Research on the Removal of Phosphorus by Activated Alumina Adsorption in Eutrophication Water

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Abstract

Eutrophication is a major water pollution problem faced with today's world. In this paper, through adsorption test used of small particle size of the activated alumina to phosphorus, research on factors and phosphorus adsorption isotherm characteristic about the removal of activated alumina adsorption to phosphorus in nutrient-rich water. Experimental results show that the main role of activated alumina adsorption of phosphorus occurs within 3h and the effect of removal is best of pH 5,6. After the removal rate of activated alumina to phosphorus increases with the increase of initial concentration, it tends to be stable. The removal rate of activated alumina to phosphorus increases with increasing dosage. Treated with phosphorus content of 0.20 mg/L, 100 ml water sample. Adsorption time is 4 h and pH is adjusted to 6. When the dosage of activated alumina is 3.0g, the removal rate of phosphorus is above 90%. Langmuir adsorption isotherm can be better to describe the adsorption characteristics of activated alumina.

Keywords

Activated alumina, adsorption, eutrophication, phosphorus.

1. Introduction

Eutrophication is a major water pollution problem faced with today's world [1, 2]. A large number of industrial waste and domestic sewage discharge excessive, leading to the deterioration of quality of the water environment. Eutrophication causes algae blooms, oxygen dropped, severely damages the water ecological environment, and threats to human health and the survival of aquatic organisms. The main cause of eutrophication is excessive phosphorus, nitrogen and other nutrients discharge into water bodies. Studies have shown that phosphorus is the major controlling factor of eutrophication. Therefore, the removal of phosphorus is important in eutrophication water.

Phosphorus adsorption achieves the separation of phosphorus from wastewater using large specific surface area provided by adsorbent, by attaching adsorption, ion exchange or surface precipitation process in the adsorbent surface. Further treatment recovers phosphorus resources through reversible. [3, 4]Activated alumina is a porous, high dispersion of material with a large specific surface area and its porous surface has strong capacity of adsorption. Activated alumina has a strong adsorption of phosphorus in water [5]. For the removal of activated alumina adsorption to phosphorus in nutrient-rich water, studies is few. Through adsorption test used of small particle size of the activated alumina to phosphorus, research on factors and phosphorus adsorption isotherm characteristic about removal of activated alumina adsorption to phosphorus in nutrient-rich water.

2. Experimental method

Laboratory equipment: UV-visible spectrophotometer UV-2600-type, temperature oscillator THZ-82-type, stainless steel portable steam autoclave YX-280D-I-type.

Water quality-Determination of total phosphorus uses People's Republic of China, national standard method of ammonium molybdate spectrophotometer (GB11893-89). Take 25mL water sample, the minimum detectable concentration of 0.01mg / L, measured ceiling of 0.6mg / L.

3. Results and discussion

3.1 The Influence of Adsorption Time

Take five 250mL conic al flasks, which are added in 3.0g of activated alumina. A 100mL water sample of phosphorus concentration of 0. 2mg / L is adjusted with H_2SO_4 and Na OH to pH of 6 in the solution. All are placed in a thermostatic shaker with 25 ℃, 180r / min , respectively oscillation is 1h, 2h, 3h, 4h, 5h.Filterwith 0.45um membrane and measure phosphorus content in the filtrated supernatant.

