

Improvement of Sludge Quality by Iron-Reducing Bacteria

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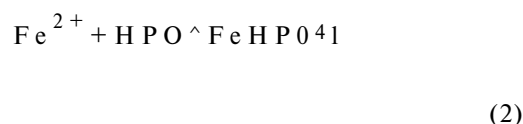
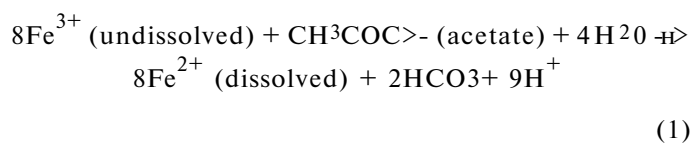
ABSTRACT: Sewage sludge can be used in agriculture as organic fertilizer. However, one of the obstacles for this use is the high concentration of heavy metals and the presence of sulphides (acidifying soil or compost). The aim of this research was to develop the biotechnology for improving the quality of sewage sludge that would be used as organic fertilizer. Microbial reduction of inexpensive sources of Fe(III) in anaerobic digester is proposed as a means of preventing the accumulation of sulphide and of enhancing the accumulation of phosphate in sewage sludge. Industrial grade iron hydroxide can serve as a suitable source of Fe(III). The results show that almost all dissolved phosphate is recovered by the reaction with Fe^{2+} . Additionally, the activity of iron-reducing bacteria inhibits the production of sulphide by sulphate-reducing bacteria and the growth of these bacteria in anaerobic digesters.

INTRODUCTION

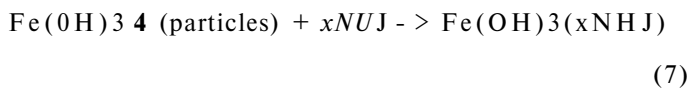
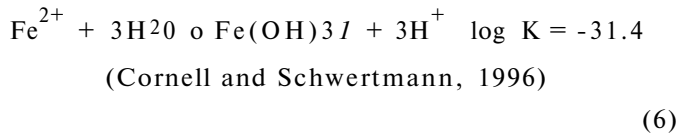
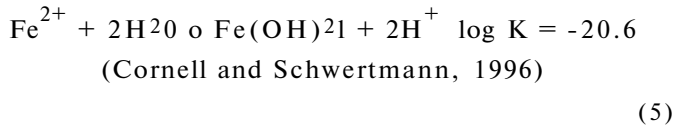
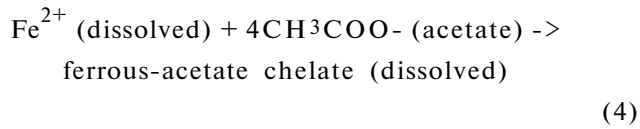
THE major secondary waste product of municipal wastewater treatment plants is sewage sludge, which often consists of dewatered microbial biomass from the anaerobic digester. This sludge is disposed of by landfilling or incineration, but can also be used in agriculture after composting if the concentrations of heavy metals and organic pollutants are not high (Matthews 2001; Vesilind and Spinosa 2001; Wang et al. 2003 a,b). Intensive in-vessel bioconversion of sewage sludge and food waste into fertilizer can be useful where land is at a premium and where the sewage sludge has low metal content (Stabnikova et al. 2003; Wang et al. 2003 a,b). The quality of organic fertilizer from sewage sludge can be improved if the content of sulphides is low and the content of phosphate is high. The accumulation of sulphides can be prevented by the competition of sulphate-reducing bacteria (SRB) and iron-reducing bacteria (IRB) in anaerobic digesters. Some engineering applications of iron-reducing bacteria in the remediation of groundwater, soil, and wastewater treatment have been reported (Fredrickson and Gorby, 1996; Ivanov et al., 2002; Monserrate and Haggblom, 1997; Phels and Young, 1999; Stabnikova

et al., 2000; Tay et al., 2004). Additional effect of Fe(III) reduction may be formation of dissolved Fe(II) which can precipitate phosphate and sulphide. Salts of Fe(II) are not applicable in large scale wastewater treatment because these compounds are expensive and are not stable at neutral pH.

The ions of Fe^{2+} can be formed in anaerobic digesters from inexpensive sources of Fe(III) by IRB. These bacteria are present in anaerobic reactor (Nielsen, 2002). IRB reduce Fe(III) to Fe(II) coupled with oxidation of hydrogen or organic substances under anaerobic conditions (Lovely, 2000). Fe(III) added into anaerobic reactor can be reduced to Fe(II) in case when anaerobic sludge was previously adapted to the presence of Fe(III) (Ivanov et al., 2002; Nielsen, 2002). Iron-reducing bacteria can release Fe(II) from not dissolved Fe(III) minerals. The cheapest and suitable sources of Fe(III) for reduction by iron-reducing bacteria are iron-containing clay, crushed iron ore, wetland iron ore, or industrial grade iron hydroxide (Ivanov et al., 2002). The theoretical sequence of iron transformations during anaerobic process may be shown by the equations below:



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Therefore addition of inexpensive source of Fe(III) in anaerobic digesters and the bioreduction of Fe(III) to Fe(II) can be expected to improve the quality of sewage sludge as raw material for biofertilizer due to accumulation of phosphate and prevention of accumulation of sulphides. The aim of the present research was to examine the bioprocesses improving quality of sewage sludge as a raw material for organic fertilizer.

CONCLUSIONS

Reduction of Fe(III) and formation of dissolved Fe(II) in anaerobic digester of activated sludge prevents sulphate reduction and the formation of sulphide, and enhances the accumulation of phosphate in sludge. Initiation of iron-reducing microbial activity in anaerobic digesters can improve the quality of sewage sludge as a raw material for production of organic fertilizer.

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