Research on Adsorbent Using Modified Fly Ash for Campus Domestic Sewage Treatment

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Abstract. As a kind of extensive sources and low cost industrial waste, fly ash has many features, such as porosity, large surface area, adsorption capacity, chemical activity and weakly alkaline, which seem a wide prospect of application in wastewater treatment. This study proposed the acid modification test on fly ash. The effect of key factors including the particle size, pH, the dosage of fly ash, adsorption time and dosage of the modifier on domestic sewage removal efficiencies were evaluated. The optimum conditions and the corresponding removal efficiency were determined. The results show that the removal efficiency is increased firstly and steady subsequently with the increase of fly ash dosage, increased firstly and decreased subsequently with the increase of adsorption time, and increased firstly and decreased subsequently with the increase of pH value. The removal efficiency can up to 95.19% when 0.7 g fly ash added in 200 mL wastewater when the pH value was adjusted to 5 at the adsorption time of 20 min. And the best particle size of fly ash is 200 meshes, when used 2mol/L hydrochloride as modifier and soaked fly ash for 2h, and the ratio of hydrochloride and fly ash is 1mL / g, the effect is best. It also finds obviously that fly ash can have a better effect on removal efficiency than raw fly ash.

1 Introduction

Adsorption is an important method to process contaminant which is harmful and difficult to degrade in waster water and air [1-3]. Activated carbon, an adsorbing material in common use, is restricted by shortage in raw materials, high cost, difficultly in regeneration. It is an important research direction adsorbing material from industrial and agricultural waste, used to be a preparation and development of cheap and efficient adsorption material to instead of activated carbon [4-5]. With phosphorus detergent and pesticides widely used, the phenomenon of eutrophication affects people's lives, and restricts the further development of the economy, which becomes a serious environmental problem concerned by people all over the world [6-7]. The majority of people researching on this problem choose fly ash to be the key, for good adsorption effect in phosphorus waster water because

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of porous loose structure and many kinds of active substances. What we have done conforms to the principle 'treatment of wastes with processes of wastes against one another', Meanwhile the material is cheap and available [8-10].

Fly ash, waste from coal-fired power plants, nearly 90% proportion consists of $A1_2O_3$、SiO_2、CaO、Fe_2O_3.It is composed of many particles with different structure and morphology [9]. Most of them are vitreous body with a porous structure and a large specific surface area, which has a strong adsorption capacity. At the same time, for the large number of properties of silica, alumina and other components, the application range and application of fly ash are limited, the surface or structure of the surface or structure should be modified, so that it can be enhanced [10-11]. It is one of the main ways to explore the utilization of fly ash in the treatment of waste water and waste gas by using fly ash. This study provides a new method for the treatment of domestic wastewater.

2 Experimental Material and Apparatus

2.1 Test materials and apparatus

Screen fly ash taken from coal-fired power plant through 60, 100 and 200 target sets orderly to obtain different particle sizes. Then wash the fly ash screened in de-ionized water repeatedly to remove grease and other impurities. Put the fly ash in the drying at 105℃ after washing. Life sewage is taken from the discharge port of the school.

Main apparatus: Spectrophotometer, Agitator, Color dish, Analytical balance, Sieve and so on.

Major chemical reagent: Hydrochloric acid (analytical reagent), sodium hydroxide (analytical reagent), etc.

2.2 Experimental analysis methods

The adsorption capacity of fly ash was expressed by q.

$$q=V(C_0-C)/m \qquad (1)$$

Explain: q: fly ash adsorption capacity, the mass of the adsorbed substance on the unit weight of the adsorbent, (g/g). V : Sewage volume. C_0, C: the concentration (g/L) of the wastewater and the adsorption equilibrium of the wastewater before adsorption. m : Fly ash dosage (g).

In this experiment, we used the absorbance removal rate to characterize the comprehensive adsorption effect of fly ash. Absorbance is measured by spectrophotometer. Absorbance is measured by spectrophotometer. The absorbance of domestic sewage is tested by spectrophotometer. The removal rate (μ) of domestic sewage was determined by spectrophotometer, and the absorbance of domestic sewage was measured before and after treatment.

$$\mu= (A_0-A) /A_0\times100\% \qquad (2)$$

Explain: A_0 represents the absorbance of treated effluent, and A indicates the absorbance of treated effluent.

PH, particle size, the dosage of adsorbent, adsorption time, dosage of modified agent and so on, the effect of different factors on the effect of the modified gray treated sewage treatment were discussed.

3 Results and Discussions

3.1 Determination of absorbance wavelength λ

In order to make a comparison between the water and the waste water, the amount of water in the wastewater was determined by using a spectrophotometer to measure the absorbance of the wastewater from 340 to 660nm [12]. The results are shown in Table 1. The results show that the absorbance of the living wastewater is the maximum when the wavelength is 340nm. Therefore, 340nm is selected as the optimum wavelength for the measurement of the absorbance.