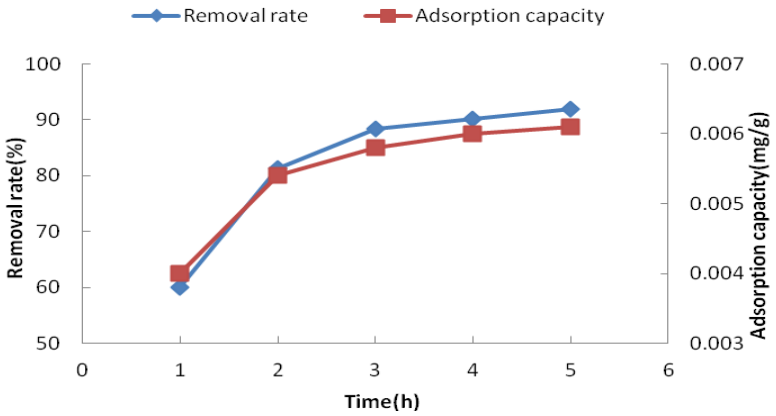

Fig.1 The Influence of Adsorption Time

Changes of phosphorus removal rate and adsorption capacity with the adsorption time have shown in Figure 1. Figure 1 shows that the phosphorus removal rate increases with the increase of adsorption time and the adsorption removal rate increases slightly after 3h; Activated alumina adsorbs phosphorus for 1-3h, adsorption changes from 0.0040mg / g to 0.0058mg / g increasing about 45%; The amount of activated alumina adsorption of phosphorus keeps stable after 3h. To analyze, activated alumina adsorption of phosphorus mainly occurs within 3h, and activated alumina adsorption rate of phosphorus decreases, absorption is slower, adsorption amount tends to balance after 3h.

3.2 The Influence of Solution's pH

Take seven 250mL conical flasks, which are added in 100mL, 0.2mg / L of phosphorus in water samples, adjusted with H_2SO_4, NaOH solution to pH of 3,4,5,6,7,8,9, then added in 3.0g of activated alumina. All are placed on a constant temperature oscillator with 25℃, 180r/min, oscillating after 4h. Filter with 0.45um membrane and measure phosphorus content in the filtrated supernatant.

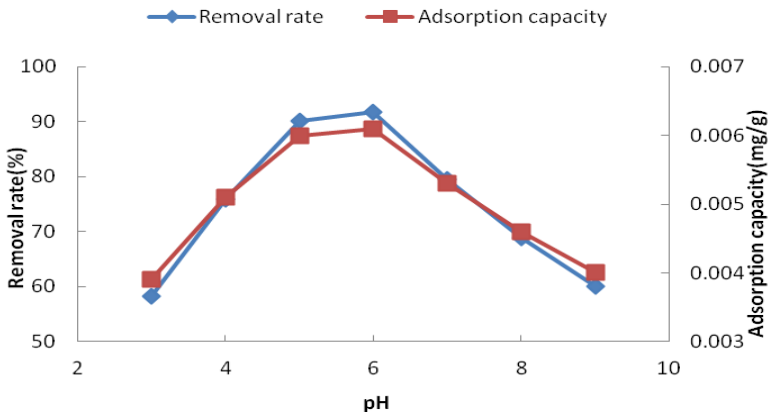

Fig.2 The Influence of Solution's pH

Figure 2 shows that when the pH increases, activated alumina removal rate of phosphorus increases and then decreases. When pH of 5,6, phosphorus removal is the best and the removal rates reach 90.08% and 91.85% respectively. Phosphorus removal greatly reduces with the continued increase in

pH. Activated alumina adsorption to phosphorus may be considered that adsorption can be adsorbed in the form of anions only. Such model which has been built up conforms to the law that the adsorption amount increases with the increase of pH until all are dissociated substantially.

It is generally recognized that the mechanism of activated alumina adsorption removal of phosphorus is that surface molecules of activated alumina combined with water generates aluminum hydroxide, and then generates phosphate through ion exchange with phosphate ions.

Surface complexation adsorption theory recognized that aluminum ions in the solid surface of activated alumina first complex with ligand molecule of water, complexing ligand molecule of watercauses proton transfer process in the oxidesurfaceand generates surface hydroxyl groups; Hydroxylated oxide surface creates charged surface phenomenon with the different pH in aqueous solutions of non-adsorbed H + or OH- ions.The charge of the surface can absorb aqueous phosphorous.In summary, activated alumina adsorption coexists ion exchange and electrostatic adsorption. Lowering the pH is favorable of the phosphorus adsorption, but activated alumina will cause the acid dissolution if the pH is too low, which is not conducive to adsorption ; On the contrary, when the pH is too high, the reaction in order to maintain balance will reverse the reaction, resulting in phosphorus cannot be effectively removed and desorption phenomenon with the poor removal of phosphorus.

3.3 The Influence of Initial Concentration

Take 3.0g of activated alumina into 100mL water samples approximately which concentrations are 0.05mg /L, 0.1 mg/L, 0.2mg/L, 0.3mg/L, 0.5mg/L, then adjust with H_2SO_4 and NaOH to pH of 6. All are placed on a constant temperature oscillator with 25 ℃,180r/min, oscillating after 4h.Filter with 0.45um membrane and measure phosphorus content in the filtrated supernatant .

