

Fluoride removal from water by lime sludge waste of paper mill in presence of phosphoric acid

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Introduction

The present study was carried out to evaluate the defluoridation potential of lime sludge waste, a solid waste, produced in paper manufacturing process. Series of batch experiments were performed to observe its fluoride removal ability under different experimental circumstances that affect the process of adsorption. The aspects which were analysed include effect of phosphoric acid concentration, initial fluoride concentration, contact time and adsorbent dose.

Materials and Methods

The lime sludge waste, obtained from a local paper mill, was dried at 120°C for 24 h and crushed to produce powder. This powder with particle size of <200 µm was used. GR grade sodium fluoride (NaF) from Merck, Mumbai and 85% w/v phosphoric acid (PA) from Rankem, Gujarat were obtained and used as such. 1000 mg/L of fluoride stock solution was prepared by dissolving NaF in double distilled water and working solutions were prepared with this for batch experiments. Fluoride concentration was measured on an ion meter using an ion selective electrode. To decomplex fluoride ions, Total Ionic Strength Adjustment Buffer III supplied by Orion Ionplus® was used.

The experiments were carried out at room temperature (300 ± 2 K) in 250 ml Erlenmeyer flasks. 100 ml of fluoride adulterated water pre-acidified with PA were added to premeditated amount of lime sludge waste. This mixture was agitated at 140 rpm for a certain time interval using thermostated shaker. The suspension was then filtered using Whatmann 42 filter paper. The treated water were measured for remaining fluoride concentration. In order to check reproducibility the experiments were repeated at least thrice.

Results and Discussion

From the batch tests, sorption of fluoride was detected to be quick amid the initial 30 min and after that increasing gradually achieving equilibrium in around 1 h (Fig. 1). This quick contact time required to accomplish equilibrium was found to be superior to limestone as adsorbent Gogoi *et al.* (2015). There was an increase in fluoride removal with increase in adsorbent dose. It was noticed that around 91% of fluoride was removed with an adsorbent dose of 25 g/L, for an initial fluoride of 5 mg/L and phosphoric acid concentration of 0.05M (Fig. 2). However, with increase in initial fluoride concentration, the adsorption capacity of the lime-sludge waste was found to decrease (Fig. 1). On the other hand, the fluoride removal decreased but the pH of the treated solution increased with decrease in the concentration of PA (Fig. 3 & Fig. 4). Analogy of these observations with synthetic nano hydroxyapatite (HAP), a highly efficient adsorbent of fluoride reported by Sundaram *et al.* (2008), has been attributed to formation of HAP in the reaction between CaCO₃ and PA. The observed fluoride adsorption capacity of lime sludge waste, 0.901 mg/g is quite high and promising for a solid waste.

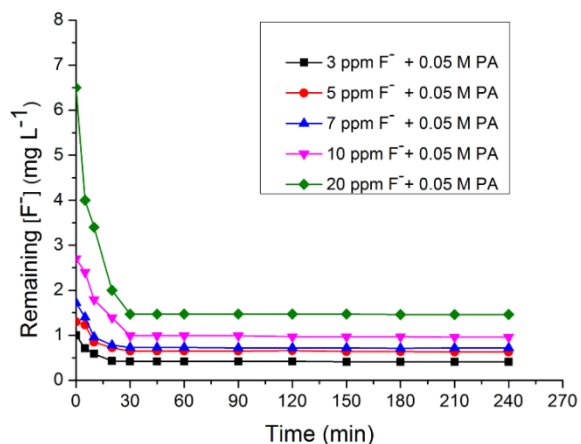


Fig. 1. Effect of contact time and initial fluoride concentration on fluoride removal with sorbent dose of 1.5 g/100 mL of water at 300 K.

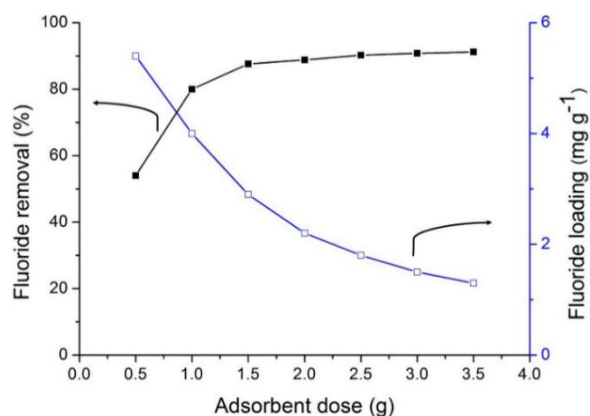


Fig. 2. Plots of fluoride removal (%) and amount of fluoride loading in equilibrium (mg g^{-1}) vs. adsorbent dose at 300 K with $[\text{F}^-]_0 = 5 \text{ mg/L}$, $[\text{PA}]_0 = 0.05\text{M}$ and contact time = 90 min.

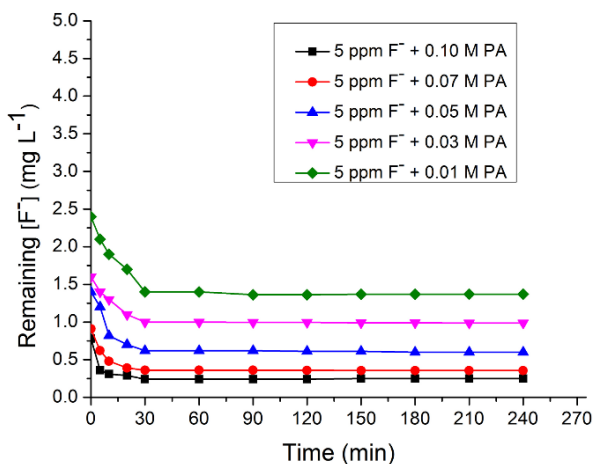


Fig. 3. Effect of initial $[\text{PA}]_0$ on fluoride removal with sorbent dose of 1.5 g/100 mL of water at 300 K.

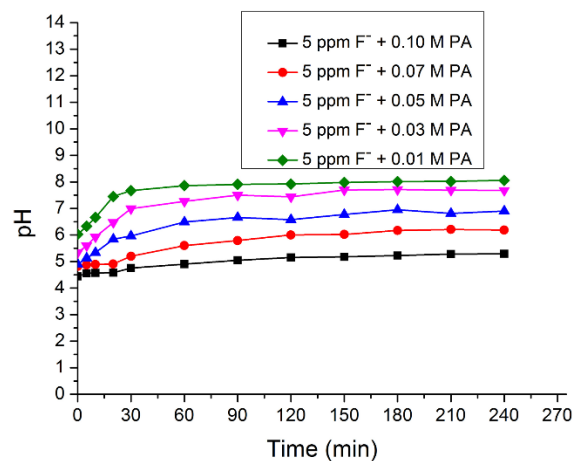


Fig. 4. Effect of initial $[\text{PA}]_0$ on pH of treated water with sorbent dose of 1.5g/100 mL of water at 300 K

Conclusions

The results with lime sludge waste as adsorbent has proven it as a simple, non-toxic, fast and promising material for removal of excess fluoride from water. This comprehensive appraisal demonstrates that, this waste material can be a potential candidate for scaling up of the process for application as an environment-friendly defluoridating material.

References

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