Review on the application of tea residue biochar

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Abstract: As a new type of environmental functional material, biomass charcoal has become a current research hotspot. Existing studies have shown that biomass charcoal has good adsorption properties for heavy metals in solution and soil, and biomass charcoal can improve agricultural soil and increase crop yield. solid carbon and reduce greenhouse gas emissions environmental functions and so has a great value, as one of the world's four major tea beverages account for a large proportion in China's beverage industry, with tea production increased year by year, tea production and other tea processing tea leaves produced in a large number of students, resulting in problems such as environmental impact, this paper aims to make a brief review of the physical and chemical properties and application of biochar tea leaves of tea leaves in order to effectively solve the problem of resource waste biochar.

1. Basic overview

1.1 Biochar overview

All manuscripts must be in English, Biochar is produced by the pyrolysis of biomass under anaerobic or anoxic conditions. Due to its large specific surface area, developed pore structure, oxygen-rich surface functional groups, phenolic hydroxyl, hydroxyl, carboxyl and other functional groups, it has Strong adsorption capacity, can be used to absorb a large number of organic pollutants and heavy metals [1-3, 19]. Not only can it be used as a soil conditioner, reducing agent and high-quality energy source, but also as a preservative and a slow-release carrier. It has good adsorption and fixation properties in soil, water, sediments and metal organic pollutants. It is an ideal general-purpose adsorbent. It has been widely used in the field of environmental pollution, such as water purification and carbon sequestration, and the adsorption of soil amendments. Heavy metals and others [4, 20] can provide scholars with some solutions to this problem. Scholars can apply biochar to improve the characteristics of soil in environmental pollution, soil degradation and global warming to conduct a lot of research and demonstration.

2. Biochar properties and applications

2.1 Biochar properties

The main elements of biochar are small amounts of carbon, oxygen, hydrogen, nitrogen, sulfur and trace elements, as well as rich soil elements, such as calcium, potassium and phosphorus. The carbon content is as high as 60%, and because of their affinity, they are very stable at high temperature or low temperature. Biochar has the characteristics of large specific surface area, high pore size, high aromatics degree, good thermal stability and good dispersibility. Biochar is beneficial to the growth of microorganisms in the soil and the uptake of nutrients by plants. It has the characteristics of small

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volume, large gas volume and strong water absorption, so that it has high adsorption capacity, can adsorb pollutants in water and soil, and reduce the bioavailability of pollutants [5,21,22]. For example, biochar can effectively enhance the adsorption of polycyclic aromatic hydrocarbons in soil. In biochar, carbon and phosphorus form inorganic carbonate with various minerals in the form of high molecular weight and high-density carbohydrate, which makes the pH value of biochar relatively high, and with the increase of pyrolysis temperature, the basic biomass can be prepared. Mineral elements will be enriched at different temperatures: different biomass and different pyrolysis methods have a great influence on the specific surface area of biochar [6, 7, 23]. Generally, with the increase of pyrolysis temperature, the specific surface area of biochar increases, the water holding capacity of biochar decreases, and the surface polar functional groups decrease. With the increase of pyrolysis temperature, the basic groups in biochar increased, the acidic groups decreased, the total functional groups decreased, the functional group density decreased, and the pH value increased. The difference and diversity of biochar produced by different pyrolysis temperature and biomass show different environmental effects. In recent years, researchers believe that it is a new type of green adsorption material and has been widely applied. Greenhouse gas emission reduction, soil and water conservation and other environmental problems.

2.2 Application of biochar

With the continuous development of industry, the degree of pollution of organic pollutants and heavy metals is becoming more and more serious. Soil remediation and water treatment are especially concerned. Biochar is a porous structure with a large specific surface area. The surface contains rich functional groups, which have strong adsorption effect on pollutants [8, 24]. Therefore, the use of biochar to remove pollutants can reduce the effectiveness of pollutants, and prevent certain environmental risks. The surface properties, pore structure, pH value, functional groups, mineral content and other aspects of biochar prepared by different biomass have different characteristics. These characteristics are also the key factors affecting the adsorption performance of biochar, such as charcoal, pericarp carbon and other biomass carbon have high specific surface area, and contain a variety of oxygen functional groups, and have rich pore structure. However, the ash content of biochar is small, and the content of exchange cation and cation exchange ion is also lower. The surface chemical structure and pore structure of biochar are closely related to adsorption performance. The biomass charcoal produced by animal manure is small in specific surface area, but has high ash content and contains more carbonate and phosphate. The biomass carbon prepared from crop straw contains rich oxygen functional groups, high specific surface area and a variety of inorganic mineral salts in ash, but the adsorption mechanism is inconsistent [10, 11, 25]. The different nutrient, nutrient absorption, soil type and management measures in fertilization process are different in the growth process. Biochar with different structure characteristics and element content will be prepared. Soil is an important natural resource for human survival and development. However, with the rapid development of agriculture, a large number of pesticides and some unreasonable applications have resulted in the residue of pesticides, heavy metals and pollutants in the soil exceeding the self-purification capacity of the soil itself, resulting in soil pollution, the soil environmental quality tends to decline, even seriously polluted surface water and groundwater, which endangers human health The balance between food safety and ecological environment. Soil remediation is a long-term process. Many biochar adsorbents are used to adsorb and remove pollutants from soil.

