Phosphorous retention in granulated apatite: assessing the maximum saturation level, kinetics and reaction mechanisms

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WETPOL 2019
AARHUS UNIVERSITY - DENMARK

8th International Symposium on Wetland Pollutant Dynamics and Control

June 17-21, 2019

PHOSPHOROUS RETENTION IN GRANULATED APATITE: ASSESSING THE MAXIMUM SATURATION LEVEL, KINETICS AND REACTION MECHANISMS.

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Natural apatites have a great capacity for phosphate retention from wastewater. Accordingly, a granulated apatite product called Phosclean® has been developed and manufactured in a similar way fertilizers pellets does, by using a binder product in order to control the particle size distribution (3-6 mm) of the filtration bed. Like natural apatites, this product is supposed to remove phosphorus (P) from wastewater by means of adsorption, at the very beginning of its lifespan, followed by precipitation of calcium phosphate as a long-time retention mechanism. About 20 full-scale treatment wetlands plants have been implemented with Phosclean® filters in France, however, a survey pointed out some limits in terms of the performance durability without defining the causes.

New experiments are carried out in laboratory to assess the maximum saturation level of Phosclean® and the kinetic rate, in controlled conditions. Anions and cations' concentrations are also monitored for a better understanding of P retention mechanisms. The experimental setup consists of two vertical flow Phosclean® columns with equidistant depth sampling points to assess the kinetics at different retention times. They are fed with a synthetic tap water solution with 14.8 mg $P\text{-}PO_4^{-3}$/L and 70 mg Ca^{2+}/L for column 1 and 14.2 mg $P\text{-}PO_4^{-3}$/L and 115 mg Ca^{2+}/L for column 2.

Results of column 1 have shown that Phosclean® behaves as a low rich natural apatite as the kinetic rate stabilizes at low values. For column 2, the higher concentration in Ca^{2+} has improved the kinetic rate at low saturation levels, as well as it has quickly increased the saturation of the media in terms of g $P\text{-}PO_4^{3-}$/kg of material. Samples from column 2 have been analysed by SEMx (saturation = 6.2 g $P\text{-}PO_4^{3-}$/kg of Phosclean®). Images have shown the formation of a crystal deposit at the pellet's surface (Figure 1.c), identified as a calcium phosphate (Ca-P) precipitate by X-ray analyses. SEM images have also shown that the surface of apatite particles in the granule are not readily accessible to act as seeds for Ca-P precipitation (Figure 1.a). It may means that the extra Ca^{2+} addition promotes the oversaturation of the solution leading to a nuclei formation by homogeneous precipitation onto the granules surface. Instead, little Ca-P precipitation occurred without an excess of calcium ions (column 1) and P retention may preferably happen due to adsorption phenomena, leading to low kinetic rates at high saturation levels. Presentation will detail kinetics dynamic and explain in which conditions P retention is limited or not.

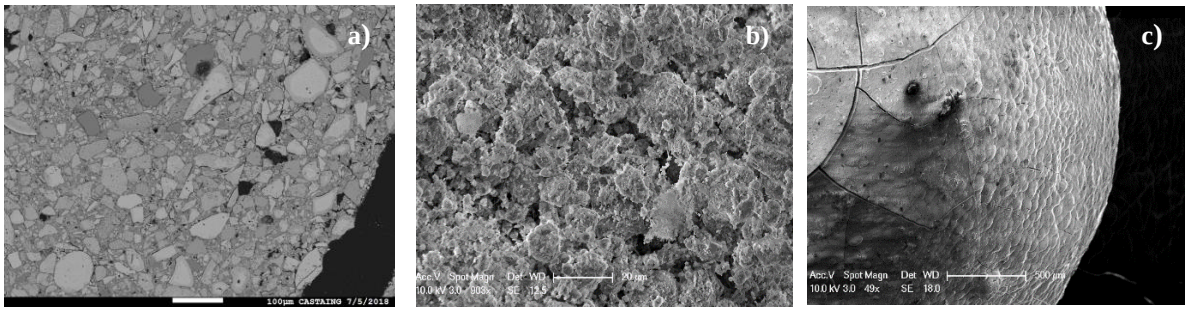

Figure 1. SEM images of: a) a virgin granule section; b) of a virgin granule's surface; c) the Ca-P deposit onto the granule's surface.

BIO: Laura Delgado is a PhD student at Irstea. Her research work is called "Apatite for P removal and valorization: an evaluation" (APPROVE) and it is co-funded by Syntea SAS. and the French Water Agencies AG and RMC.
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