Research on Preparation of Bio-char and Cadmium Adsorption by the Sewage from the Urban Sewage Plant

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Abstract: In this paper, sludge bio-carbon was prepared by pyrolysis and carbonization of sewage sludge from the first sewage treatment plant and the second sewage treatment plant of A city. The physicochemical properties and cadmium adsorption properties were characterized. The results show that the optimum activation temperatures of sludge in different sewage treatment plants are different. The optimum activation temperature of the sludge in the first sewage treatment plant is 300 centigrade, and the sludge in the second sewage treatment plant is 400 centigrade. In the first sewage treatment plant, the adsorption equilibrium of cadmium by bio char is formed about 7h later. The adsorption equilibrium of cadmium by bio char is formed about 5h later in the second sewage treatment plant. The adsorption capacity of bio char to cadmium increases with the increase of pH value in the sewage plant.

Keywords**:** Bio-char, Cadmium adsorption, Urban sewage plant

1. INTRODUCTION

Sewage is the secondary pollutant produced by sewage treatment plant, which is rich in heavy metals, organic pollutants, pathogenic microorganisms and other harmful substances. Among them, heavy metals are considered as an important bottleneck in the safe disposal of sewage. The sewage with high content of heavy metals has high risk in the environment. If untreated, the environment will do harm to human health and the ecological environment. However, sewage is also rich in organic matter and nitrogen, phosphorus, potassium and other nutrients, which is also considered a cheap resource. Therefore, how to effectively cure heavy metals in sewage is the focus of the study on the utilization of sewage. Pyrolysis has attracted much attention as an efficient sewage utilization technology. Pyrolysis of sewage by high temperature treatment can kill pathogens, cure heavy metals, decompose antibiotics and organic pollutants, and obtain solid products bio char. Bio-char has many properties, such as abundant pore structure, large surface area and many organic functional groups, which are usually used as adsorbent, soil amendment, bio-char fertilizer and so on. Urban sewage treatment plant sewage is a sewage treatment system. It has large capacity, easy to corrupt, unstable, odor, high processing cost. In foreign sewage, the disposal costs accounted for about forty percent of the operating costs of the sewage treatment plant. If it cannot be safely handled and disposed. It will cause serious secondary pollution problems. The sewage contains a lot of organic matter and humus organic matter, which has been a bottleneck of development of city sewage treatment plant. The purpose of this paper is the preparation of bio-carbon heating sewage through previous research to study the bio-char adsorption of heavy metal cadmium and provide reference for later bio-char in heavy metal contaminated soil.

2. MATERIALS AND METHODS

A. Materials.

The experimental bio-char was paralyzed from the excess sludge of the sewage treatment plant at low temperature (less than 600 degrees Celsius). The excess sludge used in the experimental material was taken from A city's first sewage treatment plant and second sewage treatment plant. The sewage treatment processes adopted by the three sewage treatment plants are oxidation ditch process, SBR process and A^2/O process. The features of the sewages are shown in Table 1.

Table 1. Features of Different Sewages in different sewage plant used for experiment

Source	PH Value	Nitrogen content (%)	Phosphorus content (%)	Organic compound content (%)
First plant of wastewater treatment of A city	7.12	3.25	2.84	55.7
Second plant of wastewater treatment of A city	6.91	2.74	1.96	57.3

According to the above table and relevant national standards, the sludge meets the processing requirements. According to the use of activated carbon, the activated carbon preparation of raw material has different requirements, such as for medicine or activated carbon for water purification. It requires not only the raw material of ash in as little as possible, but also the strict requirements of the harmful impurities in the activated carbon. However, the activated carbon used in sewage treatment has no special requirement for the preparation of activated carbon ash, impurities and so on. The organic contents of sludge from two sewage treatment plants range from fifty percent to sixty percent with the continuous improvement of living standards. The organic content in the sludge is still increasing. The domestic and foreign research shows that carbon adsorption on COD and heavy metal ions have so high removal rate that sewage sludge contains large amounts of organic matter. It has been processed into organic content of objective conditions of bio-char in sludge. The higher the biological carbon quality is, the larger the adsorption capacity of heavy metal is.

