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➢ ***ORAL PRESENTATION***

Effect of Organic Loading Rate and Temperature on Dewaterability of Sewage Sludge at Anaerobic Mesophilic and Thermophilic digestion

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Abstract

Sewage sludge is a by-product of the wastewater treatment process. Dewatering of the sewage sludge in the wastewater treatment plants (WWTPs) is a major challenge due to the large amounts of residual sludge that are produced. Anaerobic digestion is commonly used in WWTPs to stabilize sludge produced in primary and secondary treatment and reduce their volume for final disposal. In recent years, research and development have focused on improving the dewatering process to reduce subsequent sludge handling and transport costs. To achieve this, optimization of the temperature and organic loading rate (OLR) in anaerobic sludge digestion at mesophilic and thermophilic conditions were studied in the present study. The influence of anaerobic digestion process temperature at mesophilic (35°C) and thermophilic (52°C) temperatures and three levels of OLR of 0.72, 0.94 and 1.3 kg VS/m^3/day was investigated on the dewaterability using the Time-to-Filter (TTF) parameter.
The lowest TTF values under mesophilic and thermophilic conditions were obtained as 200 and 450 s, respectively, at the lowest OLR level (0.72 kg VS/m^3/day). Dewaterability was kept mostly similar at mesophilic level but worsened significantly at thermophilic level and OLR increases. The TTF at 35 and 52°C, respectively, were 230 and 600 s at OLR 1.3 kg VS/m^3/day, much better dewaterability at mesophilic level despite higher VS content. The results showed that mesophilic operating level can provide lower chemical costs for dewatering and keep iths characteristics even at higher OLR despite higher volatile solid reduction in thermophilic digestion. Increase in colloidal substances due to enhanced hydrolysis may be a governing factor for the worsened dewaterability in the thermophilic digestion compared to mesophilic condition.

Keywords: anaerobic digestion, dewaterability, time-to-filter (TTF) , mesophilic, thermophilic, temperature.

INTRODUCTION

A significant cost issue in the operation of wastewater treatment plants is the dewatering and disposal of waste sludge. Sludge dewatering accounts for 30–50% of annual operational expenditures. Additionally, there are significant expenditures associated with the following disposal. The best sludge management practices include: a high dewatering rate; a low conditioner dose; a low sludge mass for disposal; and low solids mass and high dry matter content of the dewatered sludge cake. Dewatering often has no impact on the overall amount of solids for disposal, but stabilization through anaerobic digestion provides reduction in the volatile content (Mikkelsen and Keiding, 2002). The success of anaerobic digestion is attributed to the advantageous economics of methane production. It is now economically advantageous to subject primary and activated sludge to anaerobic digestion prior to dewatering and disposal due to rising sludge disposal prices. Thermophilic digestion has been preferred progressively due to its lower retention time need and higher reduction ability. When mesophilic digestion is switched to thermophilic, existing anaerobic reactor's capacity increases. As a result, reactors designed for primary sludge digestion may have their capacity increased to handle both primary and activated sludge. This lowers the total solids mass for disposal in the future but could affect dewaterability (Mikkelsen and Keiding, 2002). Anaerobic digestion has long been practiced in mesophilic (35-37ºC), and thermophilic (50–60ºC) temperature with good operational results (Kim et al., 2002). Contrarily, mesophilic anaerobic digestion (MAD) of sewage sludge is more frequently employed than thermophilic anaerobic digestion (TAD) because it requires less energy and has a more stable process despite higher methane yield and organic reduction in thermophilic digestion. Studies conducted by a number of researchers revealed that thermophilic systems had a greater specific growth rate and were able to handle higher organic loadings than mesophilic operation (Kim et al., 2002). Anaerobic digestion's (AD) temperature (mesophilic or thermophilic) influences particle size, protein, polysaccharide and