Table 1 The Absorbance At Different Wavelengths

Wavelengths λ(nm)	340	380	420	460	500	540	580	620	660
Absorbance A	0.512	0.365	0.318	0.280	0.248	0.219	0.201	0.183	0.168

3.2 Effect of fly ash particle size on treatment effect

Take the campus sewage 200mL in 4 beakers, add fly ash 0.3g respectively to 60, 100 to 60 under 200, stir for 30 min with electric mixer on medium speed (150r / min) , then measured absorbance of filtrate. The result is shown as Fig. 1.

Generally speaking, the specific surface area is bigger; the more activated alumina, silicon oxide and unburned carbon, as well as the better removal effect. The size of the fly ash particles directly affects the adsorption performance of the strength of the strength. The finer the adsorbent particles, the larger the surface area , the larger the contact area of the sewage, the more favorable to the adsorption, the higher the removal rate [13,14]. In contrast, as shown in Figure 1, fly ash particle size of 200 meshes, have the best treatment effect of domestic sewage. Therefore, the selection of 200 mesh of fly ash is used for the test material.

3.3 Effect of dosage of acid modified agent on modification effect

The modified agent of different dosage of hydrochloric acid in 2 mol/L is used to modify the fly ash. The dosage of the modified agent and fly ash are 0.5:1, 1:1, 2:1, 3:1, 4:1, 5:1 (mL/g). Reaction time is 2h, and then drying. Take the campus sewage in 6 200mL beaker, and then add the modified fly ash 0.3g, stir for 30 min with electric mixer on medium speed (150r / min) , then measured absorbance of filtrate. The result is shown in Fig.2.

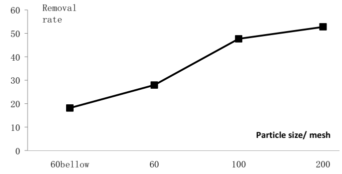

Fig.1 Effect of particle size on removal rate

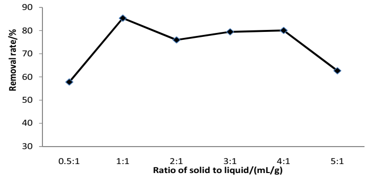

Fig.2 Effect of HCl to fly ash ratio on removal rate

Acid modifying agent has functions as bellow: 1 Stimulate activity of fly ash and make a large number of Al, Si and other active point exposure [15].2 Make the surface of the fly ash rough and increase specific surface area. 3 Open the pores of the fly ash and increase the porosity. A special phenomenon is that before the activity of fly ash does not stimulate finished, modifier dosage of fly ash is greater, the higher the removal rate. However, when the activity of fly ash is completely excited, the removal rate decreases with the increase of the modifier. This is due to the addition of the modified agent will make the pH value of the wastewater decreased, so that the removal rate decreased. As shown in Fig. 2-3 when the dosage of modified agent and fly ash was 1 (mL/g), the modified effect was the best, and the removal rate of wastewater was the highest, reaching 85.35%.

3.4 Effect of pH value on treatment effect

Take the campus sewage 200mL in six beakers, adjust pH value of 1, 3, 5, 7, 9, 11 respectively, add 0.3g optimum particle size no modification fly ash, stir for 30 min with electric mixer on medium speed (150r / min) , then measured absorbance of filtrate. A set of comparative experiments was made with modified fly ash instead of non-modified.

The active component of the fly ash is a few basic oxides whose state of surface can be affected by hydrogen ion concentration in solution. pH is one of the most important factors in the process of adsorption, which directly affects the adsorption site of modified fly ash and the form of organic matter and their binding reaction [16]. Fig.3 shows that the removal rate of pH is lower than that of acid or alkaline condition when the pH value is neutral. This may be due to the same power of the pH value of the fly ash and sewage, the strong repulsion between them, so that the adsorption effect is poor. Under the acidic condition, the removal rate was 82.03% at the optimum pH value 3. However, after modification, the removal rate of weak acid and neutral fraction was significantly increased, the optimum pH value was 5, and the removal rate was 92.38% at this time.

3.5 Effect of adsorption time on treatment effect

Take the campus sewage 200mL in 6 beakers, add non-modified fly ash 0.3g, stir for 10、20、30、40、50、60min respectively with electric mixer on medium speed (150r / min) , then measured absorbance of filtrate. A set of comparative experiments was made with modified fly ash instead of non-modified. Results are shown in Fig.4.