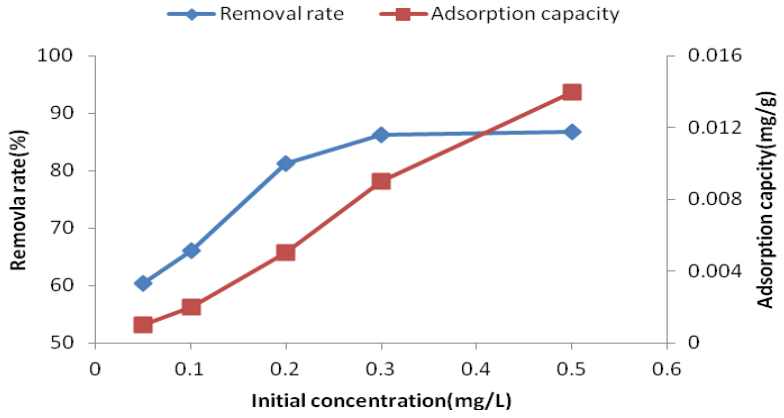

Fig.3 The Influence of Initial Concentration

The figure 3 shows that phosphorus removal rate of activated alumina first increases, then tends to be stable with the increase of initial concentration; The adsorption capacity increases with the increase of initial concentration. When the initial solution concentration is higher, the concentration of adsorbed solution is higher, in other words, the more phosphorus content,because it generates a large concentration difference between the film and the surface of the adsorbent solution body, forcing the phosphorus to move to the surface of activated alumina and to be adsorbed on the surface of activated alumina.

Determine the Adding Amount

Take five 250 ml conical flask, which are added 100 ml 0.2 mg/L water samples.Then add respectively 1.5 g ,2.0 g, 2.5 g, 3.0 g ,3.5 g of activated alumina. Adjust with H_2SO_4 and NaOH to pH of 6. All are placed in a thermostatic oscillator with 25 ℃,180 r/min,oscillating after 4h. Filter with 0.45um membrane and measure phosphorus content in the filtrated supernatant .

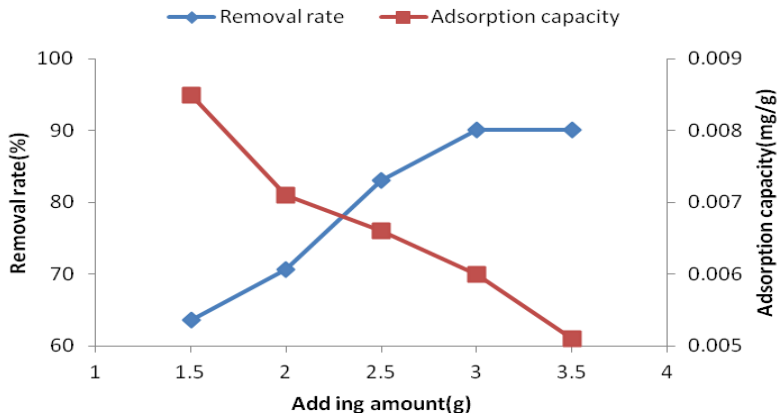

Fig.4 The Influence of Adding Amount

The figure 4 shows that activated alumina phosphorus removal rate increases with the increase of adding amount; The adsorption capacity decreases with the increase of adding amount.Adding amount increases from 1.5 g to 3.5 g, with the removal rate of phosphorus increases from 63.53% to 90.08%, increased by 26.55%; Adsorption capacity decreases from the original 0.0085 mg/g to 0.0051 mg/g, and the decline rate is 40%. When the adding amount is3.0g, the phosphorus removal rate reaches 90.08%.

Adsorption Isotherm

Take 3.0 g of activated alumina into 250 ml conical flasks, respectively, which are added in 100 ml water samples that phosphorous concentration are 0.05 mg/L, 0.1 mg/L, 0.2 mg/L, 0.3 mg/L, 0.5 mg/L. Adjust with H_2SO_4 and NaOH to pH of 6.All are placed on a thermostatic oscillator with 25 ℃,180 r/min,oscillating to be balance after 4h.According to concentration change, calculate activated alumina phosphorus adsorption capacity and protract adsorption isotherm.

