Increasing Phosphorus removal from wastewater using a new reactive material (XXX®).

Samuela Guida*, Florent Chazarenc**

* Département Systèmes énergétiques et environnement, Ecole des Mines de Nantes, 4, rue Alfred Kastler. B.P. 20722 F-44307 NANTES Cedex 3, FR (E-mail: *samuela.guida@mines-nantes.fr; samuela.guida@studenti.unipd.it;)*
** Département Systèmes énergétiques et environnement, Ecole des Mines de Nantes, 4, rue Alfred Kastler. B.P. 20722 F-44307 NANTES Cedex 3, FR (E-mail: florent.chazarenc@emn.fr; florent.chazarenc@mines-nantes.fr;)

Abstract
Agriculture, wastewater and surface diffuse pollution can cause an increasing in the concentration of phosphorus resulting in degradation of the water quality. For this reason, there is a need to find a way to reduce phosphorus in surface water implementing the treatment system in small wastewater treatment plants (sWWTP) or using reactive filters in sWWTP. Our studies have investigated the potential use of a new reactive material (XXX®) in WW treatment as raw or manufactured material. In particular, the adsorption kinetic, the applicable isotherm models and the maximal phosphorus removal capacity have been analysed with batch tests using different concentration of phosphorus, from 0 to 100 mg/L. XXX® has also shown really interesting properties when it is employed in a small column (h = 23 cm, d = 6 cm, HRT = 12h) and in a reactor (V = 63L, HRT = 48h) fed with real wastewater with an initial phosphorus concentration of 10 mg/L. Samples at the inlet and the outlet had been taken weekly for 13 weeks and total phosphorus, orthophosphate, pH, total suspended solids (TSS) had been analysed. The results show that when XXX® is used in the pilot it can remove more than 92% of the initial total phosphorus. When it is used in the column, XXX® can remove more than 94% of the initial total phosphorus. In this case the results show that the reaction is really fast and almost all the total phosphorus is removed in the first layers of the column.

Keywords
Wastewater, surface water, sWWTP, reactive material, phosphorus removal;

INTRODUCTION

The raw material is treated with hot concentrated caustic soda and then subjected to further processing. The undigested residue can be treated to produce XXX® which can be used to remove Phosphorus from wastewater. It is rich in Fe and Al and Ca which are elements with a strong affinity for P binding. Our studies aimed to evaluate its potential use as reactive material to treat wastewater. In particular, we performed batch tests to evaluate its phosphorus removal capacity (PRC) and the speed of adsorption. Moreover, we compared the results obtained when XXX® is used in a small column and in a pilot in terms of total phosphorus removal capacity, orthophosphate removal capacity, pH and TSS.

MATHERIAL AND METHODS

The batch tests have been performed following the *Standard Test Method for 24-h Batch-Type Measurement of Contaminant Sorption by Soils and Sediments*, (*ASTM International*, 2008). The results of the adsorption test were modeled with the pseudo second-order kinetic and the linearized models of Langmuir and Freundlich isotherms using equation (1), (2) and (3) respectively:

$$\frac{1}{(q_c - q_t)} = \frac{1}{q_c} + kt \quad (1)$$

Where q_t is amount of solute sorbed on the surface of the sorbent at any time t (mg/g); q_c is the amount of soluted sorbate sorbed at equilibrium (mg/g); k is the rate constant of sorption (g/mg min).

$$\theta_A = \frac{K_{eq}^A p_A}{1 + K_{eq}^A p_A} \quad (2)$$

Where θ_A is the fractional occupancy of the adsorption sites; K_{eq} is the associated equilibrium constant; p_A is the adsorbate's partial pressure.

$$\log \frac{x}{m} = \log K + \frac{1}{n} \log c \quad (3)$$

Where x is the mass of adsorbate; m is the mass of adsorbent; p is the equilibrium pressure of adsorbate; c is the concentration of adsorbate at the equilibrium in solution; K and n are constants.

Regarding the column and the pilot, samples at the inlet and the outlet had been taken weekly for 7 and 13 weeks respectively and total phosphorus, orthophosphate, pH, total suspended solids (TSS) had been analysed. The total phosphorus and the orthophosphate content were analyzed following the *Acid Persulphate digestion standard method* and the *Ascorbic Acid Method*. Total suspended solidis were analyzed following the *Standard Test Methods for Nonfilterable Matter (Total Suspended Solids).*

RESULTS AND DISCUSSION

The results of the adsorption test were modeled with the pseudo second-order kinetic and the linearized models of Langmuir and Freundlich isotherms and the best results have been obtained with the pseudo second-order kinetic and the Langmuir isotherm.
Increasing the mg P / kg material added, both in the column and in the pilot, also the mg P / kg material removed increase (Fig. 1).
Our results show that XXX® can remove more than 92% and 94% of the initial total phosphorus when it is used in the pilot and the column respectively. After the treatment with XXX®, pH is around 8.5 (pH_{inlet} = 8) while there is no significant different in terms of TSS.

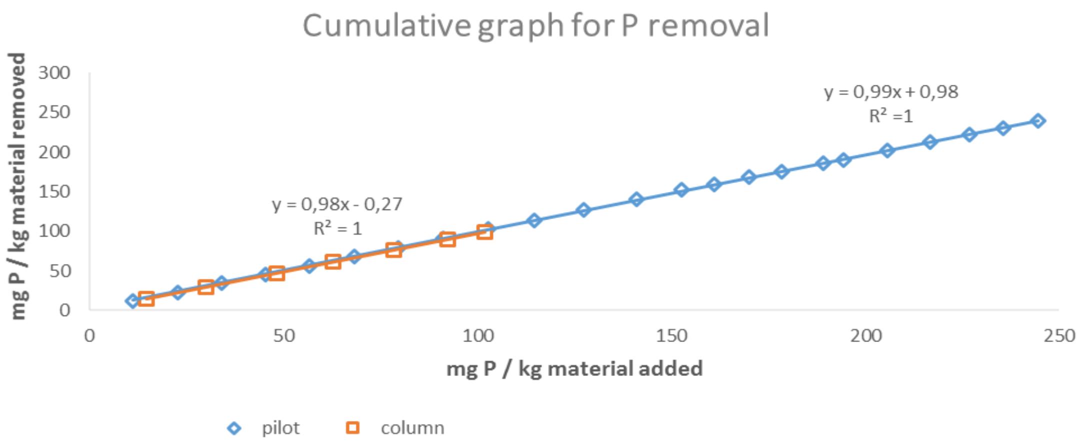

Figure 1. Cumulative graph for phosphorus removal