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Executive Summary

1. The objectives of this Study are to evaluate the feasibility of using laboratory-scale reactor to mimic full-scale anaerobic sludge digestion process, and to assess the effectiveness of digestion process in Shatin Sewage Treatment Works (STW) at three different digestion temperatures and at three different hydraulic retention times.

2. The experiment was carried out in Central Laboratory in Shatin STW. The experimental setup of each laboratory-scale digester comprised a glass reactor with an air-tight mechanical mixer, water-bath, plastic pipes for withdrawing and feeding sludge, air pipes and MilligasCounter® for biogas flow measurement. The use of MillgasCounter® was important to collect reliable daily gas production data.

3. Many physical, chemical and biological factors can affect the process, such as digestion temperature, digester volume, hydraulic retention time (HRT), sludge composition, organic loading, pH, chemical dosing, presence of inhibitors, mixing. In this Study, only two important variables were tested, namely digestion temperature and HRT. Three sets of laboratory-scale digesters were constructed for this Study.

4. Three-temperature experiment was conducted at 32, 35 and 37°C, all within mesophilic range. Anaerobic sludge digestion of 35°C was commonly adopted in Hong Kong, both in summer and winter. Tests were under identical condition of 16d HRT, 8L digestion volume, average 0.5L sludge per day, same feed sludge and same ferric chloride dosing for sulfide suppression. Results showed biogas generation of 9.6, 9.9 and 10.0 L/d and %VSR (volatile solids reduction in %) of 52%, 50% and 54% for 32, 35 and 37°C respectively. Specific rate of biogas generation was 1.25 m^3/kg volatile matter reduced. The ratio of VFA/alkalinity (volatile fatty acid to alkalinity) indicated the healthy status of all three digesters. The difference between 35 and 37°C was minor, and this suggested 37°C would be as good as 35°C a temperature for mesophilic digestion, especially in summer. The favorable outcome of 32°C was quite unexpected. The biogas production and %VSR at 32°C was found to be comparable to those of 35 and 37°C. Based on this result, digestion process at 32°C average can be adopted. However, digestion at temperature as low as 32°C is generally not recommended by literature, operation of anaerobic digestion at this low temperature has to be exercised with care.

5. Three-HRT experiment showed a systematic effect of HRT on biogas generation and %VSR. In this experiment, *combined primary sludge* was used because, during this period, surplus activated sludge was co-settled in primary sedimentation tank. Tests

were under identical condition of 35°C, average 0.5L sludge per day, same feed sludge and same ferric chloride dosing for sulfide suppression, with three digestion sludge volumes of 6L, 8L and 10L. Biogas generation of 7.5, 8.7 and 9.2 L/d and %VSR of 54%, 54% and 56% for HRTs of 12d, 16d and 20d respectively. Specific rate of biogas generation was 1.28 m^3/kg reduced, and VFA/alkalinity ratio indicated all three digestion processes was healthy and well-balanced. The results are supportive of the positive effects of longer HRT in biogas production. When HRT of 20d was taken as the reference, HRT of 12d and 16d gave 81% and 95% biogas production. It was found that the results of VSR or %VSR for three HRTs were very similar. The observed negative effect of short HRT (12d) in anaerobic digestion of saline sludge was rather mild, and the behavior of an STW treating non-saline sewage could be different.

6. The two experiments demonstrated that meaningful data related to digestion process could be obtained from careful operation of the three laboratory-scale digesters. Significant effort had been exerted to prevent gas leakage from the digesters because biogas generation would always be a very important measure of the performance of a sludge digestion process.

7. Results of full-scale digestion in Shatin STW were not identical to laboratory-scale digestions over the same period. Hence, we *cannot* conclude that laboratory-digestion can *fully* mimic full-scale digestion. Nonetheless, results obtained from carefully side-by-side comparison of digestion processes, in a more controlled environment, were valuable. The laboratory-scale digester apparatus can be used to conduct additional digestion experiments in the laboratory for trials designed to test parameters which are difficult, risky or too costly to try in full-scale, with an aim to improve both biogas generation and volatile solids reduction in the digestion process.

8. Based on results of laboratory digestion of saline sewage sludge from Shatin STW, a few recommendations can be made. We should design anaerobic digester with minimum HRT with not less than 16 days in order to maximize energy recovery. Digestion temperatures of 35 and 37°C are highly comparable, the operator does not need to bother with the exact digestion temperature as long as the it does not go beyond 37°C. The result of digestion at 32°C was optimistic in biogas production and %VSR, however, in order to advocate that this temperature can be adopted in winter, a more thorough investigation should be conducted before full-scale implementation.