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Research Progress on the Properties of Biochar and its Impact on Soil Environmental Functions Based on Bibliometric Analysis

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Abstract: Biochar is a solid product formed by the pyrolysis of biomass (such as crop straw, forest waste, animal manure, etc.) in a high temperature and anoxic environment. In recent years, biochar, as a carbon-fixing soil improvement material, has attracted much attention at home and abroad. The purpose of this paper is based on the research progress of the properties of biochar and its impact on soil environmental functions based on bibliometric analysis. The effect on soil microbial biomass was evaluated, and the differences in this effect were further analyzed according to soil properties, biochar properties and experimental conditions. Then, the cinnamon soil polluted by long-term heavy metals in site A was selected for the field experiment of carbonaceous biomass remediation. The test results showed that with the increase of the amount of biomass char added, the ratio of MBC to MBN in each soil layer increased first, then decreased and then increased; the BC2 treatment rate was the highest in the 0-10 cm soil layer, which was 5.87, the 10-10 cm soil layer was the highest, and the 20-cm and 20-40 cm soil layers had the highest BC5 treatment rates, which were 7.11 and 8.46, respectively.

1. Introduction

As an important part of the terrestrial ecosystem, soil provides the material basis for the survival of humans, animals and plants, and is an important natural resource. Biochar can affect the abundance and community structure of microorganisms in soil through direct and indirect effects, thereby changing soil biological functions and ecosystem material cycling [1]. Due to the wide variation in soil properties, biochar species, and field test conditions, huge uncertainties remain about the microbial effects of biochar in soil. Although there are many reports on the use of biomass char to control heavy metal pollution, the lack of understanding of the changes in soil microbial

abundance, activity and function has become a weak link in soil technology, namely agricultural biomass charring [2].

In recent years, biochar has been widely used to improve soil environment. Brennan C searched the Web of Science database for any HIV-related articles published in orthopedic journals. These have been assessed for regional origin and level of evidence. Results 48.7% of orthopaedic journals in the Web of Science database published articles on HIV. During the time period analyzed (January 2007 to September 2017), only 40.5% (n = 68) of 168 HIV-related articles were published in orthopaedic journals. Articles from low-income countries are rare, and any articles published in the field are collaborative. All articles are low-level evidence [3]. Fusco F used bibliometric methods to analyze the characteristics, reference patterns, and content of 38 books published in international academic journals. Contemporary approaches to social and environmental accounting research applied to the public domain are described, highlighting different schools of thought and key gaps in the current literature, and providing evidence for future research. The findings suggest that public sector research in social and environmental reporting is still in its infancy. Current research, albeit slowly increasing, is still limited. Numerous papers discuss why, what and how CSOs report differences between ICR and IR [4]. Weber K reviews and summarizes the results of several biochar production experiments, explaining the properties that can be achieved through feedstock selection and process design. The production process includes high temperature freezing and slow pyrolysis. Analysis of the data shows that, of all process conditions, process temperature has the greatest impact on all properties. Especially narrow temperatures between 200 and 400 ℃ cause the most significant changes and are therefore very sensitive to effects and difficult to control [5]. Further research is needed on the properties of biochar and the mechanism of its impact on soil environmental functions.

In this paper, bibliometric analysis was used to study the properties of biomass char and its impact on soil environmental functions, and meta-analysis was used to quantitatively study the effects of biomass char on microbial biomass and respiration after being applied to soil. At present, there are many studies on the removal of oxytetracycline from media and functional materials at home and abroad, but there are few literatures using biomass charcoal as adsorbent and oxytetracycline as the target pollutant. Therefore, this paper aims to enrich agricultural waste. It also reveals the influence and mechanism of biochar on soil, which has important guiding significance for the rational preparation of high-efficiency environmental functional materials and the control of antibiotic pollution in soil.

2. Research on the Properties of Biochar and its Impact on Soil Environmental Functions Based on Bibliometric Analysis

2.1. Bibliometric Analysis

Bibliometrics takes the bibliographic system and bibliographic characteristics as the research object, adopts mathematical and statistical measurement methods, studies the distribution structure, quantitative relationship, regular changes and quantitative management of bibliographic information, and then explores a certain scientific and technological structure, the characteristics of an industry and rules. Analyzing the various definitions of bibliometrics, we can see that they have something in common, first of all, they are all a discipline, secondly, they all use statistics, mathematics and other methods, and finally they are all based on various documents (text communication carriers), and quantitatively analyze the literature and its various characteristics [6-7].

