Chapter 11
Waste-Activated Sludge Treatment Processes

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ABSTRACT

Biological processes are the most common methods to treat wastewater but they produce huge amounts of waste-activated sludge (WAS) as a by-product. WAS generated during wastewater treatment must be stabilized sufficiently prior to ultimate disposal. The most common methods of sludge stabilization are biological processes (aerobic or anaerobic digestion) due to simplicity of the operation, and lower operating and maintenance costs for similar wastes. Anaerobic digestion remains the principal process for the stabilization of sludge solids as organic waste is converted into methane-rich biogas and fertilizer in an oxygen-free environment. However, WAS treatment processes are often a challenging problem. Therefore, the characteristics of WAS are discussed to have a better understanding so as to treat it efficiently. Various kinds of treatment processes such as physicochemical treatment, biological treatment, and combined treatment are the focus of this chapter; however, many concepts developed in this chapter apply to anaerobic digestion to stabilize the WAS.

INTRODUCTION

Sludge production in the industrialized world has been steadily increasing during the last decades, with biological wastewater treatment processes being one of the major contributors (Feng et al., 2009; Neyens, Baeyens, Dewil, & De heyder, 2004). Sludges of biological origin such as waste activated sludge (WAS) are known to exhibit high organic and solids content as well as poor dewaterability. The particulate organic matters of WAS are difficult to convert into soluble substances, therefore its efficiency of

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treatment is generally low (Xu et al., 2017). Together with more stringent disposal regulations, this has caused a demand for more efficient sludge conditioning and dewatering techniques to reduce the volume of sludge, resulting in lower costs of further processing as well as transport and disposal of sludge. The management of sludge, or biosolids, requires major investment and operating costs. Typically, about 50–60% of the operating cost of a wastewater treatment plant caters for sludge management (Mininni, Laera, Bertanza, Canato, & Sbrilli, 2015; Tomei et al., 2016). Thus, sludge dewatering is of paramount importance in wastewater treatment systems. Organic polymers are the most widely employed conditioners in the wastewater treatment industry. The polymers mainly consist of acrylamide and acrylate, which are potential toxins to aquatic animals and human beings at certain concentrations, even though they are sometimes biodegradable (Bolto & Gregory, 2007). The residual polymers in dewatered sludge cakes may also pose a long-term risk to surrounding environment when the cakes are subject to landfill as the final disposal and it is usually very expensive. Despite conditioning, a considerable amount of water is retained within the sludge, leading to extreme compressibility and moderate dewaterability.

Many wastewater treatment facilities employ biological processes such as activated sludge process as they are an effective way of treating wastewater. The activated sludge (biomass) serves as a catalyst for the conversion of pollutants originating from wastewater to harmless gaseous products or biomass, which can be removed by sedimentation. The chemical conversions in a biological wastewater treatment system are mainly carried out by microorganisms. Under substrate limiting conditions, part of the microorganisms live on available substrate to survive and grow, whereas a huge fraction of them die and contribute to the WAS which also include the living excess biomass. A typical lifecycle for microorganisms consists of the hydrolysis of slowly degradable matter (e.g. in particulate form) into easily degradable matter, which may be soluble. This is further hydrolyzed into very easily degradable matter, i.e. substrate (acetic acid, methanol, propionic acid, glucose, ammonium, nitrite etc.) that are used for the growth of the biomass. Therefore, biological processes in WWTPs have the serious drawback of continually producing huge amounts of WAS.

Municipal and industrial wastewater treatment plants (WWTPs) generate large amounts of sludge as a by-product of the physical, chemical and biological processes used during treatment. Biological processes, such as activated sludge process are the most common methods to treat wastewater but at the same time, they produce huge amounts of waste activated sludge (WAS). Hence, the WAS is an inevitable drawback inherent to the activated sludge process and must undergo some pretreatment or post-treatment in order to reduce its associated volumes, improve its characteristics for reducing the associated health problems as well as handling and disposal. However, sludge treatment is one of the most difficult and expensive problems in WWTPs. The treatment and disposal cost of WAS may be as high as 50% of the operating cost of the WWTPs (Mininni et al., 2015; Tomei et al., 2016). Generally, pretreatments are applied to (i) firstly reduce the water content of the WAS (dewatering), (ii) transform refractory organic material into biodegradable residue, and (iii) finally transfer the residue to the subsequent treatments.

OVERVIEW OF WASTEWATER TREATMENT PROCESSES

Activated sludge, aerated lagoons, rotating biological contactors and trickling filters are the most common wastewater treatment processes being used in Malaysia (“Sewage,” 2016). In an activated sludge system, the wastewater first passes through the preliminary process (screening, grease and grit removal),

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