Smoldering Combustion Treatment of WWTP Sludge and Other Organic Wastes

Applicability and Development

Overview

Ex situ smoldering combustion (STARx) is a low cost, energy efficient process initially developed for the treatment of contaminated soils and oil waste sludges. STARx systems have been successfully deployed across the world to treat hydrocarbon contaminated waste materials, where the contaminants provide the fuel that supports the flameless combustion reaction (IMAGE 1). This same process can also be applied for the treatment of other organic wastes, including sludges generated from wastewater treatment plants (WWTPs) and various industrial applications (e.g., pulp and paper industry).

Management of WWTP sludge can be challenging depending on the desired end use. High costs associated with dewatering and energy consumption for incineration applications, and regulation of contaminants of emerging concern in relation to land application may limit these options in some jurisdictions. STARx provides a low energy alternative for the management of WWTP sludge, and represents a a conservative case for assessing STARx treatability due to the relatively low energy content of WWTP sludge in comparison to other organic wastes.

IMAGE 1: STARx Hottpad system for hydrocarbon applications

Conclusions and On-Going Development

The STARx technology is a rapid, safe, and energy efficient treatment option for WWTP sludge and other organic wastes Depending on the characteristics of the waste, STARx may require co-treatment (e.g., WWTP sludge) or may be applied without modifications to the waste (e.g., pulp and paper residue). On-going development work includes:

- Expansion of the list of potential co-treatment options for WWTP sludge;
- Further evaluation of continuous smoldering and required modifications to existing STARx equipment;
- Development of resource recovery options, including energy and nutrient recovery

Technical Approach and Results

Proof of concept work was completed at the University of Western Ontario to evaluate STARx treatment of combined primary and waste activated sludge (collected after dewatering) from Greenway Pollution Control Centre in London, Ontario, Canada (herein termed 'sludge'). The sludge was mixed with varying ratios of sand to provide the porous matrix required for smoldering and develop a direct comparison to conditions used for STARx treatment of contaminated soils and oily wastes (IMAGE 2). A series of laboratory column tests were conducted to evaluate the sludge parameter space under which self-sustaining smoldering could be achieved. Through this study, successful smoldering treatment was demonstrated for sludge with up to 80% moisture content (IMAGE 3; Rashwan et al, 2016).

IMAGE 2: Combined primary and waste activated sludge sample (left), mixture of sludge and sand before STARx treatment (centre), and remaining sand after STARx treatment (right)

Follow-on testing in large-scale reactors (~35x and 300x larger than the laboratory column, respectively) demonstrated increasing energy efficiency with increasing scale. Air channeling within these larger reactors was, however, observed due to the compressibility of the sludge when mixed with a sand matrix. The use of a smolderable porous matrix (e.g., wood chips) was shown to reduce air channeling effects and permitted successful treatment of WWTP sludge at larger scales.

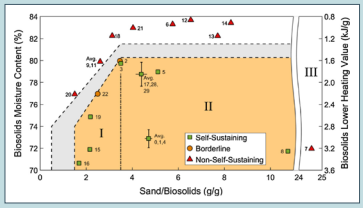

IMAGE 3: Parameter space illustrating sludge ('biosolids') moisture content, lower heating value, and sand/biosolids mass ratio combinations that facilitate self-sustained smoldering (Rashwan et al., 2016)

On-going testing has demonstrated successful co-treatment of WWTP sludge with other organic wastes (e.g., mushroom and macadamia nut pulp), which provide both a porous matrix and fuel to support smoldering. In these cases, a limited volume of ash remains following STARx treatment, providing opportunities for continuous smoldering reactors and further improvements in energy efficiency. STARx treatment and the potential for continuous smoldering has similarly been demonstrated for other organic wastes (e.g., pulp and paper residue and mixed waste anaerobic digestate) (IMAGE 4).

IMAGE 4: Pulp and paper residue prior to STARx treatment (left) and ash remaining after STARx treatment (right)