

SHALE OF THE IVORY COAST AS A FILTRATION MATERIAL FOR PHOSPHATE REMOVAL FROM WASTE WATER

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The annual population growth rate of African cities is on average 5 %. This situation leads to increasing quantities of wastewater generated in most cities. For example, in the Ivorian capital Abidjan, the daily volume of collected wastewater is actually ~ 190 000 m³. The Abidjan wastewaters only undergo a passive treatment prior to discharge into the Ebrié lagoon. Moreover, excess of orthophosphate is at the origin of eutrophication that leads to strong perturbation of the lagoon biodiversity. Therefore, there is a growing interest to identify easily available minerals for performing tertiary treatment of dephosphatisation [1].

In this study, samples of shale were collected from Toumodi region (*i.e.* Lomo North site) in the Center of Ivory Coast. The solid samples were characterized by several techniques including XRD, Mössbauer spectroscopy, SEM-EDX, XPS and ICP-MS. The major minerals of the shale are silicates and phyllosilicates, *i.e.* quartz, albite, muscovite and clinocllore. Structural Fe^{III} and Fe^{II} species are present in substitution of other cations of the clays minerals and a minor part of the Fe^{III} species is present in goethite α -FeOOH.

The reactivity of the shale with phosphate (PO₄) was studied in both homogeneous suspension ("batch reactor") and in hydrodynamic conditions ("column reactors"). A particular attention was devoted to determine both residual phosphate and metal species (Ca²⁺, Mg²⁺, Al³⁺ and total iron) released in solution after phosphate sorption. Kinetics experiments in "batch reactors" showed that the saturation of the shale surface by PO₄ occurred after ~ 24 hours of contact time. Adsorption isotherms led to a maximal PO₄ adsorption capacity of ~ 0.4 mg g⁻¹ at neutral pH. The PO₄ removal capacity decreased with increasing pH and reached a minimum around pH= 10. In strong alkaline conditions an increase of the PO₄ removal capacity was observed that was linked to an increase of the aluminum solubility. During the column experiments, the phosphate solution circulated continuously during a five days period and then was stop during 2.7 days to study the effect of residence time on phosphate removal. This sequence was repeated several times in order to reach a quasi- saturation of the column by PO₄. The PO₄ breakthrough of the column was strongly dependent on the contact time. Interestingly, a correlation between the increase of PO₄ removal rate observed at longer contact time with an increase of Ca²⁺ and Mg²⁺ solubility was established. Therefore, these species could play a more important role than iron in the PO₄ removal mechanism of shale.

In conclusion the shale of Ivory Cost is an interesting material for PO₄ removal from wastewater. Nevertheless, it should be compared in terms of removal efficiency and cost to other readily available natural compounds, *e.g.* laterite and sandstone, or recently developed synthetic Fe^{III} nanocomposites [2].

[1] Kõiv, M., Bavor, H.J., Chazarenc, F., Mander, Ü. (2011) Filter materials for phosphorus removal from wastewater in treatment wetlands-A review. *Ecological Engineering*, 37(1), 70-89.

[2] Ruby, C. Barthélémy, K., Hanna, K. Mallet, M. Naille, S. (2015) Synthesis process and hydrodynamic behavior of a new filtration material for passive wastewater dephosphatation, *Materials and Design*, 86, 168-177.