Nutrient Removal and Recovery by the Precipitation of Magnesium Ammonium Phosphate

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Master of Philosophy

DECLARATION

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ABSTRACT

Phosphate and ammonium are the main nutrient sources in wastewater, contributing to eutrophication of water bodies. Removal of these nutrients from wastewater using conventional technologies is a challenge in water industry. Many processes have been developed to remove these two nutrients. On the other hand, phosphorus from nature is not infinite, which will be running out in about 50 – 100 years. Therefore recycling phosphorus is becoming an issue, as well as a challenge, for researchers all over the world.

This research is to investigate a chemical process technology to recover the nutrients by the precipitation of magnesium ammonium phosphate (MAP), which is valuable product and nutrient fertiliser. This is a new process based on the chemical equilibrium, which is greatly affected by pH of the solution, concentrations of Mg^{2+}, NH_4^+, PO_4^{3-}, and other ions and organic matters included in the wastewater. In order to implement this process, the optimal pH, and the best molar ratio of Mg^{2+}, NH_4^+ and PO_4^{3-} must be adequately studied.

In this thesis, the optimal pH and optimization of the molar ratio of Mg^{2+} :NH_4^+ :PO_4^{3-}, were studied based on synthetic wastewater. It was found that the best pH range was 9-9.5, and the best molar ratio was Mg^{2+} :NH_4^+ :PO_4^{3-} =1.3:1:1.1 Visual MINTEQ 3.0 software was then introduced to predict the possible solids precipitated and additional alkaline required in order to maintain the optimal pH value during experiments. Laboratory scale experiments were carried out under the same conditions of model input. Struvite yielded from laboratory experiments was tested and confirmed by SEM and X-ray diffraction. The results indicated that the experimental results agreed well with that of model prediction within the error deviation. Reagent addition rate and temperature were also tested in terms of removal efficiency and morphology of the precipitates. These two factors can affect size and morphology of crystals, but have limited impact on the removing efficiency compared to pH and concentration.

The main advantages of this technology are to recover nutrients and to prevent eutrophication. Preliminary results of operational factors of laboratory scale MAP system have been discussed and presented. Conclusions and recommendations were also made in this work.

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List of Abbreviations

STPs: Sewage treatment plants

SDE: Sludge dewatered effluent

WWTP: wastewater treatment plant

MAP: Magnesium ammonium phosphate

SEM: Scanning electron microscopy

XRD: X-ray diffraction

AD: Anaerobic digestion

LCFAs: Long chain fatty acids

EPA: Environmental protection agency

BNR: Biological nutrient removal

PAOs: Polyphosphate accumulating organisms

A^2/O: Anaerobic-aerobic-oxic

ICW: Integrated constructed wetland

SBRs: Sequencing bench reactors

UASB: Upflow anaerobic sludge blanket

RSM: Response surface technology

CCD: Central composite design

TS: Total solids

PS: Solubility product

HAP: Hydroxyapatite

OCP: Octacalcium phosphate

TCP: Tricalcium phosphate

DCP: Monetite

DCPD: Brushite

CBA: Cost-benefit analysis

List of Equations