P-recovery from glasshouse wastewater using lime and biodegradable flocculants to produce fertiliser product.

Lime was used to precipitate calcium phosphate from greenhouse wastewater and the precipitate was flocculated with biodegradable flocculants to improve solid separation by settling. The use of biodegradable flocculants improves the perspective for the use of the recovered solids as a fertiliser.

The seasonal concentration of phosphorous (P) in greenhouse wastewater range typically 30-60 mg P-PO$_4^{-}$ /l but can be as high as 370 mg. Other nutrients (nitrogen, potassium, etc.) and micronutrients can also be highly concentrated. Ontario state legislation limits the total P discharges in surface water to 1 mg P$_{\text{total}}$/l. Unlike nitrogen, wetlands, which are currently used for greenhouse wastewater treatment systems in North America, cannot effectively reduce P. The use of lime to precipitate P is efficient and well known, but the complexation of fine calcium phosphate particles with organics generally limits the separation process. The use of biodegradable flocculants is a promising route to enable use of the recovered phosphate solids as fertiliser.

**Experimental set-up**

The authors tested powder hydrate lime with three different biodegradable flocculants (chitosan 13 USD kg$^{-1}$, guar gum 3.5 USD kg$^{-1}$ and cationic starch 0.6 USD kg$^{-1}$) in low (78 mg/l CaCO$_3$) and high (tap water 200 mg/l CaCO$_3$) alkalinity simulated greenhouse wastewater (100 mg/l PO$_4^{-}$-P), and in real vegetable (Pepper and Eggplant), Begonia and Campanula greenhouse wastewater (51 and 13 mg/l PO$_4^{-}$-P, respectively). While the alkalinity for vegetable wastewater was 42 mg/l CaCO$_3$, for Campanula wastewater it was nil. All the greenhouse wastewaters contained very low visible organic matter (low turbidity), which is typical of greenhouse wastewaters. The lab scale experiment was performed in triplicate by adding lime in 0.5 l of wastewater sample, obtaining a final pH of 9.5 for simulated wastewater and 9 for real greenhouse wastewater. Respectively, the lime:P molar ratio obtained was 0.7 and 1.3 for the low and high alkalinity simulated wastewater, and 1.3 and 1.4 for vegetable and campanula real greenhouse wastewater. The P removal rate was determined by measuring the higher supernatant composition for each test after 2, 10, 30 and 60 min.
Precipitation/Flocculation effectiveness

The flocculation experiments showed that the addition of guar gum and cationic starch improved the precipitation of the produced calcium phosphate by reducing the settling time and the P concentration in the effluent. For very low alkalinity greenhouse wastewater, such as the studied Campanula case, addition of flocculant was not successful due to the formation of slow settling precipitates. Chitosan did not show an improvement in precipitation for the tested wastewater. This is probably due to the high pH that eliminates the cationic character of the amino groups in chitosan and reduces the solubility.

In all cases with low alkalinity simulated wastewater, the target discharge concentration of 1 mgP/l was achieved. This was also achieved using 12 mg/l guar gum or 24 mg/l cationic starch for the high alkalinity simulated wastewater and for the vegetable greenhouse wastewater, but not for the campanula greenhouse wastewater.

Recovered nutrient product

Elemental analysis on the recovered Ca-P complex from vegetable greenhouse wastewater showed a P content of 5.7% and high levels of K (5.3%) and Mg (5.8%). The high Mg and K content is probably related to K and Mg-struvite since the Ca:P molar ratio was only 1.25, which is lower than the theoretical molar ratio for amorphous calcium phosphate (1.5). More than 90% of the P could be extracted with citric acid, suggesting applicability of the precipitate for fertiliser applications.

Cost assessment

The chemical costs of the process for vegetable and campanula greenhouse wastewater treatment were 0.16 and 0.07 USD/m$^3$, respectively, when guar gum was used as flocculant. However, research at full-scale would be necessary for a proper financial and logistical evaluation of the process. Issues that would require more evaluation are for example the dewatering of the precipitate and possible degradation of the biodegradable flocculent during dosing and storage. Also regulatory issues are important since this process increases the pH of the waste water to values above pH limits for discharge of waste water (pH 9.5 in Ontario). Reduction of the pH to
meet legal limits may add further costs to the process. The authors describe that also the use of the recovered product presents a challenge as the volume is low and the product will have a variable composition. Therefore the main driver for recovery is P removal and any use value of the recovered product is an additional benefit.

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Original article:
http://hortsci.ashspublications.org/content/50/6/921.abstract

See also:
http://www.tandfonline.com/doi/abs/10.1080/09593330.2014.924567

See also:
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