B. Preparation Method of Bio-char by Sewage.

Taking municipal sewage as the research object, the water content is 80%. The sewage in the oven drying, drying temperature of 120 degrees, dried to water content of less than 5%, and grinding to 200 mesh, into the dryer storage standby. After the 30g is dried, the sewage is loaded into the ceramic boat and placed in a tube furnace. It is closed and connected with nitrogen gas 30min to ensure the inert atmosphere and the nitrogen flow rate is kept 300ml/min. Tube furnace after starting 30min program started in accordance with the set to 5 degrees /min from room temperature to the target temperature, stay in a certain period of time the target temperature of tube furnace to maintain constant temperature during this period of time after the completion of the reaction apparatus, program stop. After pyrolysis, the product is weighed and then washed several times with deionized water at 70 DEG C until pH is neutral. Finally, bake in 24h oven at 105 DEG C and grind 200 mesh screen. The sewage derived organisms are placed in a dryer and named after SBC. Through the observation of SEM amplification of the surface morphology of the samples after different times, the solid powder drying on circular sample tray, to filter and do conductive sample treatment before the test, the sample evenly sprayed a layer of metal film to increase conductivity. Then, the surface morphology of the sample is observed. The experimental device adopts Contador production company nova2000e, with high purity nitrogen as adsorption target by volumetric method, adsorption desorption experiments in the relative pressure between 0 and 1.0, after the determination by BHJ formula to draw the adsorption desorption isotherm adsorption target, according to the calculation method of the specific surface area of SBC. When the t-plot formula is obtained after the treatment of SBC micro pore volume, the specific surface area and microspore surface area can be calculated. The BHJ formula can obtain the mesoporous volume, the total pore volume and the average pore size of SBC.

C. Adsorption Experiment Method.

First of all, take the sludge based bio-char to more than ninety percent through the mesh of 200 mesh, and then dry at 120 ± 5 degrees in two hours, drying in the dryer, cooling to room temperature. Then, take a certain amount of specimen accurately into the drying capacity of 250mL conical flask, adding hydrochloric acid solution 10mL5%, plug a good glass stopper, shake the biological carbon infiltration, unstop, heated to boiling 30s (to remove the interference of sulfur), cooled to room temperature. Join the 100mL I2 standard solution, a good glass plug is arranged on the oscillator oscillation 15min, static 5min filtering; 50mL filter liquid were titrated with $Na_2S_2O_3$ standard solution when the solution is light yellow, add 2ml of starch indicator solution, and continue the titration to the disappearance of the blue, write down the consumption of sodium thiosulfate standard solution the volume. We will after centrifugation of the sample removed, with a dropper to remove the supernatant, the sample bottle of joining the 10ml, and then called out the quality of the sample solution into the nitric acid solution, then adding nine times of nitric acid to ten times. The concentration of cadmium ion was determined by atomic absorption spectrophotometer in diluted sample solution. The formula of the cadmium adsorption by the sewage is:

$$Q = \frac{(C_0 - C_e)}{W} \times v$$

Among the above formula, Q is the adsorption quantity; C_0 is the initial concentration of the solution; C_e is the concentration of the cadmium in the time of t; V is the volume of the cadmium nitrate solution; W is the quality of the bio-char.

3. RESULTS AND ANALYSIS

A. Influence of Activation Temperature on Adoption Capacity.

The adsorption effect of bio-char on heavy metals is related to the firing temperature and precursor materials of bio-char. The adsorption capacity of Cd^{2+} for sewage prepared at different activation temperatures (DEG C) in different sewage treatment plants is shown in Figure 1.