Freundlich and Langmuir adsorption isotherm is often used to describe the phenomenon of that solid adsorbent adsorbs phosphorus in water.The expression of Langmuir and Freundlich equation is as shown in formula (3-1) and (3, 2)

$$q=KC^{1/n} \quad (3\text{-}1) \qquad (3\text{-}1)$$

$$q=abC/(1+aC) \qquad (3\text{-}2)$$

Type: q for adsorption quantity in adsorption equilibrium, mg/g; C for the rest of the water's concentration of adsorbed substance in adsorption equilibrium , mg/L; K, a and b are constant.

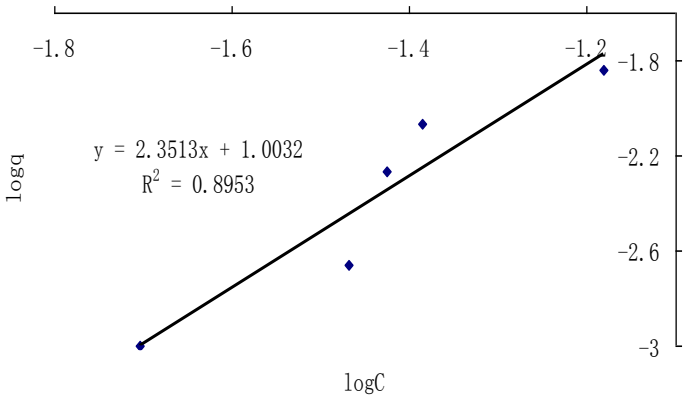

Fig.5 Freundlich Adsorption Isotherm

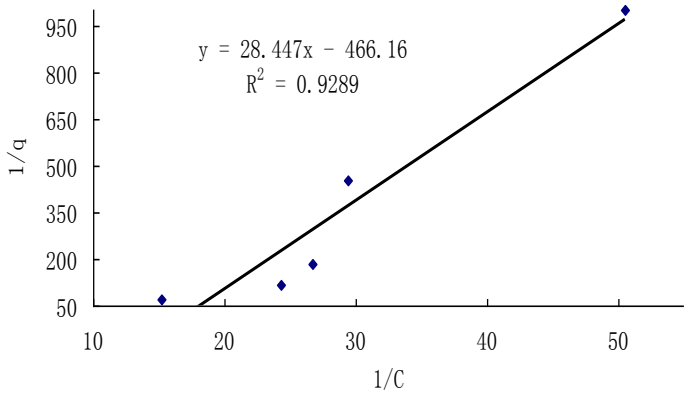

Fig.6 Langmuir Adsorption Isotherm

Freundlich and Langmuir adsorption isotherm describe isotherm adsorption feature of activated alumina phosphorus adsorption, respectively, as shown in figure 5 and figure 6. According to the expression of Freundlich and Langmuir adsorption isotherm equation, using the least square method to do regression analysis on the two types of adsorption isotherm. In the Freundlich equation, the 1/n is 2.3513; The correlation coefficient R^2 is 0.8953. In the Langmuir equation, a is the constant of -17.5, b is -0.002, the correlation coefficient R^2 is 0.9289. It can be seen that the correlation of Langmuir equation is better than the Freundlich equation. Using Langmuir adsorption isotherm equation can more accurately describe the characteristics of activated alumina phosphorus adsorption, and it is consistent with the activated alumina isotherm adsorption feature reported in the literature[6]. Activated alumina adsorption method to remove low concentration of phosphorus in the Langmuir adsorption isotherm equation is $q = 0.035 \times C / (1-17.5 \times C)$.

4. Conclusion

Experiments showthat the activated alumina adsorption to phosphorus mainly occurs within 3 h; The affect of phosphorus removal is best for PH of 5, 6; Activated alumina on phosphorus removal rate first increases with the increase of initial concentration, then tends to be stable;Adsorption capacity increases with the increase of initial concentration; Activated alumina on the removal rate of phosphorus increases with the increase of adding amount; Activated alumina phosphorus adsorption capacity decreases with the increaseof adding amount. Treated with activated alumina phosphorus content of 0.20 mg/L, 100 ml water sample, the adsorption time is 4 h and pH is adjusted to 6. When activated alumina adding amount is 3.0 g, the phosphorus removal rate reaches above 90%.

Using Freundlich and Langmuir adsorption isotherm to describe adsorption process, the correlation coefficient are 0.8953 and 0.9289 respectively. As can be seen from the correlation, Langmuir adsorption isotherm is more accurate to describe the adsorption performance of activated alumina.

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