Innovative Environmental Friendly Sludge Treatment Scheme with Co-settling

Every year, Hong Kong people generated about 1000 million m^3 of sewage. About 17% of the total sewage generated receives secondary biological treatment and it consumes about 90 million kWh of electricity a year for achieving the required higher quality effluent standard. Studies suggested that co-settling of activated biological sludge with primary sludge could improve primary sludge settling and digestion efficiency which could bring energy saving and other environmental benefits.

This paper introduces an environmental friendly sludge treatment scheme developed by the Drainage Services Department (DSD), the Government of the Hong Kong Special Administrative Region for secondary treatment works with innovative application of the concept of sludge co-settling. The environmental benefits in saving of energy, solid waste, facilities and footprint after a year of trial at Shatin Sewage Treatment Works (STW) would be covered.

Sludge Treatment in Secondary Treatment Works in Hong Kong

In conventional STW, pollutants in wastewater are removed as solid in the form of primary sludge (PS) and the overgrown biomass after biological degradation of the pollutants known as wasted activated sludge (WAS). The removed PS and WAS require further treatment (Figure 1) by (i) WAS thickening; (ii) sludge digestion; and (iii) final sludge dewatering to solid waste for disposal.

In WAS thickening, due to space limitation, energy consuming mechanical thickeners are commonly used in majority of the STWs in Hong Kong.

In sludge digestion, the PS is mixed with thickened WAS to form a mixed sludge and then fed into a digestion tank (digester) for conditioning by undergoing anaerobic digestion to further reduce solid content, odour and pathogens of the sludge. The digesters have to be maintained at a temperature around 35^0C for effective degradation of around 20 days. In winter, additional heat is normally required for keeping digesters warm. Biogas, which is a renewable energy source, is produced as by product during the digestion process and utilized for generating electricity and heat for use by the plant.

In final sludge dewatering, the digested sludge will be dewatered to solid waste of 30% dryness for disposal at landfill.

With the use of substantial number of mechanical thickeners and digesters for treating large amount of sludge, the sludge treatment processes consumed a relatively high percentage of energy of 29% as compared to overseas plants of 18%. For the case of Shatin STW, the energy used in the above three processes was 10.5 million kWh of electricity against 36.4 million kWh used by the whole STW in 2010.

Problems

Analysis was carried out on operational data from 2009 to 2010 on the impact of WAS to various treatment processes. Table 1 summarised the findings.

Processes	Impacts Caused by Large Amount of WAS
WAS Thickening	More energy used in thickening of WAS by mechanical thickener.
Digestion of sludge	• Require more time when compared to PS for digestion and gas production. • Increase volume of mixed sludge to digester, thus more digesters for treatment and associated heating energy.
Dewatering of final sludge to landfill	• Worsen the dewaterability of the final sludge leading to poorer dryness of the dewatered solid waste. • Increase amount of final dewatered solid waste to landfill.

Table 1 : Impacts of WAS on Sludge Treatment Processes

The analysis indicated that reducing the generation of WAS could bring multiple benefits. It is believed that the biological natures of activated sludge with microbial cell rich of water content and hard-to-break cell wall attribute to the negative effects of WAS on the thickening, digestion and dewatering processes.

Constraints

In biological treatment, wastage of activated sludge is to suppress the excessive growth of micro-organism which, if not properly controlled, may result in biological foaming (Photo 1) and affect the effluent quality. So, there is a limitation in substantial reduction of activated sludge wastage (WAS) so as to minimise the impact on sludge treatment processes. As such, it requires a new way to balance the demand on energy saving, the constraints and effluent quality.

Photo 1: Biological Foaming in Winter

Environmental Friendly Treatment Scheme

An innovative, environmental friendly sludge treatment scheme (Figure 1) comprising the followings was tried at Shatin STW from June 2011 to May 2012.

(1) Co-settling - to provide an alternative path for portion of generated WAS to recycle to the primary tank. In this way, the sedimentation, biological treatment and sludge thickening processes could be carried out simultaneously. By doing so, the time and energy consumed in sludge treatment could be saved.

(2) Reducing the sludge digestion time from 20 days to 10 days benefited from improved digestion efficiency of the sludge (less WAS content in the sludge) produced under the co-settling measure. With both the digestion time and total amount of sludge to digester reduced, the number of operating digesters could be substantially reduced resulting in saving of energy for digester heating. Besides, the rate of biogas production was also found increased.

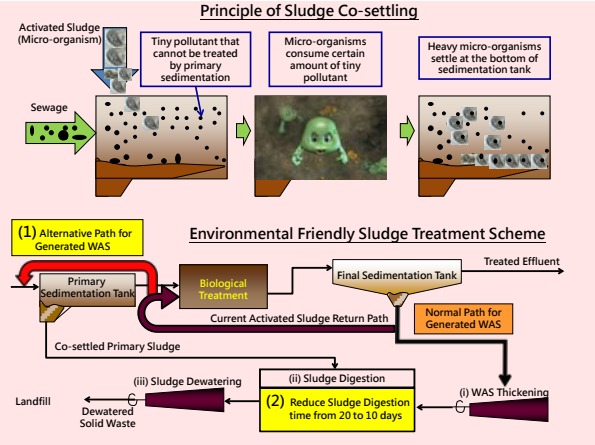

Figure 1 : The Innovative, Environmental Friendly Sludge Treatment Scheme with Co-settling

Figure 2 : Shatin STW and the Alternative Path for WAS Wastage

Implementation Challenges

During the implementation, the primary sedimentation process was found upset with excessive surface scum by full return of generated WAS for co-settling. It was believed that the excessive surface scum was caused by biological denitrification of which the nitrogen gas released brought with them the settled primary sludge to rise to the surface of the primary tank. To tackle this problem, substantial trials were carried out to find out the optimal recycling rate which could maximise the energy saving without affecting the primary sedimentation process.

Benefits

In terms of energy savings, after a year of trial, the scheme saved 6.6 million kWh, 63% of the total energy previously used in sludge treatment, with 4.4 million kWh coming from saving in the three sludge treatment processes and 2.2 million kWh from regenerative power due to increased biogas production. In money term, it reduced electricity cost by $4.3M a year. Besides, the alternative path (Figure 2) identified only required about $120,000 for installation resulting the payback period of this scheme being only 2 weeks.

In terms of waste production, due to improved sludge dewatering characteristic of the co-settled sludge after digestion, the final sludge was found easier to be dewatered to solid of 30% dryness. In addition, 700 tonnes of solid waste for disposal at landfill was reduced annually.

In terms of facilities and footprint required, the scheme reduced 60% of the mechanical thickeners required for WAS thickening and 35% of the digesters required for sludge conditioning which in turn saved a total area of about 5,800 sq.m for accommodation of the concerned sludge treatment facilities

Conclusion

The sludge treatment scheme developed by the DSD with innovative application of sludge co-settling has been successfully proven with plant trial to be a sustainable and cost-effective configuration for a secondary treatment works. The scheme also brings multiple environmental benefits.

References

1 U. YEIS and E. Tarlan (2000) - Improvement of Primary Settling Performance with Activated Sludge. Environmental Technology, Vol. 23 pp 363-372

2 Shatin Sewage Treatment Works Stage III Extension Design Memorandum, 2000

3 Water and Wastewater Energy Best Practice Guidebook. Focus on Energy (Dec 2006)

About the author : Ir. Max C K CHIANG is a Senior Electrical and Mechanical Engineer in the Sewage Treatment 2 Division of the Drainage Services Department of the HKSARG.