Biochar is highly aromatic, containing a large number of functional groups, porous and stable structure, which makes it have good adsorption characteristics and stability, and can significantly affect the migration and transformation behavior of heavy metals in soil [12, 26]. The abundant pore structure of biochar particles makes it have larger specific surface area and higher surface energy efficiency. The fat double bond and aromatization structure in biochar make its adsorption performance for hydrophobic pollutants increase with the increase of aromaticity. Studies have shown that biochar is a composite structure composed of inorganic minerals, indeterminate organic matter and crystalline organic matter. The surface is coated with inorganic minerals, and has higher cation exchange capacity. Anion exchange with H+ in water, so that the amount of OH- in solution increases

and pH increases. In a word, as a good adsorption material, biochar contains a variety of surface functional groups, such as carboxyl group, phenolic hydroxyl group and other groups, as well as its unique surface physical and chemical properties, such as large specific surface area and surface energy, loose porous, highly aromatic structure and so on. These characteristics enable them to have high adsorption characteristics and have strong adsorption properties for organic pollutants in soil environment. Studies have shown that in the process of adsorption, biochar includes two processes: surface adsorption and distribution. Functional groups and ions on the surface of biochar can form relatively stable chemical bonds with organic matter, thus surface adsorption occurs. Because of the different pyrolysis temperature, the physical and chemical properties and chemical structure of different biochar surface will be significantly different, and the adsorption capacity of particle surface will increase with the increase of pyrolysis temperature. Biochar fired at low temperature contains more organic components, so distribution plays a major role. The adsorption and desorption lag of biochar on organic pollutants is also closely related to the pore structure, specific surface area and aromaticity of biochar, and also related to the size of organic pollutants, hydrophobicity and pH of the environment.

3. Research status of tea biochar

3.1 Overview

China is a big tea producing country. The annual output of tea is 5 million tons, but a large number of tea residues are seldom used, resulting in the waste of tea residues. Yunnan is also an important and only producing area of Pu'er tea, with a huge output of tea. Yunnan Pu 'er tea (Pu' er tea) was promulgated by the Yunnan provincial quality and Technical Supervision Bureau (DB53/T103-2003). Puer tea is defined as Pu 'er tea, which is made from the dried tea of Yunnan in a certain area of Yunnan. Its shape is brown and red, and the soup inside is bright red. Its fragrance is unique and fragrant. Its taste is mellow and sweet, and its leaves are reddish brown [13-15]. This definition includes four meanings: first, in the history of Simao and Xishuangbanna in Yunnan, it belonged to the ancient Pu'er area, and expanded to Kunming, Yiliang, Dali, Shuang Jiang, Lincang and Fengqing after 1973. Second, shaqingmao tea, which is made from fresh leaves of Yunnan tea, uses seeds as raw materials; Third, after fermentation, green tea and its products can be stored and aged for a long time, and can also be used to promote the aging of green tea. Fourth, loose tea and pressed tea have unique shape and excellent internal quality. There are more than 10000 tea shops in Puer City. Most tea leaves are discarded directly.

Pu'er tea has been planted for 3000 years in Pu'er, and there are many kinds of Pu'er tea and various classification methods. In order to facilitate the experiment, it is introduced and selected briefly

Classification by tea tree type:

1. Arbor tea, the traditional Pu'er tea, uses tree leaves as tea cyanine, with large leaves, which is called big leaf tea.
2. Crown wood tea, with the increase of demand for Pu'er tea, tea people transplant tea trees to make tea garden tea. In recent years,
3. Taidi tea (tea garden tea), in order to facilitate the collection, more shrub species are cultivated. The bush tea is thin and has little nutrients.

By age:

1. Ancient tea, not all of which is left behind in ancient times, refers to Pu'er tea made from hundreds of years of wild tree type ancient tea trees.
2. Old tea, Pu'er tea is made from tree type tea trees over hundreds of years old.
3. New tea, the production of raw materials mostly from the artificial planting of shrub tea garden. The leaves are thin, nutritious and easy to produce pollution.

