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Activated Carbons Derived from Livestock Sewage Sludge and Their Absorption Ability for the Livestock Sewage

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Abstract

An improved method, microwave heating with direct chemical activation, was applied to prepare activated carbons from livestock sewage sludge (LCA) in the work. Preparation parameters' influences on iodine adsorption capacity and yield rate of the product were explored. It is found that the activated carbon activated by KOH has a higher iodine value compared to that done by zinc chloride and H_3PO_4.These ideal activation conditions are attained: microwave power, 480W; radiation time, 14min; the KOH concentration, 10mol/L. Under these conditions, the activated carbons' BET surface area is 684.65m^2/g, the iodine value is 721.64mg/g, and the yield ratio is 25.71%. Other physical properties are also reported. Then the activated carbon made under the ideal conditions was used to treat livestock sewage. When the dose of activated carbon is 0.4g/L and the absorption time reaches 3h, this product can promote obviously the removal of chemical oxygen demand (COD), odor and chroma.

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Keywords: Livestock sewage sludge; Activated carbons; Microwave heating; Activation; Adsorption

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1. Introduction

As a kind of main wastes after sewage treatment, the volume of livestock wastewater sludge accumulated quickly with the rapid expansion of livestock and poultry breeding (Xu et al., 2004). Moreover, the volume of excess sludge is usually for less than 1% of the sewage's volume (Fang et al., 2011), but cost of sludge disposal could surpass more than 50% of the total sewage treatment's operational expenses (Li, 2010).

Some traditional methods, such as incineration, farmland utilization, landfill, etc, have been used to utilize or dispose sewage sludge (Chen, 2012; Qi, 2012; Huang et al., 2012; Zhang et al., 2011). But they have their shortcomings, e.g., incineration can release some harmful gases and pollute the air (Qi, 2012). Thus, it is necessary to further research other recycling technologies for sewage sludge disposal (Li, 2011). Due to its high content of organic matters, sewage sludge can act as raw material to prepare activated carbons. In recent years, A lot of relevant researches have concentrated on urban sewage sludge (Huang, 2008; Zhang et al., 2008; Wu et al., 2011; Rio et al., 2005; Smith et al., 2012; Pietrzak and Bandosz, 2007; Zhang et al., 2005). In addition, some researchers have also adopted other types sludge to prepare activated carbon (Geethakarthi and Phanikumar, 2012; Li et al., 2011; Ding et al., 2012; Guo et al., 2011; Wu et al., 2012). But few researchers pay attention to the fabrication of activated carbon using livestock wastewater sludge through microwave heating. Livestock wastewater sludge has plentiful organic matters, and thus can act as a potential raw material for preparing adsorbent.

Chemical activation could control flexibly products' surface area and pores' structure. Microwave heating is more rapid and efficient during the heating process, and pore structure of products is more equally distributed compared to the traditional heating (Abais and Valente, 2004; Ai et al., 2009). In this study, livestock sewage sludge was used to make the activated carbon by microwave heating with three different kinds of activator for exploring the optimal process parameters, and then this carbon prepared under the optimal conditions was applied to treat livestock sewage so as to test its role. This work could provide a beneficial reference for the reuse of livestock sewage sludge.

2. Materials and methods

2.1. Materials

The livestock wastewater sludge came from the livestock sewage treatment plant of Sichuan Agricultural University, located in Yaan City, Sichuan Province in China. The fresh sludge needed firstly drying at room temperature about three days, then heating at 75℃ for 4h to keep weight unchangeable, finally comminuting and sieveing to attain a closely graded size between 0.25 and 0.83 mm. Constituents of the dried raw material see Table 1. Its chemical element compositions include Carbon (34.25%), Hydrogen (4.65%), Nitrogen (3.64%) and Sulfur (1.27%). KOH, H_3PO_4 and $ZnCl_2$ with analytical grade acted as activating reagents. High purity nitrogen with concentration of 99.99% was adopted to create the oxgen-free atmospheric environment. The research of Li et al (2008) provided a reference for the heating system of the work.

Table 1 Constituents of the raw material.

Constituents	Water	Fixed carbon	Volatile matter	Ash
Value (wt. %)	4.34	13.92	55.38	32.70