Comparison of Magnesium Olivine Phosphorous Removal Characteristics in Different Temperature Firing

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Abstract. As a kind of magnesium rich material, magnesium olivine has been proved to be a kind of artificial wetland substrate, which has a good effect on phosphorus removal. Therefore, it selected firing of the magnesium olivine under the 800°C, 1000°C, 1600°C as the research object. The characteristics of phosphorus removal were investigated and compared. The experimental results show that the adsorption isotherm equation of Langmuir can well describe the adsorption process of phosphate on the magnesium olivine at different temperatures. Its phosphate saturated adsorption capacity was 195.65mg·kg⁻¹, 169.49 mg·kg⁻¹ and 145.43 mg·kg⁻¹. At the same time, all kinds of magnesium olivine phosphorus desorption degree is low. It is proved that the performance of the magnesium olivine with low temperature is better. It is more suitable to be used as artificial wetland substrate.

1.Introduction

Phosphorus is one of the main inducing factors of eutrophication, which is very easy to lead to eutrophication of water. The eutrophication of water will lead to the decrease of water quality and increase of water turbidity, which will affect the photosynthesis of aquatic plants. It leads mass death of aquatic organisms. The eutrophication of the water body will destroy the aquatic ecological balance. Therefore, phosphorus has been regarded as the main content of wastewater treatment.

As a new type of ecological engineering technology, constructed wetland is used to coordinate the principle of species symbiosis, material recycling principle, structure and function. Through a series of physical, chemical and biological pathways of the substrate, aquatic organisms and microorganisms, the depth treatment of the sewage is completed, and the phosphorus in the sewage is excellent. Among them, the deposition and adsorption of the matrix is the main way to remove phosphorus. The contribution rate is as high as $70\% \sim 87\%$ ^[1-5].

Wetland matrix has been recognized as the final destination of phosphorus in wetland system ^[6]. The removal efficiency of phosphorus is closely related to the selection of wetland matrix materials ^[7-11]. Al³⁺, Fe³⁺, Ca²⁺ of the substrate can be achieved by adsorption and precipitation of phosphorus removal efficiency ^[12]. The phosphate in the water has better removal ability ^[13]. Therefore, it is one of the core ideas to select suitable materials for artificial wetland to improve the purification capacity of constructed wetland. In the preliminary study in the laboratory, we found that magnesium olivine has a good effect on phosphorus removal. But the temperature of the firing of the magnesium olivine with the best phosphorus adsorption effect has not yet been directly demonstrated. The purpose of this experiment is that adsorption treatment effect of forsterite by comparing different temperature

firing phosphorus, demonstrates the burning temperature on the effect of forsterite phosphorus uptake. It can select the best effect of magnesium olivine and provide the basis for selecting suitable artificial wetland substrate.

2.Material and Methods

2.1Testing instruments and medicines.

Desktop bed temperature, ultraviolet-visible spectrophotometry meter, 0.45µm membrane, syringes, glassware, 10% ascorbic acid solution, 1+1 sulfate, molybdate solution, phosphate standard solution, deionized water.

Magnesium olivine is a kind of magnesium olivine minerals which fired by Yichang Hubei Stone Gold Technology Development Co., Ltd. It is orthorhombic, and the molecular structure of Mg2SiO4 silicate materials. It is rich in MgO, respectively, by 800°C, 1000°C, 1600°C calcined. The size of the matrix was 2~3mm. The size of the matrix was 2~3mm. The magnesium olivine is cleaned with de ionized water and soaked in 12h before use it. And then it dried at 105 C after 24h.

2.2Test method.

2.2.1Isothermal adsorption test

It selected three kinds of matrix 10.0g (Set 2 parallel), and putted it in the conical flask with a volume of 250ml. According to the matrix and solution solid-liquid ratio 1:20, respectively added 0.02 L-1KCl mol solution prepared by the different phosphorus concentration (in the P meter, the same below) of the KH2PO4 standard solution 200mL. Phosphorus concentrations were 1, 2, 5, 10, 20, 50, 100, 200, 400 mg·L⁻¹. The tapered bottle is arranged in the thermostatic shaker, in $150 \cdot r \cdot min^{-1}$, (25 + 5) °C under the condition of continuous oscillation 24h. To determinate the phosphorus concentration, the phosphorus adsorption capacity of matrix was calculated, and the phosphorus adsorption isotherm was drawn.