the protein/polysaccharide ratio in EPS of sludge flocs which influences the dewaterability of the digested sludge. Therefore, OLR, biogas output and dewaterability of digested sludge are crucial factors in the sludge line economics (An et al., 2017). Numerous investigations have demonstrated that sewage sludge dewaterability is significantly influenced by the properties of extracellular polymeric molecules (EPS) (Lü et al., 2015). According to Houghton and Stephenson's findings in 2002, the best sludge dewaterability can be obtained with an ideal EPS content and composition. Particle size and feed substrate composition, operation temperature, sludge age, and EPS production are factors that affect dewaterability (Suhurtini et al., 2014). The operating conditions have an impact on the sludge floc size distribution which is altered by anaerobic digestion (Mahmoud et al., 2006). The filtration rate has typically been evaluated in terms of the capillary suction time (CST) or specific resistance to filtration in studies on sludge dewatering (SRF). Whether the increase in dispersed particles is due to physical chemical or biological processes, the presence of dispersed particles adversely affects filtration rate. The amount of dispersed particles has also been linked to the amount of polymer needed to condition sludge optimally before dewatering. With regard to filtering rates and conditioner dosing, the distribution of sludge mass between flocs and dispersed colloidal particles is crucial.

The influence of anaerobic digestion process temperature at mesophilic (35°C) and thermophilic (52°C) levels and increasing OLR was investigated on the dewaterability of the digested sludge using the Time-to-Filter (TTF) parameter in this study.

MATERIALS AND METHODS

Materials

Primary sludge (PS) and waste activated sludge (WAS), collected from a full-scale municipal WWTP in Konya with an equivalent population of 1.2 million, employed in this study. As a feed sludge, a mixture of PS and WAS at a fixed ratio (60:40, v: v) was used. Raw sludge samples were stored at 4±1°C, immediately after collection, to avoid biodegradation during storage. Sludge from the mesophilic digestion of a real-scale municipal wastewater treatment plant (WWTP) was used as the seed. The Total solids (TS) of PS and WAS ranged between 30000-50000 and 7000-11000 mg/L respectively. The Volatile solids values determined 20000-35000 mg/L for PS and 5000-8000 mg/L for WAS.

The experimental set-up

Semi-continuous, laboratory-scale anaerobic digester was fed at three levels of organic loading rates (OLRs) (0.72, 0.94, and 1.3 $kgVS/m^3d$) consecutively as two periods at mesophilic (35°C) and thermophilic temperature (52°C). The experimental reactor was a completely mixed reactor has 5 L total volume. The system was run on a semi-continuous basis by daily peristaltic pump feeding and withdrawal of sludge. The reactor's temperature was controlled with a SCADA (supervisory control and data acquisition) system.

Analyses

Sludge filterability was measured by Time-to-Filter method (2710 H) (APHA, 2005) enabling comparison of the samples capacity to release their water content. Better dewaterability at a lower filtering time indicated lower chemical need for decanting of the stabilized sludge. Total solids (TS) and volatile solids (VS) were determined (2540B and 2540E, respectively) according to the Standard Methods (APHA, 2005).

RESULTS and DISCUSSION

The sludge's dewaterability characteristics as TTF values were presented in the Figure 1. Lower filtering times of the digested sludge were obtained at 35°C compared to 52°C digestion. Filtration times for OLR 0.72, 0.94 and 1.3 kgVS/m^{3}d at 35°C under steady-state conditions were found to be 205, 210 and 230 s. As can be seen in the results, increase in the OLR did not produce a significant effect on the dewaterability of the digested sludge in mesophilic digestion. Contrarily, the temperature had a negative effect on dewatering ability. TTF values were obtained as 450, 500 and 610 s at increasing OLRs in thermophilic digestion. TTF increase to multiplied durations despite lower VS content (higher VS reduction) compared to mesophilic digestion was correlated to a higher inorganic content in the thermophilicly digested sludge (Figures 2-3). Dewaterability seemed unaffected by the TS and VS increase in the mesophilicly digested sludge. As OLR increase from 0.72 to 1.3 kg VS/m^3/d resulted in 20 and 14% higher TS and VS concentrations at thermophilic digestion, hydrolysis rate seemed to be exceeded by the OLR. Similarly, studies on capillary suction time and filterability at 33, 35, 37, 39 and 55°C in a completely mixed continuously fed reactor showed the best result at 37°C and worsening at 55°C (Bouskova et al., 2006).

