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The removal of nitrogen and phosphorus from reject water of municipal wastewater treatment plant using ferric and nitrate bioreductions

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ABSTRACT

Reject water, which is the liquid fraction produced after dewatering of anaerobically digested activated sludge on the municipal wastewater treatment plants (MWWTPs), contributes up to 80% of the nitrogen and phosphorus loads to the MWWTP. It was proposed to combine the removal of nitrogen from reject water using the sequential biooxidation of NH+ and bioreduction of NOJ with precipitation of phosphate by Fe^{2}+ ions produced due to bioreduction of Fe^{3}+ in iron ore. Bioreduction of NOJ decreased Fe^{3}+ bioreduction rate in reject water from 37 to 21 mg Fe^{2}+/Ld due to competition between NOJ and Fe^{3}+ for electron donors. Addition of acetate as electron donor increased both bioreduction rates of Fe^{3}+ and NOJ but acetate interfered with the competition between nitrate and phosphate anions reacting with ferrous cat¬ ions decreasing efficiency of the phosphate removal from reject water. The stages of denitrification and ferric bioreduction/phosphate precipitation must be performed sequentially.

2. Methods

2.1. Iron ore, reject water, aerobic and anaerobic sludges

The iron ore, with iron content 60% (w/w), was supplied from China. Major mineral was hematite (Fe_2O_3). The sizes of iron ore particles used in experiments were between 0.5 and 1 mm. The porosity of these iron ore particles was 46 ± 0.5% (v/v, average value ± s.d.).

The samples of reject water, aerobic sludge (aerobic microbial biomass from activated sludge tanks) and anaerobic sludge (anaerobic microbial biomass from anaerobic digester) were collected from the MWWTP in Singapore.

Aerobic sludge (biomass from aerobic bioreactor) was used as a source for enrichment culture of facultative anaerobic denitrifying bacteria, which were grown anaerobically in reject water with addition of 0.4 g NO_3-N/L. Electron donor do bioreduction of nitrate was organic matter of reject water. Reject water with addition of nitrate was a model of reject water after nitrification. Maximum of denitrifying activity of enrichment culture after 2 days of growth was 103 mg NO_3-N/L d.

It is known that there are a lot of iron-reducing bacteria in anaerobic digester (Nielsen et al., 2002). Therefore, anaerobic sludge (i.e. biomass from anaerobic digester) was used as a source of iron-reducing bacteria. Biotic production of ferrous ions from iron ore in experiments (Fig. 3) was due to the presence of iron-reducing bacteria in anaerobic sludge. Biotic production of ferrous ions from iron ore using anaerobic sludge as inoculum was shown also in previous experiments (Ivanov et al., 2009).

The reject water, aerobic and anaerobic sludges, and the enrichment culture of denitrifying bacteria were stored at 4 °C before experiments. The example of the characteristics of one sample of reject water, aerobic sludge and anaerobic sludge is given in the Table 1. There were significant temporal variations of the concentrations of ammonium, phosphate, and dissolved organic carbon (DOC) in reject water of MWWTP.

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