2.2. Basic Characteristics of Biochar

Biochar is a highly aromatic carbonaceous solid product produced by the pyrolysis of biomass under anaerobic or anoxic conditions. It has the characteristics of large specific surface area, abundant porosity, stability and strong adsorption. The chemical composition of biochar mainly depends on the chemical composition of the substrate used for biochar production. Some studies believe that the moisture content of biomass char is about 1-15%, the content of volatile substances is about 40%, and the content of minerals is about 5%; biomass char contains stable organic carbon, aromatic compounds, and aliphatic compounds and ash [8-9]. The chemical composition of biochar added to soil is relatively stable, which can affect soil physical and chemical properties, microbial activity, and crop growth, and promote the stability of soil carbon pools and reduce greenhouse gas emissions. However, the properties and functions of biomass char mainly depend on the biomass source, heating rate, maximum heating temperature, and the degree to which volatiles produced during pyrolysis are separated from biomass char before cooling [10-11].

Biochar is a material rich in black carbon, which is more chemically and biologically stable than charcoal, activated carbon and other black carbon materials. Generally speaking, the ash in biomass char is composed of nutrients such as nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, manganese, iron and zinc required for plant growth, and the content of each element depends on the type of biomass raw material [12-13]. The pH value of biomass char is usually alkaline, but the pH value of biomass char produced under different pyrolysis temperature, different raw materials and different pyrolysis time ranges from slightly acidic to highly alkaline. In some studies, the pH of the prepared biochar was close to neutral. Therefore, the content of nutrients such as P, K and Ca will also be higher. As the specific surface area and volatile nitrogen content in thermal biomass char decreased, the cation exchange capacity increased; with the increase of temperature, pH, porosity and surface area also increased significantly [14-15].

2.3. Reduction of Biochar

(1) Adsorption of heavy metals by biomass charcoal

Due to the large specific surface area, high organic matter, pH value and cation exchange capacity of biochar, the adsorption capacity of soil for heavy metals can be improved [16-17].

(2) The application of biochar increases soil pH

Reduce the mobility in soil. The research on soil pH and soil heavy metal availability has been very clear, and many studies have shown that in the normal pH range, soil heavy metal mobility decreases with the increase of pH. The increase of soil pH will increase the combination of hydroxides and oxides such as iron and manganese in the soil with heavy metals such as cadmium and lead to form stable precipitates, thereby reducing the mobility of Cd and Pb in the soil [18-19].

(3) Biochar improves and enhances soil fertility by improving

Some biochar itself contains elements, etc. It directly increases soil fertility, and studies have shown that the application of P and S can significantly reduce the mobility of Cd in paddy soil [20].

3. Experiment and Research on the Properties of Biochar and its Impact on Soil Environmental Functions Based on Bibliometric Analysis

3.1. Data Sources

The literature used in this meta-analysis comes from Wiley-Blackwell, SpringerLink,

WebofScience, CNKI and other databases. By entering the two keywords "biochar" and "soil" in the database, the literature published from 2001 to March 2015 related to the effect of biochar on soil microorganisms was collected. Through preliminary search, 550 articles were obtained. Further screening was carried out with keywords such as "respiration", "mineralization" and "microbial biomass" to obtain articles reporting microbial indicators, and screened out articles that were not agricultural soils. Among them, review literatures and articles without strict control and treatment were also excluded. Because the detailed information on biomass char in some articles is not comprehensive, the biomass char in such articles cannot be classified as pure biomass char or mixed biomass char.

Ultimately, 98 articles were used in this meta-analysis, of which 70 reported changes in soil respiration (SR) after biochar application, 27 literatures simultaneously reported the changes of biomass char on SMBC and SR. In these literatures, the measurement methods of SR include total CO2 emission over a period of time and soil respiration rate at a certain time point. Data on soil SOC, SR, and SMBC/SMBN, including mean, standard deviation/error, and sample size, were extracted from each independent experiment with and without charcoal. In each independent experiment if there was a treatment of biomass char mixed with other substances, the results of this treatment were not used. If the parameters in the literature appear in the form of graphics, use Gmfola?3 software to extract data. Finally, a total of 1024 pairs of valid data were obtained. If there are average values of SOC, SR and SMBC/SMBN in the literature and no relevant data variation (standard deviation, standard error or coefficient of variation, etc.) is reported, the average coefficient of variation is calculated from the existing data as its coefficient of variation. In addition, in order to systematically analyze the response of soil microorganisms to biochar, the biochar production process, basic soil properties, and experimental conditions were extracted and classified in each experiment. Among them, the basic properties of soil include soil pH, texture and SOC content; the basic information of biomass char includes raw materials, pyrolysis temperature, pH and application amount (the application amount of biomass char is uniformly converted into tons per hectare tha-1); in addition, the experiment Types were divided into indoor culture experiments, pot experiments and field experiments, and the duration of each experiment was also recorded.