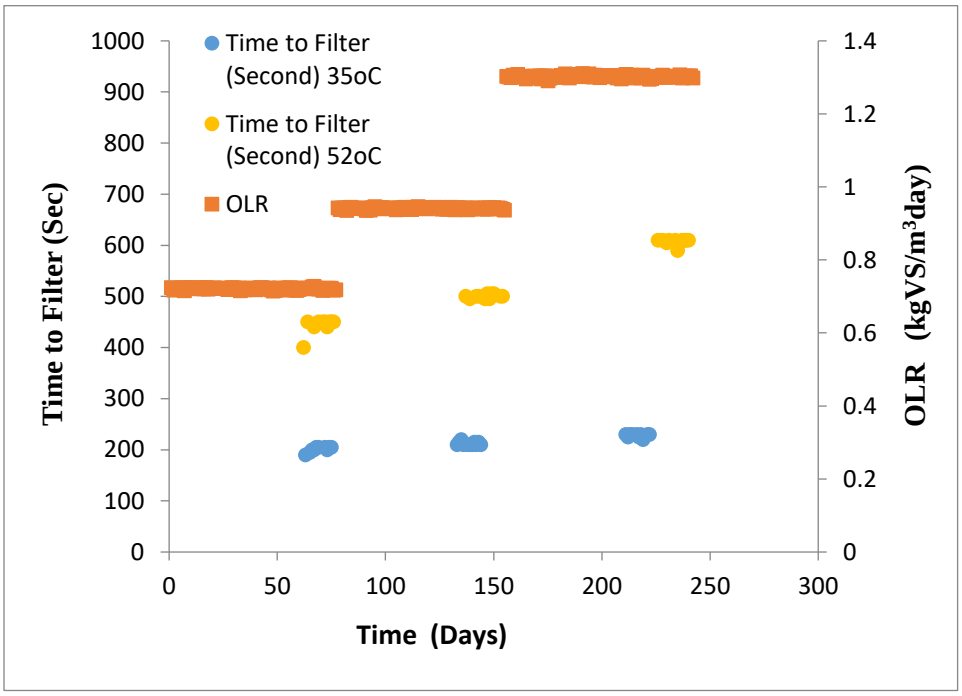

Figure 1. Effect of temperature on dewatering

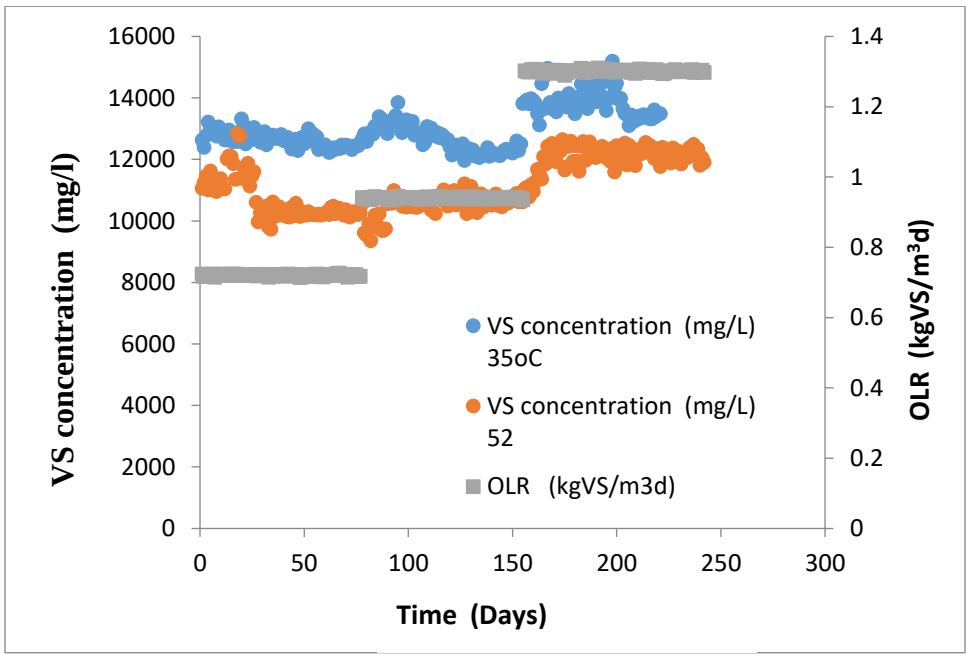

Figure 2. VS concentration against OLR change in effluent sludge

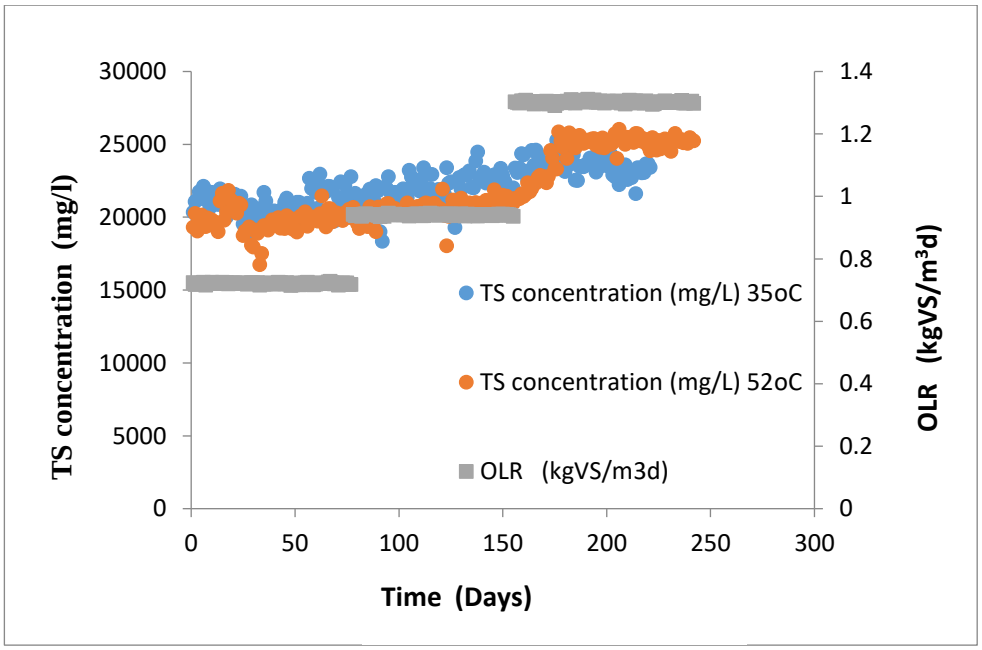

Figure 3. TS Concentration against OLR change in effluent sludge

CONCLUSION

The effect of OLR and temperature on the dewaterability of sewage sludge at anaerobic mesophilic and thermophilic digestion was investigated. The best dewaterability was obtained at OLR 0.72 kgVS/m^{3}d at 35^{o}C. TS and VS increased for OLR 1.3 kgVS/m^{3}d at mesophilic temperature, there was no increase in filtration time. Increase in OLR and subsequently in TS and VS content was tolerated by the mesophilic digestion in terms of dewaterability. The increase to thermophilic temperature had a significantly negative effect on dewatering despite lower VS content that was correlated to the higher inorganic content of the digested sludge.

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