



Phosphate recovery through adsorption assisted precipitation using novel precipitation material developed from building waste: Behavior and mechanism



Shengjiong Yang^{a,b,*}, Pengkang Jin^a, Xiaochang Wang^a, Qionghua Zhang^a, Xiaotian Chen^a

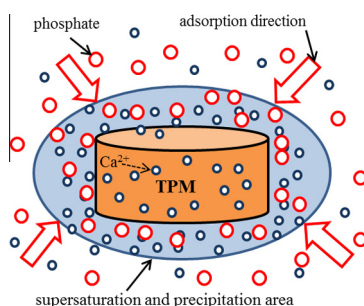
^aSchool of Environmental and Municipal Engineering, Xi'an University of Architecture and Technology, No. 13, Yanta Road, Xi'an, Shaanxi, 710055, PR China

^bState Key Laboratory of Architecture and Technology in Western China (XAUAT), No. 13, Yanta Road, Xi'an, Shaanxi, 710055, PR China

HIGHLIGHTS

- A novel tablet material was developed for phosphorus removal and recovery.
- The tablet material was developed from building wastes.
- Phosphate was recovered through an adsorption assisted precipitation process.
- The phosphate was recovered as hydroxyapatite and brushite.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 25 November 2015

Received in revised form 1 February 2016

Accepted 2 February 2016

Available online 8 February 2016

Keywords:

Adsorption assisted precipitation

HAP

DCPD

Building waste

ABSTRACT

Phosphate is very important basic material in agricultural and other industrial applications. In present study, phosphate was precipitated and recovered through a tablet precipitation material (TPM) which was developed from solid building waste. The development of TPM provided an alternative for the management of building waste. The results showed that TPM could effectively recover phosphate from aqueous solution; the final precipitates were consisted of hydroxyapatite and brushite. The precipitation recovery process was assisted and drove by adsorption mechanism. The adsorption process concentrated and attracted phosphate that supplied partial phosphate supersaturation surround the surface of TPM and assisted the precipitation process. The equilibrium of removal and recover process could be attained in 60 min. The maximum recovery capacity achieved $3.81 \pm 0.24 \text{ mg g}^{-1}$. In addition, the release of Ca^{2+} from TPM fitted a pseudo-2nd order model, and the release process was divided into two stages according to the Fick's law. Totally, TPM developed from building waste exhibited sufficient potential in phosphate recovery.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Phosphorus is very important material to many industries. In the past decades, the accelerating growth in human population

* Corresponding author at: School of Environmental and Municipal Engineering, Xi'an University of Architecture and Technology, No. 13, Yanta Road, Xi'an, Shaanxi, 710055, PR China. Tel./fax: +86 29 8220 5652.

E-mail address: yangshengjiong@163.com (S. Yang).

caused a larger consumption of natural resources and increased the burden of food shortage [1]. Meanwhile the industries required a large amount of phosphorus to the production of detergents, chemical fertilizer, semiconductor, emulsifier, etc [2,3]. It was noteworthy that the phosphorus resources were limited. Some alarming report stated that reserves of phosphate ores on earth would be depleted in this century and the scarcity of phosphorus would become a serious challenge globally [4]. Furthermore, the extensively utilization of the product which containing phospho-

rus in the agriculture, industry and domestic life would increase the nutrient element load to the environment when it was discharged into water body and caused many environmental issues [5,6], such as eutrophication of the water bodies, which was one of the most severe environmental problem [7]. Eutrophication always causes abundant development of aquatic plants, further deteriorated aquatic ecosystems and led to the death of aquatic animals [8]. In most cases, phosphorus had been considered as a key element for eutrophication control [9]. Thus, the necessity to remove and recover the phosphorus from wastewater was important and urgent for the sustainable development.

The broad categories of phosphate treatment had been used for phosphate removal including biological process [10], membrane interception [11], chemical precipitation [12] and Electrochemistry [13]. These technologies exhibited effective phosphate removal efficiency but it should be noted that removed phosphorus was transported from the aquatic solution to the sludge (active and chemical sludge) that hindered the phosphorus recovery process. Chemical precipitation could be regarded as the best method for phosphate removal and reclamation due to its convenience in recovering the removed phosphorus [14]. During the past years, diverse researches on phosphate precipitation were conducted for phosphate removal and reclamation. It could be divided into two types, the magnesium ammonium phosphate (MAP) precipitation [15] and calcium phosphate (CP) precipitation [16]. To be specific, MAP always recovers the phosphate as struvites ($\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$) in the presence of Mg^{2+} and NH_4^+ in solution. CP always recovers the phosphate as different phases at the existence of Ca^{2+} . Compare with the CP precipitation, the MAP precipitation process can simultaneously recover N and P, but it is invalid in the absence of NH_4^+ in solution. Thus, CP was always selected when NH_4^+ was absent in solution. The precipitates of calcium phosphate always divided into several phases such as $\text{Ca}_5(\text{PO}_4)_3\text{OH} \cdot (\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2)$, $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$, and $\text{Ca}_9(\text{PO}_4)_6 \cdot x\text{H}_2\text{O}$ in different reaction condition. The Ca^{2+} was always added as calcium sources using powder chemical agent, thus increased the inconvenience in recovery process. For alternatives, the calcium-containing materials, such as calcite had been used as Ca^{2+} sources and exhibited desirable phosphate removal and recovery capacity [17]; but it could not be conveniently gained in many areas.