3.2. Data Processing

The calculation of the effect value (Response ratio, abbreviated as R) uses the natural logarithm of the effect ratio of each pair of data treatment groups and the control group, and the calculation formula is as follows:

$$RR = \ln(X_t / X_c) = \ln(X_t) - \ln(X_c) \quad (1)$$

Among them, and Xc represent the average value of each data treatment group (biochar application) and control group (no biochar application), respectively. A positive effect value indicates that the effect of biochar is a positive effect, and a negative effect value indicates a negative effect.

The formula for calculating the standard deviation of the effect value of each group of data is as follows:

$$v = \frac{s_t^2}{n_t X_t^2} + \frac{s_c^2}{n_c X_c^2} \quad (2)$$

Among them, nt represents each data processing group, and St represents each data processing

group.

3.3. Experimental Design

The experiment was a single-factor randomized block design, with 5 treatments including CK, BC1, BC2, BC3, and BC4, respectively representing no biomass char addition, 5, 10, 15, 20, and 25 t ħm-2 biomass char addition (Natural air-dried weight), each treatment was repeated twice, the area of the experimental area was 25m2 (5m ×5m).

4. An empirical Analysis of the Properties of Biochar and its Impact on Soil Environmental Functions

4.1. Effect of Biochar on PH and Conductivity of Leaching Solution

Table 1 shows the pH and conductivity values of the leaching solution in each leaching period.

Table 1. Effect of biochar on pH of leaching solution

Leaching times	1	2	3	4	5	6
Control	7.2	8.1	8.0	8.05	7.9	7.5
RB	7.55	8.05	8.1	8	7.9	7.7
PB	7.6	8	8.05	7.8	7.9	8