From Fig.4, we know that with the increase of time, the change of the removal rate of the wastewater by the non-modified fly ash is relatively slow, and the removal rate is only 55%. On the contrary, the removal rate of modified fly ash increases significantly with the time on. When the stirring time reaches 30min, the removal rate start to decreased, and the maximum removal rate is 84.18%. The reason of this phenomenon is that in the initial stage of adsorption, the surface area of the fly ash is larger, and the surface is a lot of free adsorption sites, so the initial adsorption is faster. With the extension of adsorption time, adsorption is occupied gradually, and the solute diffusion to the concentration of the surfactant is poor (force) fell [17]. It can be concluded that the adsorption process may occur mainly in the first 30min and may reach the adsorption saturation. In the subsequent mixing process, the adsorption process is weakened and the analytical process is enhanced, which leads to a decrease of the removal rate. The adsorption of fly ash in wastewater can be divided into three kinds: physical adsorption, chemical adsorption and adsorption and flocculation precipitation. Physical adsorption depends on the porosity and specific surface area of fly ash, and the physical adsorption is reversible [18]. The experimental results also show that the removal of the physical adsorption of fly ash plays an important role.

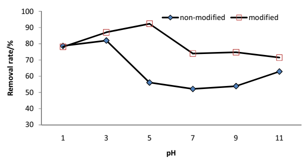

Fig 3 Effect of different pH on removal efficiency

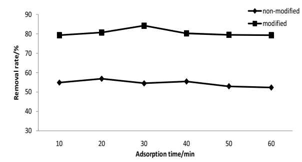

Fig 4 Effect of adsorption time on removal efficiency

3.6 Effect of dosage on treatment effect

Take the campus sewage in 6 200mL beaker, add 0.1, 0.3, 0.5 respectively, 0.7, 0.9, 1.1g modified fly ash, stir for 30 min with electric mixer on medium speed (150r / min) , then measured absorbance of filtrate, A set of comparative experiments was made with modified fly ash instead of non-modified. Results are shown in Fig.5.

Fig.5 shows that the removal rate of modified and non-modified fly ash is similar with the dosage increasing. The removal rate of the modified removal rate was significantly improved, from 63.09% to 94.73%. Fly ash can adsorb some organic matter in the sewage because of the porous structure, and when the initial concentration of the wastewater is certain, the organic matter which can be adsorbed in the wastewater will not increase with the increase of the amount of fly ash. Meanwhile, fly ash itself also contains a certain amount of organic compound, which makes the removal rate decreased. Therefore, the best dosage of fly ash is 0.7g/200mL.That is 3.5 g/L.

3.7 Effect of wastewater removal under optimum conditions

Take the campus sewage 200 mL in 6 beakers, the optimum value of pH, amount of the fly ash and mixing time of the experiment in the first few groups were put into the experiments, then measure absorbance of filtrate in average. A set of comparative experiments was made with modified fly ash instead of non-modified. The results are shown in Figure 6.

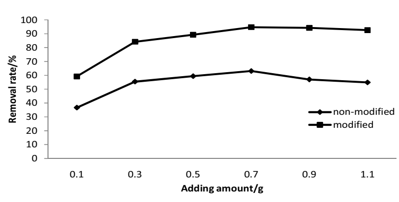

Fig 5 Effect of dosage on removal rate

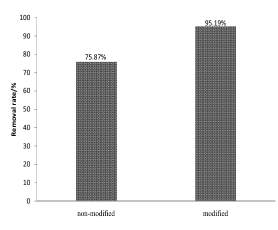

Fig 6 Removal rate on optimum condition

Fig.6 shows that the removal rate of non modified fly ash on domestic sewage is 75.87%, and the removal rate of modified fly ash for domestic sewage was 95.19%. Both of them are in optimal conditions. Fly ash contains a large amount of silicon, aluminum oxide, and a porous shape, with a certain adsorption performance [19]. Acid or alkali can increase the surface area of the fly ash to improve the adsorption performance. After acid treatment, the fly ash released a large number of Al^{3+} and Fe^{3+}, can effectively reduce or eliminate the potential of suspended particles to remove the suspended particles in water. At the same time, the surface of fly ash particles is formed on the surface of a lot of grooves and holes, which can enhance the adsorption of the colloidal particles.

4 Conclusions

Through the above experimental study, the main results and conclusions are drawn below:

(1) When the wastewater was treated with the non-modified fly ash, the removal rate reached 78.87% in the conditions as bellow: particle size is 200, pH = 3, mixing time is 20 min, the dosage of 0.7g/200 mL is 3.5g/L.

(2) When the wastewater was treated with the modified fly ash, the removal rate reached 95.19% in the conditions as bellow: particle size is 200, pH = 5, mixing time is 20min, the dosage of 0.7g/200mL is 3.5g/L.

(3) The effect of modified fly ash on the treatment of domestic wastewater is obviously improved than that before modification.

(4) For non-modified fly ash, the order of various factors on the effect of treatment of domestic sewage is: pH > particle size > fly ash dosage > stirring time.

(5) For modified fly ash, the order of various factors on the effect of treatment of domestic sewage is: pH value> the dosage of modified agent to fly ash > the dosage of fly ash > mixing time.

5 Acknowledgement

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