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Environmental profile of typical anaerobic/anoxic/oxic wastewater treatment systems meeting increasingly stringent treatment standards from a life cycle perspective

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HIGHLIGHTS

- ▶ We employ a life cycle perspective to estimate the wastewater treatment systems.
- ▶ Six typical A/A/O alternatives are evaluated from an environmental profile standpoint.
- ▶ Sophisticated treatments are at the cost of higher resource consumption and GHG emissions.
- ▶ The only positive trade-off with improved treatments is observed when using bioenergy recovery.
- ▶ Optimal alternatives are identified from different positive perspectives.

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ABSTRACT

Stringent new legislation for wastewater treatment plants (WWTPs) is currently motivating innovation and optimization of wastewater treatment technologies. Evaluating the environmental performance of a wastewater treatment system is a necessary precursor before proposing implementation of WWTPs designed to address the global requirements for reduced resource use, energy consumption and environmental emissions. However, developing overly-sophisticated treatment methods may lead to negative environmental effects. This study was conducted to employ a process modeling approach from a life cycle perspective to construct and evaluate six anaerobic/anoxic/oxic wastewater treatment systems that include a water line, sludge line and bioenergy recovery system and was designed to meet different treatment standards in China. The results revealed that improved treatments optimized for local receiving watercourses can be realized at the cost of higher resource consumption and greenhouse gas emissions. Optimal Scenarios were also identified from different positive perspectives.

1. Introduction

Wastewater treatment plants (WWTPs) have been designed and operated to minimize the environmental effects of discharging untreated water into natural aquatic systems, with a focus on preventing eutrophication and health hazards in surface water. Global demographic trends as well as new stringent legislation for WWTPs are current motivators for the development and innovation of new treatment technologies, as well as optimization of existing ones (Guerrero et al., 2011; Liu et al., 2008; Machado et al., 2009). However, increasingly sophisticated improvements in treatment have led to increased resource degradation, higher electrical energy consumption, and elevated environmental emissions (Foley et al., 2010a). Taken together, these factors lead to increased environmental burdens. To date, these additional environmental loads have largely been neglected in the regulatory push for cleaner local water environments. Furthermore, numerous WWTP options have varied performance at different treatment levels and consequently varying direct effects on the environment. To this end, there is a need for comprehensive environmental assessments of a range of wastewater treatment options to meet different treatment standards from a life cycle perspective that primarily focus on broader environmental consequences.

Life cycle assessment (LCA) is a tool for evaluation of the environmental consequence of goods, as well as processes or services (Dennison et al., 1998). To date, LCA has been used to investigate the environmental consequences of wastewater treatment systems in several existing cases, with a focus on interest in the construction and demolition phase of WWTPs (Hospido et al., 2004; Pasqualino

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