Pre-treatment Methods To Enhance Anaerobic Digestion of Food Waste

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Food waste (FW) is one of the largest compositions of municipal solid waste (MSW). A study by FAO suggests that roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year [1]. Anaerobic digestion (AD) and composting are the main biological treatment technologies available for organic solid waste. However, in most cases the FW is not treated, and is buried in landfills. In USA, 2.5% of FW is recycled, and principal technology is composting [2]. In UK 2% of the available amount is collected separately for AD or composting [3,4]. Although composting provides an alternative to landfill disposal, it requires large areas of land; produces volatile organic compounds [5]. Therefore, anaerobic digestion is more favourable than composting, due to its high energy recovery and limited environmental impacts [6]. AD is a well studied biological process, and it was matured in many technical aspects whereas most sustainable alternative of the process in terms of environmental and economical aspects is still being studied.

One of the major concerns of AD is the long retention time, which is due to the rate-limiting factor, hydrolysis of complex polymeric substances [7]. In this regard, to enhance the biogas yield and reduce the retention time and volume of digesters, extensive research has been conducted on various pre-treatment methods. Nevertheless, among the numerous studies, fewer studies are available on the effects of pre-treatment methods on AD of FW [8]. Various microbial consortia, which have substantially different physiological properties and nutrient requirements, govern the different biological stages of AD process; thus, multi-stage AD systems are more preferable than one-stage systems [9]. However, due to economical reasons one-stage systems are absolutely predominant in industrial scale [7].

Based on the reasons mentioned above, this research aims to investigate the most sustainable alternative to treat FW with AD. To achieve the aim several objectives are pointed out: 1) to conduct batch experiment on mesophilic AD of FW; 2) to study the effect of thermal and chemical pre-treatment methods, through batch experiments; 3) to estimate the most economical method through cost benefit analysis; 4) to conduct one-stage and multi-stage semi-continuous experiment using the batch experiment results; 5) to investigate the environmental impacts of the semi-continuous systems through Life cycle assessment (LCA).

Thermal and chemical (ozonation) pre-treatment methods are selected to be studied for this research. The reasons for selecting these pre-treatment methods or the advantages include the following: 1) previous studies have shown that both thermal and chemical pre-treatment methods enhance the AD process performance; 2) both pre-treatment methods can reduce the amount of pathogen micro-organisms; 3) no additional chemicals needed to neutralize the substrate after pre-treatment and prior to AD; 4) extra-cost can be recovered by the increased biogas production due to pre-treatments. Different concentration of ozone, and different temperatures with various contact times will also be investigated. The net profit of each pre-treatment method

will be calculated based on the extra biogas production due to pre-treatment method, and the total extra cost.

Semi-continuous experiments will be conducted with both one-stage and multi-stage reactors at mesophilic conditions. Moreover, temperature phased anaerobic digestion (TPAD) will also be conducted as another type of the multi-stage system. TPAD will consist of two stages, namely: 1) the fermentation stage at thermophilic temperature; and 2) methanation stage at mesophilic temperature.

Finally, the environmental impacts of the single and multi stage AD process will be evaluated through LCA, using software SigmaPro. To create the Life cycle inventory system boundary is chosen from the feeding of substrate and ends at biogas production. In other words, the cradle is chosen as the feeding and grave is chosen as the biogas production.

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