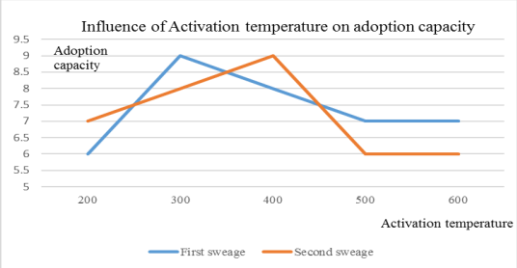

Figure 1. Influence of Activation temperature on adoption capacity

In the first sewage treatment plant, when the activated sludge temperature is 300 degrees centigrade, the prepared biological carbon has the best adsorption effect on the heavy metal cadmium. The biological carbon prepared from the sewage treatment plant is the best for the adsorption of heavy metal cadmium. At high temperature, the biological carbon adsorption capacity of sludge prepared by the first sewage treatment plant in Kunming is better than that of second sewage treatment plant sludge. At low temperature, with the increase of pyrolysis temperature, the polar group content of carbon surface increased obviously, but reached the limit at a certain temperature. When the temperature exceeded this limit, the content of polar groups on the surface of bio-char decreased gradually with the increase of pyrolysis temperature. Therefore, when the temperature is low, the polar groups of bio-char surface are much, so the adsorption capacity is large, and when the temperature exceeds the limit temperature, the polar groups on the surface of bio-char will decrease with the increase of temperature. Therefore, the adsorption capacity of bio-char obtained by pyrolysis at high temperature is less than that of bio-char obtained by pyrolysis at low temperature. Effect of water treatment with biological activated carbon is mainly pore structure and surface chemical groups, adsorption capacity and pore size and the bio-char structure. The smaller the particle size, pore diffusion rate is, the stronger the adsorption capacity of bio-char is. The experimental results show that the activation degree of bio-char has influence on the amount of adsorption. The control of activation temperature directly influences the particle size and pore size of bio-char, and directly affects the adsorption properties of bio-char.

B. Adsorption Equilibrium Curves.

In the simultaneous adsorption desorption, adsorption and removal rate of apparent adsorption velocity is zero. The adsorbate concentration in solution and on the surface of the adsorbent concentration is no longer changed when the state called adsorption equilibrium. Physical adsorption is a dynamic equilibrium process, the gas molecules can be adsorbed onto the solid surface. The adsorbed gas molecules to the solid surface can also be freed when the number is equal to the number of molecules adsorbed and free, reached the adsorption equilibrium, adsorption time is called balance adsorption capacity for certain solids and gases, in a certain temperature and pressure. The ratio of the equilibrium adsorption capacity is certain. In the simultaneous adsorption desorption, adsorption and removal rate of apparent adsorption velocity is zero with equal speed, the adsorbate concentration in solution and on the surface of the adsorbent concentration are no longer changed when the state called adsorption equilibrium. The adsorption isotherms can be obtained in the adsorption equilibrium. From the Figure 2, the adsorption of heavy metals with biological activated carbon in the first sewage treatment plant sludge prepared in seven hours reached the adsorption equilibrium; and in the second sewage treatment plant, the adsorption of heavy metal sludge biochar prepared reached the adsorption equilibrium after five hours.

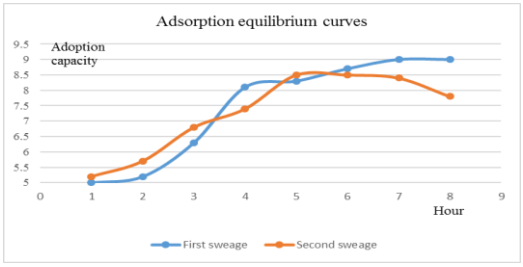

Figure 1. The adsorption of heavy metals with biological activated carbon in the first sewage treatment plant sludge prepared in seven hours reached the adsorption equilibrium

C. Influence of Activation Temperature on Adoption Capacity.

The cadmium adsorbed at different pH values at the concentration of at 50mg /L is shown in Figure 3. The biological carbon prepared from the first sewage treatment plant and the second sewage treatment plant is at the activation temperature of 300 and 400

DEG C. With the increase of pH value, the anions on the adsorbate surface increase gradually. Each heavy metal ion has a limit pH value, when the pH value of the solution exceeds the limit pH value. It shows the state is no longer ionic, but manifested in a state of precipitation. Therefore, when the pH value continues to increase, the amount of adsorption will decrease as the pH value increases.

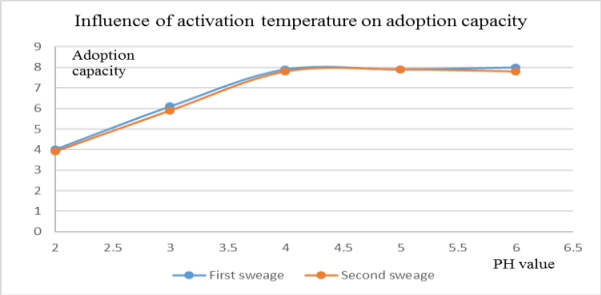

Figure 3 The cadmium adsorbed at different pH values at the concentration of at 50mg /L is shown.

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