2.2.2Substrate phosphorus release test

Each of these tests was taken to get the saturated adsorption of phosphorus in the matrix 1g (Set 2 parallel), added $0.02 \text{mol} \cdot \text{L}^{-1}$ KCl in the solution with 50mL, and placed in the bed temperature. Continuous oscillation under150r·min¹ (25 + 5)°C. At 30 min and 1, 2, 4, 6, 8, 10, 12.0 h, respectively taken the amount of supernatant, and analyzed phosphorus concentration after the water sample was 0.45 μ m.

2.3Analysis method.

2.3.1Drawing of standard curve

Taken 50ml with SEBI color tube, and added to the standard solution phosphate 0, 0.50ml, 1.00ml, 3.00ml, 5.00ml, 10. 0ml, 15.0ml. Deionized water is added to 50ml. Plugged 1ml ascorbic acid solution with 10% into color tube. Added 2ml molybdate solution mixing after 30s, and placed 15min. The samples were moved to 10mm or 30mm color tube, the measurement of absorbance, drawn standard curve at the 700nm wave strengths with zero concentration of the solution as the reference.

2.3.2Sample determination

Respectively taken appropriate membrane water (containing less than 30 mu g) in the cuvette, diluted with deionized water to mark. And then, according to the standard curve steps, develop color and measure. Minus blank test absorbance, and find out the phosphorus content from the standard curve.

2.4Adsorption equation.

Langmuir is one of the most commonly used equations to describe the adsorption equilibrium.

$$\frac{1}{q_e} = \frac{1}{q_e^{*b^*C_e}} + \frac{1}{q_m}$$
(1)

 q_e is the equilibrium adsorption capacity of adsorbent, $mg \cdot kg^{-1}$. q_m is the saturated adsorption capacity of adsorbent, $mg \cdot kg^{-1}$. C_e is the equilibrium concentration, $mg \cdot L^{-1}$. b is a Langmuir constant.

Langmuir adsorption isotherm equation is assumed to be uniform, which is mainly used to describe the adsorption of single molecule layer ^[14].

3.Discussion and Conclusion

3.1Isothermal adsorption test.

Through the analysis of different burning temperature of 25 °C under the condition of forsterite for isothermal adsorption curve and equation of phosphate, we can see from the Fig. 1, Fig. 2 and Fig. 3 that the total amount of phosphorus adsorption on the three substrates showed a positive correlation with the concentration of the solution, and with the same concentration, the total amount of phosphorus adsorption isotherm equation is more suitable for the adsorption of phosphate in water by three kinds of magnesium olivine. The saturated adsorption capacity of the substrate can reflect the purification ability of the substrate to phosphorus, which is an important parameter to select the artificial wetland substrate. According to the Langmuir equation, the three phosphate saturated adsorption capacity was 195.65mg·kg-1, 169.49 mg kg⁻¹ and 145.43 mg kg⁻¹. Theoretical saturation adsorption shows that it is easier to adsorb phosphate in water with low firing temperature.



Fig. 1 Adsorption isotherms of phosphorus in aqueous solution of 800°C



Fig. 2 Adsorption isotherms of phosphorus in aqueous solution of 1000°C





The horizontal coordinate is the concentration of phosphate balance solution and mg/L^{-1} ; the vertical coordinate is phosphorus adsorption mg/kg^{-1} .

3.2Substrate phosphorus release test.

As shown in Fig. 4, the liquid solution in the same place, small amount of phosphorus magnesium olivine 12h, phosphorus release percentage was 11.19%. It can be known that when the magnesium olivine is used as the filler of the artificial wetland, it is less likely to be polluted by two times.



Fig. 4 Phosphorus release curve of saturated adsorption of magnesium olivine The horizontal coordinates are time/h; the vertical coordinate is the rate of phosphorus release /%.

4.Result and Conclusion

1) The lower the firing temperature, the better the adsorption ability of the magnesium olivine.

2) The release of phosphate from olivine to phosphate is low, and the risk of the second contamination is small.

3) Langmuir adsorption isotherm equation can well describe the phosphate adsorption process of three kinds of magnesium olivine.

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