and research and find out different combinations that are suitable for different types of conditions. (iii) Large-scale application of biochar, recycling and post-treatment of plants. (iv) Strengthen the search for large biomass cash crops suitable for growing in heavy metal polluted soil, and study the remediation effect of biochar and its combination. At the same time, attention should be paid to choosing the right crops (flowers, seedlings, etc.) to avoid heavy metals entering the food chain to harm the health of animals and humans.

5. Conclusion

In the context of the country's increasing attention to pollution control and resource recovery, the use of biomass has played an important role in energy recycling and environmental protection. According to the summary of most studies, biochar can be divided into four categories: domestic waste, crop straw, forest resources and livestock manure. Biochar is also widely used in all aspects of human development and life. In the aspect of heavy metal pollution, many measures to control heavy metal pollution are put forward according to the characteristics and present situation of soil heavy metal pollution. Combining biomass and heavy metal pollution control, biochar can not only effectively improve phytoremediation efficiency through passivation, but also remove heavy metal

pollutants in soil by chemical leaching, so as to achieve soil heavy metal pollution control. Faced with the increasingly severe situation of soil heavy metal pollution, biomass should be better combined with soil heavy metal pollution control in the future, and the interaction between biochar and microorganisms and plants in soil should be innovated to improve soil environmental conditions. The purpose of combining biomass and heavy metal pollution is to explore the new development direction of soil heavy metal pollution control, make better use of renewable resources to deal with environmental pollution problems, and realize the two-way development of resource recycling and environmental protection.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

References

[1] Chang T.C., Yen J.H., On-site mercury-contaminated soils remediation by using thermal desorption technology. Journal of Hazardous Materials, 2006, 128(2-3): 208-217.

[2] Makino T., Sugahara K., Sakurai Y., et al., Remediation of cadmium contamination in paddy soils by washing with chemicals: Selection of washing chemicals. Environmental Pollution, 2006, 144(1): 2-10.

[3] Ashraf S., Ali Q., Zahir Z.A., et al., Phytoremediation: environmentally sustainable way for reclamation of heavy metal polluted soils. Ecotoxicology And Environmental Safety, 2019, 174: 714-727.

[4] Shi H.D., Cai X.Q., Sources and classification of biomass clean energy. Biology Teaching, 2017, 42(03): 67-68. (In Chinese)

[5] Zhang K.R., Basis and basis for formulating GB/T 21923-2008 "General Rules for Inspection of Solid Biomass Fuels". Coal Quality Technology, 2009, 04: 23-25. (In Chinese)

[6] Xiao Y., Liu H.F., Li N., Development and utilization of biomass energy. Hubei Agricultural Mechanization, 2020, 246(09): 44-45. (In Chinese)

[7] Song Y., Jia X., Chen Y.L., et al., Research progress on preparation and application of biomass carbon. Guangzhou Chemical Industry, 2020, 48(24): 11-13. (In Chinese)

[8] Shen Z.W., Liu T.F., Cao O.G., et al., Guangzhou Chemical Industry, 2015, 43(05): 15-17. (In Chinese)

[9] Sun Y.X., Zhu L., Impact of heavy metal pollution on environmental management and protection [J]. Environmental Engineering, 2023, 41(04): 304-305. (In Chinese)

[10] Ma Q., Zhang X.L., Research progress of new technologies for heavy metal wastewater treatment at home and abroad. Journal of Environmental Engineering, 2007, 07: 10-14. (In Chinese)

[11] Wang Y.Y., Kei O., Lu H.H., et al., Effect of biochar from sheepshead on cadmium-contaminated soil properties and cadmium morphology. Journal of Agricultural and Environmental Sciences, 2018, 37(6): 1132-1140.

[12] Sun K., Miao C.B., He Y., Research status of application of biochar in remediation of heavy metal contaminated soil. Engineering Science and Technology 1, 2017, 51(4): 70. (In Chinese)

[13] Xu L., Application case study of chemical leaching method for remediation of heavy metal Hg contaminated soil, Leather Making and Environmental Protection Technology, 2022, 3(11): 88-90. (In Chinese)

[14] Azeem M., Jeyasundar P., Ali A., et al., Cow bone-de-rived biochar enhances microbial biomass and alters bacterial community composition and diversity in a smelter contaminated soil. Environ Res, 2022, 114278.

[15] Luo Y., Jiao Y.J., Zhao X.R., et al., Improvement to Maize Growth Caused by Biochars Derived From Six Feedstocks Prepared at Three Different Temperatures. Journal of Integrative Agriculture, 2014, 13(3): 533-540.

[16] Luo M., Lin H., He Y., et al., The influence of corncob-based biochar on remediation of arsenic and cadmium in yellow soil and cinnamon soil. Sci total environ, 2020, 717: 137014.