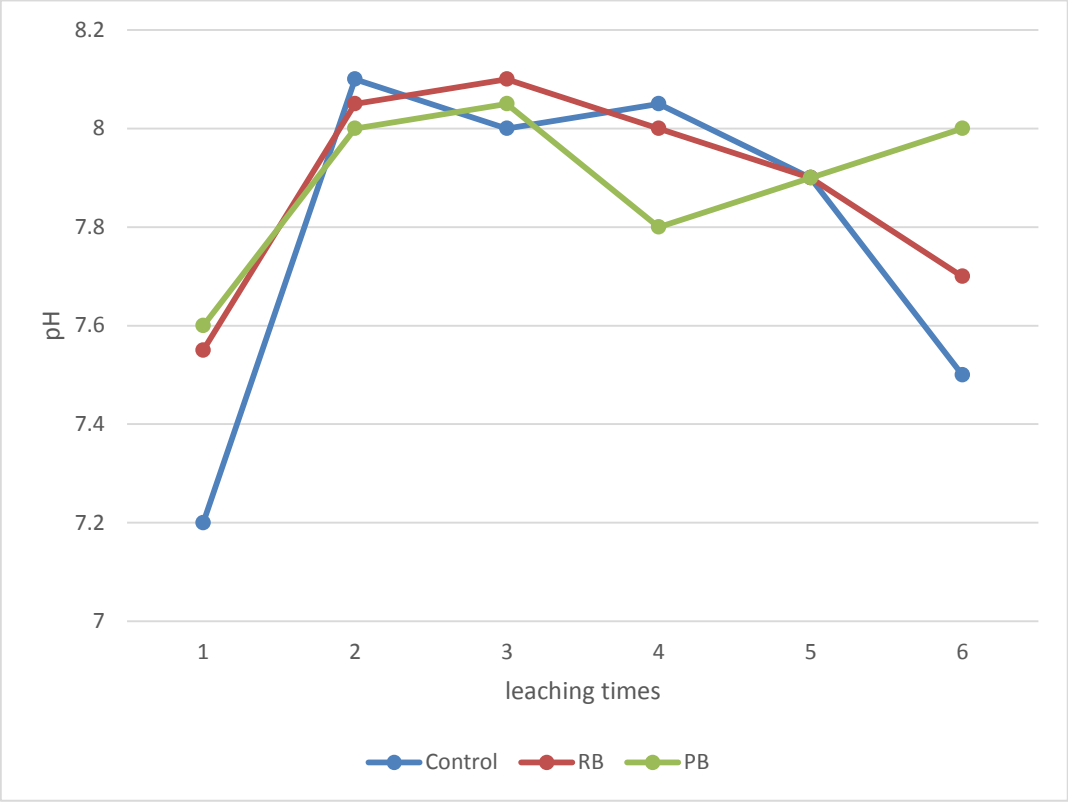

Figure 1. Comparison of the effect of biochar on the pH of the leaching solution

During the whole leaching period of RB and PB), the pH of the leaching solution was significantly (P<0.05) higher than that of the Control treatment, and the pH of the leaching solution increased with the increase of the addition amount of the same biomass charcoal treatment.

4.2. Effect of Adding Biochar on Carbon-nitrogen Ratio

As shown in Table 1. Under the treatment of adding biochar, the ratio of soil MBC to MBN in the 0-40cm soil layer was greater than that of the treatment without adding biochar, and the variation range was 3.45-8.46.

Table 2. Effects of biochar treatment on soil BC/BN

Soil depth (cm)	CK	BC1	BC2	BC3	BC4	BC5
0-10	3.46	3.79	5.84	5.64	4.67	5.87
10-20	3.51	4.76	5.87	5.39	3.64	7.11
20-40	2.91	4.51	5.84	5.89	3.45	8.46

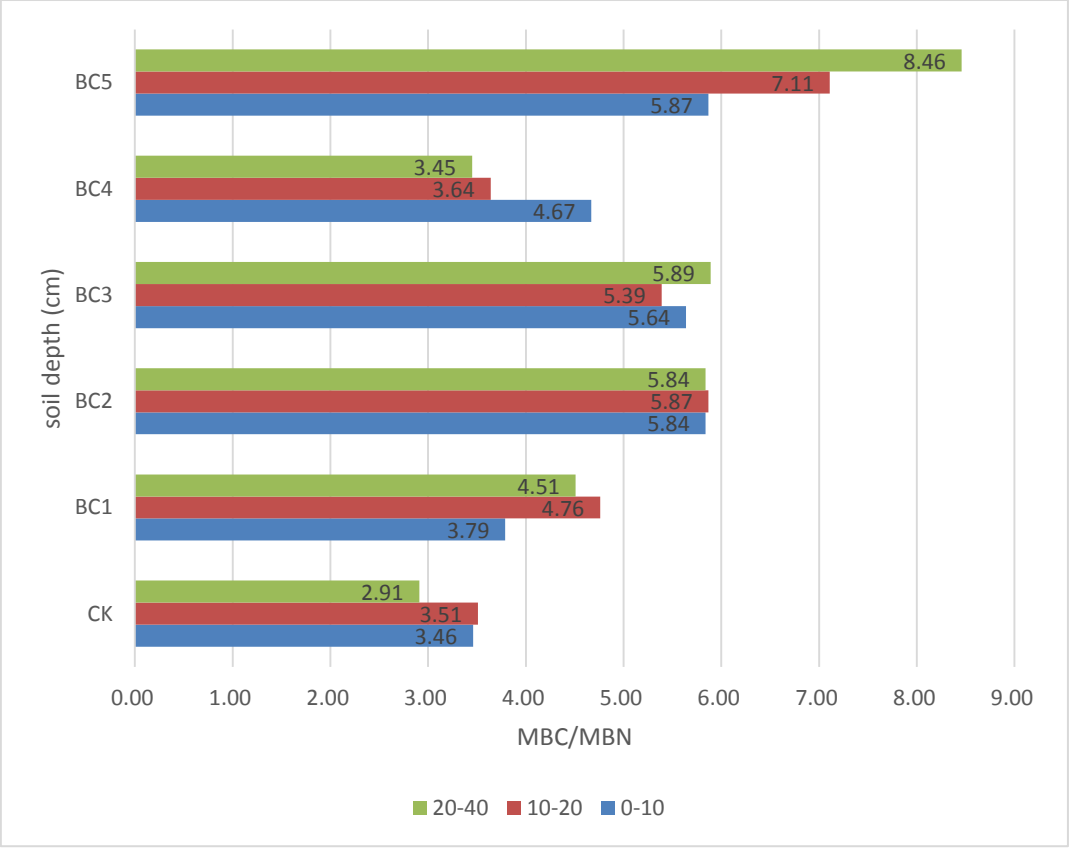

Figure 2. Comparison of the BC/BN

According to 2, with the increase of the amount of biomass char added, the ratio of MBC to MBN in each soil layer showed a trend of first increasing; the ratio under the BC2 treatment was the highest at 5.87, while 10 In the -20cm and 20-40cm soil layers, the ratios in the BC5 treatment were the highest, which were 7.11 and 8.46, respectively.

