A NEW METHOD FOR CONVERTING SEWAGE TO ENERGY USING SELF-SUSTAINING SMOULDERING

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EXECUTIVE SUMMARY

A major challenge in designing resilient infrastructure is to meet the needs of sustainable development (Kennedy & Corfee-Morlot, 2013). Sustainable development requires a high degree of energy efficiency. Municipal wastewater treatment plants (WWTPs), in particular, have the potential to be much more sustainable. In the U.S., 3 – 4% of the total energy consumed is dedicated to WWTPs and drinking water services, accounting for 30 – 40% of energy consumed by municipalities (U.S. EPA, 2014). In Canada, 25% of the $123 billion municipal deficit in 2006 was tied to water supply systems (i.e., drinking water, wastewater, and storm water) (Mirza, 2006). This problem becomes further complicated as much of North America’s WWTP infrastructure approaches the end of its design life. An estimated $298 billion and $39 billion is required in the U.S. and Canada, respectively, to satisfactorily refurbish WWTP infrastructure (ASCE, 2013; Félio et al., 2012). Within WWTPs, around 50% of the operating and capital costs are dedicated to managing the solid by-product, biosolids, making it the most expensive system component (Khiari et al., 2004). In Canada, 90% of biosolids are either incinerated or land applied for agricultural purposes (Apedaile, 2001). These methods are expensive, requiring high energy inputs in various forms (e.g., fuel, labour, transportation) (Wang et al., 2008). Land application is also subject to limitations and uncertain risks due to the potential for introducing synthetic contaminants into the environment (Hale et al., 2001; U.S. EPA, 1995). In general, managing biosolids persists as a major energy intensive challenge within WWTPs and there is a strong need to provide novel solutions (Tyagi & Lo, 2013).

Self-sustaining smouldering combustion of organic wastes was originally developed as a chemical waste management and soil-clean up technology (Pironi et al., 2011; Scholes et al., 2015; Switzer et al., 2009). Smouldering is a flameless form of combustion for solid and liquid fuels, where a common example is glowing red charcoal in a traditional barbeque (Ohlemiller, 1985). The fuel (e.g., oil sludge) is mixed with sand to form a fixed-bed; this increases the surface area for reaction, provides porosity for the oxidant (air), and efficiently transfers, stores, and recycles the released reaction energy (Switzer et al., 2009). The smouldering reaction typically reaches temperatures between 500-800°C for many minutes in one location resulting in upwards of 99% conversion of organic waste to heat (Pironi et al., 2011). Smouldering in this configuration is unique as it supports an extremely energy efficient, self-sustaining reaction; therefore, following ignition, no external energy is required to sustain the reaction indefinitely. As a result, the process can smoulder fuels containing little energy or significant water contents that would otherwise not burn (e.g., via incineration) (Switzer et al., 2009; Yermán et al., 2015).

Proof-of-concept experiments demonstrated for the first time that biosolids, obtained from Greenway Pollution Control Centre (London, ON) could be successfully destroyed via self-sustained smouldering. Thirty experiments in 40 cm tall, 15 cm diameter fixed-bed columns mapped the parameter space of self-sustained smouldering as a function of sand dilution, biosolids water content, and injected air flow rate. The results demonstrate that a self-sustaining reaction was achieved using biosolids with water contents as high as 80% (1.6 MJ/kg, effective calorific value). With little input of energy, the biosolids were converted to heat, steam, and emissions dominated by carbon dioxide. These
results suggest that smouldering presents strong potential as a cost and energy effective waste management alternative for WWTP biosolids, achieving on-site destruction with minimal energy input and limited preliminary processing (Rashwan et al., 2016). This underscores the beneficial application of smouldering as a novel waste management technique that may be useful in designing resilient infrastructure.

REFERENCES