In past years, the management of building waste became a serious challenge because of its difficulty in controlling and management [18]. The building waste often constituted a prodigious portion of the total domestic solid waste in contributing to the environment degradation [19]. Because of its un-combustible nature, the building waste usually solved through landfills and the 3-R (reduce, reuse and recycle) could be hardly executed during building waste management [20]. However, the unrecyclable portions of building waste always consisted and transformed from construction material, such as the cement. As is known, the cement contains a large percentage of Ca^{2+} even it was used. Based on this situation, it should be considered that whether the sufficient Ca^{2+} in building waste could be used as a Ca^{2+} sources for CP precipitation for phosphate contamination controlling and phosphorus resource recovery.

In present study, a novelty tablet precipitation material (TPM) was developed from the building waste to achieve the building waste reuse, phosphate contamination controlling and phosphorus resource recovery. The characteristics of the TPM and the obtained precipitates were investigated. The effect of initial concentration, effect of initial pH, mechanism of precipitation process and the Ca^{2+} release rate from TPM were discussed to evaluate its capacity of phosphate recovery. In addition, the risk of the harmful component release from the TPM was also evaluated.

2. Experimental

2.1. Preparation of the tablet precipitation material

The TPM was developed from the used white cement which was provided by Daiso Industries Co., LTD, Japan. The white cement was firstly used for bathroom repair. After weeks (over two month), the used cement was collected and smashed, then further manually granulated as tablet through a sample tablet performing mold. The produced tablets were naturally dried at room temperature for 24 h and then calcined at $600\text{ }^\circ\text{C}$ for 120 min in a muffle furnace for gaining the desirable TPM. The TPM were cooled to room temperature and used in the followed experiments for phosphate removal and recovery.

2.2. Phosphate removal and recovery experiments

The phosphate solution was prepared by dissolving KH_2PO_4 (anhydrous, analytical grade) in deionized water. All the experiments were conducted more than triplicate in a thermostat at temperature of $30\text{ }^\circ\text{C}$.

2.2.1. Effect of initial phosphate concentration

A series phosphate solution with initial concentrations of 5, 10, 20, 30, 40 and 50 mg L^{-1} were prepared without pH adjusting in test tubes, and 0.75 g TPM were dosed in each solution, respectively. The test tubes were afterward set in the thermostat. The concentration of phosphate was monitored after 3 h.

2.2.2. Effect of initial pH

Phosphate solutions with initial concentration of 30 mg L^{-1} (50 mL) were added to 11 test tubes with 0.75 g TPM dosage, respectively. 0.1 mol L^{-1} HCl and NaOH solution were used to adjust the initial solution pH ranging from 2.0 to 12.0, respectively. All the test tubes were capped to avoid evaporation, the phosphate concentration and pH values were determined after 3 h.

2.2.3. Effect of the contact time

A series of 0.75 g TPM were dosed into several test tubes with 50 mL phosphate solution (20 mg L^{-1}), respectively. The concentration of phosphate was monitored at different times for different samples. The concentration monitoring times were 30, 60, 90, 120, 150, 180 and 210 min after the TPM were dosed into the solution for different samples, respectively.

2.2.4. Kinetic research of Ca^{2+} release

TPM (1 g) was dosed into a beaker containing 300 mL of deionized water with continuously stirring through a magnetic stirrer operating at 200 rpm. The concentration of Ca^{2+} in solution and pH was monitored every 30 min.

2.2.5. Risk evaluation of harmful component release

TPM (5 g) were dosed into a beaker containing 1 L of deionized water and preserved for 4 weeks at room temperature to ensure all releasable components were released. The concentration of harmful heavy metals in solution was afterward monitored.

2.3. Analytical methods

The surface image, element distribution and chemical component of TPM and final precipitates were characterized by Scanning Electron Microscope – Energy Dispersive X-ray Spectroscopy (SEM-EDX, Quanta FEG 250, USA) and X-ray diffractometer (XRD, UltraIV, Rigaku, Japan). The phosphate concentration was analyzed with the ascorbic acid method (4500-P.E) [21]. The Ca^{2+} concentration

Download English Version:

<https://daneshyari.com/en/article/145667>

Download Persian Version:

<https://daneshyari.com/article/145667>

[Daneshyari.com](https://daneshyari.com)