3.2 Preparation method

Taking tea residues as biomass, fan shisuo et al pyrolytically prepared into biochar under oxygen limiting conditions at 300, 500 and 700°C to study its adsorption effect on antibiotics, and fan shisuo

et al., through response surface methodology (RSM) optimized method, was used to prepare biochar. The optimum conditions for biochar preparation from tea residues were pyrolysis temperature of 300°C, preparation time of 1.8 h,

Lin wanpin et al explored the effects of tea residue biochar on NH in soil from tea plantations through simulated cultivation experiments, equilibrium adsorption method and HCl desorption Effect of 4 ~ + - N adsorption desorption the results showed that the application of biochar could effectively improve ammonium adsorption from tea planta soils and enhanced with the increase of biochar addition. The weak alkalinity, large surface area, and strong stability of TSBC showed amendment and sorption potential for acidic soil amendment and heavy metal sorption. However, the influence of pyrolysis time on biochar characteristics was not obvious. The exchange fraction of CD decreased by 25.56% at pyrolysis temperatures from 500 to 600°C , which was obviously higher than that of other pyrolysis temperatures. TSBC can better immobilize Cd contaminated soils. Gu Chun Xiang et al simulated the adsorption treatment of methylene blue in printing and dyeing wastewater by using tea residues as raw materials, and found that tea residues had a better adsorption removal rate and adsorption amount of methylene blue.Ying Ying Wang et al modified tea residue with iron oxyhydroxide, sodium hydroxide, formaldehyde and used it to adsorb Cr (VI) wastewater, the adsorption rate of tea residue can reach 96%, which is consistent with the study of Li bicai et al. Ying Ying Wang et al modified tea residue with iron oxyhydroxide, sodium hydroxide, formaldehyde and used it to adsorb Cr (VI) wastewater, the adsorption rate of tea residue can reach 96%, which is consistent with the study of Li bicai et al. Li bicai et al used black tea tea residues as raw materials to prepare biochar using an oxygen limited controlled temperature pyrolysis method to adsorb Cr (VI) in water, and the adsorption effect of biochar was significantly better than that of untreated tea residues; Jianjun Zhang found that this diet can lower the concentration of harmful gas in broiler houses after adding tea residues to the chicken diet, not only alleviating its damage to humans and broilers, but also favoring the healthy growth of herd.

MD. tamez Uddin et al used tea waste for adsorption removal of methylene blue from aqueous solution, P. panneerselvam used magnetic nanoparticles prepared from agricultural biomass and impregnated onto tea residues (Fe_3O_4 TW) to remove Ni (II) from aqueous solution, M. ahmaruzzaman research found that the active tea waste (ATW) could serve as a removal agent for p-nitrophenol (p-NP) removal from aqueous system,

3.3 Application prospects

Tea residues itself are a porous, reticular structure and large surface area adsorbent [16]. at present, there are many reports on using tea residues to adsorb heavy metal ions from wastewater. Some scholars have studied the adsorption of tea residues for Cu^{2+} from aqueous solution [17]. Zhidan Wu et al studied the kinetics and thermodynamics of arsenic adsorption from tea residues [18]. Their research objects were the same kind of tea, while the adsorption of heavy metals by biochar prepared from tea infused with different kinds of tea had not been studied. Some scholars studied the preparation methods of tea biochar his research found that tea biochar and 450-degree mixed salt expanded pore biochar had abundant pore structure, which was beneficial to ion migration and weakening resistance. Therefore, to explore its adsorption study on heavy metal contaminated soils, which can effectively treat tea residues, and at the same time, it also has a certain guidance for soil improvement.

4. Conclusions

China is a large country of tea production and consumption, producing a large amount of tea waste annually, which both contaminates the environment and causes great waste of biological resources. From the perspective of utilization, the research progress of tea waste as raw material in extracting active ingredients, preparing tea residue adsorbent, activated carbon, bio-organic fertilizer, animal feed, edible fungi culture material and so on is briefly described. The comprehensive research on tea waste needs further study.

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References

[1] Dongdong Wang a study on the combined removal of no and gaseous monomeric mercury by tea-based biochar [D].

[2] Anzheng Li, Yanwei Hou, Chao Cai, et al. Adsorption characteristics of rice straw based biocharfor Pb (II) [J]. Environmental chemistry, 2011, 30 (11): 1851 - 1857.

[3] Jing Dai,Yang Sheng Liu. Adsorption characteristics of Pb 2+and CD^2+on biochars produced by pyrolysis of four raw materials [J]. Peking University Journal: Natural Science Edition, 2013 (6): 1075 - 1082.

