Adsorption Characteristics of Ethyl Paraben from Aqueous Solution Using Rice Husk Biochar

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Abstract. The rice husk was used as raw material to prepare the biochar adsorbent at 300°C, 400°C and 500°C, which were named BC300, BC400 and BC500. Ethyl paraben was subject to batch adsorption in aqueous medium by the prepared rice husk biochar. The results of adsorption experiments show that the preparation temperature of biochar significantly affects its adsorption effect on ethyl paraben. The adsorption capacity of ethyl paraben from three kinds of biochar was BC500 > BC400 > BC300. In addition, the initial concentration of ethyl paraben in waste water, the temperature and time of adsorption can also affect the adsorption effect. The reaction reached adsorption equilibrium after 270min. The results showed a theoretical basis for the removal of organic pollutants such as ethyl paraben.

1. Introduction
Rice husk, as an important renewable biomass resource, has attracted more and more attention [1-2]. Due to the decomposition of non carbon elements in the process of carbonization, biochar has formed a loose porous structure. As a useful adsorption material, biochar attracts more and more attention from researchers in adsorption of organic pollutants and improvement of soil environment [3-4]. Ethyl paraben (EP) is mainly used as antiseptic for food, cosmetics and medicine. In this study, rice husk was used as raw material to prepare biochar at different pyrolysis temperatures to adsorb EP in wastewater. The effects of pyrolysis temperature, initial concentration of EP, adsorption temperature and adsorption time on the adsorption efficiency of EP were studied. The adsorption characteristics of rice husk biochar on EP were revealed, which provided a reference for the resource utilization of rice husk.

2. Materials and Methods

2.1. Biochar preparation
The rice husk was taken from a rural area of Hanzhong City, Shaanxi Province. After cleaning and drying, it was dried in an oven at 60°C for 72h. After crushing, it was placed in a porcelain crucible,
covered, and put into a muffle furnace. The temperature was raised to the target temperature (300℃, 400℃, 500℃) at a rate of 2℃/min, and then kept for 2h. Take it out after cooling, grind it through 60 mesh sieve, and store it in the dryer for standby. Marked as BC300, BC400, BC500.

2.2. Experimental design
The removal efficiency of rice husk biochar at different pyrolysis temperature was studied by setting EP initial concentration gradients (20, 30, 40, 50, 60, 70, 80 mg/L).

The adsorption of rice husk biochar was studied at 25℃, 35℃ and 45℃, respectively.

2.3. Determination of EP content
The content of EP was detected by UV spectrophotometry. The maximum adsorption wavelength of EP was 247nm when the background solution was blank and scanned in the wavelength of 200-400 nm. Three parallel tests were carried out in each group, and the average value was taken. Accurately weigh 0.125g EP, put it into a 250ml volumetric flask, add distilled water to dilute it to the scale, and obtain 500mg/L EP stock solution. The solution was diluted to 10, 20, 30, 40 and 50mg/L with distilled water, and the adsorption values were measured with ultraviolet spectrophotometer (Shimadzu uv-2600, Japan) at 247nm. The regression equation was \( y = 0.0709x + 0.0127 \), \( R^2 = 0.9999 \) (n = 5).

2.4. Adsorption of EP by rice husk biochar
Accurately weigh 0.1g BC300, BC400 and BC500 respectively, add 25ml EP solution with concentration of 20, 30, 40, 50, 60, 70 and 80mg/L respectively, place it in constant temperature oscillator, shake it for 4h under the temperature of 25, 35, 45℃ and rotation speed of 150r/m respectively, and then pass through 0.45μm filter membrane, and use ultraviolet visible spectrophotometry (λ = 247 nm) to determine the concentration of EP after adsorption, three parallel experiments were carried out in each group, and the average value was taken. The amount of adsorption \( q_e \) and removal rate \( \eta \) of EP after reaching adsorption equilibrium are calculated by the following formula:

\[
q_e = \frac{(C_0 - C_e)}{W} \cdot V
\]

\[
\eta = \frac{C_0 - C_e}{C_0} \times 100\%
\]

Formula: \( q_e \) is the adsorption capacity of equilibrium, mg/g, \( C_0 \) and \( C_e \) are content of phenol before adsorption and after adsorption, mg/L, \( V \) is volume of solution, L, \( W \) is adsorbent dosage, g, respectively.

2.5. Adsorption changes with time
Accurately weigh 0.2g BC300, BC400 and BC500 respectively, add 50ml EP solution with concentration of 50mg/L, place it in constant temperature oscillator, and fully oscillate at 30℃ and 150r/m respectively at 5, 10, 30, 60, 90, 120, 150, 180, 210, 240, 270min. The residual EP concentration was measured, and the adsorption of EP by biochar was studied.
3. Results and Discuss

3.1. Adsorption of EP by rice husk biochar at different pyrolysis temperatures
The adsorption efficiency of rice husk biochar to EP is different at different pyrolysis temperature. In the three selected temperature ranges, the removal efficiency increases with the increase of pyrolysis temperature which is shown in figure 1.

![Figure 1](image.png)

**Figure 1.** The removal rate of EP with different initial concentrations by rice husk biochar.

3.2. Effect of temperature on adsorption of EP by rice husk biochar
The EP removal rates of BC300 after adsorption at 25, 35 and 45°C for 4 hours are shown in Figure 2. The removal rate of EP by rice husk biochar increased with the increase of temperature. The temperature has an obvious effect on the adsorption of EP.

![Figure 2](image.png)

**Figure 2.** Effect of temperature on adsorption of different concentrations of EP.

3.3. Changes of adsorption rate of rice husk biochar to EP with time
In the same adsorption time, the adsorption capacity of three biochar to EP is BC500 > BC400 > BC300. When the adsorption equilibrium is reached, the adsorption rate of BC300 is nearly 50%, that of BC400 is nearly 70%, and that of BC500 is almost 90%.
4. Conclusion
Rice husk biochar is a good absorbent, which has a broad application prospect in the field of sewage treatment. As a new type of absorbent, the raw material is easy to obtain and the preparation method is simple, which has high development and application value.

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