4.3. Influence of Biochar on the Variation Characteristics of DOC in Leaching Solution

Figure 3 shows the cumulative leaching amount of DOC in the leaching solution during the leaching period.

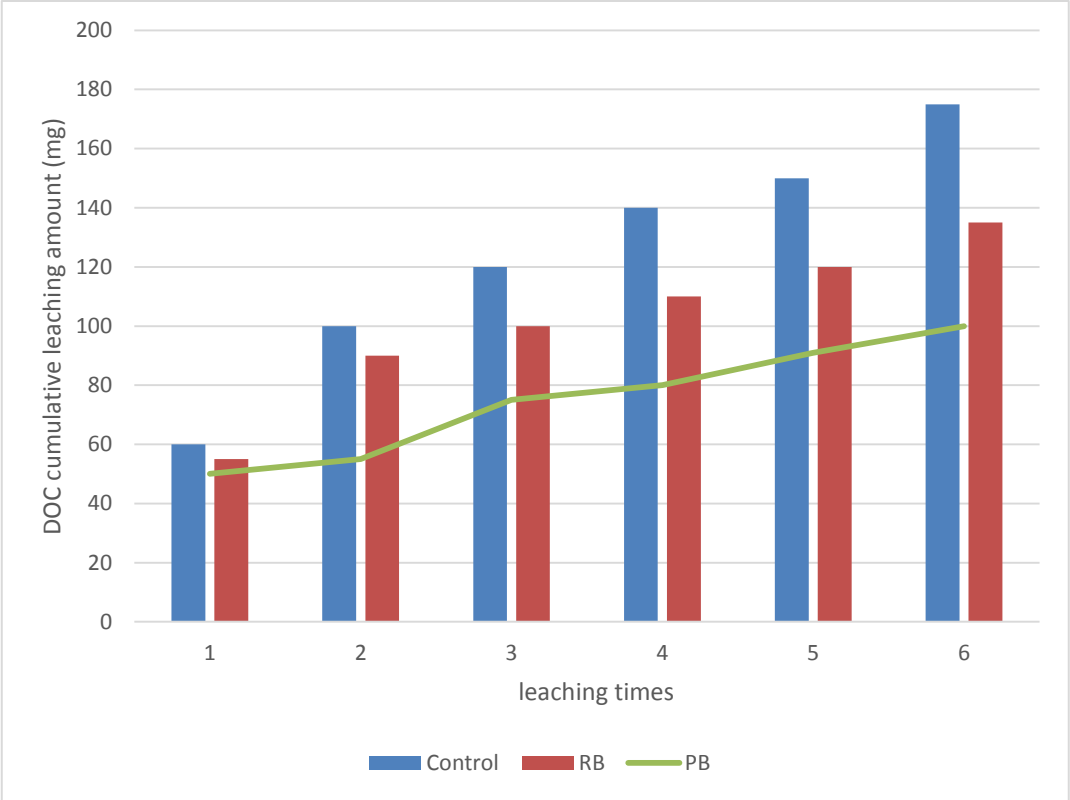

Figure 3. Cumulative leaching loss of soil DOC in different treatments

It can be seen from Figure 3 that with the increase of leaching times, the cumulative leaching amount of soil DOC gradually increased, but the increasing range gradually decreased. 175, 135, and 100 mg, compared with the Control treatment, the RB and PB treatments significantly ($P<0.01$) reduced the leaching of soil DOC. The amount of leaching was higher than that of the treatment with PB added.

5. Conclusion

In this paper, through integrated analysis, it was found that the effect is affected by soil properties, test types and time. It provides a reference for the current agricultural development goals: increasing crop yield, realizing the unification of economic and environmental benefits. It is of great significance for scientific and rational application of biomass charcoal, increase of greenhouse gas sinks and emission reduction in farmland, food security, and construction of ecological civilization. However, this paper mainly focuses on the feedback of soil microorganisms after the application of biochar. In the future, it is necessary to further reflect the coupling relationship between microbial effects, heavy metal form availability, and plant accumulation, which needs to be further improved.

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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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