[4] Qingxiang Zhu a pilot study of biochar remediation for Pb and Cd contaminated soils[D]. Chongqing University, 2011.

[5] Weiwei Cao. Efficacy and mechanism of Pb (2+), CD (2+) removal from wastewater by magnetic biochar. A review[DOI]2016.

[6] Wu Yu, Xu Gang, LV Yingchun, et al. development of biochar on soil physicochemical properties [J]. Advances in Geoscience, 2014, 29 (1): 68 - 79.

[7] Liu J, Shi x, Jia YH, et al. Study on Pb (II) adsorption by biochars at different pyrolysis temperatures [J]. Journal of agricultural environmental science, 37 (11).

[8] Zhou Dandan, Qu Fang Zhou, Wu Min, et al. Effects of organic acid secreted from Plant Rhizosphere on Pb (II) adsorption by biochar [J]. Chinese Environmental Science, 2019, 39 (03): 305 – 313.

[9] Xu, Ren Zhi. Effects and mechanisms of biochar on soil characteristics, heavy metal speciation and bioavailability in CD/Pb contaminated grayish calcium soils [D].

[10] Wang Tong. Preparation and Al modification and adsorption properties of citraconic biochar study [D].

[11] Guo Suhua, Xu Zhijian, Li Fangwen, et al. Adsorption characteristics of biochar for Pb (II)and Zn (II) in water [J]. Journal of environmental engineering, 2015 (7): 3215 - 3222.

[12] Fangweishan, Hongguang Huo, Junmin Yang, et al. Pu'er tea spermatine and its processing methods: 2006.

[13] Hai Peng Lu, Qiu Sheng Zhong, Lin Zhi. A study on aroma composition of Chen Xiang Pu'er tea [J]. Tea science ,2009, 29 (3): 219 - 224.

[14] Zhou XJ, cryming Ming, Han JY, et al. Efficacy and quality formation mechanism of Pu'er tea. A review of [J]. Tea, 2003 (02): 16 - 18.

[15] Chongren Yang, cocoa Chen and Yingjun Zhang. Classification of tea and definition of Pu'er tea [J]. Tea journal, 2006 (2): 37 - 38.

[16] Yang zhanpu, Zhang Meng Di,Liu Xin Cong, et al. characterization of biochar from tea residues and a remediation method for cadmium contaminated soil based on pyrolysis conditions:

[17] Sun, Shaaban m, he zlong, et al. Effect of biomass char on soil amendment and tea quality in tea plantations [J]. Soil and fertilizers in China, 2017 (6).

[18] Zhidan Wu, Zhiming you, Fuying Jiang, et al. Analysis of physicochemical characteristics of biochar from tea tree branches carbonized at different temperatures and times [J]. Journal of ecology and rural environment, 2015 (04): 143 - 148.

[19] Yin Q, Ren H, Wang R, et al. Evaluation of nitrate and phosphate adsorption on Al-modified biochar: Influence of Al content [J]. Science of The Total Environment, 2018, 631 - 632: 895 - 903.

[20] Fan S, Tang J, Wang Y, et al. Biochar prepared from co-pyrolysis of municipal sewage sludge and tea waste for the adsorption of methylene blue from aqueous solutions: Kinetics, isotherm, thermodynamic and mechanism [J]. Journal of Molecular Liquids, 2016, 220: 432 - 441.

[21] Fan S, Li H, Wang Y, et al. Cadmium removal from aqueous solution by biochar obtained by co-pyrolysis of sewage sludge with tea waste [J]. Research on Chemical Intermediates, 2017.

[22] Zhang X, Xia J, Pu J, et al. Biochar-Mediated Anaerobic Oxidation of Methane [J]. Environmental Science and Technology, 2019.

[23] Rui-Fang X, Pu-Cui S, Xiu-Lan Z. Effects of three types of biochar on bioavailability of cadmium in a red soil and a yellow soil[J]. Journal of Agro-Environment Science, 2017.

[24] Rékási Márk, Szili-Kovács Tibor, Takács Tünde, et al. Improving the fertility of sandy soils in the temperate region by combined biochar and microbial inoculant treatments [J]. Archives of Agronomy and Soil Science, 2018: 03650340.2018.1482536-.

[25] Zhang J, Pu L, Li G. Preparation of biochar adsorbent from straw and its adsorption capability [J]. Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering, 2011, 27 (14): 104 - 109.

[26] Zhang Y L, Chen L J, Zhang Y G, et al. Examining the Effects of Biochar Application on Soil Phosphorus Levels and Phosphatase Activities with Visible and Fluorescence Spectroscopy [J]. Guang pu xue yu guang pu fen xi = Guang pu, 2016, 36 (7): 2325 - 2329.