NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Nanyang Environment and Water Research Institute

PYROLYSIS FOR SLUDGE MANAGEMENT & BIOCHAR APPLICATION

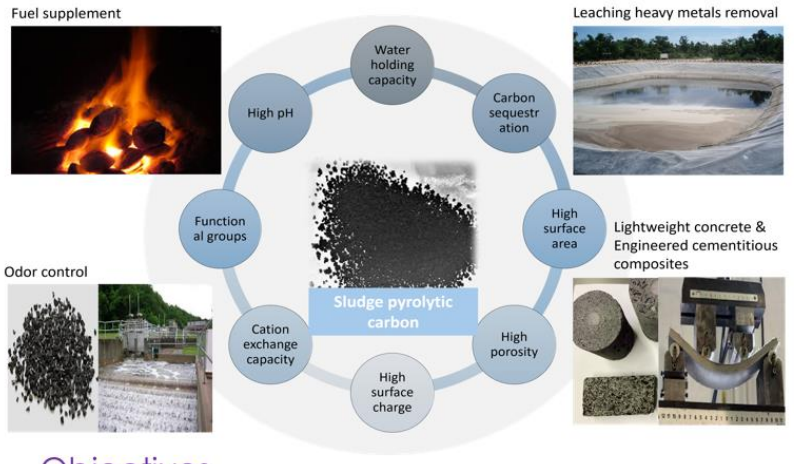
Abstract

The objectives of sludge treatment are mass reduction, stabilization, sterilization, energy and resource recovery, and low carbon emission. Leader Environmental Technologies Limited (LET) has developed its proprietary closed-loop sludge management technologies with the core process of continuous thermal hydrolysis (CTH) and continuous pyrolysis and has achieved excellent full-scale results in China, including 90% mass reduction and commercial usage of pyrolytic carbon in non-sintered bricks.

However, the sludge in Singapore and end-uses of the resulting pyrolysis material can differ from the China situation. Consequently, there is need to not only demonstrate the technology but also to investigate the impact such differences may have on system performance and hence the possible modifications to process and hardware required. A demonstration plant with 5 tons/d sludge (20% dry solids) treatment capacity is proposed for the treatment of dewatered Anaerobic Digestion (AD) sludge at a PUB plant. The expected electrical (the substitute energy source for the demonstration project) consumption for heat energy at the demonstration plant is expected to be 514 kWh/ton of 20% dry solids sludge (equivalent to 52 m^3 natural gas/ton), which is higher than that of the full-scale plant in China (25 m^3 natural gas/ton). Under full-scale conditions, the carbon emission from the CTH + pyrolysis integrated system for dewatered AD sludge treatment can be reduced substantially due to carbon utilization and carbon sink (as in the pyrolytic carbon).

The NTU team supports LET on sample analysis and results/data analysis. Concurrently, the NTU project team study applications of the pyrolytic carbon generated from the demonstration plant. The study focuses on applying sludge pyrolytic carbon as feedstock for production of value-add materials such as:1) activated carbon for air pollution control (eg odour and H_2S removal), 2) additive to facilitate safe placement of incinerator bottom ash in the environment, 3) engineered cementitious composites (ECC) with enhanced workability, and 4) as a fuel supplement alternative to imported charcoal. These pyrolytic carbon derived materials shall be ranked by their performance in the target application and respective scalability (on basis of desk-study estimates) to assess commercial viability. The project objective is to develop a suitable cost effective CTH-pyrolysis technology with appropriate pyrolytic carbon application which will be able to meet PUB's objective of completely closed-loop sludge management.

BLACK GOLD: PYROLYTIC CARBON FROM SLUDGE



In this project, sludge biochar will be used as a feedstock for the purposes:

- Activated carbon for odor control and H_2S removal
- Additive to facilitate safe placement of incinerator bottom ash (IBA)
- Lightweight concrete (LWC) and engineered cementitious composites (ECC) with enhanced workability
- Fuel supplement for gasification plants to replace imported charcoal

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Objectives

- Pyrolytic carbon-based activated carbon (PCAC) for odor control: removal capacity 30-40 mg H_2S/g PCAC.
- PCAC to adsorb leaching HMs from IBA: > 90% removal efficiency
- Sludge pyrolytic carbon to produce suitable LWC/ECC: density of LWC/ECC around 1700 to 2000 kg/m^3
- Sludge pyrolytic carbon as fuel supplement: LHV > 2000 Kcal/kg

Benefits

- ✓ Reduce cost for odor control, with savings of 6.3 SGD per kg of H_2S removed
- ✓ Solve the common HMs leaching problem from landfill IBA
- ✓ Ready Mix Concrete can be replaced with produced LWC/ECC economically
- ✓ Lower cost for MSW incineration, with savings of 100 SGD per ton of MSW treated

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